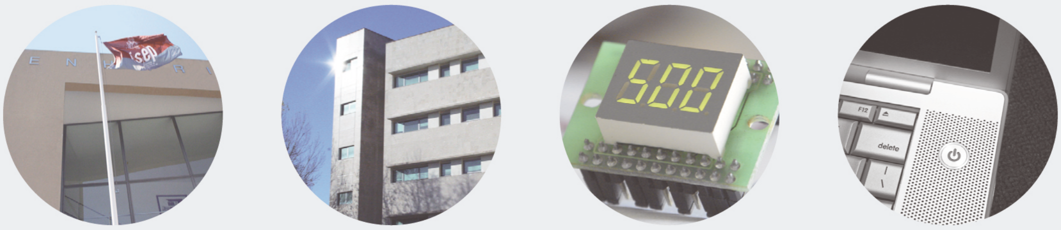
INSTITUTO SUPERIOR DE ENGENHARIA DO PORTO

MESTRADO EM ENGENHARIA ELECTROTÉCNICA E DE COMPUTADORES



RECONFIGURAÇÃO E DESENVOLVIMENTO DO SISTEMA DE CONTROLO DE UM AGV

CARLOS VITORINO MAGALHÃES RANGINHA

Outubro de 2015

POLITÉCNICO
DO PORTO

RECONFIGURAÇÃO E DESENVOLVIMENTO DO SISTEMA DE CONTROLO DE UM AGV

Carlos Vitorino Magalhães Ranginha

Instituto Superior de Engenharia do Porto

Departamento de Engenharia Eletrotécnica

Mestrado em Engenharia Eletrotécnica e de Computadores

Área de Especialização em Automação e Sistemas

2015

Relatório elaborado para satisfação parcial dos requisitos da Unidade Curricular de Tese/Dissertação do Mestrado em Engenharia Eletrotécnica e de Computadores

Candidato: Carlos Vitorino Magalhães Ranginha, Nº 1990136, 1990136@isep.ipp.pt
Orientação científica: Mestre Adriano Manuel de Almeida Santos, ads@isep.ipp.pt

Departamento de Engenharia Eletrotécnica
Mestrado em Engenharia Eletrotécnica e de Computadores
Área de Especialização em Automação e Sistemas

2015

Agradecimentos

É com prazer que finalizo este capítulo de estudos mas sem antes agradecer ao Engº Adriano Santos por todo o apoio, dedicação e paciência ao longo de todo o projeto, apesar de todas as dificuldades tidas.

Um especial agradecimento ao Engº C. Miguel Silva pelo tempo despendido e a ajuda incansável.

Ao Sr. Arlindo Vargas, administrador da Tecnilab Portugal, pela oferta do PLC usado no projeto.

Aos meus pais e ao meu irmão por me estarem sempre a incentivar e chatear para que nunca desistisse.

À Luzia, por me aturar, apoiar e ajudar, mesmo nos momentos mais difíceis e pelos quais sei que irei “pagar”.

Resumo

O veículo guiado automaticamente (AGV) adquirido pelo Departamento de Engenharia Mecânica (DEM) tem vindo a ficar obsoleto devido ao hardware, que nos dias de hoje começa a dar sinais de falhas bem como falta de peças de substituição, e ao software, sendo o PLC (Programmable Logic Controller) usado muito limitado quanto às suas funções de controlo, ficando as principais tarefas de controlo do AGV a cargo de placas eletrónicas de controlo.

Para promover o controlo autónomo do AGV, foi decidido retirar toda a parte de hardware que detinha o controlo do mesmo e passou a ser um novo PLC, com maior capacidade de processamento, a executar todo o tipo de controlo necessário ao funcionamento do mesmo.

O hardware considerado apenas incluí, de forma resumida, os motores responsáveis pelo movimento e direção, placa de controlo de potência dos motores, placa de interface entre as saídas digitais do PLC e as entradas da placa de controlo de potência dos motores e os demais sensores necessários à deteção de obstáculos, fins de curso da direção, sensores dos postos de trabalho e avisadores de emergência.

Todo o controlo de movimento e direção bem como a seleção das ações a executar passou a ficar a cargo do software programado no PLC assim como a interação entre o sistema de supervisão instalado num posto de controlo e o PLC através de comunicação via rádio.

O uso do PLC permitiu a flexibilidade de mudar facilmente a forma como as saídas digitais são usadas, ao contrário de um circuito eletrónico que necessita de uma completa remodelação, tempo de testes e implementação para efetuar a mesma função.

O uso de um microcontrolador seria igualmente viável para a aplicação em causa, no entanto o uso do PLC tem a vantagem de ser robusto, mais rápido na velocidade de processamento, existência de software de interface de programação bastante intuitivo e de livre acesso, facilidade de alterar a programação localmente ou remotamente, via rádio, acesso a vários protocolos de comunicação robustos como Modbus, Canbus, Profinet, Modnet, etc., e acesso integrado de uma consola gráfica totalmente programável.

É ainda possível a sua expansão com adição de módulos de entradas e saídas digitais e/ou analógicas permitindo expandir largamente o uso do AGV para outros fins.

A solução está a ser amplamente testada e validada no Laboratório de Automação (LabA) do Departamento de Engenharia Mecânica do ISEP (Instituto Superior de Engenharia do Porto), permitindo a otimização dos sistemas de controlo de direção bem como a interatividade entre o PLC e o programa de interface/supervisão do posto de trabalho.

Palavras-Chave

AGV, PC, Posto Cliente, PLC, Modbus, Linha Guia, Controlo.

Abstract

The automatically guided vehicle (AGV) acquired by the Department of Mechanical Engineering (DEM) has become obsolete due to hardware, which nowadays begins to give signs of malfunction as well as lack of spare parts, and to software, being the PLC (Programmable Logic Controller) used very limited, leaving the main control tasks of the AGV to the electronic control boards.

To promote the autonomous control of the AGV, it was decided to remove the entire hardware that hold its control and a new PLC was installed, with greater processing capacity and capable of executing all kinds of control required to operate the AGV.

This hardware includes, in a summary form, the electric motors responsible for movement and steering, electric motors control drive board, interface board from the digital outputs of the PLC and the electric motors control drive board and other sensors necessary for the detection of obstacles, steering limit switches, infrared sensors to detect destination towers and emergency buttons.

All movement and steering control as well as the selection of actions to perform has become in charge of the software programmed in the PLC as well as the interaction between the supervision system workstation and the PLC via radio communications.

The use of the new PLC allowed the flexibility to easily change the way the digital outputs are used, as opposed to an electronic circuit that require refurbish, testing and implementation time to perform the same function.

The use of a microcontroller would be also a viable path for the application. Nevertheless, the use of the PLC has the advantage of being robust, faster processing speed, programming software very intuitive and freeware, capacity to change the programming locally or remotely through radio, access to various communication protocols such as Modbus, Canbus, Profinet, ModNet, etc., and fully programmable integrated graphical console.

It is also possible to expand the PLC capabilities with the addition of digital and/or analog input and output modules, allowing the use AGV for other purposes.

The solution being widely tested and validated in the Automation Laboratory (LabA) of Engineering Mechanical Department of ISEP (Engineering Institute of Porto), allowing optimization of steering control systems and the interaction between the PLC and the interface program/supervision from the workstation.

Keywords

AGV, PC, Workstation, PLC, Modbus, Guide Line, Control.

Índice

Índice de Figuras

Acrónimos

PLC – Programmable Logic Controller

AGV – Automated Guided Vehicle

PC – Personal Computer

DEM - Departamento de Engenharia Mecânica

LabA - Laboratório de Automação

CAD - Computer Aided Design

SCADA - Supervisory Control And Data Acquisition

HMI - Human Machine Interface

NA - Normalmente Aberto

IGSS - Interactive Graphical SCADA System

ISEP - Instituto Superior de Engenharia do Porto

1. INTRODUÇÃO

O conceito de veículo sem condutor surgiu em meados de 1950, tendo sido o primeiro AGV com aplicações industriais, desenvolvido pela empresa Barret Electronics Corporation em 1954 [1].

Apenas em meados de 1980 é que o termo AGV surgiu pela primeira vez. Até então, este tipo de equipamento era designado como “driveless vehicles”.

Antes do desenvolvimento do AGV, a movimentação de cargas apenas era efetuado em tapetes automatizados, quando a movimentação era linear, ou por equipamento de movimentação de cargas, empilhador, operado pelos trabalhadores.

Com a introdução do AGV, as empresas passaram a poder trabalhar 24h por dia, enquanto um trabalhador apenas labora entre 8 a 10h por dia.

Também no que concerne à movimentação de cargas, um operador apenas pode deslocar cargas de elevado peso com o auxílio de um empilhador. Este tipo de tarefa tem velocidades diferentes consoante o operador que executa a tarefa bem como o trajeto por ele escolhido.

O AGV, com a sua velocidade de deslocação constante, permite uma movimentação das cargas de forma fluida, sendo o seu trajeto otimizado aumentando a sua produtividade.

Mas não só apenas em sistemas de movimentação de carga é que os AGV são utilizados, certo é que alguns de nós temos um pequeno AGV em casa.

O mini-aspirador “Roomba” é um exemplo de um AGV mas, ao contrário dos irmãos maiores, não permite deslocar cargas mas sim aspirar o chão da residência autonomamente evitando obstáculos como paredes, mobiliário ou outros.

Figura 1 - Robô de aspiração Roomba [2]

Na Figura 2 pode observar-se a imagem de um AGV usado numa linha de transporte de carga.

Figura 2 - AGV na Industria [3]

Na Figura 3 apresenta-se um AGV usado para movimentar um avião.

Figura 3 - AGV na Aviação [4]

1.1. TIPOS DE CONTROLO DE UM AGV

1.1.1. CONTROLO CENTRALIZADO

No controlo centralizado, como o nome indica, existe um computador ligado através de uma rede de comunicações onde são geridas as rotas, ordens e demais informação enviada para cada AGV.

É também este o sistema central que monitoriza e previne qualquer tipo de colisão entre os diversos AGV, caso existam [13].

1.1.2. CONTROLO DESCENTRALIZADO

No controlo descentralizado, é o sistema de controlo do próprio AGV, usualmente um PLC ou PC industrial, que faz a gestão do trabalho executado pelo AGV.

Para evitar qualquer tipo de colisão entre diversos AGV ou com alguma pessoa na sua envolvente, o sistema usa equipamento próprio para deteção de obstáculos.

O sistema descentralizado é preferível ao sistema centralizado uma vez que, em caso de falha do sistema de controlo centralizado, todos os veículos dependentes deste sistema ficam parados.

Em termos de custos, existe pouca diferença entre um sistema descentralizado e um sistema centralizado.

No sistema descentralizado, o custo do AGV é elevado pois necessita que a programação seja realizada especificamente para cada equipamento.

No sistema centralizado, o software é igual em todos os equipamentos baixando assim o custo dos AGVs instalados. No entanto, os servidores e os equipamentos de comunicações necessários colmatam a diferença do baixo preço dos AGVs [7].

1.2. TIPOS DE NAVEGAÇÃO

1.2.1. MARCAÇÃO NO CHÃO

Apesar de ser o sistema de navegação mais conhecido, não é dos sistemas de marcação de rotas dos AGV mais usado.

Muito embora seja um sistema de baixo custo na sua instalação e que facilmente permite a sua re-disposição, a fita facilmente fica suja ou mesmo danificada.

Este sistema também não é muito flexível quanto à utilização de diversos AGV no mesmo “Layout” a não ser em sistemas de linha de montagem em que, apesar de usar vários AGV, a rota é sempre linear e todos os veículos seguem a mesma rota a igual distância entre eles.

1.2.2. FIO MAGNÉTICO EMBEBIDO NO CHÃO

De igual utilização que a marcação da linha no chão, o fio magnético é instalado numa ranhura efetuada no chão onde o AGV vai circular.

Ao contrário da linha marcada, o fio pode ser magnetizado por troços ficando o sistema centralizado responsável por definir o trajeto a seguir.

A principal desvantagem deste sistema é a sua inflexibilidade em traçar novas rotas. Qualquer alteração necessita que se proceda ao rasgo do novo caminho no chão, normalmente em cimento, e à colocação de novo fio.

Outro problema está relacionado com a duração do fio. Com o passar do tempo o fio torna-se quebradiço e podem ocorrer interrupções do fluxo magnético responsável pela definição da rota do AGV [5].

1.2.3. SISTEMA DE TRIANGULAÇÃO POR GPS OU WIFI

Não existindo sistemas de controlo de rota, o veículo desloca-se com base nas coordenadas do destino, usando sistemas de deteção de obstáculos para evitar colunas e paredes.

Não existe limitação de distância e o caminho usado é dinâmico visto ser constantemente calculado pelo equipamento.

No entanto, o sistema GPS não pode ser usado dentro de edifícios, local onde grande parte dos AGVs é usada, devido à fraca receção do sinal GPS dos satélites e interferências constantes com telemóveis [6].

1.2.4. SISTEMA DE MEDIÇÃO LASER

O sistema baseia-se na triangulação para manter o veículo na rota pretendida. Para isso o veículo é equipado com um emissor/recetor laser rotativo.

Desta forma pode-se detetar colunas, paredes e outros obstáculos.

A distância e ângulo dos respetivos obstáculos são comparados com um mapa em formato CAD armazenado na memória do equipamento.

1.3. MÉTODOS DE SELEÇÃO DE DESTINO

O veículo recebe informação do destino localmente (sistema descentralizado) ou remotamente (sistema centralizado).

Em sistemas simples, o destino é introduzido localmente na consola do veículo. Em sistemas mais complexos, o AGV pode ser “chamado” através de terminais locais e os seus destinos são controlados por sistemas centralizados ou através de rotinas implementadas no AGV [5].

1.4. ALIMENTAÇÃO DO AGV, SISTEMA DE BATERIAS

Os AGVs podem apresentar três tipos de sistemas para trocar/carregar as baterias: manual, carga automática e troca automática.

Modo Manual, em que o operador se desloca ao veículo e efetua a troca da bateria gasta por uma totalmente carregada, modo de carga automática em que o AGV se desloca a uma estação de carga e ai permanece até a bateria ter um nível mínimo de carga e o modo de troca automático em que o veículo se desloca a uma unidade automatizada para efetuar a troca da bateria gasta por uma bateria carregada.

Devido à evolução das baterias e respetivos sistemas de carga, é possível hoje termos baterias de maior capacidade e com tempos de carga reduzidos [1].

1.5. PLC

Programmable logic controller – controlador lógico programável – foi inventado em 1968 pela Bedford Associates, que fundou, posteriormente, a empresa MODICON – Modular Digital Control. O primeiro PLC foi denominado “084” pois tratava-se do 84º projeto da Bedford Associates [8].

Em 1979 a Modicon foi responsável pelo lançamento da primeira rede de comunicações industriais “Modbus”. Esta rede permitia a comunicação entre os PLC’s e os computadores, sendo o seu protocolo de comunicação aberto para todos os utilizadores e hoje considerado um “standard” na comunicação de equipamentos industriais.

Em 1997 a Modicon foi adquirida pela Schneider.

1.6. PROTOCOLO DE COMUNICAÇÃO MODBUS

Desenvolvido pela Modicon, o protocolo Modbus permitiu a interligação entre os PLC’s e os computadores numa lógica *Master-Slave* [11].

Neste tipo de comunicação, apenas o “Master” é que efetua pedidos de informação e envia ordens para o escravo, “Slave”.

O “Slave” apenas se limita a responder aos pedidos do “Master” e a executar as ordens recebidas.

1.7. IMPLEMENTAÇÃO DO PROTOCOLO

O protocolo Modbus é amplamente utilizado a nível industrial, estando neste momento estandardizado no mundo da automação.

Todos os PLCs existentes permitem este protocolo de comunicação, libertando o utilizador para o uso de diferentes marcas de PLCs, mas não inibindo a troca de informação entre os mesmos.

No caso do AGV, a implementação foi realizada com um SCADA (*Supervisory Control And Data Aquisition*) de licenciamento livre, IGSS da Schneider [8].

1.8. FUNÇÕES USADAS PELO PROTOCOLO

Apesar de algo complexo, o protocolo modbus assenta no princípio de troca de dados entre o master e o slave.

As funções usualmente implementadas nos sistemas de controlo e supervisão são as funções com os códigos 01-Read Coils, 03-Read Holding Registers, 15-Write Multiple Coils e 16-Write multiple registers [11].

A função 01-Read Coils permite a leitura de dados digitais, exemplo de leitura do estado dos sensores e demais informação digital fornecida pelo PLC, sendo o seu inverso a função 15-Write Multiple Coils, permitindo dar comandos digitais ao PLC.

Já no âmbito de medidas analógicas, a função 03-Read Holding Registers, é usada para a leitura de dados em formato, tipicamente, inteiro. Exemplo disso pode ser a leitura da carga da bateria através do PLC.

Já para enviar algum tipo de dados no formato inteiro, para o PLC, a função 16-Write Multiple Registers deve ser usada. Como exemplo da empregabilidade desta função, poderemos implementar uma *task* de controlo da carga da bateria, usando premissas de níveis de tensão para nos informar se a carga da bateria está com nível baixo ou quando a carga da bateria atingiu o nível ótimo de carga durante a fase de carregamento.

1.9. SCADA (*SUPERVISORY CONTROL AND DATA ACQUISITION*)

O SCADA é um software de aquisição de dados de campo, sejam eles no formato digital ou analógico.

Grande parte dos scadas existentes permitem a comunicação através do protocolo modbus, sendo uma minoria aqueles que estão fechados em protocolos de comunicação proprietário da marca que lhe deu origem.

Além do sistema ter um ambiente de operação intuitivo para visualização de informação e controlo dos equipamentos, permite ainda a gerência de alarmes, gráficos históricos e relatórios [10].

1.10. CONTEXTUALIZAÇÃO

Este trabalho vem na sequência da alteração/atualização do sistema de controlo atualmente instalado no AGV do LabA do Departamento de Engenharia Mecânica.

Com este projeto, pretende-se aumentar as funcionalidades, minimizar o tempo de deteção de avarias, permitir o controlo do AGV remotamente e possibilitar futuras expansões do sistema ao nível das funcionalidades.

1.11. OBJETIVOS

O objetivo principal deste projeto é a melhoria do sistema de controlo e aumentar a flexibilidade da programação do PLC. Dada a complexidade inerente a este objetivo, sentiu-se a necessidade de o subdividir em múltiplas tarefas de realização mais simples, tais como:

- A reavaliação do sistema de controlo do AGV através de um PLC;
- O estudo e implementação de um PLC mais flexível na programação e de maior capacidade nas funcionalidades;
- O estudo e implementação de alterações aos componentes mecânicos;
- O funcionamento e configuração dos circuitos de aquisição de sinais para controlo;
- O desenvolvimento do programa de controlo do movimento e sua implementação.

1.12. ORGANIZAÇÃO DO RELATÓRIO

Neste capítulo faz-se uma pequena introdução quanto aos diferentes aspetos técnicos abordados no capítulo 2 deste relatório para melhor contextualização do leitor. No segundo capítulo são apresentadas as diferentes tarefas elaboradas de uma forma detalhada enquanto no terceiro capítulo são apresentadas algumas dificuldades verificadas durante o processo de desenvolvimento deste projeto. No quarto capítulo, e último, são apresentadas as conclusões e as propostas de trabalhos futuros que visão ultrapassar as dificuldades identificadas durante o desenvolvimento deste projeto.

2. ANÁLISE E IMPLEMENTAÇÃO

Apesar das potencialidades do AGV existente, o sistema de controlo implementado atualmente não permite qualquer flexibilidade quanto ao funcionamento do mesmo.

A implementação do circuito segue normas rígidas e não oferece ao utilizador a possibilidade de este poder criar caminhos conforme a necessidade do espaço.

A pensar nesta flexibilidade, decidiu-se pela substituição do sistema de controlo atual, em que o PLC apenas adquiria sinais de campo, sinais dos sensores, e um circuito eletrónico que geria o controlo dos movimentos do AGV, por um PLC que permita gerir todo o movimento onde os circuitos eletrónicos apenas servirão de interface com os equipamentos de potência.

Um dos maiores problemas com o controlo é o circuito de potência dos motores.

Uma vez que o circuito controla a velocidade e direção, torna-se um circuito complexo e, em caso de avaria, torna-se moroso encontrar a anomalia.

Centralizando tudo no software, conseguimos seccionar todo o controlo em diferentes tarefas, conseguindo descentralizar a análise em caso de anomalia, facilitando a análise e respetiva resolução.

2.1. PLC UNITRONICS

A substituição do PLC Mitsubishi pelo PLC Unitronics permite maior capacidade de execução de tarefas complexas em vez de simples aquisição de sinais.

Existiam alguns requisitos fundamentais para elevar as funcionalidades do AGV.

Usar um PLC que permita programação com o mínimo de custos possível em licenciamento de software, PLC com capacidade modelar, existência de consola de visualização, teclado de interface, portas de comunicação, utilização de diversos protocolos de comunicação e ser compacto.

O PLC V120 da Unitronics [16] é um autómato pequeno, com possibilidade de expandir com cartas de I/O, extensas librarias de programação e potente o suficiente para o projeto em vista, Figura 4.

Figura 4 - PLC V120 Unitronics [16]

A flexibilidade do PLC Unitronics passa pela disponibilidade de portas de comunicação RS232/485, CanBus, comunicação com encoders para motores de passo, entradas digitais para aquisição de sinais, entradas analógicas, saídas digitais em PWM e possibilidade de utilização de protocolos de comunicação, no nosso caso Modbus (Anexo A).

Além das vantagens anteriormente mencionadas, contém ainda uma consola de visualização, totalmente configurável. Esta HMI, *Human Machine Interface*, permite a visualização das informações disponíveis pelo PLC e demais dados disponibilizados pelo programador.

Sendo a alimentação do AGV através de uma bateria de 12 volt, o facto de a alimentação do V120 ser $12V_{dc}$, permite-nos simplificar o sistema de distribuição de energia pelos diversos equipamentos em vez de usar circuito de elevação de tensão, conforme modelo usado na alimentação do PLC Mitsubishi.

2.2. MOTORES DE CONTROLO

Por forma a uniformizar as tensões de alimentação do AGV, decidiu-se optar pelo uso de motores de $12V_{dc}$ em vez dos atuais de $24V_{dc}$, Figura 5.

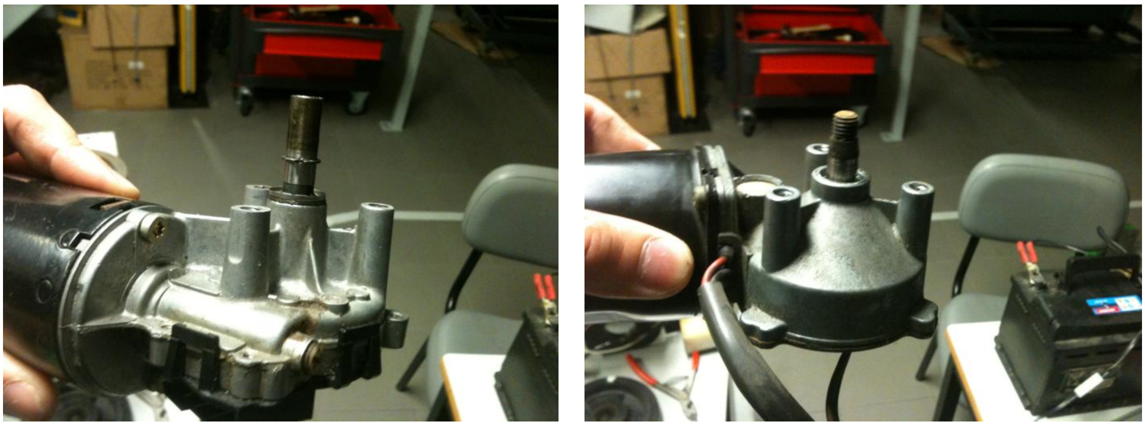


Figura 5 - Motor da direção: $24V_{dc}$ (esquerda) e $12V_{dc}$ (direita)

Esta mudança permitiu eliminar o circuito de elevação de tensão que partilhava a sua quota-parte de problemas com o circuito de potência do controlo dos motores.

Assim, foram usados dois motores BOSCH com binário máximo de 16,9Nm, 98rpm, 1.5A de corrente.

Apesar do binário ser baixo, a caixa de redução de 73:1, faz com que seja possível o uso dos mesmos.

No caso do motor usado para controlo da direção, a adaptação foi mínima pois o motor usado de $24V_{dc}$ e o motor atual têm exatamente a mesma construção, sendo uma substituição direta, ver Figura 5. O motor que controla a velocidade (tração) foi o que necessitou de maior adaptação devido essencialmente ao tamanho, peso e aplicação. Para aplicar o novo motor ao sistema de controlo de direção foi necessário fabricar uma peça intermédia para adaptação entre o novo motor e a placa de direção do AGV (ver Figura 6).

Figura 6 - Motor 12V$_{dc}$ da direção após montagem

A título de comparação, mostra-se na Figura 7, a comparação entre o motor substituído, à direita, e o substituto à esquerda.

Figura 7 - Comparação entre o Motor de movimento de 24V$_{dc}$ e o novo Motor de 12V$_{dc}$

Do mesmo modo e, devido essencialmente à alteração das dimensões do novo motor, foi necessário fabricar uma peça intermédia a aplicar entre o novo motor, caixa de redução, e a roda de tração do AGV. Na Figura 8 apresenta-se o processo de fabrico da peça intermédia, veio de acoplamento, bem como o veio já montado na caixa de redução.

Figura 8 - Torneamento da peça a adaptação ao suporte da roda (esquerda); Veio de ligação do motor de movimento à roda (direita)

Na Figura 9 mostra-se a montagem do motor de $12V_{dc}$, de tração, com o respetivo suporte de fixação da roda motora já instalada.

Figura 9 - Motor de movimento de $12V_{dc}$ já montado no suporte e com a roda instalada

Na Figura 10 mostra-se o conjunto de tração e de direção devidamente instalados na respetiva placa de fixação e de controlo da direção.

2.3. CIRCUITO DE CONTROLO

Visto o controlo dos motores ser realizado pelo PLC, não é possível colocar os motores diretamente ligados às saídas do autómato.

Figura 10 - Motor da direção e Motor de movimento já instalados

Para superar esta contrariedade usou-se um circuito de potência composto por um driver L298N (Anexo B), capaz de gerir dois motores com consumos até 2A (Figura 11).

Figura 11 - Drive para controlo de 2 Motores [14]

Apesar da tentativa em adaptar todos os circuitos elétricos do AGV a $12V_{dc}$, o circuito lógico de controlo dos motores funciona a $5V_{dc}$.

Para uso de todo o potencial de controlo dos motores através do PLC, é imperativo que as saídas em PWM sejam usadas. Por esta razão, foi adicionado um circuito divisor de tensão, convertendo as saídas do autómato de $12V_{dc}$ em sinais lógicos de $5V_{dc}$ e com tempo de reação mínimo. Esquema unifilar presentado na Figura 12.

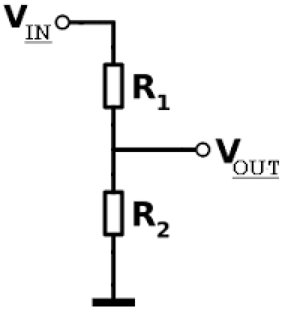


Figura 12 - Circuito teórico Divisor de tensão

Usando a fórmula de cálculo de um divisor de tensão: Vout = (R2/(R1+R2))×Vin;

Substituindo Vin = $12V_{dc}$, R1 = 1kΩ e Vout = $5V_{dc}$, temos que R2 = 714,29Ω.

Usando um potenciómetro de 1kΩ, temos a possibilidade de regular a tensão de saída entre $6V_{dc}$ e $0V_{dc}$.

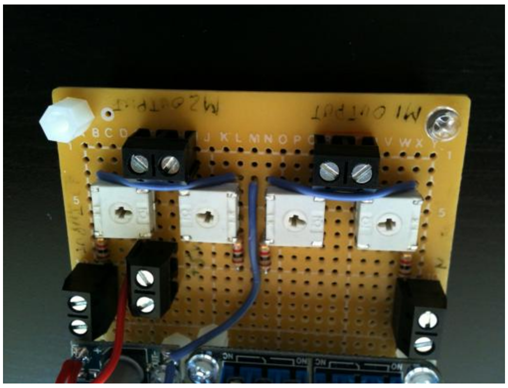


Figura 13 - Circuito Divisor de tensão desenvolvido

2.4. CIRCUITO DE DETEÇÃO DE LINHA

Mantendo a mesma filosofia de funcionamento do AGV, tentou-se usar o mesmo circuito de deteção de linha. Mas, após alguns testes, verificou-se que o mesmo já não se encontrava a funcionar nas melhores condições, facto esse que levou ao desenvolvimento de um novo circuito.

Na Figura 14 apresenta-se a placa original e respetivos componentes eletrónicos da placa de deteção de linha original.

Figura 14 - Circuito de deteção de linha, original

Uma vez que o objetivo é a simplificação e flexibilização do controlo e dos sistemas eletrónicos, foi desenvolvido um circuito simples, que tirou proveito das ligações de alimentação e dos sinais digitais de retorno existentes.

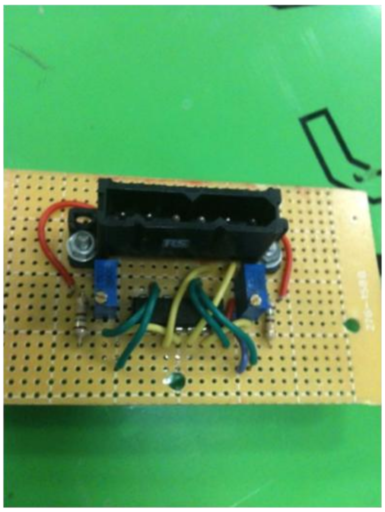


Figura 15 - Circuito deteção de linha desenvolvido

Usando dois sensores infravermelhos, recetor e emissor encapsulados, e alguns componentes passivos, é possível construir um circuito de deteção de linha capaz de operar a uma distância, máxima, de 10 mm (Anexo G).

Uma vez que as entradas digitais do PLC usado são a $12V_{dc}$, é necessário o uso de um circuito de interface de forma a obter a tensão necessária.

Mais uma vez e de forma a simplificar ao máximo a deteção de avarias, usou-se um circuito composto por dois relés de $5V_{dc}$ que são atuados sempre que um dos sensores estiver em contacto visível com a linha.

Os contactos comuns dos relés são ligados diretamente à tensão de alimentação, $12V_{dc}$, e o contacto NA, normalmente aberto, é ligado às respetivas entradas do PLC.

Sempre que um dos dois relés se encontrar atuado, será gerada uma tensão de $12V_{dc}$ na entrada do PLC, refletindo a disposição da linha. A implementação deste conceito encontra-se materializada na *board* de deteção apresentada na Figura 16.

Figura 16 - Circuito interface entre circuito deteção de linha e o PLC [14]

2.5. CIRCUITO ALIMENTAÇÃO $5V_{DC}$

Para garantir uma alimentação estável do circuito de controlo dos relés e do circuito de deteção por infravermelhos, optou-se pelo uso de um conversor de tensão com saída regulada. Este conversor garante uma tensão estável na saída de $5V_{dc}$ e corrente máxima de 3A, com tensão de alimentação variável entre $4,5V_{dc}$ e $32V_{dc}$.

Figura 17 - Circuito conversor de precisão [15]

Com o intuito de minimizar o espaço, reuniu-se numa única placa de circuito impresso os circuitos de alimentação de 5V$_{dc}$, circuito de interface de relés e o divisor de tensão. Desta junção resultou a placa apresentada na Figura 18.

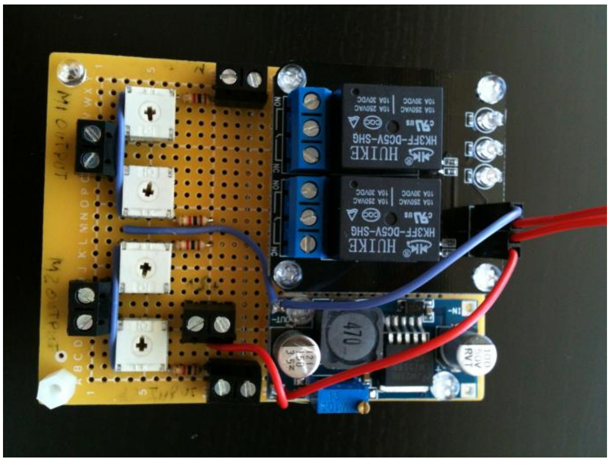


Figura 18 – Reunião dos circuitos elétrico numa única placa

2.6. DETEÇÃO DE OBSTÁCULOS

O AGV original encontra-se dotado de um sensor de infravermelhos na frente do mesmo para deteção de obstáculos. Este sensor, visto ser do tipo NPN, quando ativo, coloca a saída a 0V$_{dc}$.

De forma a inverter o sinal, usamos um relé da marca Finder, modelo 55.34 de 12V$_{dc}$ como interface para as entradas digitais do PLC.

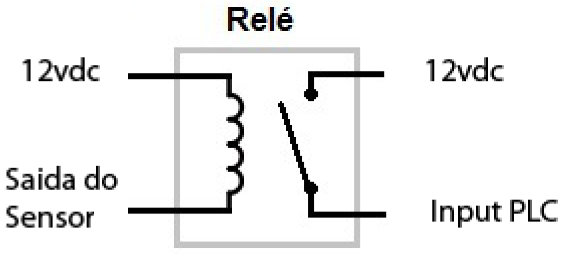


Figura 19 – Ligação elétrica do relé ao sensor e à entrada do PLC

2.7. OUTROS EQUIPAMENTOS INSTALADOS

Existe ainda, mantendo a mesma filosofia de funcionamento do AGV original, dois botões de paragem de emergência na frente do AGV, uma luz na parte frontal para indicação de presença, um buzzer interno para alarme em caso de obstáculos e dois sensores infravermelhos na lateral do AGV para indicação do posto em que o AGV se encontra.

2.7.1. BOTÕES PARAGEM EMERGÊNCIA

Os botões de emergência (ver Figura 21), como o nome indica, servem para parar imediatamente o AGV.

Adicionalmente, sempre que a paragem de emergência esteja ativa, é possível controlar o AGV através dos botões na consola local.

Figura 20 – Botões de controlo na consola do PLC V120

As setas com o sentido superior e inferior fazem andar o AGV para a frente e para trás, respetivamente. As setas com sentido para a esquerda e direita, fazem movimentar a roda para a esquerda ou direita, respetivamente.

2.7.2. LUZ FRONTAL

A luz frontal (ver Figura 21) é ativada de forma intermitente, sempre que o AGV se tenha de deslocar automaticamente, sendo, no entanto, possível desativa-la nos casos em que as condições de operação assim o permitam. O processo de ativação/desativação é realizado, localmente, através da consola do PLC.

Figura 21 – Luz frontal de deslocamento do AGV

2.7.3. BUZZER

Em caso de o AGV encontrar um obstáculo, o buzzer emitirá um som contínuo, com um único tom, para indicar a presença de um obstáculo sobre a linha demarcada do trajeto do AGV.

Caso seja necessário recuar o AGV, o mesmo buzzer irá emitir um som intermitente, a dois tons, para informação que do movimento de recuo.

2.7.4. SENSORES DOS POSTOS DE TRABALHO

Na lateral do AGV, existem dois sensores, recetores de infravermelhos, colocados na vertical.

Existem três postos de trabalho caracterizados da seguinte forma:

- Posto de carga: Pilar com emissor infravermelho superior;
- Posto de descarga: Pilar com emissor infravermelho inferior;
- Posto de recarga da bateria: Pilar com emissor infravermelho superior e inferior.

A conexão entre os sensores e o PLC segue a mesma lógica descrita no ponto 2.6.

Apesar de os pilares de carga e descarga terem apenas carácter informativo, o pilar de recarga da bateria tem uma função específica para o PLC.

Figura 22 – Pilar de carga da bateria do AGV (esquerda);
Conetor de carga da bateria no AGV (direita)

Sempre que o AGV esteja neste ponto, o PLC ativará uma saída digital encarregue de ligar os terminais da bateria interna a um dispositivo de contacto existente na lateral do AGV. No pilar em causa, existe o mesmo tipo de contacto que, quando em contacto com o dispositivo do AGV, faz com que a bateria interna recarregue.

3. SISTEMA DE CONTROLO DO AGV

3.1. SOFTWARE PLC

O software usado é o Visilogic da Unitronics. É um software *freeware*, não necessitando de licenciamento [17].

A linguagem de programação está limitada a LADDER, no entanto a interface de utilização é intuitiva e tem à nossa disposição diversas funções e exemplos de programação como ajuda em caso de dificuldade.

3.1.1. SEPARAÇÃO DE TAREFAS

Visto o AGV ser controlado integralmente pelo PLC, o software está separado conforme o equipamento que pretendemos operar.

O software (Anexo I), está ainda subdividido em interface e *tasks* de controlo. As *tasks* existentes no nosso software são as seguintes:

- Interface;
- Direção;

- Movimento;
- Buzzer;
- Luz;
- Carga_Bateria;
- Base_Dados.

3.1.2. INTERFACE

A *task* de interface é, como o nome sugere, uma rotina em que o PLC atualiza para variáveis internas os *inputs* das suas entradas digitais e os *outputs* nas suas saídas digitais (Anexo C e D).

Todo o controlo é feito nas restantes rotinas.

3.1.3. DIREÇÃO

A *task* responsável pelo controlo da direção do AGV não controla apenas o movimento da direção mas também a velocidade com que o faz.

Além do movimento da direção depender dos sensores afetos ao seguimento da linha de trajetória, a velocidade com que o AGV movimenta o eixo da direção vai depender de o mesmo se encontrar num movimento estável ou se encontrar num movimento oscilante sobre a linha de trajetória.

O AGV usa duas velocidades diferentes para movimentar a direção. Uma velocidade lenta para quando o mesmo se move num circuito estável e uma velocidade rápida quando o circuito é mais oscilante.

O AGV tem ainda a possibilidade de ser controlado manualmente (ver Figura 20), para reposição ou simplesmente porque é necessário repor o AGV noutro trajeto. Assim sendo, o controlo da direção pode ser dividido em dois tipos de controlo:

- Controlo Automático, em que é o PLC com a interação com os sensores de seguimento da linha e sensores de obstáculos ou emergência que toma a decisão de quais as ações a tomar e qual a velocidade usada para mover o eixo da direção;

- Controlo Manual, em que o operador é que controla a direção do AGV, sendo sempre usada a velocidade lenta. Neste modo, toda a responsabilidade de qualquer ação tomada é do operador.

São apresentados seguidamente três fluxogramas, um para o controlo da velocidade a que o eixo da direção se irá mover e um para cada tipo de controlo (automático e manual), em que se ilustra a forma como o software desta *task* está implementado, Anexo I.

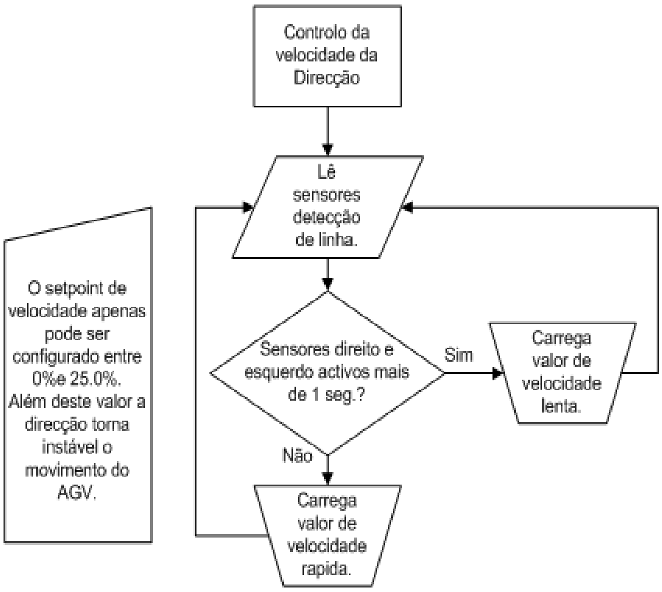


Figura 23 - Fluxograma de controlo da velocidade de movimento de direção

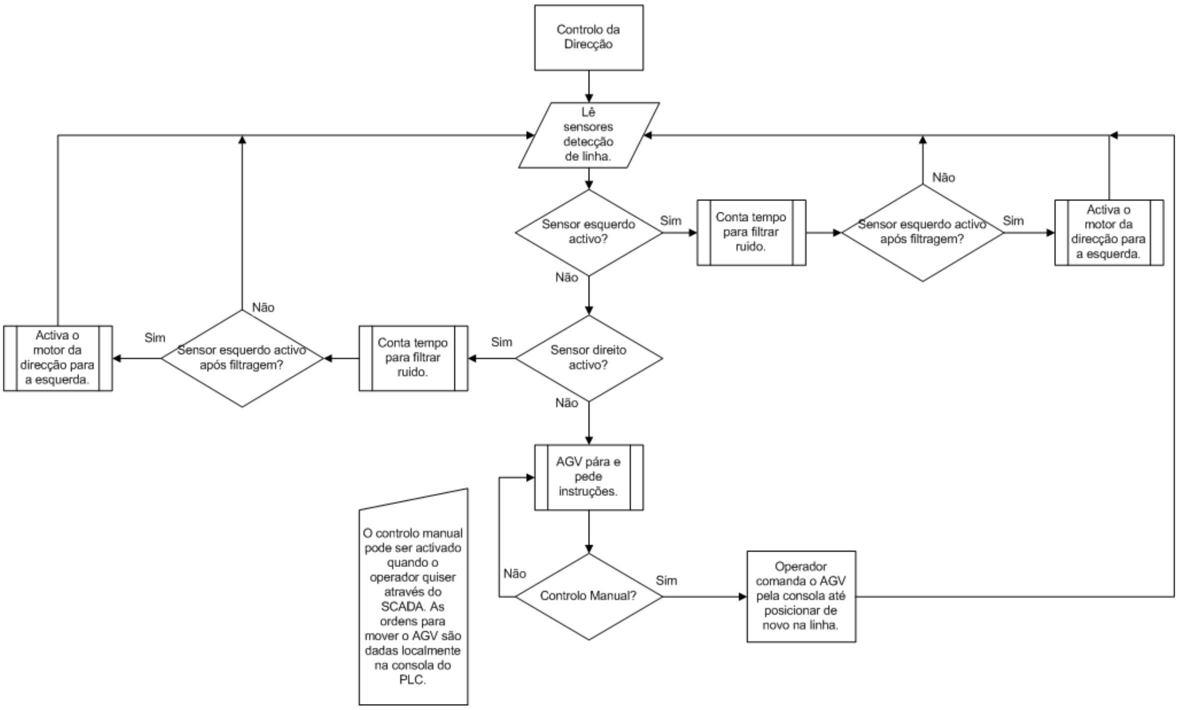


Figura 24 - Fluxograma de controlo de direção, automático

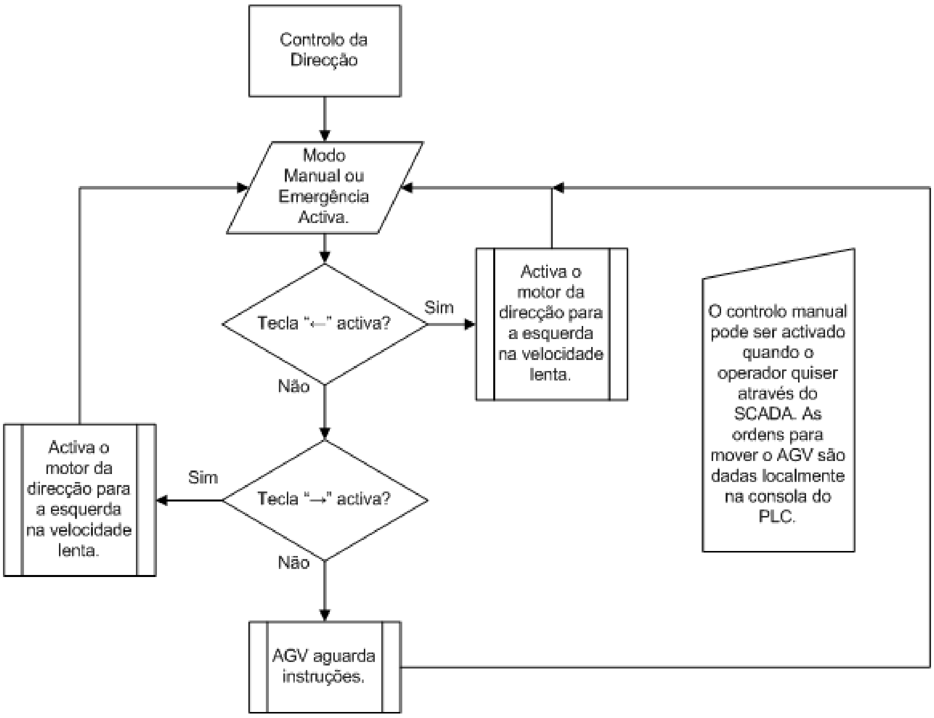


Figura 25 - Fluxograma de controlo de direção, manual

3.1.4. MOVIMENTO

A *task* responsável pelo controlo do movimento do AGV não controla apenas o sentido do movimento mas também a velocidade que o mesmo se movimenta.

Neste projeto apenas o sentido para a frente foi implementado no software, no entanto, apesar do movimento do AGV depender dos sensores afetos ao seguimento da linha trajetória, a velocidade com que o AGV se movimenta vai depender de o mesmo se encontrar num movimento estável ou se encontrar num movimento oscilante sobre a linha de trajetória.

O AGV usa duas velocidades diferentes para se movimentar. Uma velocidade lenta para quando o mesmo se move num circuito estável e uma velocidade rápida quando o circuito é mais oscilante de forma a corrigir mais rapidamente o trajeto.

O AGV tem ainda a possibilidade de ser controlado manualmente, para reposição ou simplesmente porque é necessário repor o AGV noutro trajeto. Assim sendo, o controlo da direção pode ser dividido em dois tipos de controlo:

- Controlo Automático, em que é o PLC com a interação com os sensores de seguimento da linha e sensores de obstáculos ou emergência que toma a decisão das ações a tomar e qual a velocidade usada para se mover;

- Controlo Manual, em que o operador é que controla o sentido do AGV, sendo sempre usada a velocidade lenta. Neste modo, toda a responsabilidade de qualquer ação tomada é do operador.

É apresentado seguidamente três fluxogramas, um para o controlo da velocidade a que o AGV se irá mover e um para cada tipo de controlo, em que se ilustra a forma como o software desta *task* está implementado.

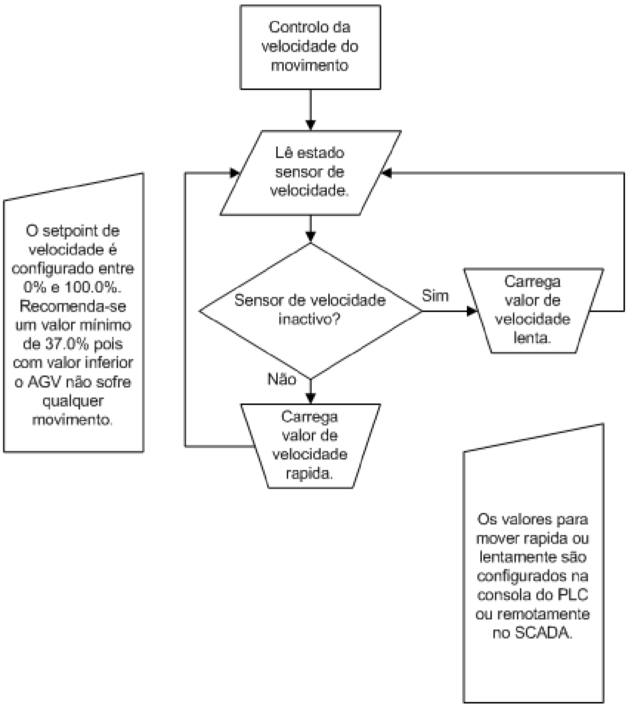


Figura 26 - Fluxograma controlo da velocidade do movimento

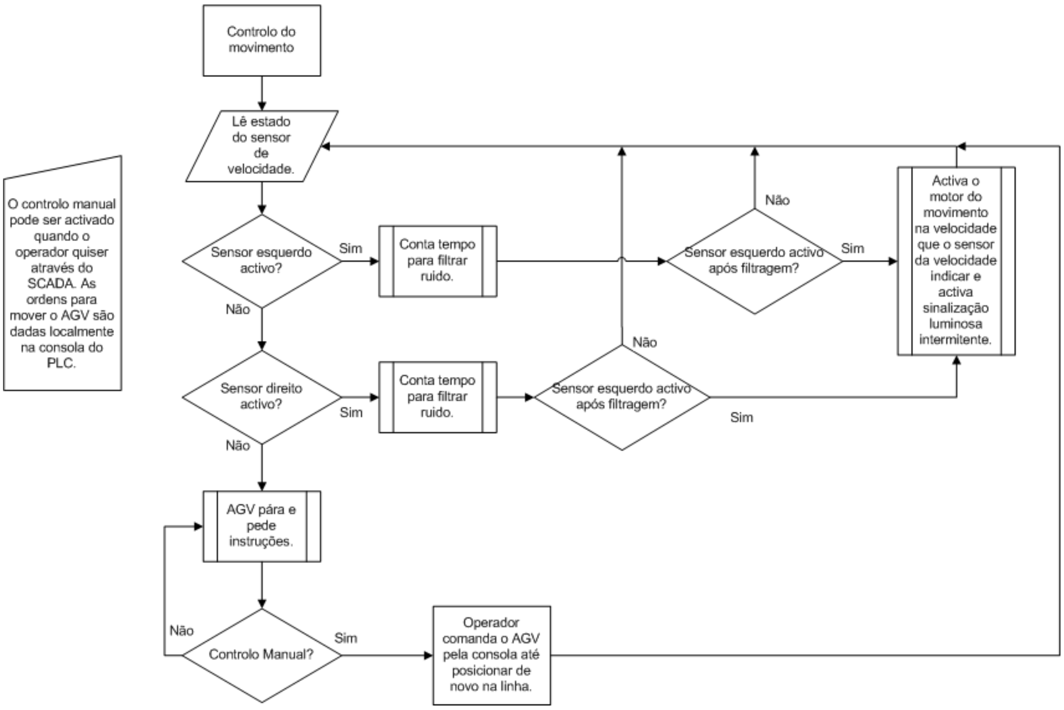


Figura 27 - Fluxograma de controlo de movimento, automático

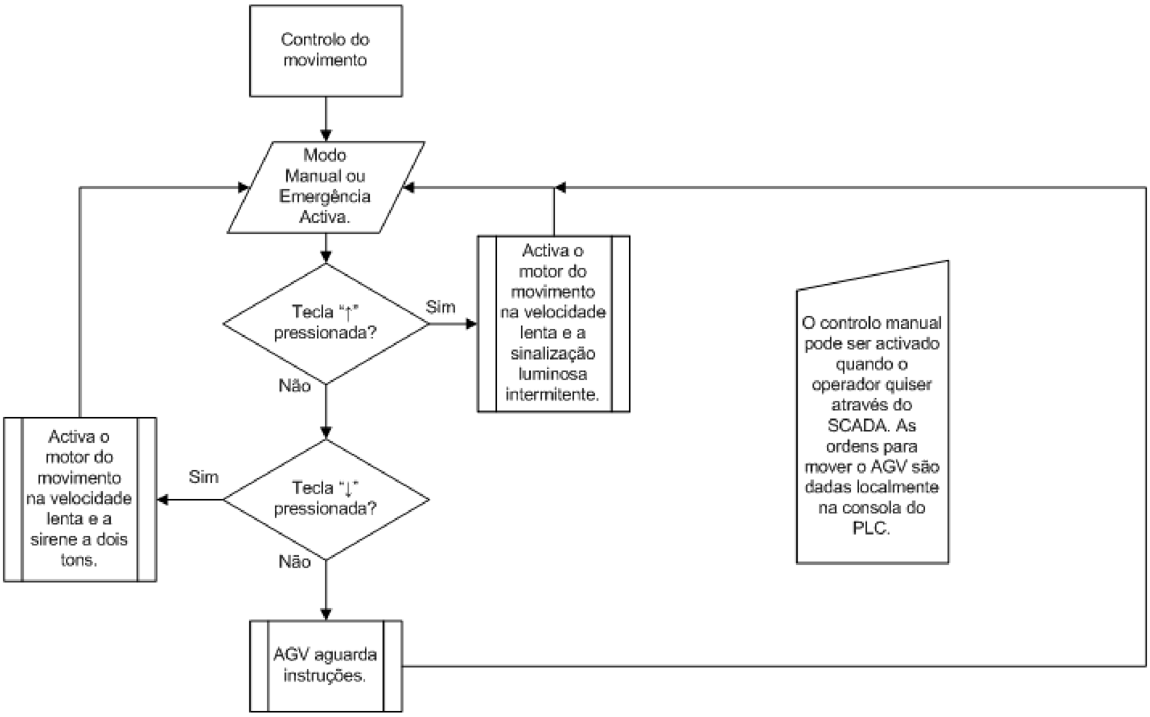


Figura 28 - Fluxograma de controlo de movimento, manual

3.1.5. BUZZER

Sempre que a entrada digital do PLC correspondente ao sinal de obstrução na frente do AGV esteja ativa, é ativada a saída digital responsável por ativar a sinalização do buzzer de forma contínua.

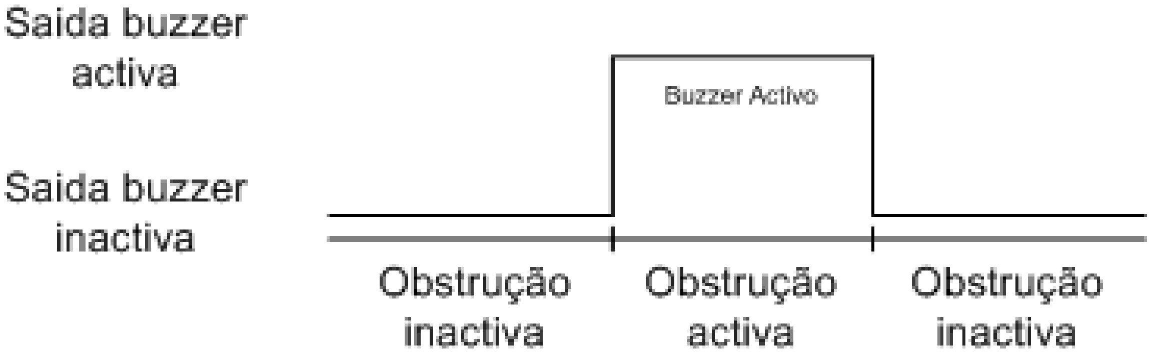


Figura 29 – Formato da saída digital buzzer com obstrução

Caso o PLC esteja a recuar o AGV, serão ativadas as saídas digitais responsáveis pela sinalização a dois tons do buzzer.

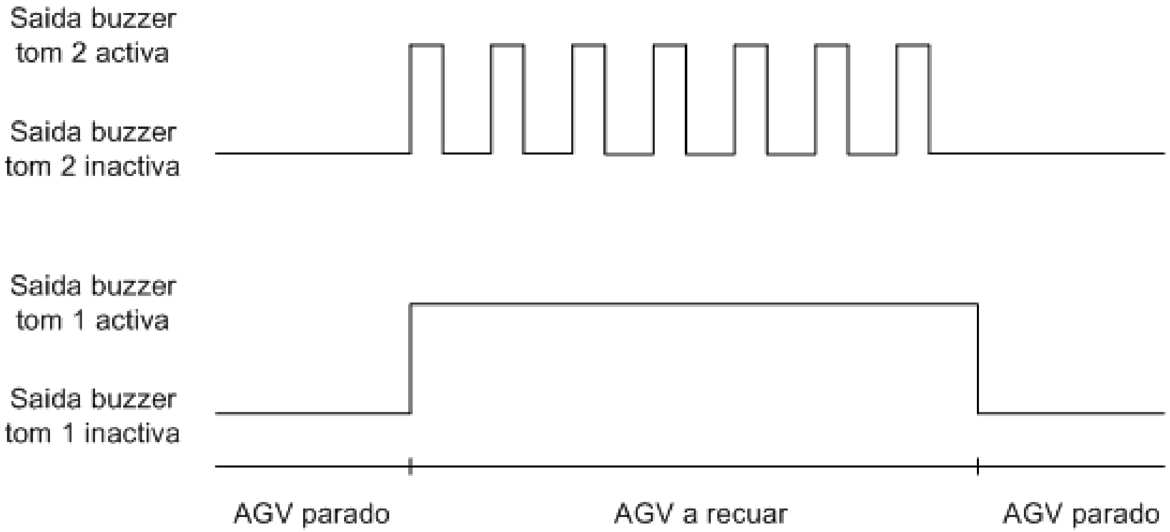


Figura 30 - Formato da saída digital buzzer durante recuo do AGV

A saída digital referente ao buzzer do tom 1 fica sempre ativo enquanto a saída digital do tom 2 é ativada durante 500ms a cada 1 segundo de intervalo.

3.1.6. SINALIZAÇÃO LUMINOSA

A saída digital que ativa a sinalização luminosa é ativada sempre que o AGV se desloque para a frente.

A cada 1 segundo, a saída é ativa durante 250ms fazendo o efeito de um *flash* de aviso.

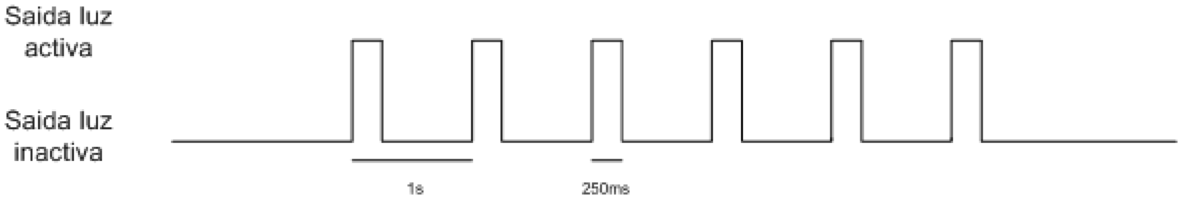


Figura 31 - Formato saída digital sinalização luminosa

3.1.7. CARGA DA BATERIA

Quando o AGV estiver parado e detetar que os dois detetores laterais estão ativos, detetor de infravermelhos, superior e inferior, é ativada a saída digital para possibilitar a carga da bateria através da atuação do rele de carga correspondente, Figura 32.

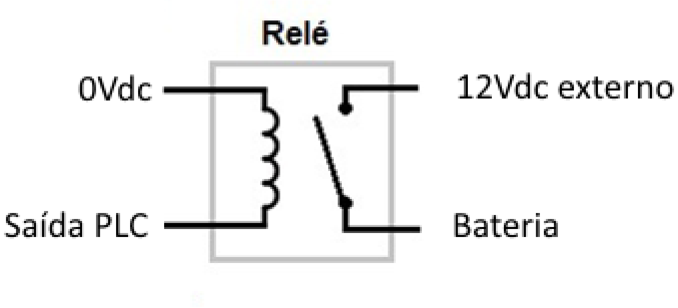


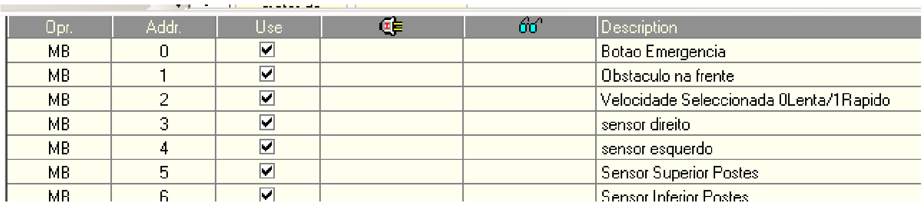
Figura 32 - Ligação elétrica do relé de carga da bateria à saída digital do PLC

3.1.8. BASE DE DADOS

Ao utilizar o protocolo *Modbus* para comunicação entre o PLC e o SCADA, temos acesso direto a todas as posições de memória do PLC sem necessidade de alocar memória às comunicações.

Exemplo:

Usando a posição MB0, *memory bit 0*, do PLC como o sinal correspondente à entrada digital do botão de emergência, no nosso SCADA, via *Modbus*, teremos correspondência direta no endereço 00001.



Opr.	Addr.	Use			Description
MB	0	☑			Botao Emergencia
MB	1	☑			Obstaculo na frente
MB	2	☑			Velocidade Seleccionada 0Lenta/1Rapido
MB	3	☑			sensor direito
MB	4	☑			sensor esquerdo
MB	5	☑			Sensor Superior Postes
MB	6	☑			Sensor Inferior Postes

Figura 33 - Excerto das variáveis digitais usadas no PLC

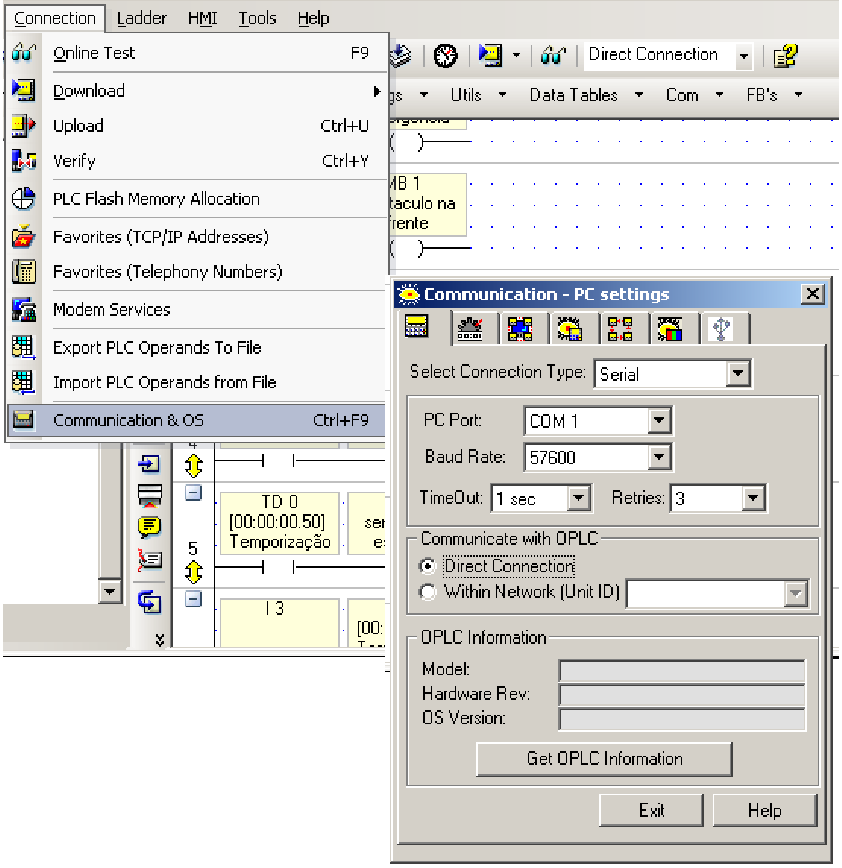
Apesar de simples o facto de termos diretamente mapeado os endereços da memória no banco de endereços do protocolo *Modbus*, torna-se um pouco complicado não misturar os endereços usados na comunicação com os endereços usados na nossa programação.

Por este motivo foi criada uma *task* “Base_Dados”, onde fazemos a correspondência direta entre o endereço que usamos na programação com um endereço por nós selecionado correspondente no SCADA.

3.1.9. DESCARREGAR O SOFTWARE

Após compilar o software e o mesmo não ter qualquer erro, resta-nos enviar o software para o PLC.

Antes de proceder ao envio do software, é necessário selecionar o meio físico com o qual nos ligamos ao PLC.



Select Connection Type: Serial

PC Port: COM 1

Baud Rate: 57600

TimeOut: 1 sec

Retries: 3

Communicate with OPLC

● Direct Connection

○ Within Network (Unit ID)

OPLC Information

Model:

Hardware Rev:

OS Version:

Figura 34 - Janela configuração ligação ao PLC

Podendo de seguida descarregar-se o software e testa-lo.

Figura 35 - Janela download software para PLC

3.2. SOFTWARE SCADA

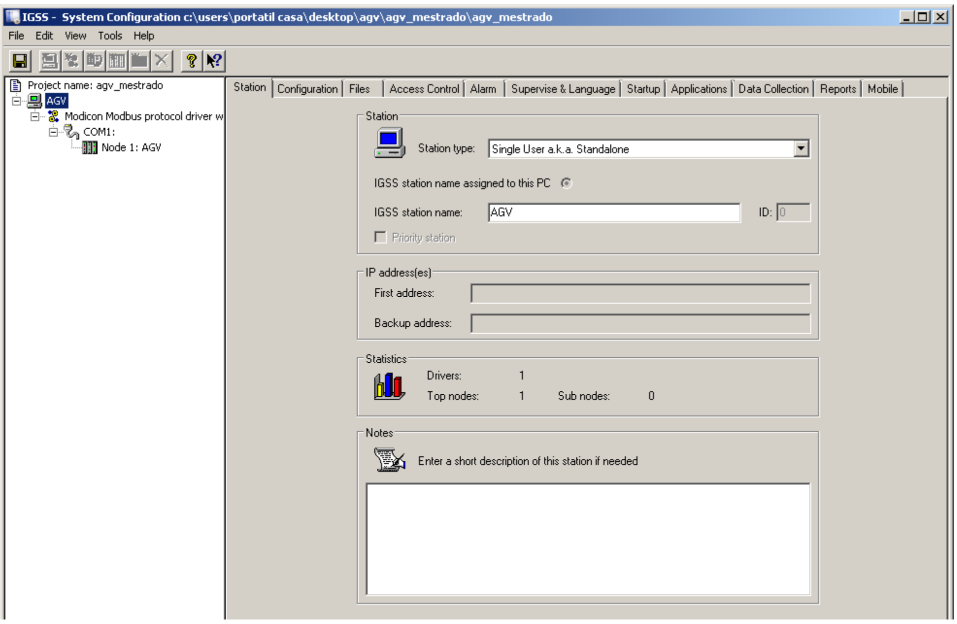
Como software de SCADA escolhemos o IGSS da Schneider [18]. Este software funciona como *Freeware* até 50 objetos declarados.

Para o nosso projeto e tendo em conta que não necessitaremos mais de 50 objectos na nossa base de dados, a escolha do IGSS recai também na disponibilidade de diversos protocolos de comunicação sem necessidade de licenciamento bem como a sua facilidade de programação.

3.2.1. PLC A COMUNICAR

Quando iniciado o software IGSS pela primeira vez, é necessário inicializar o software definindo o meio físico de comunicação e o respetivo protocolo a usar.

No nosso caso, o meio físico é a porta série do PC e o protocolo será o MODBUS.



Project name: agv_mestrado
AGV
Modicon Modbus protocol driver w
COM1:
Node 1: AGV

Station type: Single User a.k.a. Standalone

IGSS station name assigned to this PC ●

IGSS station name: AGV ID: 0

☐ Priority station

First address:

Backup address:

Drivers: 1

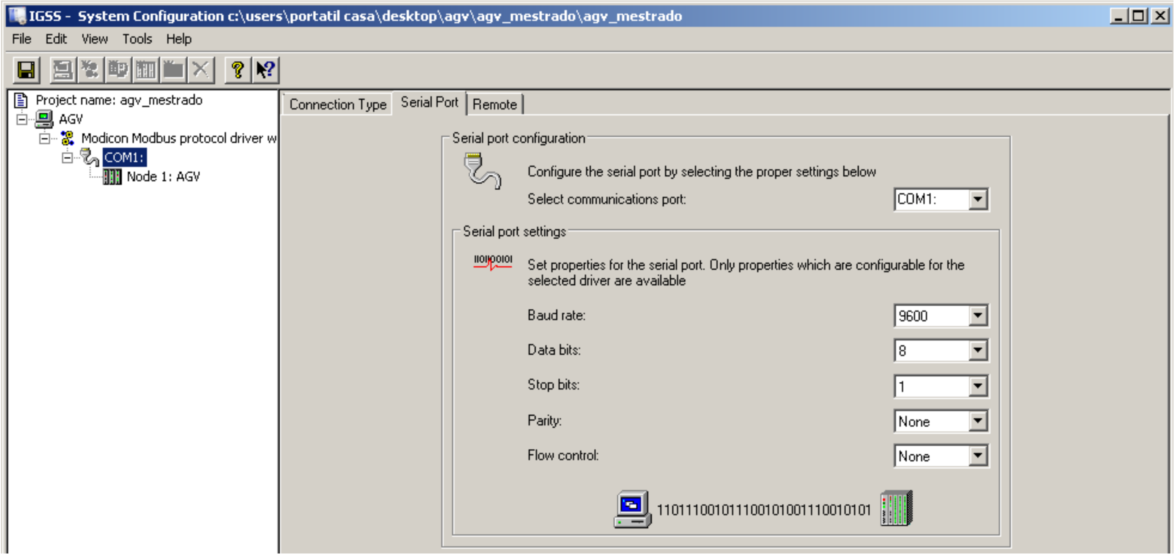
Top nodes: 1 Sub nodes: 0

Enter a short description of this station if needed

Figura 36 - Janela configuração da estação "AGV" no IGSS

Para tal, iniciamos a configuração através do menu *System Configuration*. Adicionamos uma nova estação, AGV, e selecionamos o protocolo n.76 – *Modicon Modbus driver with extended functionalily.*

Definindo o tipo de sistema que vamos usar, *Single User*, falta configurar o meio físico, COM1 (porta série 1 do PC) e os dados relativos à comunicação.



IGSS - System Configuration c:\users\portatil casa\desktop\agv\agv_mestrado\agv_mestrado

Project name: agv_mestrado
AGV
Modicon Modbus protocol driver w
COM1:
Node 1: AGV

Serial port configuration

Configure the serial port by selecting the proper settings below

Select communications port: COM1:

Serial port settings

Set properties for the serial port. Only properties which are configurable for the selected driver are available

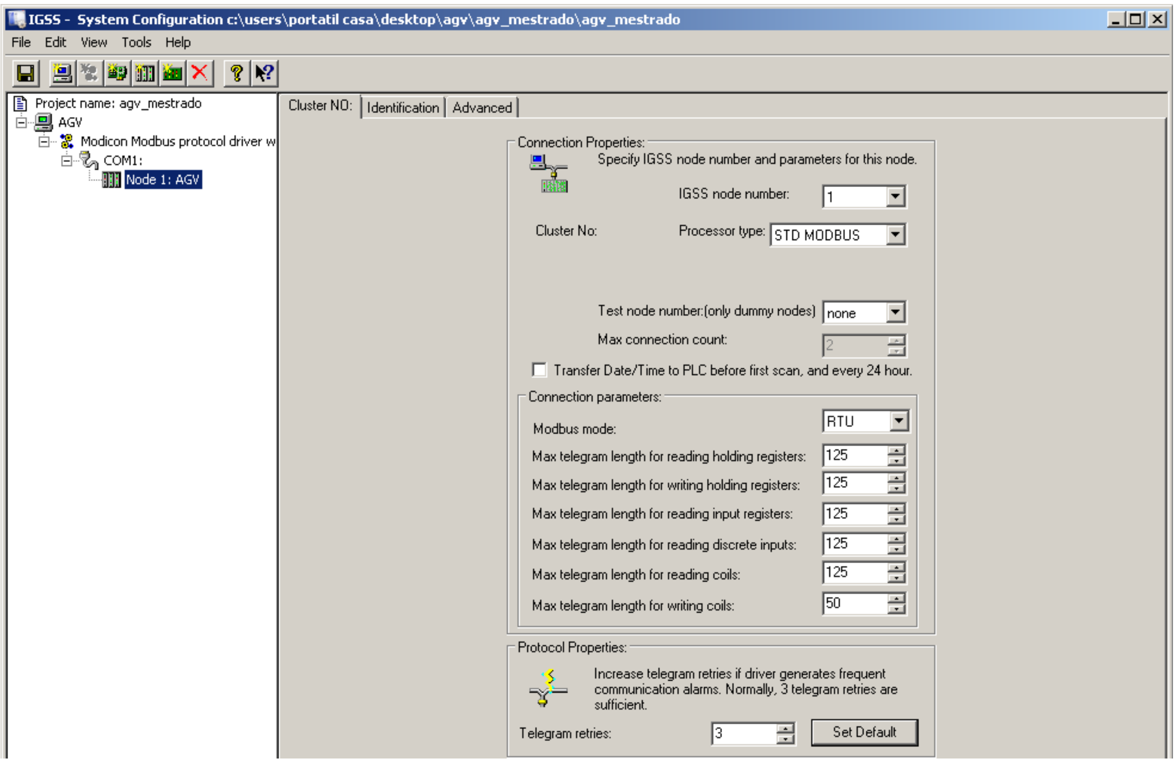
Baud rate: 9600
Data bits: 8
Stop bits: 1
Parity: None
Flow control: None

110111001011100101001110010101

Figura 37 - Janela configuração da comunicação entre PC e AGV

Na nossa configuração, para a comunicação, iremos usar o *Baud rate* a 19200bps, 8bits de dados e 1 stop bit, sem paridade. Esta configuração foi escolhida devido ao sistema de transmissão de dados usado e que será discutido com mais detalhe no ponto 3.3.

Para concluir a nossa configuração, apenas é necessário escolher o *NODE*, endereço do PLC, a comunicar.



IGSS - System Configuration c:\users\portatil casa\desktop\agv\agv_mestrado\agv_mestrado

Project name: agv_mestrado
AGV
Modicon Modbus protocol driver w
COM1:
Node 1: AGV

Connection Properties:

Specify IGSS node number and parameters for this node.

IGSS node number: 1
Cluster No:
Processor type: STD MODBUS
Test node number:(only dummy nodes) none
Max connection count: 2
☐ Transfer Date/Time to PLC before first scan, and every 24 hour.

Connection parameters:

Modbus mode: RTU
Max telegram length for reading holding registers: 125
Max telegram length for writing holding registers: 125
Max telegram length for reading input registers: 125
Max telegram length for reading discrete inputs: 125
Max telegram length for reading coils: 125
Max telegram length for writing coils: 50

Protocol Properties:

Increase telegram retries if driver generates frequent communication alarms. Normally, 3 telegram retries are sufficient.

Telegram retries: 3

Figura 38 - Janela configuração do endereço do PLC

3.2.2. SINÓPTICOS

Depois da configuração, procedemos à elaboração do nosso esquema onde poderemos visualizar todas as informações recebidas do PLC bem como proceder o envio de comandos para o PLC.

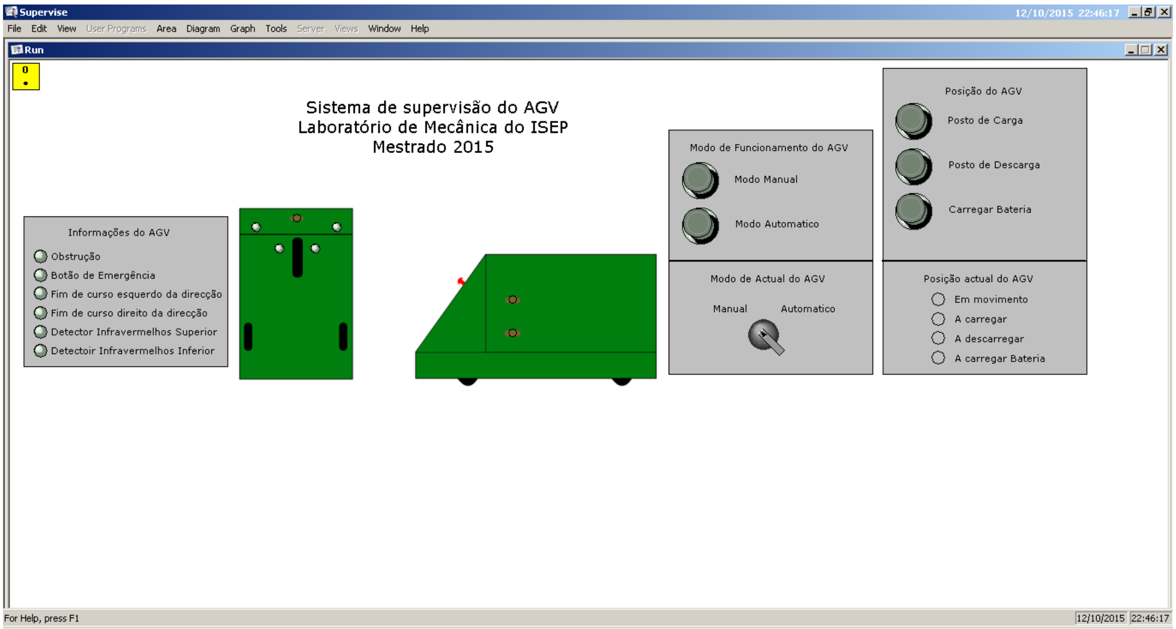


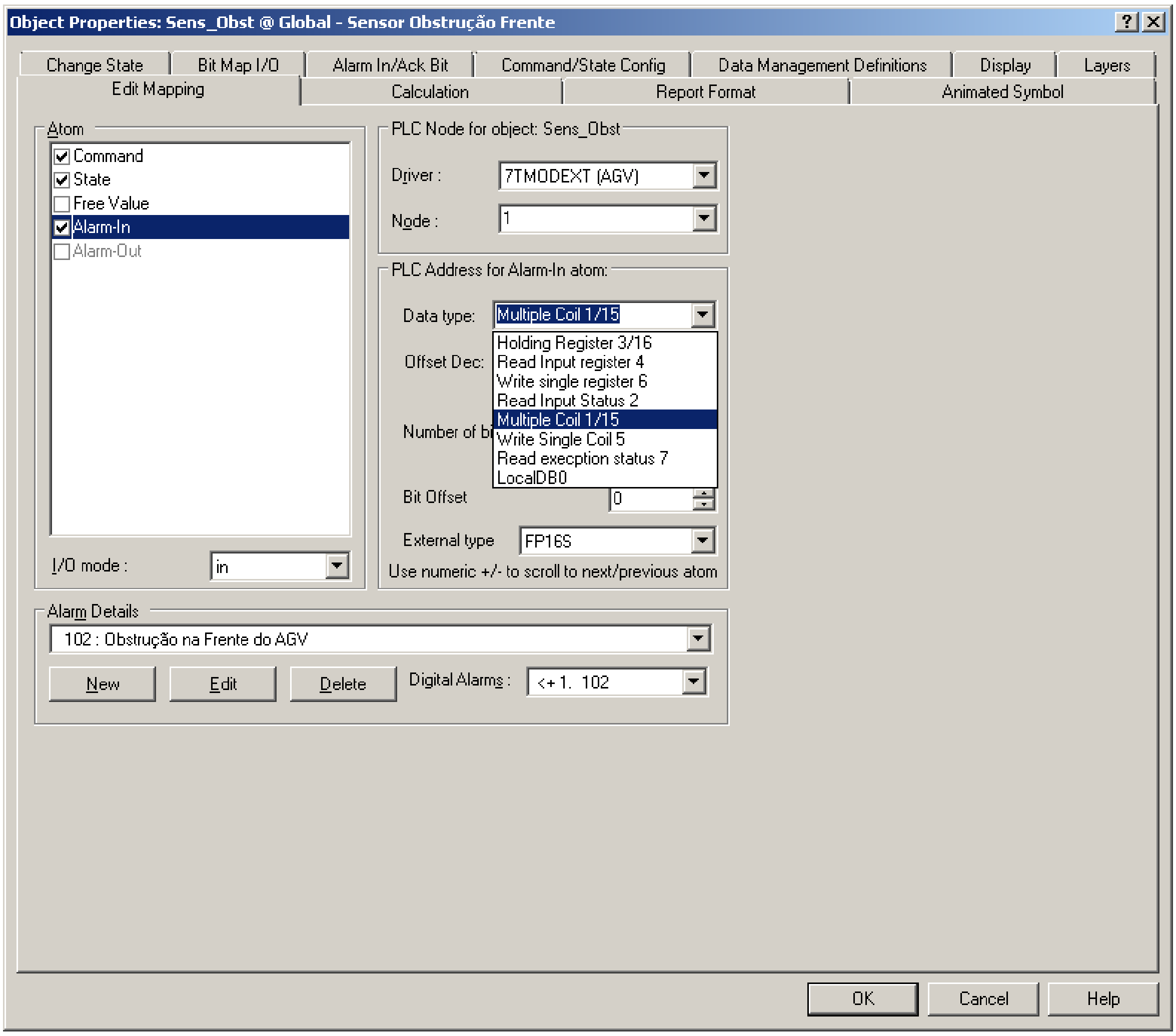
Figura 39 - Sinóptico de informação e comando

Os dados consultados no sinóptico referido estão de acordo com a *task* “Base Dados” definida no PLC.

3.2.3. PROTOCOLO

O protocolo escolhido para a comunicação é o protocolo MODBUS RTU. Sendo o protocolo escolhido um protocolo vastamente implementado e universalmente disponível em praticamente todos os PLCs e SCADAS, torna-se simples diagnosticar qualquer problema.

O site www.modbus.org é o sítio onde estão publicados todos os fabricantes que implementam ou disponibilizam as normas do protocolo nos seus sistemas, PLCs ou SCADAS.



Object Properties: Sens_Obst @ Global - Sensor Obstrução Frente

Atom
☑ Command
☑ State
☐ Free Value
☑ Alarm-In
☐ Alarm-Out

I/O mode : in

PLC Node for object: Sens_Obst
Driver : 7TMODEXT (AGV)
Node : 1

PLC Address for Alarm-In atom:
Data type: Multiple Coil 1/15
Holding Register 3/16
Read Input register 4
Write single register 6
Read Input Status 2
Multiple Coil 1/15
Write Single Coil 5
Read execption status 7
LocalDB0
Offset Dec:
Number of bi
Bit Offset 0
External type FP16S
Use numeric +/- to scroll to next/previous atom

Alarm Details
102 : Obstrução na Frente do AGV
Digital Alarms : <+1. 102

Figura 40 - Sinóptico de configuração dos dados a ler/escrever

È também aqui que temos disponível a toda a informação sobre as componentes de comunicação e tramas usadas pelo protocolo que nos auxiliam no diagnóstico dos problemas de comunicação e interpretação dos dados.

No nosso sistema, também a comunicação das variáveis entre o PLC e o SCADA obedece ao protocolo.

Quando é definida uma variável, além da definição do tipo de variável, comando, estado ou alarme, temos de escolher o tipo de dados a ler/escrever.

No anexo “Modbus” no CD, o protocolo é vastamente e detalhadamente descrito bem como todas as variantes existentes.

No nosso projeto, apenas iremos usar as funções 1/15 (*Read Multiple Coils*), no caso de ler o estado das variáveis, e a função 5 (*Write Sigle Coil*) no caso das variáveis usadas para enviar os comandos para o PLC.

Os endereços usados podem ser consultados no Anexo M “Endereços Modbus AGV”.

3.3. COMUNICAÇÕES

3.3.1. SISTEMA DE RÁDIO

Para envio e receção de informação, uma vez que o AGV é autónomo, o sistema de transmissão por cabo está fora de questão. Foi decidido usar um sistema rádio composto por dois *transceivers*, emissor e recetor, modelo ER400TRS da *Easy Radio* [Anexo N].

Figura 41 - Módulo *transceiver* ER400TRS

Estes *transceiers* têm a vantagem de serem compactos e bastantes flexíveis, em tudo relacionado com o atual projeto.

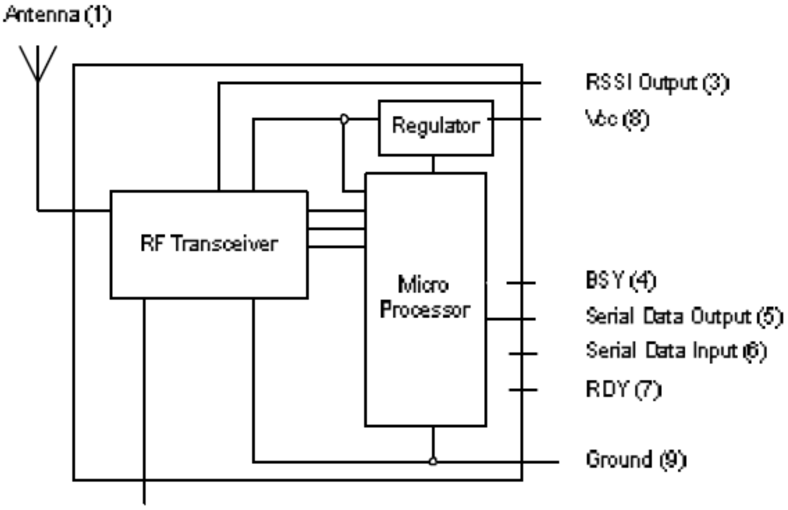


Figura 42 - Esquema e *Pin-Out* do módulo ER400TRS

O módulo é composto por um *transceiver* de baixa potência, um microcontrolador e um regulador de tensão.

Devido à sua simples configuração e esquema de ligação, a adição de um circuito conversor de sinal TIA/EIA-232-F para níveis de sinal TTL/CMOS como o circuito “MAX232”, torna este conjunto uma maneira simples e económica de interligar o sistema SCADA ao PLC usado para controlo do AGV.

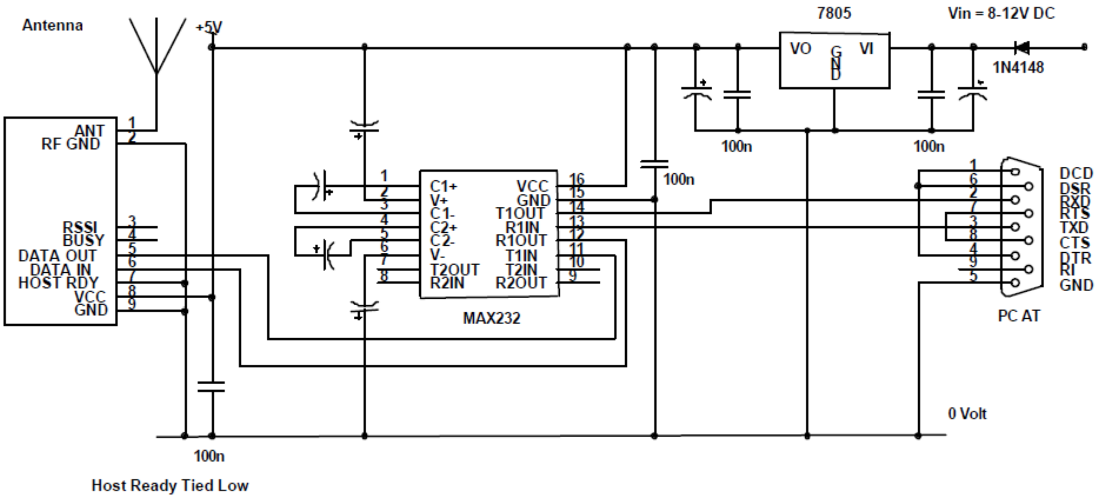


Figura 43 - Esquema elétrico típico de ligação do módulo ER400TRS a um PC

Durante os testes realizados, conseguimos uma comunicação entre dois pontos à distância de 20 metros com as configurações por defeito do módulo ER400TRS.

4. CONCLUSÕES

Deparamo-nos com diversas complicações ao longo do projeto. Desde problemas elétricos, mecânicos e de compatibilidade entre componentes existentes e a acrescentar.

Conseguimos no entanto demonstrar a viabilidade do projeto com sucesso.

Apesar de alguns problemas terem sido ultrapassados, alguns problemas, apesar de minimizados, continuam a necessitar de melhorias.

Um dos maiores problemas existentes está relacionado com a distribuição do peso do AGV. Cerca de 70% do peso encontra-se sobre a roda frontal e é nesta que incide o controlo da direção e do movimento.

Devido ao peso e esforço necessário para mover o AGV, a gulpilha de aço usada para conectar o veio do motor ao veio da roda da frente mostrou-se insuficientemente resistente.

Apesar de ter 3mm de diâmetro, o facto de não ser maciça tornava-a frágil e por diversas vezes tivemos de a substituir por a mesma ser literalmente cortada.

Figura 44 - Imagem da gulpilha com as marcas do esforço

O problema foi parcialmente resolvido ao colocar um pino de 3mm feito em aço inox. No entanto, continua a ser visível a dificuldade com que os motores se deparam para mover o AGV.

Um ponto de melhoria importante está relacionada com o esforço que o motor tem de efetuar para mover a roda. Era importante proceder-se ao cálculo do diâmetro ideal das rodas do AGV de forma a minimizar o esforço que os motores necessitam de efetuar.

Um ponto de alteração futuro e igualmente importante para o AGV seria a redistribuição de peso, sendo uma das possibilidades a colocação do motor responsável pelo movimento nas rodas traseiras do AGV, ficando a roda frontal aplicada ao motor da direção.

Mas o facto de relocalizar o motor do movimento não garante a redistribuição do peso pretendido. A estrutura onde assenta a roda frontal é extremamente pesada, principalmente numa altura em que trabalhamos com materiais leves e resistentes.

Diminuindo o peso na roda da frente e alterar a ligação do motor de movimento com a roda, passar de acoplamento direto para acoplamento com desmultiplicação, facilitaria imenso o trabalho/esforço que o motor necessita de efetuar para mover o AGV.

Para um melhor diagnóstico em futuras reparações, é também necessário proceder à reorganização e marcação da cablagem interna bem como melhorar a disposição do hardware no AGV.

Para finalizar, sendo que o AGV tem todas as condições para ser facilmente expansível, tendo sido idealizado para funcionar com o “Armazém Automático” que se encontra no

LabA, torna-se imperativo a articulação entre o PLC que controlo o “Armazém Automático” e o PLC do AGV.

Deste forma, é idealizável o funcionamento completamente autónomo do sistema composto pelo armazém em articulação com o AGV sem a intervenção do operador, simulando o que na realidade é implementado como *AS/RS (Automated Storage and Retrieval System).*

Referências Documentais

[1] *Savant Automation*. [em linha]. [Consult. 14 Out 2015]. Disponível em www: <URL:http://www.agvsystems.com/faqs/>.

[2] *Roomba*. [em linha]. [Consult. 14 Out 2015]. Disponível em www: <RUL:http://www.irobot.com/For-the-Home/Vacuum-Cleaning/Roomba.aspx>.

[3] *SoftDesign*. [em linha]. [Consult. 14 Out 2015]. Disponível em www: <URL:http://www.softdesign.se/en/automatedguidedvehicles/>.

[4] *Mototok*. [em linha]. [Consult. 14 Out 2015]. Disponível em www: <URL:http://www.mototok.com/automatic-guided-vehicle.php>.

[5] Ferguson, Kevin W. "AGV GUIDANCE AND ROUTING". [em linha]. [Consult. 14 Out 2015]. Disponível em www: <URL:http://www.okstate.edu/ceat/ie/jnazeme/Website%20-%20Example%20Student%20Papers/Ferguson_Term_Paper_IEM5303.doc>.

[6] Dudeja, Himanshu et al. "Mechanical Design of an Automated Guided Vehicle (AGV)", in *INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING*, Vol. 3, Issue 5, pp. 32-40. Maio 2015.

[7] Davich, Thomas. "Material Handling Solutions: A look into Automated Robotics", in Department of Industrial and Systems Engineering University of Wisconsin-Madison, January 2010. [em linha]. [Consult. 14 Out 2015]. Disponível em www: <URL:http://tc.engr.wisc.edu/files/2013/02/Davich2010.pdf>.

[8] Segovia, Vanessa Romero and Theorin, Alfred. "History of Control History of PLC and DCS", in Lund University. The Department of Automatic Control, June 2012. [em linha]. [Consult. 14 Out 2015]. Disponível em www: <URL:http://www.control.lth.se/media/Education/DoctorateProgram/2012/HistoryOfControl/Vanessa_Alfred_report.pdf>.

[9] Siemens, Modbus History. [em linha]. [Consult. 14 Out 2015]. Disponível em www: <URL:http://www.usa.siemens.com/intelligent-infrastructure/>.

[10] Inductive Automation. [em linha]. [Consult. 14 Out 2015]. Disponível em www: <URL:https://inductiveautomation.com/what-is-scada>.

[11] MODBUS. [em linha]. [Consult. 14 Out 2015]. Disponível em www: <URL:http://www.modbus.org/specs.php>.

[12] UNITRONICS, Technical Library. [em linha]. [Consult. 14 Out 2015]. Disponível em www: <URL:http://www.unitronics.com/support/technical-library>.

[13] Markus Bader, Andreas Richtsfeld, Wolfgang Holl. "Balancing Centralised Control with Vehicle Autonomy in AGV Systems for Industrial Acceptance", in *The Eleventh International Conference on Autonomic and Autonomous Systems - ICAS 2015*.

[14] DFRobot wiki. [em linha]. [Consult. 14 Out 2015]. Disponível em www: <URL: https://www.dfrobot.com/wiki/index.php?title=MD1.3_2A_Dual_Motor_Controller_(SKU:_DRI0002)>.

[15] ITEAD STUDIO. [em linha]. [Consult. 14 Out 2015]. Disponível em www: <URL: http://www.itead.cc/lm2596-dc-dc-buck-converter-step-down-power-module-output-1-25v-35v.html>.

[16] PLC V120 Unitronics. [em linha]. [Consult. 14 Out 2015]. Disponível em www: <URL:http://www.unitronics.com/plc-hmi/plc-vision/v120->.

[17] Visilogic Programming, Unitronics. [em linha]. [Consult. 14 Out 2015]. Disponível em www: <URL:http://www.unitronics.com/support/downloads>.

[18] IGSS, Schneider. [em linha]. [Consult. 14 Out 2015]. Disponível em www: <URL: http://igss.schneider-electric.com/products/igss/index.aspx>.

Anexo A.

V120-22-T2C Graphic Operator Panel & Programmable Logic Controller

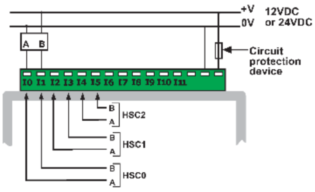
12/24VDC, 12 pnp/npn digital inputs, 2 analog inputs, 3 high-speed counter/shaft encoder inputs,
12 transistor outputs, I/O expansion port, RS232/RS485 plus CANbus

Power supply	12VDC or 24VDC
Permissible range	10.2VDC to 28.8VDC with less than 10% ripple
Maximum current consumption	130mA@24VDC (pnp inputs) 230mA@24VDC (npn inputs) 250mA@12VDC (pnp inputs) 290mA@12VDC (npn inputs)
Digital inputs	12 pnp (source) or npn (sink) inputs. See Notes 1 and 2.
Nominal input voltage	12VDC or 24VDC. See Notes 3 and 4.
Input voltages for pnp (source):	
For 12VDC	0-3VDC for Logic '0' 8-15.6VDC for Logic '1'
For 24VDC	0-5VDC for Logic '0' 17-28.4VDC for Logic '1'
Input voltages for npn (sink):	
For 12VDC	8-15.6VDC/<1.2mA for Logic '0' 0-3VDC/>3mA for Logic '1'
For 24VDC	17-28.4VDC/<2mA for Logic '0' 0-5VDC/>6mA for Logic '1'
Input current	4mA@12VDC 8mA@24VDC
Input impedance	3KΩ
Response time (except high-speed inputs)	10mS typical
Galvanic isolation	None
Input cable length	Up to 100 meters, unshielded
High-speed counter	Specifications below apply when inputs are wired for use as a high-speed counter input/shaft encoder. See Notes 5 and 6.
Resolution	32-bit
Input freq.	10kHz max.
Minimum pulse	40μs

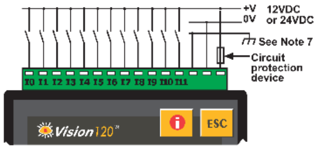
Notes:

1. All 12 inputs can be set to pnp (source) or npn (sink) via a single jumper and appropriate wiring.
2. Inputs #10 and #11 can function as either digital inputs or as analog inputs, via a single jumper and appropriate wiring.
3. All 12 inputs can function in 12 VDC or 24 VDC; set via a single jumper and appropriate wiring.
4. npn (sink) inputs use voltage supplied from the controller's power supply.
5. Inputs #0, #2 and #4 can each function as either high-speed counter or as part of a shaft encoder. In each case, high-speed input specifications apply. When used as a normal digital input, normal input specifications apply.
6. Inputs #1, #3 and #5 can each function as either counter reset, or as a normal digital input; in either case, specifications are those of a normal digital input.
   These inputs may also be used as part of a shaft encoder.
   In this case, high-speed input specifications apply.

Shaft encoder

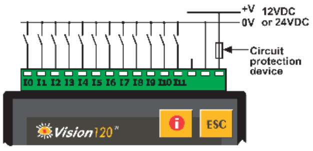


Power supply, pnp (source) inputs

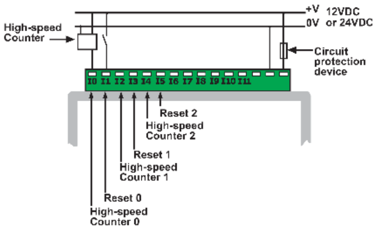


Note 7:
To avoid electromagnetic interference, mount the controller in a metal panel/cabinet and earth the power supply. Earth the power supply signal to the metal using a wire whose length does not exceed 10cm. If your conditions do not permit this, do not earth the power supply.

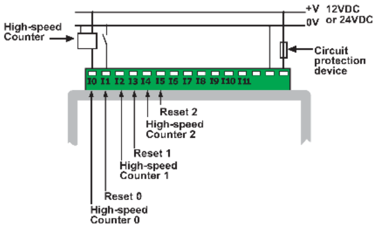
npn (sink) inputs



pnp (source) high-speed counter



npn (sink) high-speed counter



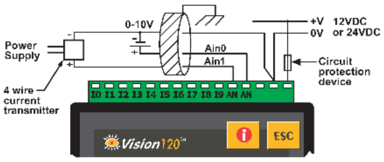
Warnings:

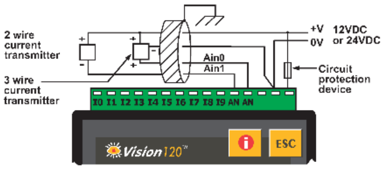
- Unused pins should not be connected. Ignoring this directive may damage the controller.
- Improper use of this product may severely damage the controller.
- Refer to the controller's User Guide regarding wiring considerations.
- Before using this product, it is the responsibility of the user to read the product's User Guide and all accompanying documentation.

Analog Inputs	Two 10-bit, multi-range inputs: 0-10V, 0-20mA, 4-20mA See Note 2.
Conversion method	Successive approximation
Input impedance	>1MΩ for voltage 243Ω for current
Galvanic isolation	None
Resolution (except 4-20mA)	10-bit (1024 units)
Resolution at 4-20mA	204 to 1023 (820 units)
Conversion time	Synchronized to scan time
Absolute max. rating	±15V
Full scale error	± 2 LSB
Linearity error	± 2 LSB
Status indication	Yes, see Note 8

Note 8:
The analog value can also indicate when the input is functioning out of range.
If an analog input deviates above the permissible range, its value will be 1024.

Voltage / Current connection



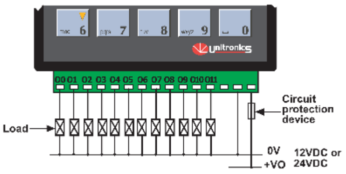


Note 9:
Voltage current connection shields should be connected at the signals' source.
The 0V signal of the analog input must be connected to the controller's 0V.

Digital outputs	12 pnp (source) outputs 12VDC or 24VDC
Output type	P-MOSFET (open drain)
Isolation	None
Output current	0.5A max. Total current: 3A max.
Max. frequency for normal outputs	50Hz (resistive load) 0.5Hz (inductive load)
High speed output maximum frequency	2kHz (resistive load) See Note 10.
Short circuit protection	Yes
Short indication	by software
On voltage drop	0.5VDC maximum
Power supply for outputs	
Operating voltage	10.2 to 28.8VDC
Nominal operating voltage	12VDC or 24VDC

Note 10:
Output #0 and Output #1 may be used as high-speed outputs.

Outputs connection



Graphic Display	STN, LCD display
Illumination backlight	LED, yellow-green, software-controlled
Display resolution	128x64 pixels

Keypad	Sealed membrane
Number of keys	16

Program	
Application Memory	448K
Memory Bits (coils)	2048
Memory Integers (registers)	1600
Long Integers (32 bit)	256
Double Word (32 bit unsigned)	64
Floats	24
Timers	192
Counters	24
Data Tables	120K (RAM) / 64K (FLASH)
HMI displays	Up to 255
Execution time	0.8µs for bit operations

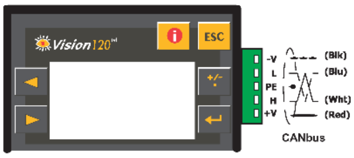
RS232/RS485 serial port	Used for: ● Application Download/Upload ● Application Testing (Debug) ● Connect to GSM or standard telephone modem: - Send/receive SMS messages - Remote access programming ● RS485 Networking
RS232 (See Note 11)	2 ports
Galvanic isolation	None
Voltage limits	±20V
RS485 (See Note 11)	1 port
Input voltage	-7 to +12V differential max.
Cable type	Shielded twisted pair, in compliance with EIA RS485
Galvanic isolation	None
Baud rate	110 – 57600 bps
Nodes	Up to 32

Note11:
RS232/RS485 is determined by jumper settings and wiring.
Refer to the controller's User Guide regarding communications.

I/O expansion port	Up to 128 additional I/Os, including digital & analog I/Os, RTD and more.

CANbus port	Up to 63 nodes
Baud rate range	20Kbps - 1Mbps
Cable length	Up to 150m for 12VDC network Up to 1000m for 24VDC network

CANbus connection



Miscellaneous	
Clock (RTC)	Real-time clock functions. (Date and Time)
Battery back-up	7 years typical battery back-up for RTC and system data.
Weight	240g (8.46 oz.)
Operational temperature	0 to 50°C (32 to 122°F)
Storage temperature	-20 to 60°C (-4 to 140°F)
Relative Humidity (RH)	5% to 95% (non-condensing)
Mounting method	DIN-rail mounted (IP20/NEMA1) Panel mounted (IP65/NEMA4X)

V120-22-T2C

I/O Jumper Settings

The tables below show how to set a specific jumper to change the functionality of the controller.
To open the controller and access the jumpers, refer to the directions at the end of these specifications.

Important:
Incompatible jumper settings and wiring connections may severely damage the controller.

JP1
Digital Inputs type

To use as	JP1
npn (sink)	A
pnp (source)*	B

JP3, JP4
Analog inputs type

To use as	JP3 for analog input #1	JP4 for analog input #0
Voltage input*	A	A
Current input	B	B

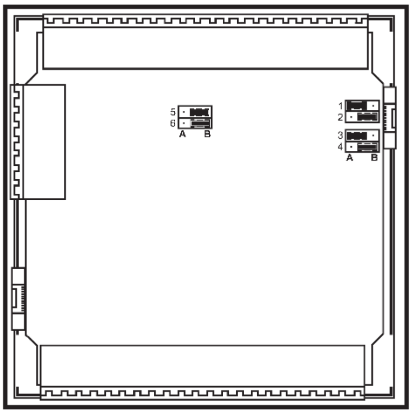
JP2
Inputs voltage

To use as	JP2
12VDC	A
24VDC*	B

JP5, JP6
Digital/Analog inputs

Range	JP5 for AN1 / In#10	JP6 for AN0 / In#11
Digital inputs*	A	A
Analog inputs	B	B

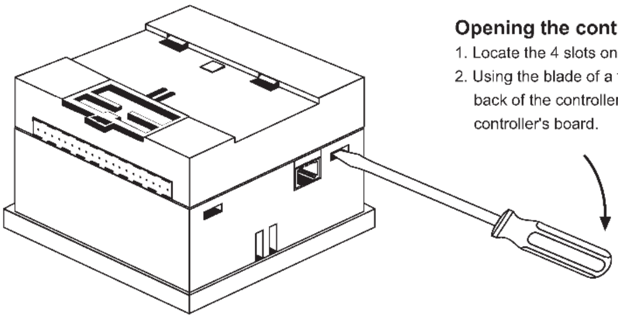
*Default factory setting



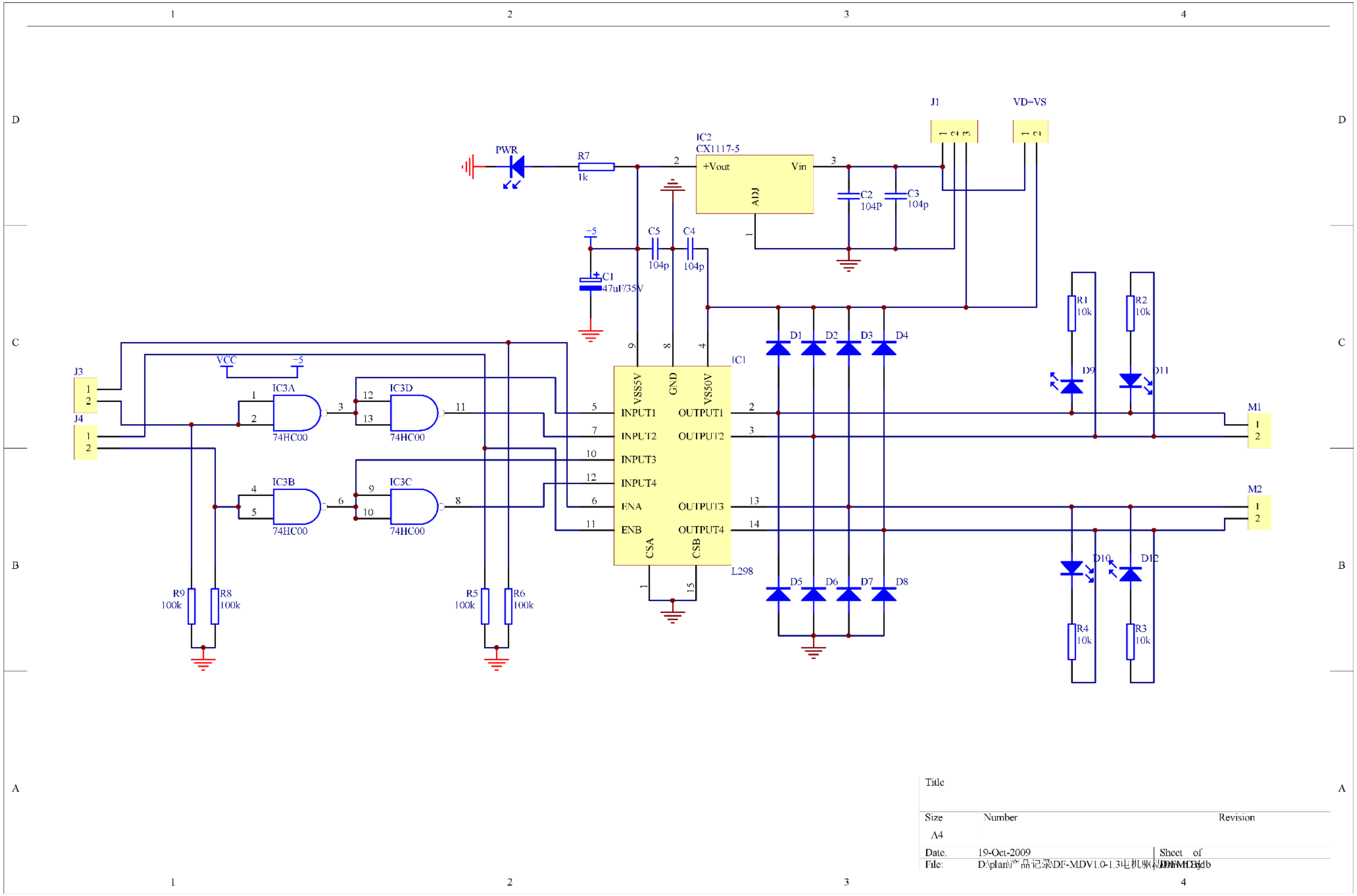
In this figure, the jumper settings will cause the controller to function as follows:
Digital inputs: npn, 24VDC inputs
Analog input #0: Voltage input
Analog input #1: Current input

Opening the controller enclosure

1. Locate the 4 slots on the sides of the enclosure
2. Using the blade of a flat-bladed screwdriver, gently pry off the back of the controller as shown in the figure below, exposing the controller's board.

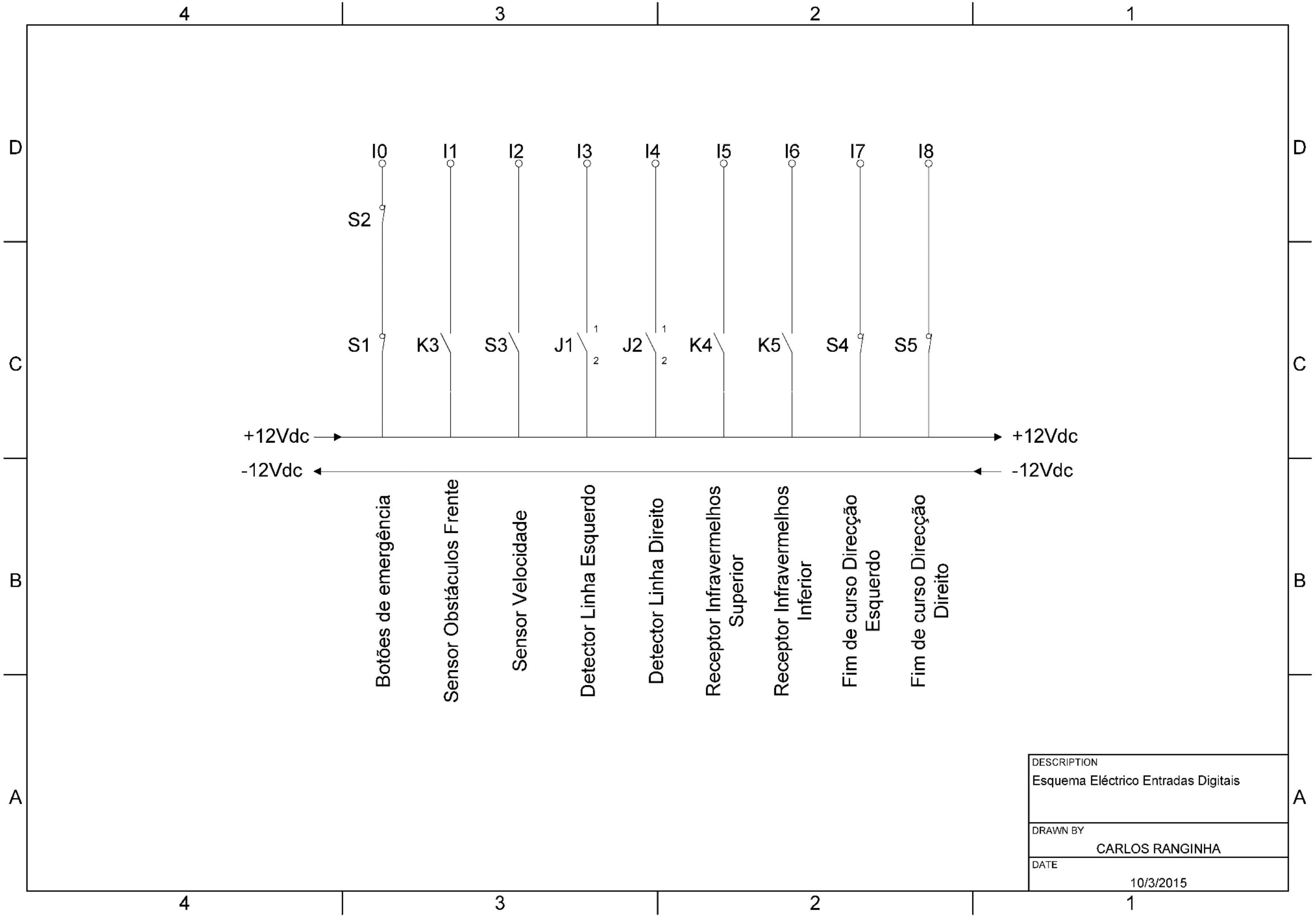


Anexo B.



1
2
3
4
D
C
B
A
PWR
R7
1k
IC2
CX1117-5
+Vout
Vin
ADJ
J1
1 2 3
VD=VS
1 2
C2
104P
C3
104p
C5
104p
C4
104p
C1
47uF/35V
+5
VCC
+5
J3
J4
IC3A
IC3B
IC3C
IC3D
74HC00
IC1
L298
VSS5V
GND
VSS0V
INPUT1
INPUT2
INPUT3
INPUT4
ENA
ENB
CSA
CSB
OUTPUT1
OUTPUT2
OUTPUT3
OUTPUT4
D1
D2
D3
D4
D5
D6
D7
D8
D9
D10
D11
D12
R1
10k
R2
10k
R3
10k
R4
10k
R5
100k
R6
100k
R8
100k
R9
100k
M1
M2
Title
Size
Number
Revision
A4
Date:
19-Oct-2009
Sheet of
File:
D:\plan\产品记录\DF-MDV1.0-1.3电机驱动\DFMD.ddb
Drawn By:

Anexo C.

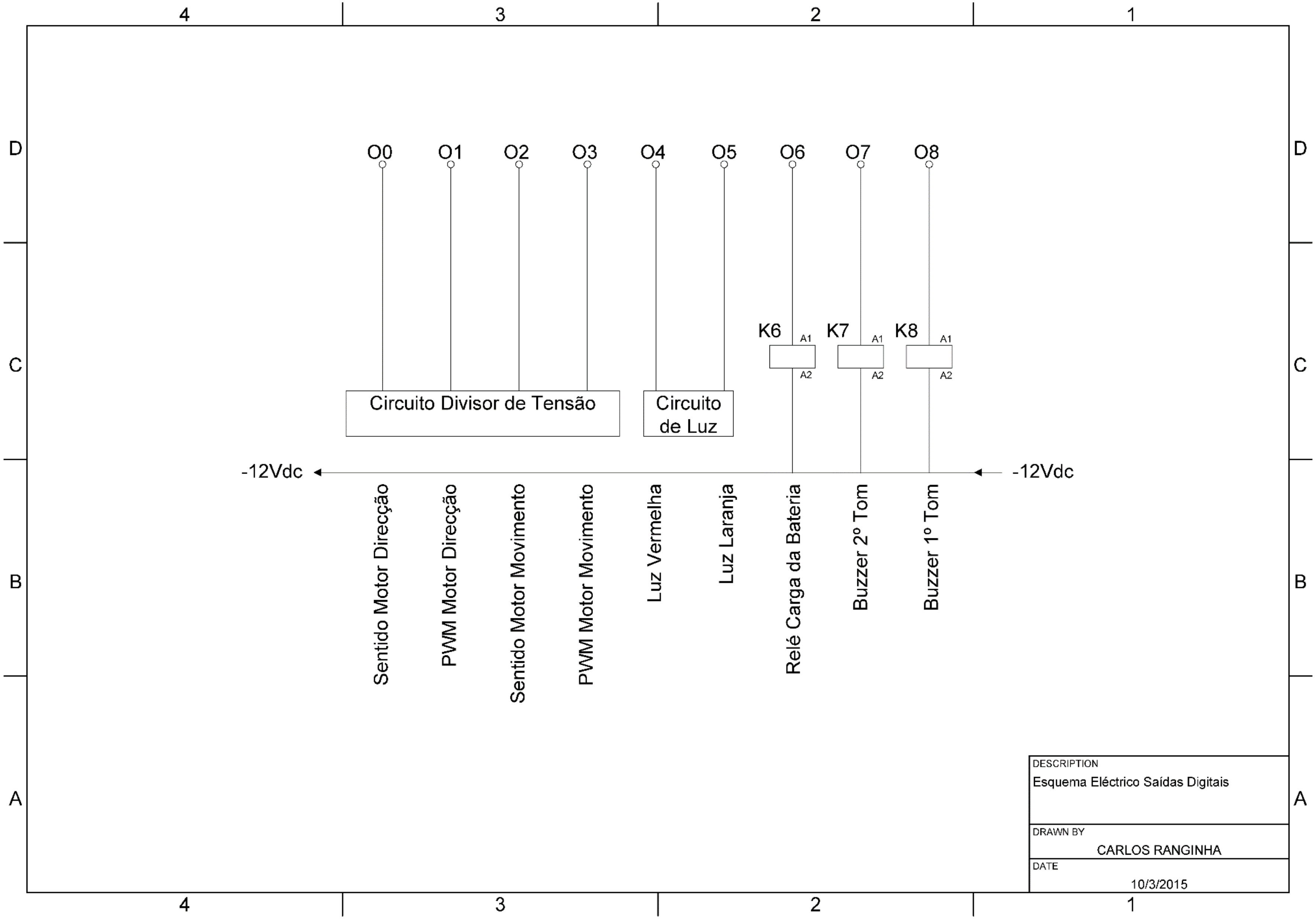


DESCRIPTION
Esquema Eléctrico Entradas Digitais

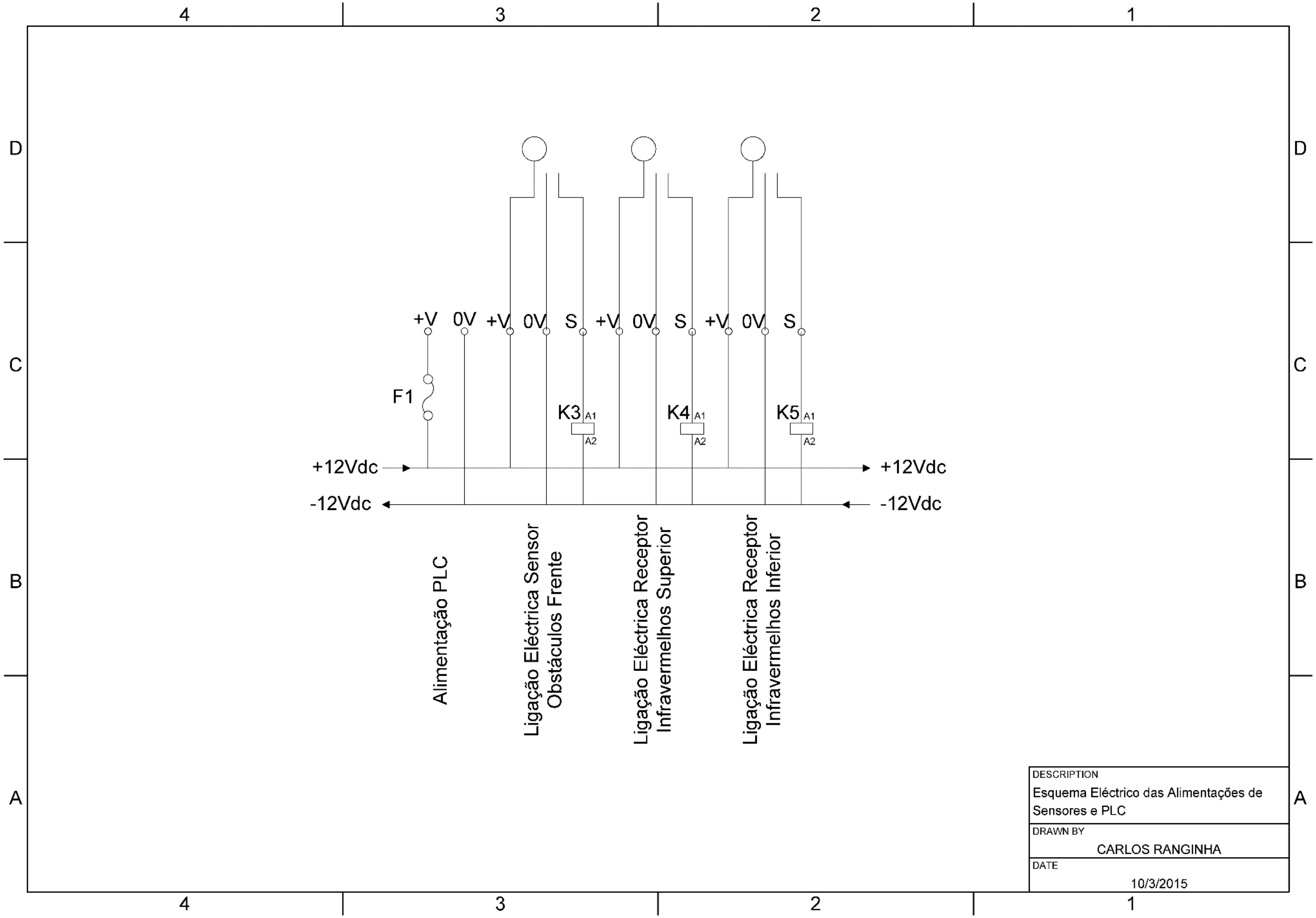
DRAWN BY
CARLOS RANGINHA

DATE
10/3/2015

Anexo D.


O0
O1
O2
O3
O4
O5
O6
O7
O8
K6
K7
K8
A1
A2
Circuito Divisor de Tensão
Circuito de Luz
-12Vdc
-12Vdc
Sentido Motor Direcção
PWM Motor Direcção
Sentido Motor Movimento
PWM Motor Movimento
Luz Vermelha
Luz Laranja
Relé Carga da Bateria
Buzzer 2º Tom
Buzzer 1º Tom
DESCRIPTION
Esquema Eléctrico Saídas Digitais
DRAWN BY
CARLOS RANGINHA
DATE
10/3/2015
1
2
3
4
A
B
C
D

Anexo E.



DESCRIPTION
Esquema Eléctrico das Alimentações de Sensores e PLC
DRAWN BY
CARLOS RANGINHA
DATE
10/3/2015

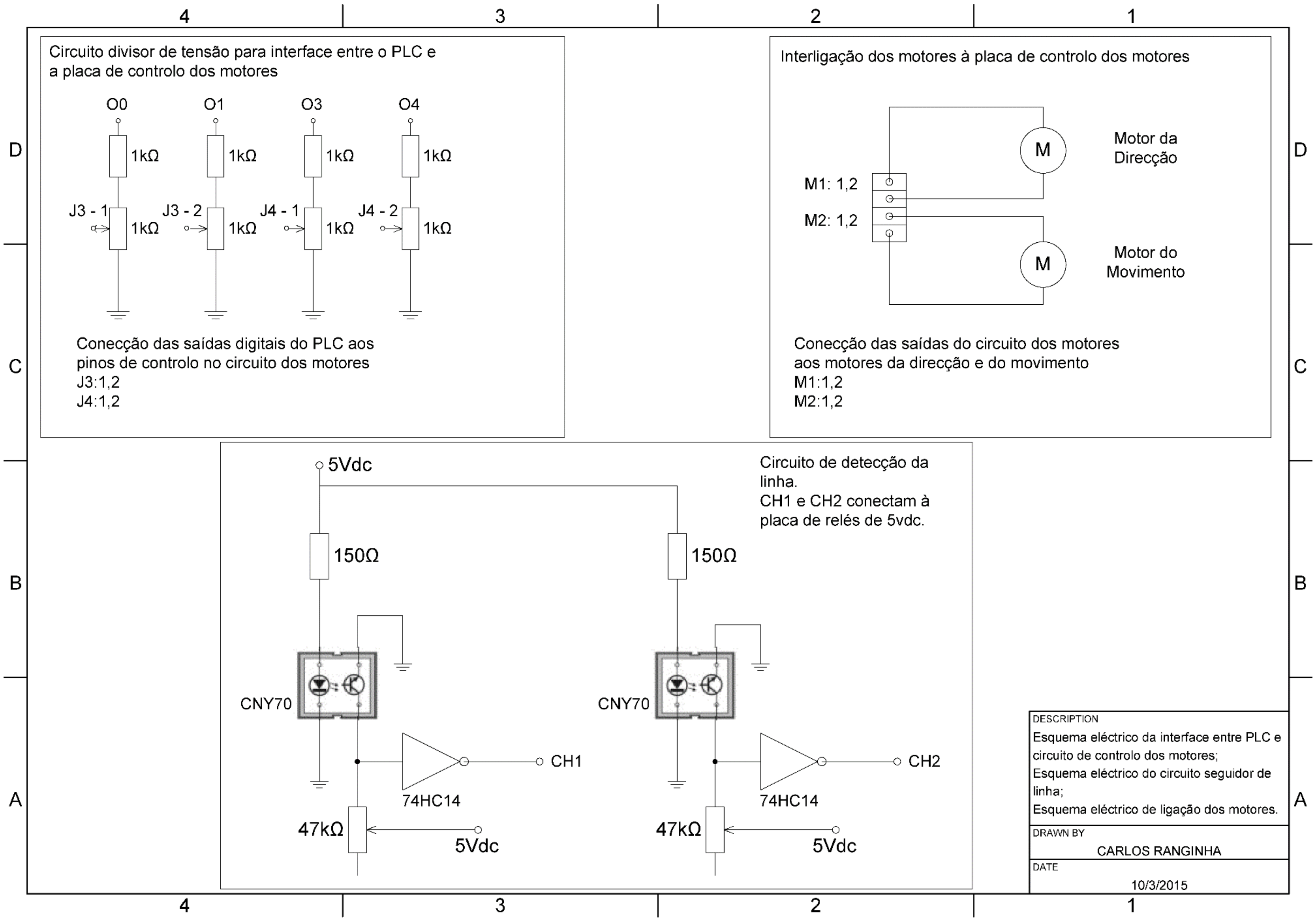
Anexo F.

DESCRIPTION
Plano detalhe das ligações no PLC

DRAWN BY
CARLOS RANGINHA

DATE
10/3/2015

Anexo G.


4
3
2
1
D
C
B
A
Circuito divisor de tensão para interface entre o PLC e a placa de controlo dos motores
O0
O1
O3
O4
1kΩ
J3 - 1
J3 - 2
J4 - 1
J4 - 2
Conecção das saídas digitais do PLC aos pinos de controlo no circuito dos motores
J3:1,2
J4:1,2
Interligação dos motores à placa de controlo dos motores
M1: 1,2
M2: 1,2
M
Motor da Direcção
Motor do Movimento
Conecção das saídas do circuito dos motores aos motores da direcção e do movimento
M1:1,2
M2:1,2
5Vdc
Circuito de detecção da linha.
CH1 e CH2 conectam à placa de relés de 5vdc.
150Ω
CNY70
74HC14
CH1
CH2
47kΩ
DESCRIPTION
Esquema eléctrico da interface entre PLC e circuito de controlo dos motores;
Esquema eléctrico do circuito seguidor de linha;
Esquema eléctrico de ligação dos motores.
DRAWN BY
CARLOS RANGINHA
DATE
10/3/2015

Anexo H.

Photoelectric Sensors/Controls

FE7B Series

Subminiature DC Sensors

FEATURES

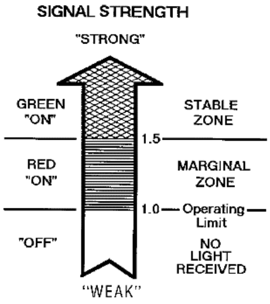
- 5 feet retro or 6.5 feet polarized scan range with FE-RR1 reflector
- 8 or 28-in. diffuse scan range
- 8 in. wide angle diffuse scan range
- 6.5 or 33 feet thru scan range
- 10 to 28 VDC operation
- Sealing: NEMA 12 and IP64
- Modulated infrared LED for ambient light rejection
- Combination alignment/self diagnostic indicator
- Sensitivity adjustment (except emitters)
- Short circuit protection
- False pulse and reverse polarity protection
- Vertical or horizontal mounting choice
- Current sourcing output (optional)

GENERAL INFORMATION

The small package size of FE7B sensors allow usage in limited access and/or restricted space areas. A mounting bracket (included) makes mounting and alignment easy. Each sensor is self-contained, incorporating a pulsed LED, phototransistor receiver and amplifier circuitry with solid state output in one package. The FE7B operates on a broad range DC voltage from 10 to 28 VDC and provides current sinking or current sourcing output up to 100 mA.

Self-diagnostic function alignment indicator. When a sufficient light level is being received, the indicator light is green. But when the light level decreases to 150% of the minimum operating level the indicator turns red. This simplifies installation, alignment, and troubleshooting.

SELF DIAGNOSIS INDICATION



FOR A COMPLETE SENSOR – RETROREFLECTIVE SENSOR

Required

- Retroreflective sensor – **FE7B-RA6G-M**
- Reflector – **FE-RR1**
- Appropriately rated DC power supply

FOR A COMPLETE SENSOR – DIFFUSE SCAN SENSOR

Required

- Diffuse scan sensor – **FE7B-DA6-M**
- Appropriately rated DC power supply

ORDER GUIDE RETROREFLECTIVE SCAN – 5 FT. RANGE (1,5 M)

Description	Catalog Listing
Dark operated (D.O.) sinking (NPN) output; horizontal mount	**FE7B-RA6G-M**
Light operated (L.O.) sinking (NPN) output; horizontal mount	FE7B-RB6G-M
Dark operated (D.O.) sourcing (PNP) output; horizontal mount	FE7B-RD6G-M
Dark operated (D.O.) sinking (NPN) output; vertical mount	**FE7B-RA6VG-M**
Light operated (L.O.) sinking (NPN) output; vertical mount	FE7B-RB6VG-M
Dark operated (D.O.) sourcing (PNP) output; vertical mount	FE7B-RD6VG-M

POLARIZED RETROREFLECTIVE SCAN – 6.5 FT. RANGE (2 M)

Description	Catalog Listing
Dark operated (D.O.) sinking (NPN) output; horizontal mount	**FE7B-RPA6-M**
Light operated (L.O.) sourcing (PNP) output; horizontal mount	FE7B-RPE6-M
Dark operated (D.O.) sinking (NPN) output; vertical mount	**FE7B-RPA6V-M**
Light operated (L.O.) sinking (NPN) output; vertical mount	FE7B-RPB6V-M
Dark operated (D.O.) sourcing (PNP) output; vertical mount	FE7B-RPD6V-M
Light operated (L.O.) sourcing (PNP) output; vertical mount	FE7B-RPE6V-M

ORDER GUIDE DIFFUSE SCAN – 8 IN. RANGE (20 CM)

Description	Catalog Listing
Light operated (L.O.) sinking (NPN) output; horizontal mount	**FE7B-DA6-M**
Dark operated (D.O.) sinking (NPN) output; horizontal mount	FE7B-DB6-M
Light operated (L.O.) sourcing (PNP) output; horizontal mount	FE7B-DD6-M
Light operated (L.O.) sinking (NPN) output; vertical mount	**FE7B-DA6V-M**
Dark operated (D.O.) sinking (NPN) output; vertical mount	FE7B-DB6V-M
Light operated (L.O.) sourcing (PNP) output; vertical mount	FE7B-DD6V-M

ORDER GUIDE DIFFUSE SCAN – 28 IN. RANGE (71 CM)

Description	Catalog Listing
Light operated (L.O.) sinking (NPN) output; horizontal mount	**FE7B-DLA6-M**
Dark operated (D.O.) sinking (NPN) output; horizontal mount	FE7B-DLB6-M
Light operated (L.O.) sinking (NPN) output; vertical mount	FE7B-DLA6V-M
Light operated (L.O.) sourcing (PNP) output; vertical mount	FE7B-DLD6V-M

Mounting bracket is included with all units.

ORDER GUIDE WIDE ANGLE DIFFUSE SCAN - 8 IN. SCAN RANGE (20 CM)

Description	Catalog Listing
Light operated (L.O.) sinking (NPN) output; horizontal mount	FE7B-DA6-M-916
Light operated (L.O.) sinking (NPN) output; vertical mount	FE7B-DA6V-M-916
Same as above except 1 m cable, no hardware, bulk packed	FE7B-DA6V-M933
Light operated (L.O.) sourcing (PNP) output; horizontal mount	FE7B-DD6-M-916
Same as above except black housing, 1 m cable, no hardware, bulk packed	FE7B-DD6-M936A

Thru scan listings next page.

Photoelectric Sensors/Controls

FE7B Series

Subminiature DC Sensors

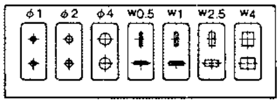
FOR A COMPLETE SENSOR

Required

- **Thru scan emitter – FE7B-TA6E-M**
- Thru scan receiver – **FE7B-TA6GR-M**
- Appropriately rated DC power supply

- Capable of detecting small objects (0,1mm dia.) by use of proper aperture mask

FE-PA7B3-M



For application information, see page C192.

ACCESSORIES

Description	Catalog Listing
Mounting bracket	FE-PA7B1
Aperture mask, set	FE-PA7B3-M

ORDER GUIDE THRU SCAN – 6.5 FT. RANGE (2 M)

Description	Catalog Listing
Emitter: horizontal mount	**FE7B-TA6E-M**
Receiver: dark operated (D.O.) sinking (NPN) output; horizontal mount	**FE7B-TA6GR-M**
Receiver: light operated (L.O.) sinking (NPN) output; horizontal mount	FE7B-TB6GR-M
Receiver: dark operated (D.O.) sinking (NPN) output; vertical mount	FE7B-TA6VGR-M
Receiver: light operated (L.O.) sinking (NPN) output; vertical mount	FE7B-TB6VGR-M
Receiver: light operated (L.O.) sourcing (PNP) output; vertical mount	FE7B-TE6VGR-M

ORDER GUIDE THRU SCAN – 33 FT. RANGE (10 M)

Description	Catalog Listing
Emitter, horizontal mount	FE7B-TLA6GE-M
Receiver, dark operated (D.O.) sinking output; horizontal mount	FE7B-TLA6GR-M
Emitter; vertical mount	FE7B-TLA6VGE-M

Note: Both the long range emitter and the long range receiver must be used together to achieve the 10M scan.

SPECIFICATIONS

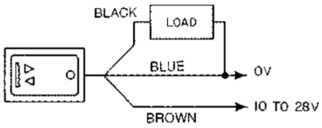
		Thru	Retro	Polar	Diffuse
Maximum Scanning Distance (in clean air)		6.5 ft (2 m), 33 ft. (10 M)	5 ft. (1.5 m)	6.5 ft. (2 m)	8 in. (20 cm), 28 in. (71 cm) Wide angle: 8 in. (20 cm)
Supply Voltage		10 to 28 VDC; 10% max. power supply ripple			
Power Dissipation		Emitter – 0.48 watts max.; Receiver – 0.36 watts max. (excluding load)		0.56 watts max. (excluding load)	
Current Consumption		Emitter – 17 mA max., Receiver – 13 mA max. (excluding load)		20 mA max. (excluding load)	
Output	Load Current	100 mA max. (open collector, light or dark operated) current sinking			
	Voltage Drop	1.0 VDC max. sinking 100 mA			
	Leakage Current	Off state: < 10μA			
Maximum Rate of Operation		15,000 operations/minute			
Typical Response Time	On	1 msec. (2 msec. max.)			
	Off	1 msec. (2 msec. max.)			
Circuit Protection		False pulsing, Short circuit, Reverse polarity			
Temperature Range		–4°F to 140°F (–20°C to 60°C)			
Sealing		NEMA 12 and IP64			
Housing		Case ABS resin, Lens PMMA acrylic resin, Cable vinyl			
Mounting		Horizontal side mounting bracket included			
Weight		3.5 ozs. (99,2 g)			
Logic		Built-in ON-OFF (immediate response) control; light or dark operated by individual catalog listing			

Note: Polarized light source is visible red.

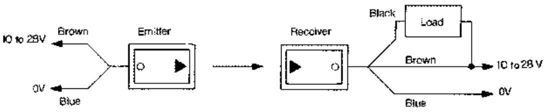
INSTALLATION/WIRING

Instruction Sheet PK 9074 is included with each sensor, and is also available upon request. Use receiver wiring for retro and diffuse units.

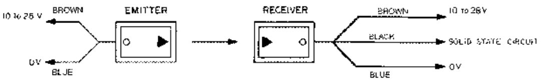
Sourcing Output Type



Standard Relay Or Solenoid Sinking Output Type



Solid State Circuit Interface

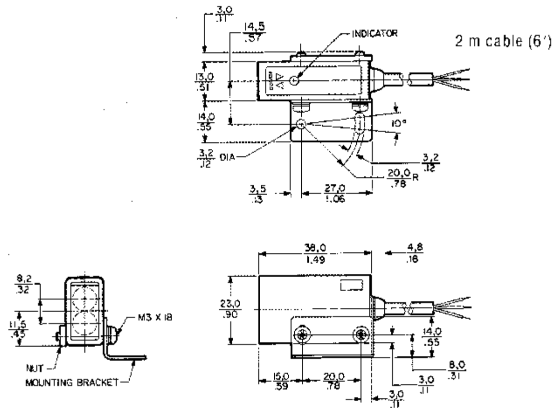


Photoelectric Sensors/Controls

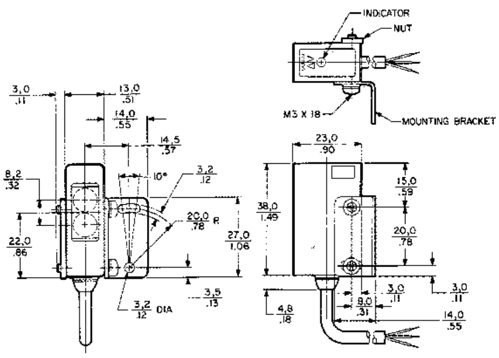
Subminiature DC Sensors

MOUNTING DIMENSIONS (For reference only)

Horizontal Mount

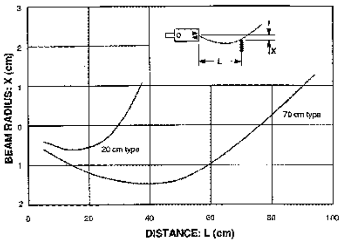


Vertical Mount

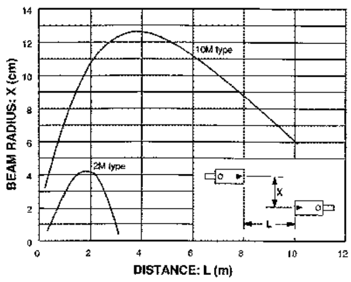


BEAM RADIUS CURVES

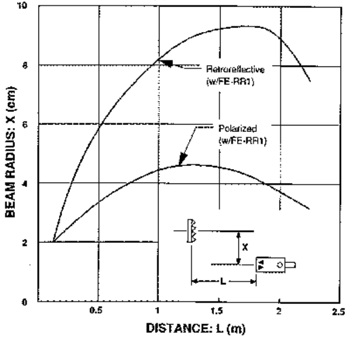
Diffuse-scan type



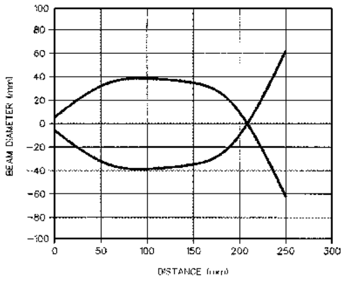
Through-scan type



Polarized retroreflective scan type
Retroreflective type

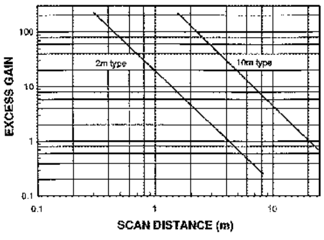


Wide-angle diffuse scan type

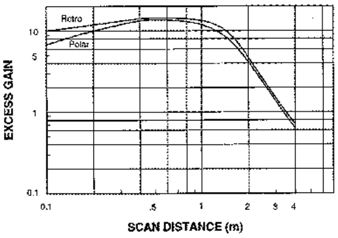


EXCESS GAIN

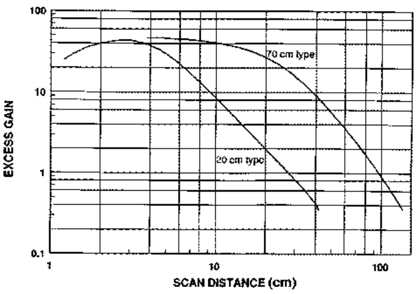
Through-scan type



Polarized Retroreflective-scan type
Retroreflective-scan type
(with FE-RR1)



Diffuse-scan type



Reference and Index Pages

Glossary of Terms

A

Actuator—mechanism of the switch or switch enclosure which operates the contacts.

Alignment—placing the emitter (light source) and receiver (photoreceiver or reflector) so as to direct the maximum amount of light on the photosensor. At long distances, when the light beam has widened, the receiver should be centered in the beam to lessen the chance of the emitter and receiver drifting out of alignment due to vibration or shock.

Alternating Current (AC)—one that reverses at regularly recurring intervals of time and has alternately positive and negative values.

Ambient—in the area. 1) light—Light in the area of the photosensor, but not originating with the control light source. Ambient light can adversely affect non-modulated control operation, and should be screened, if possible, from the sensor; 2) Temperature—average temperature of surrounding medium such as water, air, or earth, into which the heat of the equipment is dissipated.

Analog Output—having the property of being continuously variable, as opposed to having discrete states.

AND Logic—an output is produced only when all inputs are present.

Aperture—most often an external cap (with a small opening) placed over the receiver lens to help detect small objects. It lets even a small object block enough light to be detected. Also, an internal aperture in most receivers reduces the effect of off-axis ambient light.

Attenuation—loss or reduction of beam intensity as a result of environmental factors, dust, humidity, steam etc.

Auxiliary Actuator—a mechanism, sold separately, to provide basic switches with easier means of operation and adjustment and adapt switches to different operating motions by supplying supplemental overtravel.

B

Basic Switch—a self-contained switching unit. It can be used alone, gang-mounted, built into assemblies or enclosed in metal housings.

Break—to open an electrical circuit.

C

Cascade—to combine logic circuitry to get more complex logic or timing control. (Inputs and outputs are wired in series.)

Characteristics—This term is used by MICRO SWITCH in a restricted sense and refers only to switch operating characteristics such as pretravel, operating force, etc.

Clean Air—ideal conditions. Climate controlled or sterile area.

Complementary Output—both N.O. and N.C. outputs are available for use. A circuit that provides sink or source capability with a single input. Output that can be both light operated and dark operated. (Also known as 4-wire DC controls.)

Control—the complete system; sensor, amplifier, output.

Control Base—unit remote from sensor in which amplification and conditioning of the input signal takes place. Usually contains a power supply and an output device.

Convergent Beam—A variation of the diffuse scanning mode. A photoelectric control whose optical system is the key to its operation. It simultaneously focuses and converges a very small, intense beam to a fixed-focal point in front of the control. The control is essentially blind a short distance before and beyond this focal point. Convergent beam scanning is used to detect the presence or absence of small objects while ignoring nearby background surfaces.

Convertible Output—output that can be wired either as Normally Open or Normally Closed, but not at the same time.

Corrective Factor—the mathematical factor that, when multiplied by the sensing distance of a given sensor, will adjust sensing distance for the different metals being used as targets.

Current—time value of movement of free electrons. One ampere equals one coulomb per second. Conventional reference is opposite to direction of actual electron movement.

Current Consumption—the amount of current required to power a sensor or control (excluding load). See *supply current.*

Current Sinking—an output type such that when it is On, current flow is from the load into the device's output, then to ground. Output is Normally High. The sensor "sinks" current from the load through the sensor to ground. The load is connected between the positive lead of the supply and the output lead of the sensor.

Current Sourcing—an output type such that when it is On, current flow is from the device into the load. Output is Normally Low. The sensor "sources" current to the load. The load is connected between the output lead and the negative ground lead of the supply.

D

Dark Operated (D.O.)—control operating mode in which the output (load) is energized when the light is blocked (retro/thru scan) or object not present (diffuse), the photosensor is dark.

Diffuse Scan—a reflective scanning technique in which reflection from a near-by non-shiny surface illuminates the photosensor in the receiver. Sometimes called proximity scan because of the required nearness of the light source and photosensor to reflecting surface. Also used to detect color contrast as in registration control.

Digital Circuit—a circuit that has only two stable states, operating in the manner of a switch; that is, it is either On or Off.

Digital Output—output that is of only two stable states, appearing in the manner of a switch; that is, it is either On or Off or High or Low (i.e., high voltage or low voltage).

Direct Current (DC)—a unidirectional current in which changes in value are so small that they may be neglected. As ordinarily used, the term designates a practically non-pulsating current.

Direct Scan—see *thru scan.*

Disable—to prevent the output despite an input signal. A wiring terminal for this purpose is provided on most MICRO SWITCH control bases. The disabling circuit may receive its signal from the current sinking output of a photoelectric logic card, or modulated LED control, or from an electromechanical limit switch, etc. Disabling is used to prevent false or unwanted signals from triggering the control.

Double Break Contacts—(Twin break). This breaks the circuit in two places. Referred to as form Z circuitry also.

Double-Pole Double Throw (DPDT)—switches which make and break two separate circuits. This circuit provides a normally open and normally closed contact for each pole.

Reference and Index Pages

Glossary of Terms

E

Effective Sensing Distance—the difference between nominal sensing distance and the ±% manufacturing tolerance.

Enable—the opposite of disable. To allow output in response to an input signal. We often speak of one light source-photoreceiver pair (the "gating" pair) enabling a second pair (the "inspect" pair).

Enclosed Switch—a basic switch unit (contact block) enclosed in a durable metal housing. The enclosure protects the switching unit, provides mounting means, and fitting for conduit connection.

Environment-Proof Switch—a switch which is completely sealed to ensure constant operating characteristics. Sealing normally includes an "O" ring on actuator shaft and fused glass-to-metal terminal seals or complete potting and an elastomer plunger-case seal.

Excess Gain—the ratio of optical power available at a given emitter-to-receiver range to the minimum optical power required to trigger the receiver.

Explosion-Proof—having the ability to contain an explosion within the sensor or housing if it were to occur.

Explosion-Proof Switch—a UL listed switch capable of withstanding an internal explosion of a specified gas without ignition of surrounding gases.

External Inhibit—see *disable.*

Extreme Contamination—coal bins, residue on lens.

F

Fall Time—a measure of the time required for the output voltage of a circuit to change from a high voltage level to a low voltage level, once a level change has started (90% to 10%).

False Pulse—an improper change of state of the output, usually associated with Turn-Off or Turn-On.

False Pulsing—circuitry designed to clamp output Off until the power supply has time to reach proper voltage level. Typically 200-500 msec.

False Pulse Protection—circuitry designed to clamp output Off until the power supply has time to reach proper voltage level. Typically 200-500 msec.

Fiber Optics—transparent fibers of glass or plastic used for conducting and guiding light energy. Fiber optics are used in photoelectrics as light pipes consisting of a bundle of small optical fibers (glass) or single strand (plastic) housed inside a flexible sheathing.

G

Ground—a conducting path, intentional or accidental, between an electric circuit or equipment and the earth, or some large conducting body serving in place of the earth (a voltage reference).

H

Hall Effect Technology—the description given to the following phenomena: when a semiconductor, through which a current is flowing, is placed in a magnetic field, a difference in potential (voltage) is generated between the two opposed edges of the conductor in the direction mutually perpendicular to both the field and the conductor. Typically used in sensing magnetic fields.

Hardwired—physically interconnected and intended for a specific purpose. Hardwired logic is essentially unalterable.

Hazardous Location—defined as an area in which flammable or combustible mixtures are present.

Head-On—a condition whereby the target approaches the sensing face of the proximity sensor with its center along the sensing face.

High Contamination—heavy particle laden air, extreme washdown environments, grain elevators.

Hermetically Sealed Switch—a switch completely sealed to provide constant operating characteristics. All junctures made with metal-to-metal or glass-to-metal fusion.

Hysteresis, Switching—the principle associated with sensors, such that the operate point is not at the same level as the release point. In solid state sensors, it is accomplished electrically. In mechanical switches, it results from the storing of potential energy before the transition occurs. Also known as differential, and is usally expressed as a percentage of the operate point (e.g. 3-15%).

I

Immediate Response—control transfers On/Off state immediately when target enters the detection range, and reverses state immediately when target leaves detection range.

Inductive Technology—technology based on inductance, the property of an electric circuit by which an electromotive force is induced in it by a variation of current, either 1) in the circuit itself, or 2) in a neighboring circuit.

Infrared (IR)—the invisible radiation (as opposed to visible light) that certain LEDs emit. Standard MICRO SWITCH modulated LED controls have infrared emitting LEDs.

Inhibit—see *disable.*

Input—1) The device or collective set of devices used for bringing data into another device; 2) The signal or stimulus put into a circuit to make the output do something.

Input Signal Duration—a length of time the light beam is blocked (in dark operated mode), or uninterrupted (in light operated mode). Or, the length of time a target is within the operating range.

Insulator—a non-conducting support for an electric conductor. A material that does not conduct electricity.

Integrated Circuit (IC)—an interconnected array of active and passive elements integrated within a single semiconductor substrate or other compatible material, and capable of performing one complete electronic function.

Interface—a common boundary between electronic systems, or parts of a single system.

Interface Circuit—a circuit that links one type of device with another. Its function is to produce the required current and voltage levels for the next stage of circuitry from the previous stage.

Interrogate (Gate)—a function usually performed by a gating light source-photoreceiver pair; asking (interrogating) whether a certain condition has been met (for example, proper fill level in boxes moving along a conveyor), and thereby enabling or disabling an inspect light source-photoreceiver pair (which will count only full boxes).

Intrinsically Safe—limits electrical/ thermal energy to levels incapable of causing ignition. External barriers are required.

IP—European environmental ratings similar to USA NEMA ratings.

L

Latching Logic—signal modification that causes the output to be energized and remain energized (maintained output). Latched output may be immediate or delayed. Usually, the latch is released by closing a circuit between the reset (RS/D) terminal and ground.

Reference and Index Pages

Glossary of Terms

Leakage Current—small current flowing through or leaking from the output device in the Off state due to semiconductor characteristics.

LED (Light Emitting Diode)—a solid state light source that emits variable light, or (in MICRO SWITCH modulated LED controls) invisible, infrared radiation.

Light Operated (L.O.)—control operating mode in which the output is energized when the light beam is not blocked (retro/thru scan), or object is present (diffuse) the photosensor is illuminated.

Linear (Output)—output that is a continuous amplified version of its input. That is, the output is a predetermined variation of its input.

Load Current—units = Amps/milliamps (DC) or Amps RMS/milliamps RMS (AC). The maximum amount of current that a proximity sensor will switch through its load. Load current for a particular device can be calculated by dividing the load voltage by the load resistance. Attempting to switch a higher load current than the sensor is rated for will result in sensor failure.

Logic—the modification of an input signal that produces delayed, pulsed, latched, or other output response. Logic circuitry is sometimes an integral part of the control, but more often, a separate plug-in card or module.

Low Contamination—warehouse locations, light industry applications, material handling operations.

M

Magnetic Blow-Out Switch—contains a small permanent magnet which provides a means of switching high DC loads. The magnet deflects arc to quench it.

Maintained Contact Switch—designed for applications requiring sustained contact after plunger has been released, but with provision for resetting.

Manufacturer's Tolerance—the maximum variation from standard allowed by the manufacturer between products with the same catalog listing.

Make—to close or establish an electrical circuit.

Maximum Load Current—the maximum amount of current that can flow through a sensor and not cause sensor failure.

Moderate Contamination—milling operations, areas of high humidity, steam.

Modulated Light Source (MLS) Control—a photoelectric control that operates on modulated (pulsed) infrared radiation, and responds only to that frequency rather than steady light intensity. Modulated LED controls offer a high rejection of troublesome ambient light.

Momentary Short Circuit Protection—output circuit protection designed to protect the output device from damage due to a temporary (1-3 sec.) short circuit or until an external fuse can interrupt current.

Momentary Switch—a switch with contacts that return from operated condition to normal condition when actuating force is removed. Unless otherwise stated, all switches in this catalog are momentary.

N

NEMA Ratings—National Electrical Manufacturers Association ratings of an enclosure's ability to provide a degree of protection against contact with equipment and against specified environmental conditions.

Noise, Electrical—noise results from the presence of undesirable electrical voltages or current. It causes devices to operate erratically (if the noise is on the supply line to a device), or produces false information on erratic operation if present on wires carrying signals from the output of a device to the load. Noise can be present in the supply or picked up on lines in many ways. Pick-up from noisy adjacent wires or metal parts is possible. Good wiring practice and/or additional parts can be used to diminish the effects of noise.

Nominal Sensing Distance—an approximate dimension value measured from the face of the sensor to the nearest point of the target. It does not take into consideration manufacturer's tolerance or operational variables. Also known as the operating point.

Nonincendive—inability under normal operation to ignite a hazardous mixture.

Non-modulated Controls—controls designed for indoor applications subject to neither bright ambient light nor extreme vibration. Usually incandescent lamp controls, scanners and light source-photoreceiver pairs.

Normally High—the state of a control in which the output is high (logic 1) in voltage in the rest (Off) condition.

Normally Low—the state of a control in which the output is low (logic 0) in voltage in the rest (Off) condition.

O

Off Delay Logic—adjustable delay (after input signal stops) before output is de-energized.

Off State Current—the supply or bias current flowing into a solid state device when it is in the unactuated state (see Leakage Current).

Ohm—the unit of electrical resistance. Resistance through which a current of one ampere will flow when a voltage of one volt is applied.

On Delay Logic—adjustable delay (after onset of input signal) before output is energized.

One-shot Logic—see *pulsed logic.*

Opacity—the characteristic of an object that prevents light from passing through. The opposite of translucent. Opaque objects are easy to detect since they block light almost entirely.

Operating Mode—refers to the condition of the photosensor (dark or light illuminated) that energizes output. A mode selector switch determines the operating mode.

Operating Temperature—actual range over which sensors can be operated. Usage outside the temperature limits will result in loss of stability, change in operate point and possible permanent damage to the sensor. Nominal sensing distance is determined at 25 – C.

Optical Power—power or intensity of the projected light available from a particular emitter; beam intensity.

OR Logic—an output is produced when any one or more inputs are present.

Output—the useful energy delivered by a circuit or device. Can mean energy produced at the output terminals of an amplifier—a source of energy.

P

Parallel Circuit—a circuit in which current has two or more paths to follow. Two electrical elements are in parallel if both terminals of both elements are electrically connected.

Photocell—a resistive, bulk effect type of photosensor, the type used when it is desirable to wire several photoreceivers in series or in parallel. The resistance decreases with increasing light intensity.

Photoreceiver—a unit consisting of photosensor, focusing lens, and protective enclosure.

Reference and Index Pages

Glossary of Terms

Photosensor—a light sensitive portion of a photoelectric control that converts a light signal into an electrical signal. MICRO SWITCH uses photocells and phototransistors.

Phototransistor—a type of photosensor. Typically used where speed of response is important or ambient temperature variations are great.

Polarized Photoelectric Controls—controls that emit a visible LED beam and use a special lens which filters the beam of light so that it is projected in one plane only. The control responds only to the de-polarized reflected light from corner-cube type reflectors (FE-RR1) or special polarized reflective tape.

Power Dissipation—units = Watts/ milliwatts (DC) or Volt-Amps (AC). The amount of power that is consumed and converted to heat in normal operation.

Supply Voltage (max) x Supply Current (max) = Power Dissipation

Volts x Amps = Watts (DC) or Volt/ Amps (AC)

Precision Snap-Acting Switch—an electromechanical switch having predetermined and accurately controlled characteristics and having a spring loaded quick make and break contact action.

Proximity Scan—See *diffuse scan.*

Proximity Sensor—a sensor with the ability to detect the presence of a metal target, within a specified range, and without making physical contact.

Pull-Down Resistor—a resistor connected across the output of a device or circuit to hold the output equal to or less than the zero input level. Also used to lower output impedance of digital or analog devices. Usually connected to a negative voltage or ground.

Pull-Up Resistor—a resistor connected across the output of a device or circuit to hold the output voltage equal to or greater than the input transition level of a digital device. Usually connected to the positive voltage or plus supply.

Pulse—a momentary sharp change in current, voltage, or other quantity that is normally constant. A pulse is characterized by a rise and fall and has a finite duration.

Pulsed Logic—a signal modification that produces output independently of input signal duration. Pulse duration (dwell) is usually adjustable. Also referred to as one-shot logic. Pulsed logic may be immediate or delayed.

R

Rectifier—a device that converts alternating current into direct current.

Reed Technology—technology where the reed contacts are designed to be actuated by a magnet. When a magnetic field is brought close to the reed contacts, the contacts are drawn together to make the circuit.

Reflective Scan—a scanning technique in which the light source is aimed at a reflective surface to illuminate the photosensor. Retroreflective, specular, diffuse scan and convergent beam are all reflective scan techniques.

Regulation %—the ratio of voltage extremes due to loading or line fluctuations. The process of holding constant a quantity such as voltage by means of a system that automatically corrects errors. For example, as more current is drawn from a battery or power supply, the output voltage tends to decrease (load regulation). With a power supply derived from AC, the DC output voltage can vary with the variation in AC voltage (line regulation).

Repeatability—the ability of a sensor to reproduce output readings when the same value is applied to it consecutively in the same direction, for a specified number of cycles, or specified time duration.

Response Time—the time it takes for a device to respond to an input signal. The sum of the sensor, amplifier, and output response is the total response time.

Retroreflective Scan—the reflective scan technique that uses a special reflector (retroreflector) to return light along the same path it was sent.

Reverse Polarity Protection—circuitry, usually a diode which prevents current from flowing into the control in case of accidental mis-wiring of the plus (+) or minus (−) terminals, preventing damage to the unit.

Ripple—the alternating component of voltage from a rectifier or generator. A slight fluctuation in the intensity of a steady current.

Rise Time—a measure (10% to 90%) of the time required for an output voltage to rise from a state of low voltage to a high voltage level, once a level change has started.

S

Saturation Voltage—the voltage drop appearing across a control device that is fully turned On.

Scan Technique—a method of scanning objects. The two general categories are through and reflective scan.

Self-Contained Control—a photoelectric control in which all three phases of control – sensing, signal conditioning, and output – occur in a single device.

Self-Contained Sensor—a proximity sensor in which all three phases of control, sensing, signal conditioning, and output, occur in a single device.

Sensing Distance—the maximum recommended distance between the sensor and a standard target at which the sensor will effectively and reliably detect the target.

Sensitivity—maximum recommended distance between the sensor and standard target at which sensor will effectively and reliably detect the target.

Sensor—a sensing element. The basic element that usually changes some physical parameter to an electrical signal.

Series Circuit—a circuit in which current has only one path to follow.

Shielded Sensor—a sensor which "senses" only to the front of its face and ignores metals to its side. The presence of such side metal, however, may cause a slight shift in operating characteristics.

Signal Conditioning—to process the form or mode of a signal so as to make it intelligible to or compatible with, a given device, including such manipulation as pulse shaping, pulse clipping, digitizing, and linearizing.

Signal Ratio—1) broadly, the comparison of light seen by a photosensor when the beam is blocked to the light seen when the beam is not blocked; 2) More specifically, the comparison of photocell resistance when sensor is dark to when it is illuminated. Proper control application involves establishing a large dark-to-light ratio.

Single-Pole Double-Throw (SPDT)—switch which may either make or break a circuit, depending on how it is wired.

Single-Pole Single-Throw (SPST)—switch with only one moving and one stationary contact. Available either normally open (N.O.) or normally closed (N.C.).

Slide-By—the condition whereby the target approaches the sensing face of the proximity sensor in such a direction that its center will cross the axis of the sensing face at right angles.

Reference and Index Pages

Glossary of Terms

Slight Contamination—indoor locations, non-industrial areas, office buildings.

Specular Scan—a reflective scan technique in which reflection from a shiny surface illuminates the photosensor, which must be precisely positioned to receive the reflected light. The angle of incidence equals the angle of reflection.

Standard Target—an object used for making comparative measurements of operating distance. A square of mild steel, 1 mm thick. The length of the side of the square is equal to either:

A: the diameter of the circle inscribed on the active surface of the sensitive face of the sensor, or

B: three times the rated operating distance, whichever is the greater.

Supply Current—units = Amps or milliamps. The amount of current necessary to maintain operation of a photoelectric control, proximity sensor or control base. Sometimes referred to as Current Consumption.

Supply Voltage—units = Volts. The range of power required to maintain proper operation of a photoelectric control, proximity sensor or control base. The difference in potential (or range of difference in potential) necessary to operate the unit.

Switching Frequency—the actual number of targets to which the sensor can respond in a given time period, usually expressed as Hertz (cycles per second).

T

Target—the part or piece being detected.

Thermal Drift Chart—a chart illustrating sensor operating variance due to changes in temperature.

Threshold Response—a control type that responds to the change in input signal level. Plug-in amplifiers are either threshold or transition responsive.

Thru Scan—a scanning technique in which the emitter (light source) is aimed directly at the receiver. Also called direct scan and transmitted scan, since light is transmitted directly, not reflected to the sensor. Presently, it is the only scanning technique commonly used to scan distances greater than 40 feet.

Time Delay Before Availability—also known as False Pulse Protection. Outputs are turned Off when power is first applied during this time period.

Transient Protection—circuitry to guard against spikes induced on the supply lines by inductive sources such as heavy motors or solenoids turning On and Off.

Transients—in electronic usage, usually refers to an unwanted, temporary, large increase or decrease in a current or supply voltage that only occurs occasionally. Almost always due to reactive components during rapid changes in voltage or current.

Transition Responsive—a control type that responds to the rate of change in light intensity rather than the level change. Used to detect fast moving objects that cause little change in light intensity level.

Translucent—allows light to pass through. Detecting translucent objects is often best done with retroreflective scan, during which the light must pass through the object twice, thereby causing more of a signal change (larger signal ratio).

TTL Compatibility—TTL (transistor-transistor-logic) requires NPN (current sinking) input signals. Reliable operation demands maximum input sensor voltage drop of 0.8 V. Most TTL compatible interface devices have voltage drops of less than 0.7 V.

U

UL—Underwriter's Laboratories, Inc., a non-profit organization that establishes, maintains and operates laboratories for the examination and testing of devices, systems and materials primarily for safety.

Unshielded Sensor—a sensor with limited side and front sensing capabilities.

Usable Sensing Distance—sensing distance after temperature range tolerance and manufacturers tolerance are taken into account.

V

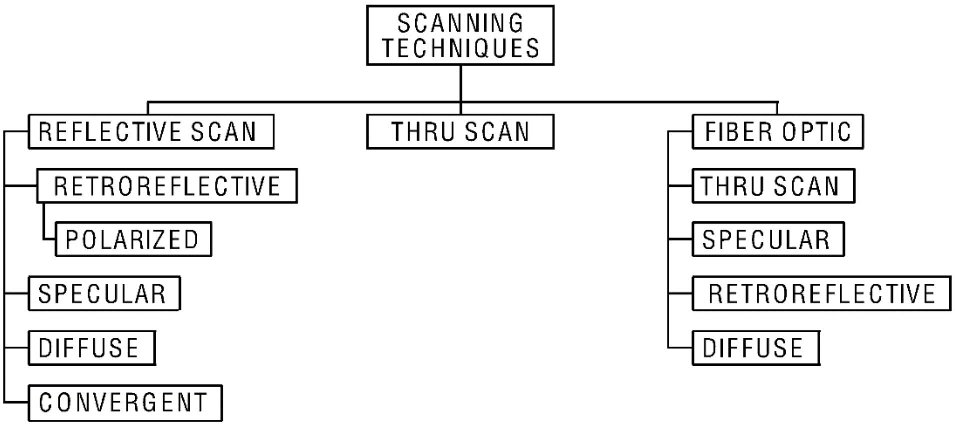
Voltage—units = Volts (DC) or Volts RMS (AC). The term used to designate the electrical energy differential that exists between two points and is capable of producing the flow of current when a closed path is connected between the two points.

Voltage Drop—units = Volts (DC) or Volts RMS (AC). Sometimes referred to as Saturation Voltage. In any solid state control that switches a load, there will be some voltage dropped across the output. This voltage drop or saturation voltage will often vary with the amount of current going through the output section and the load. It should be specified with current conditions.

Photoelectric Sensors/Controls

Scanning Techniques

OVERVIEW



Retroreflective
- Light beam is directed at a reflective target (reflector, tape or other reflective object) – one which returns light along the same path it was sent.
- The object to be detected passes between photoelectric control and reflective target.

Polarized
- Will work only with cornercube reflector or special polarized reflective tape.
- Will not false trigger when sensing shiny object.

Specular
- Light beam is directed at a shiny surface which will always occupy the same position in relationship to the photoelectric control.
- Light will be reflected at the same angle at which it was received.
- When object is not present light will be reflected at a different angle.

Diffuse
- Light beam is directed at the object to be detected.
- Light will be reflected off the object in many directions.
- Some of the light reflected from the object will be sensed by the receiver.

Convergent
- Light beam is directed at object to be detected (ignore's background surfaces).
- Object must be at a given distance in relationship to photoelectric control before light will be reflected to receiver.

Thru
- Light source (emitter) and receiver are placed opposite each other.
- The object to be detected passes between the two.

Fiber Optic
- Not a scanning technique but rather another way of transmitting light beam.
- Must use bifurcated cables when using retroreflective and diffuse scans.

Photoelectric Sensors/Controls

Scanning Techniques

ADVANTAGES/APPLICATION CONSIDERATIONS

Scan Types	Advantages	Application Considerations
Retroreflective/Polarized	1. One sided scanning 2. Ease of alignment 3. Immune to vibration	1. Avoid detecting small parts or precise positioning 2. Avoid clear material detecting 3. Avoid sensing shiny objects (use polarized controls)
Polarized	1. One sided sensing 2. Does not false trigger off highly reflective objects 3. Senses clear materials 4. Ease of alignment 5. Immune to vibration	1. Reduced scan range compared to retrotreflective 2. Avoid detecting small parts or precise positioning
Specular	1. Best for shiny versus dull surfaces 2. Detecting height differential from background, i.e., cloth on a shiny table	1. Alignment angle between emitter and receiver critical 2. Distance from control to target must be constant
Diffuse	1. No reflector required 2. Convenient for installation 3. One sided scanning 4. Senses clear materials when distance is not fixed 5. Color sensing (incandescent controls) 6. Ease of alignment	1. Sensing range is always specified to white test paper 2. Shiny material requires close control of scanning angle 3. Background object's reflectivity cannot be more than target reflectivity 4. Large effective beam, avoid small parts detection 5. Contaminated area a problem 6. Avoid counting applications
Convergent	1. First choice for detecting clear materials 2. Ignores unwanted background surface reflection 3. Detects objects with low reflectivity 4. Detects height differential	1. Distance must be constant 2. Surface reflectivity a factor
Thru	1. Most reliable when target is opaque 2. Long range scanning, most excess gain 3. Use in high contamination areas, dirt, mist, condensation, oil film, etc. 4. Precise positioning or edge-guiding of opaque material 5. Parts counting	1. Avoid clear material detecting 2. For small parts must use aperture 3. Alignment critical 4. Additional wiring (2 units) 5. Vibration a factor
Fiber Optics	1. High temperature applications 2. Where space is limited 3. Size and flexibility of fiber leads 4. Corrosive areas 5. Noise immunity	1. Cost 2. Breakage 3. Short range scanning

Photoelectric Sensors/Controls

Scanning Techniques

There are several scanning techniques — ways to set up an emitter (light source) and receiver (photosensor) to detect objects. The best technique to use is the one that yields the highest signal ratio for the particular object to be detected, subject to scanning distance and mounting restrictions.

Characteristics of the objects to be detected that have a bearing on which scan technique to use include:

- degree of opacity
- degree of reflectiveness
- position of objects as they pass the control
- color as a special consideration

REFLECTIVE SCAN

With a reflective scan control, the light source and photosensor (usually in the same housing) are placed on the same side of the object to be detected. The light beam is reflected either from a permanent reflective target or directly from the object to be detected back to the photosensor. There are five types of reflective scan:

- Retroreflective
- Polarized Retroreflective
- Diffuse
- Convergent
- Specular

Retroreflective Scan

With retroreflective scan, emitter (light source) and receiver (photosensor) are in the same housing. The light beam is directed at a retroreflective target — one which returns the light along the same path it was sent. Retroreflective targets are available as acrylic disks, tape or chalk. Perhaps the most commonly used retro target is the familiar bicycle-type reflector. A larger reflector returns more light to the receiver, and thus allows greater distance scanning. With retro targets, alignment is not critical. The control (emitter and receiver) can be as much as 15° to either side of the perpendicular to the target. Also, since alignment need not be exact, retroreflective scan is an excellent way to counteract vibration.

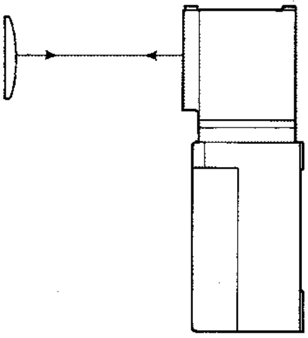
Retroreflection from a stationary target normally provides a high signal ratio as long as the object passing between the control and target is not highly reflective. Retroreflective scan is a preferred technique to detect translucent objects, and assures a higher signal ratio than is obtainable with thru scan. With thru scan, the "dark" signal may not register very dark at the photosensor in the receiver, because some light will pass through the object. With retroreflective scan, however, any light that passes through the translucent object on the reflector is diminished again as it returns from the reflector.

Another way to use retroreflective scan is to apply retroreflective tape or chalk coding to cartons or other items that must be sorted.

Retroreflective scanning is useful in conveyor applications and general beam break applications. It is not as reliable as thru scanning if the environment is dirty, if scanning distance is great, or if product breaking the beam is reflective (e.g. glass, polished stainless, etc.).

Some retroreflective controls can be used at distances up to 40 feet in clean air conditions. As the distance to target increases a larger retro target should be used to intercept and return as much light as possible.

Single-unit wiring and maintenance are additional advantages of retroreflective scanning.



Retroreflector scan advantages include single-unit wiring and non-critical alignment with reflector.

Polarized Scan

Polarized scan is a modified retroreflective scan. As with other retroreflective controls, polarized controls usually contain both an emitter and receiver in one unit. Polarized controls use a special lens which filters the emitter's beam of light so that it is projected in one plane only. The receiver responds only to the de-polarized reflected light from corner-cube type reflectors or polarized sensitive reflective tape. It is designed to ignore the light reflected from highly reflective targets such as shrink wrap materials, shiny luggage or aluminum cans.

The visible beam can be seen on the reflector for easier and more accurate alignment.

Must be corner cubed reflector or polarized sensitive reflective tape.

Photoelectric Sensors/Controls

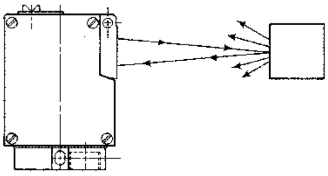
Scanning Techniques

Diffuse Scan

Usually diffuse scan controls contain both the emitter and the receiver. In the diffuse scanning mode the emitted light strikes the product surface at some arbitrary angle and the light is then diffused from the surface at all angles. The product or target is the reflector. The target actually makes the beam instead of breaking the beam.

Non-shiny (matte) surfaces such as kraft paper, rubber, and cork absorb most incident light and reflect only a small amount. Light is reflected or scattered nearly equally in all directions. In diffuse scan, the control is positioned perpendicular to a dull surface. Emitted light is reflected back from the target to operate the receiver. Because the light is scattered, only a small percentage returns. Therefore, scanning distance is somewhat limited. A portion of the diffused light is returned to the receiver. Alignment is not critical in picking up diffuse reflection. Diffuse scan is the mode to use for web break and ejected part detection, conveyor jam detection, etc.

Target makes the beam instead of breaking the beam



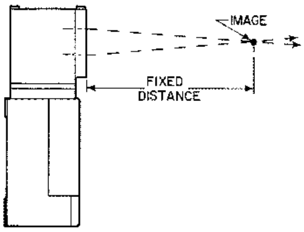
Convergent Beam

Convergent beam scanning is a special variation of the diffuse mode. The control's optical system is the key to its operation. It simultaneously focuses and converges the light beams to a fixed-focal point in front of the control. The control is essentially blind a short distance before and beyond this focal point. Operation is even possible when highly reflective backgrounds are present. Like diffuse scanning, convergent beam scanning senses light reflected back directly from an object.

Convergent beam scanning is used to detect products which are only inches away from another reflective surface. It is the first choice for edge-guiding or positioning clear or translucent materials. Because the beam is well defined, it is also a good second choice for position sensing of opaque materials.

Parts can be sensed on a conveyor from above while ignoring the conveyor belt. Or they can be sensed from the side without detecting guides or rails directly in back of the object. Convergent beam scanning can detect the presence of fine wire, resistor leads, needles, bottle caps, pencils, the stack height of material, fill level of clear liquids and discriminate the product against its background. It is also capable of sensing black code marks against a contrasting background.

Fixed focus light beams



Specular Scan

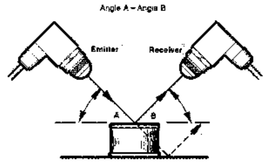
In the specular scanning mode, the emitter and receiver are in separate housings. An emitter and receiver are mounted at equal angles from the perpendicular to a reflective surface (see below). The distance from the surface of an object to the control(s) must remain constant.

The specular mode is useful in some applications where differentiating between a shiny and a dull surface is necessary. An example of this would be checking for the presence or absence of foil or poly wrap on cartons.

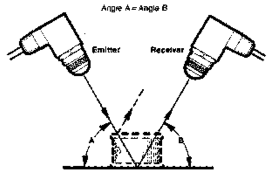
The angle at which light strikes the reflecting surface equals the angle at which it reflects from the surface. Positioning of the emitter (light source) and receiver must be precise (mounting brackets which fix the emitter-receiver relationship are available), and the distance of the reflecting surface from the emitter and receiver must be consistently controlled. The size of the angle determines the depth of scanning field. With a narrower angle, there is more depth of field. With a wider angle, there is less depth of field. In a fill level detection application, for example, this means that a wider angle between emitter and receiver allows detection of fill level more precisely.

Specular scan provides a good signal ratio when required to distinguish between shiny and non-shiny (matte) surfaces. When monitoring a non-flat shiny surface with high and/or low points that fall outside the depth of field these points will appear as dark signals to the receiver.

Target reflects beam to photoreceiver



Target interferes with beam



Photoelectric Sensors/Controls

Scanning Techniques

THRU SCAN

In thru (sometimes referred to as direct) scan, the emitter (light source) and receiver (photosensor) are positioned opposite each other, so light from the emitter shines directly on the receiver. The object to be detected passes between the two. If the object is opaque, thru scan will usually yield the highest signal ratio and is a logical first choice.

As long as the target blocks enough light as it interrupts the light beam, it may be skewed or tipped in any manner. As a rule of thumb, object size should be at least the diameter of the receiver lens. When detecting small objects, place an aperture over the receiver lens in order to reduce its diameter. Detecting small objects typically requires thru scan.

Because thru scan does not rely on the reflectiveness of the object to be detected or a permanent reflector for light to reach the receiver, no light is lost at the reflecting surface.

While thru scan provides the longest scanning distance, it has certain limitations. Alignment is critical, and difficult to maintain where vibration is a factor. Also, with separate emitter and receiver, there is additional wiring which may be inconvenient if the application is difficult to reach. This factor also adds to installation time and cost.

FIBER OPTICS

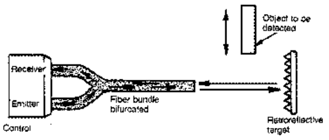
Fiber optics is not a scanning technique, but a method of controlling or transmitting the signal (light beam) from or to the control. Fiber optics use transparent fibers of glass or plastic to conduct and guide light energy. They are used in photoelectric controls as light-pipes.

The control's beam is transmitted through a cable. It returns through a separate cable either combined in the same cable assembly (bifurcated) or within a separate cable assembly (thru scan) to the receiver.

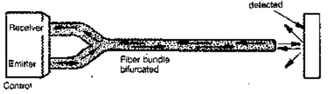
Scanning options depend on the type of cable selected. Retroreflective and diffuse scan use a bifurcated cable and thru scan uses two separate cables (emitter and receiver). Scan distances vary depending on type of scan from 0.4 to 54 inches. An optical lens accessory that attaches to some cable ends significantly increases scan distances.

Combining the optic cables with photoelectric controls has many advantages. Small parts detection and usage in limited mounting space is obvious. High temperature, high vibration or high electrical noise levels at any control can cause false triggering. With fiber optics, the light emitting and receiving components are located remotely at the control's housing and only passive light-transmission fibers need be exposed to the severe environment.

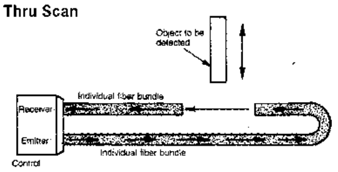
Retroreflective Scan



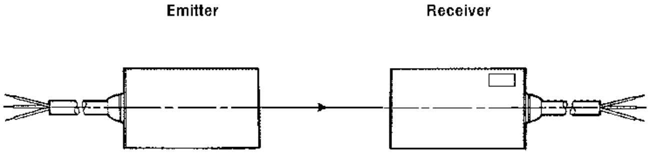
Diffuse (Proximity) Scan



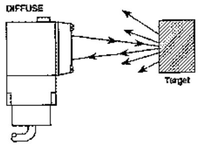
Thru Scan



In thru scan the emitter is aimed directly at the receiver.



Photoelectric Sensors/Controls
Product Selection/Feature Guide

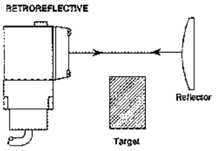


Diffuse
- Light beam is directed at the object to be detected.
- Light will be reflected off the object in many directions.
- Some of the light reflected from the object will be sensed by the receiver.

Advantages
1. No reflector required
2. Convenient for installation
3. One sided scanning
4. Senses clear materials when distance is not fixed
5. Ease of alignment

DIFFUSE

Product Type	Scan Range	Page Number	Input		Output					Logic Capab.	Diagnostic Output	Sealing	
			DC	AC	NPN	PNP	Relay	SS/ac	FET			NEMA	IP
MHP	6 or 18″	C19	●	●	●	●		●			●	4X, 6P	
HDMP/MP	18″, 3′ or 10′	C26	●	●	●	●	●	●	●	●		4X, 6P/4, 13	
FE7A	2.75″	C94	●		●							12	64
FE7B	8″ or 28″	C97	●		●	●						12	64
FE7C	15″ or 39″	C102	●	●	●	●		●			●	12	64
FE7D	2.3′	C110	●	●			●						66
FE8B	12″	C113	●		●	●						4	67
CP18	4, 8 or 16″	C77	●	●	●	●			●			4	67
GP5	3.2′	C17	●	●			●					4	66

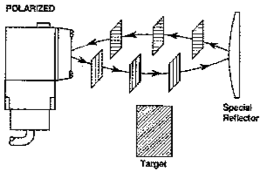


Retroreflective
- Light beam is directed at a reflective target (reflector, tape or other reflective object) — one which returns light along the same path it was sent.
- Target object passes between the sensor and a reflective surface.

Advantages
1. One sided scanning
2. Ease of alignment

RETROREFLECTIVE

Product Type	Scan Range	Page Number	Input		Output					Logic Capab.	Diagnostic Output	Sealing	
			DC	AC	NPN	PNP	Relay	SS/ac	FET			NEMA	IP
MHP	18 or 30′	C19	●	●	●	●		●			●	4X, 6P	
HDMP/MP	30′	C26	●	●	●	●	●	●	●	●		4X, 6P/4, 13	
FE7B	7′	C97	●		●	●						12	64
FE7C	10′	C102	●	●	●	●		●			●	12	64
FE8B	10′	C113	●		●	●						4	67
CP18	13′	C77	●	●	●	●			●			4	67
MLS7A	10′	C156	●		●							4, 9	
MLS8C	40′	C157	●	●			●	●	●	●		4	
GP5	23′	C17	●	●			●					4	66



Polarized
- Will work only with cornercube reflector or special polarized reflective tape.
- Will not false trigger when sensing shiny object.

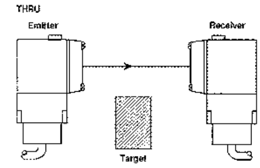
Advantages
1. One sided sensing
2. Does not false trigger off highly reflective objects
3. Senses clear materials
4. Ease of alignment

POLARIZED

Product Type	Scan Range	Page Number	Input		Output					Logic Capab.	Diagnostic Output	Sealing	
			DC	AC	NPN	PNP	Relay	SS/ac	FET			NEMA	IP
MHP	8′	C19	●	●	●	●		●			●	4X, 6P	
HDMP/MP	15′ - 20′	C26	●	●	●	●	●	●	●	●		4X, 6P/4, 13	
FE7B	6.7′	C97	●		●	●						12	64
FE7C	9.8′	C102	●	●	●	●					●	12	64
FE7D	9.8′	C110	●	●			●						66
CP18	4.9′	C82	●		●	●						4	67
GP5	13.1′	C17	●	●			●					4	66
MLS8C-P	15′	C157		●			●			●		4	

Photoelectric Sensors/Controls

Product Selection/Feature Guide



THRU

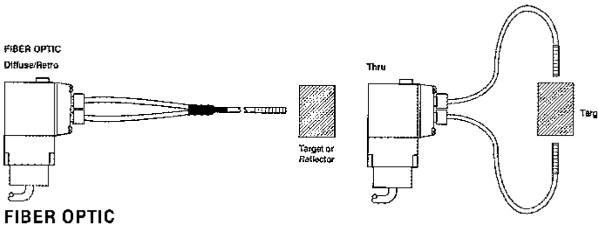
Thru

- Light source (emitter) and receiver are placed opposite each other.
- The object to be detected passes between the two.

Advantages

1. Most reliable when target is opaque
2. Long range scanning, most excess gain
3. Use in high contamination areas, dirt, mist, condensation, oil film, etc.
4. Precise positioning or edge-guiding of opaque material and parts counting.

Product Type	Scan Range	Page Number	Input		Output					Logic Capab.	Diagnostic Output	Sealing	
			DC	AC	NPN	PNP	Relay	SS/ac	FET			NEMA	IP
MHP	100′	C19	●	●	●	●		●			●	4X, 6P	
HDMP/MP	325′/200′	C26	●	●	●	●	●	●	●	●		4X, 6P/4, 13	
FE7A	5′	C94	●		●							12	64
FE7B	6.7′ or 32.8′	C97	●		●	●						12	64
FE7C	16′ or 49′	C102	●	●	●			●			●	12	64
FE7D	33′	C110	●	●			●						66
PJ7	39″	C118	●		●	●							65
FE8B	16′	C113	●		●	●							67
CP18	98′	C82	●	●	●	●			●			4	67
MLS2B	2500′	C156		●			●			●		4	
GP5	49.2′	C17	●	●			●					4	66



FIBER OPTIC

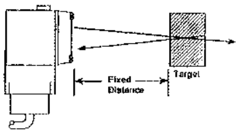
Fiber Optic

- Not a scanning technique but rather another way of transmitting light beam.
- Must use bifurcated cables when using retroreflective and diffuse scans.

Advantages

1. High temperature applications
2. Where space is limited
3. Size and flexibility of fiber leads
4. Corrosive resistance, noise immunity.
5. Color sensing

Product Type	Scan Range	Page Number	Input		Output					Logic Capab.	Diagnostic Output	Sealing	
			DC	AC	NPN	PNP	Relay	SS/ac	FET			NEMA	IP
MHP	D to 2.86″ T to 43.3″	C19	●	●	●	●		●			●	4X, 6P	
HDMP/MP	R to 60″ D to 4″ T to 30″	C26	●	●	●	●	●	●	●	●		4X, 6P/4, 13	
FE7B-F	D 0.4″	C100	●		●	●						12	64
FE7C-F	D to 9″ T to 32″	C108	●	●	●	●		●				12	64
FE5F	D to 3.15″ T to 15.75″	C122	●		●	●				●	●		40
HPX	D to 9″ T to 32″	C7	●		●	●					●		40



CONVERGENT BEAM

Convergent

- Light beam is directed at object to be detected (ignores background).
- Object must be at a given distance in relationship to photoelectric control before light will be reflected to receiver.

Advantages

1. First choice for detecting clear objects
2. Ignores unwanted background surface reflection
3. Detects objects with low reflectivity
4. Detects height differential

Product Type	Scan Range	Page Number	Input		Output					Logic Capab.	Diagnostic Output	Sealing	
			DC	AC	NPN	PNP	Relay	SS/ac	FET			NEMA	IP
MHP	1 or 2.5″	C19	●	●	●	●		●			●	4X, 6P	
HDMP/MP	1.5″ or 4″	C26	●	●	●	●	●	●	●	●		4X, 6P/4, 13	
PJ7	.79-1.6″	C118	●		●	●							65

Application Note: Enclosures are based, in general, on the broad definitions outlined in NEMA standards. Therefore, it will be necessary to ascertain that a particular enclosure is adequate when exposed to the specific conditions that might exist in intended applications. Except as might otherwise be noted, all references to products relative to NEMA enclosure types are based on MICRO SWITCH evaluation only.

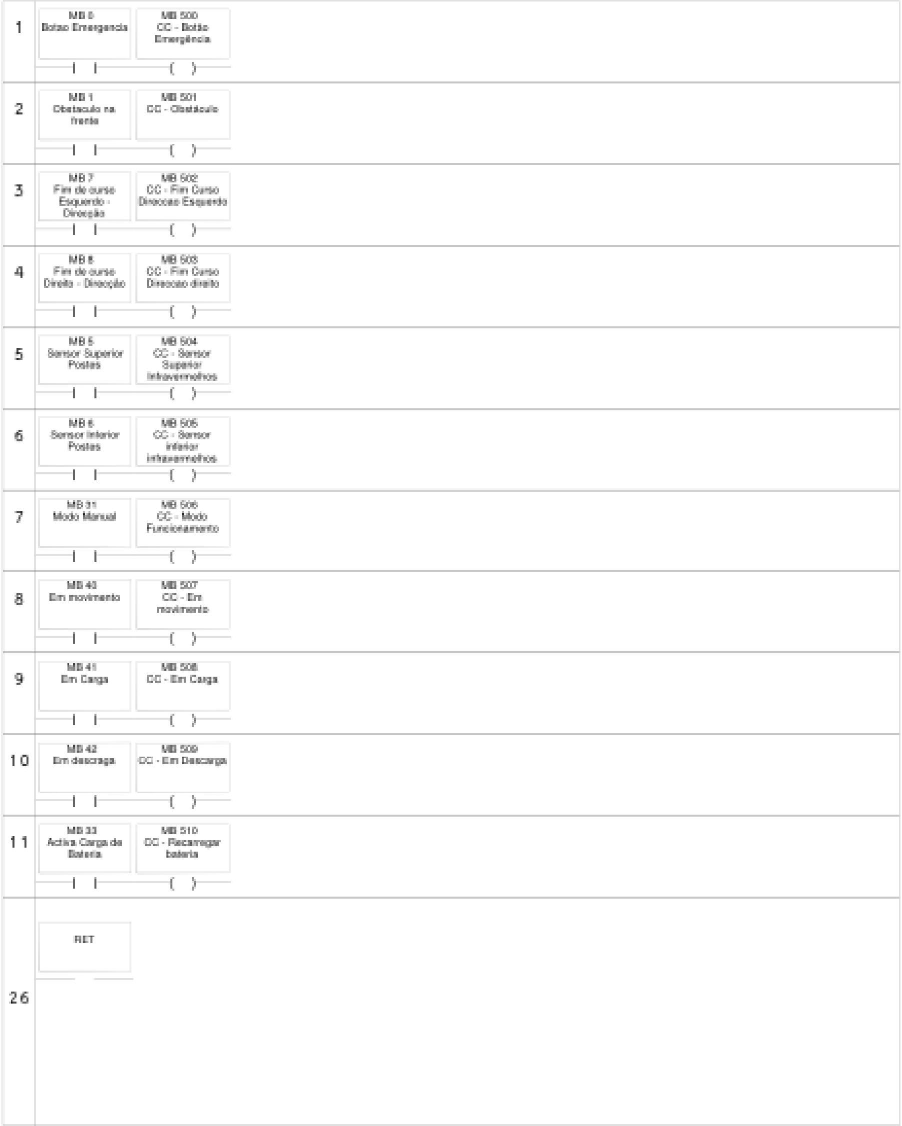
For application/scan/product use see next page.

Anexo I.

Module: ! Main Module
Subroutine: ! Main Routine

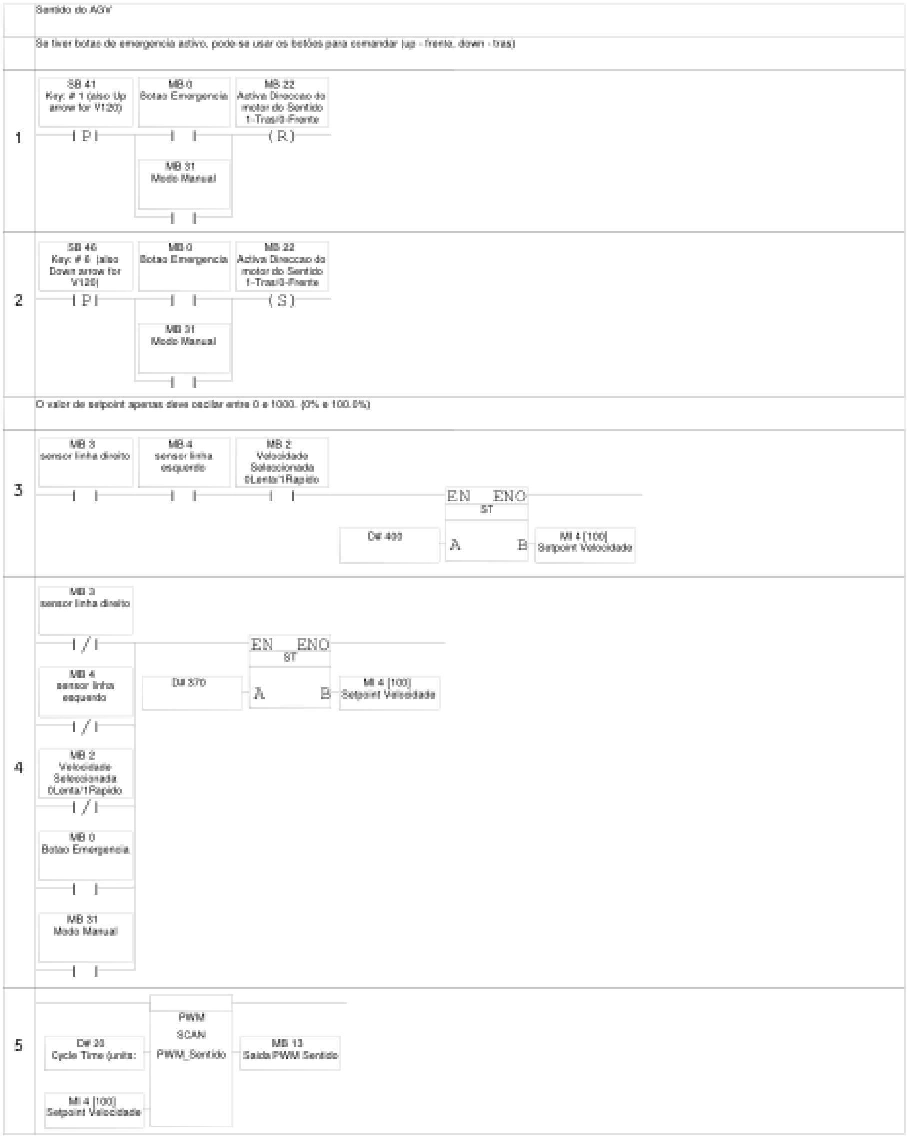
C:\Users\Administrator\Desktop\AGV\Agv_v4.vlp Page 1 of 15 quinta-feira, 22 de Outubro de 2015

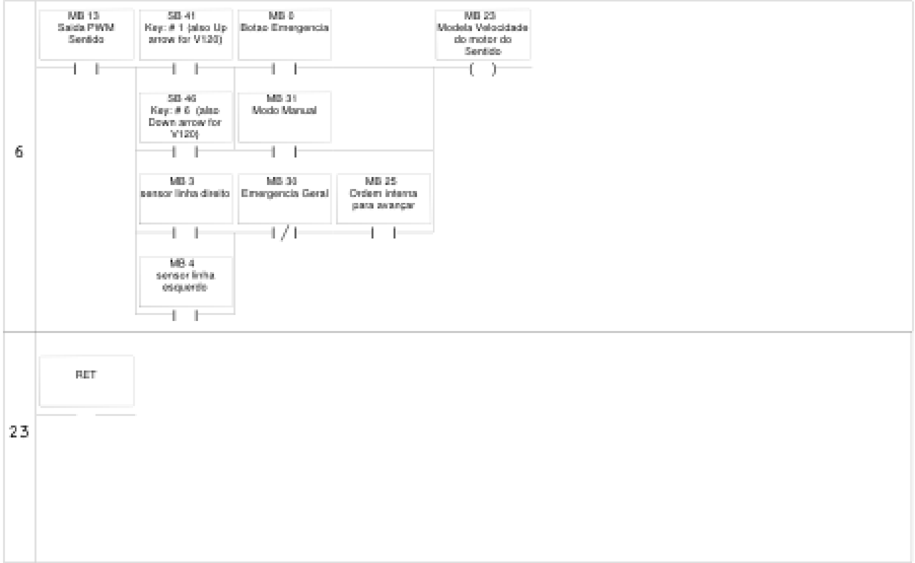
Module: Comunicacoes
Subroutine: BaseDados



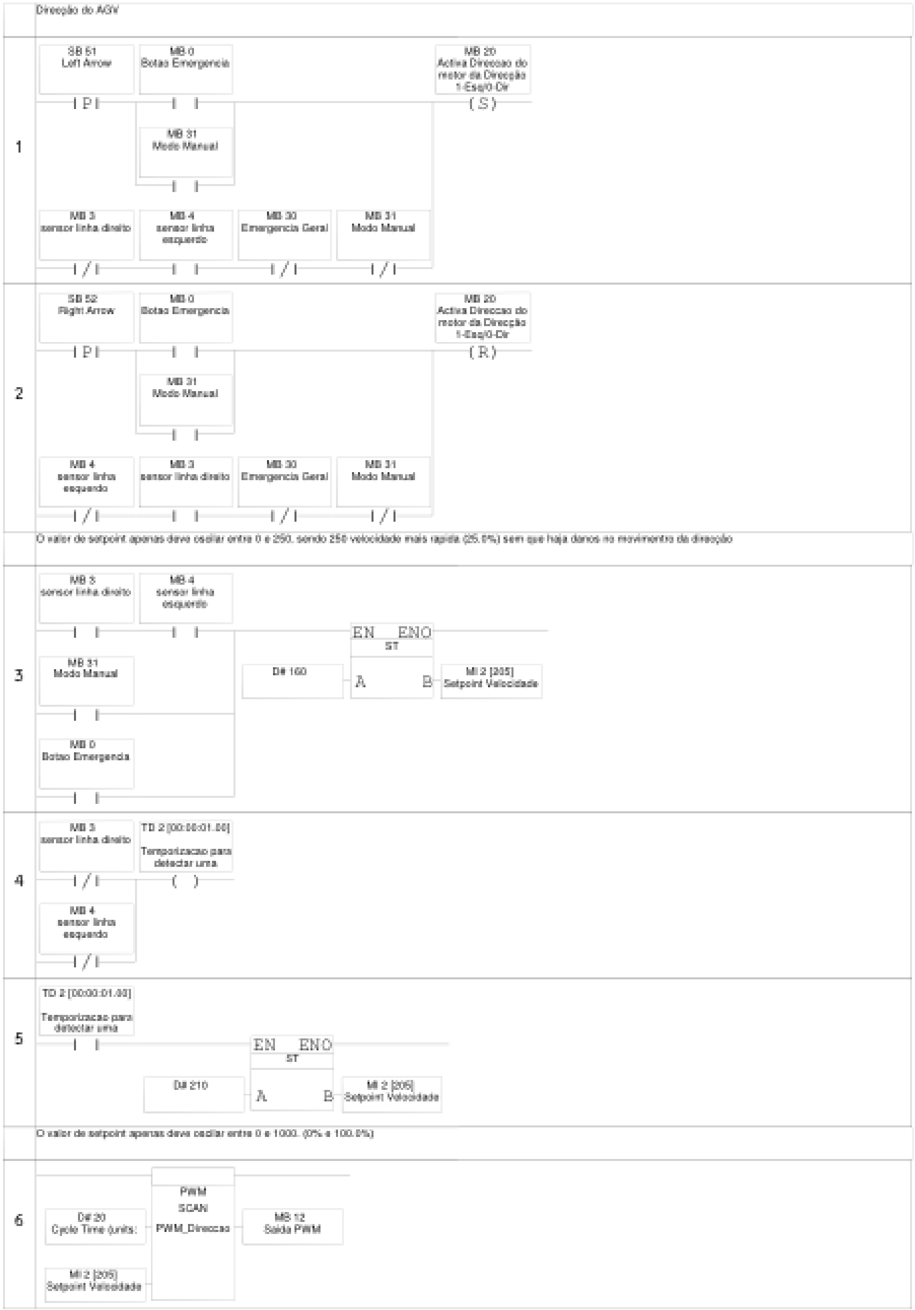
C:\Users\Administrator\Desktop\AGV\Agv_v4.vlp Page 2 of 15 quinta-feira, 22 de Outubro de 2015

Module: Controlo
Subroutine: Sentido




6
MB 13
Saida PWM
Sentido
SB 41
Key: # 1 (also Up arrow for V120)
MB 0
Botao Emergencia
MB 23
Modela Velocidade do motor do Sentido
SB 46
Key: # 6 (also Down arrow for V120)
MB 31
Modo Manual
MB 3
sensor linha direito
MB 30
Emergencia Geral
MB 25
Ordem interna para avançar
MB 4
sensor linha esquerdo
23
RET

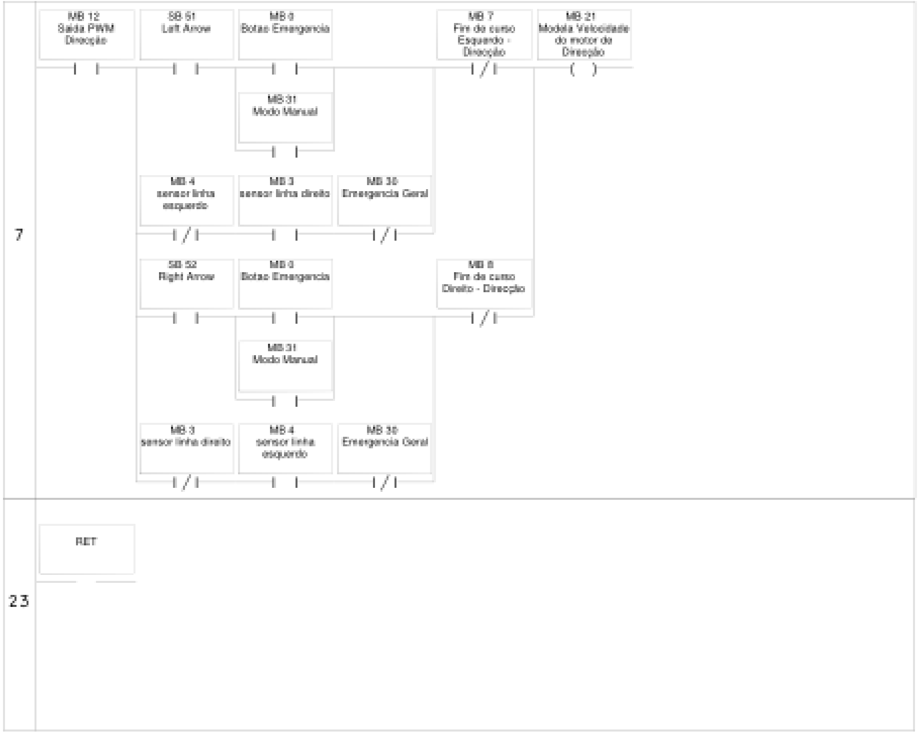
Module: Controlo
Subroutine: Direccao



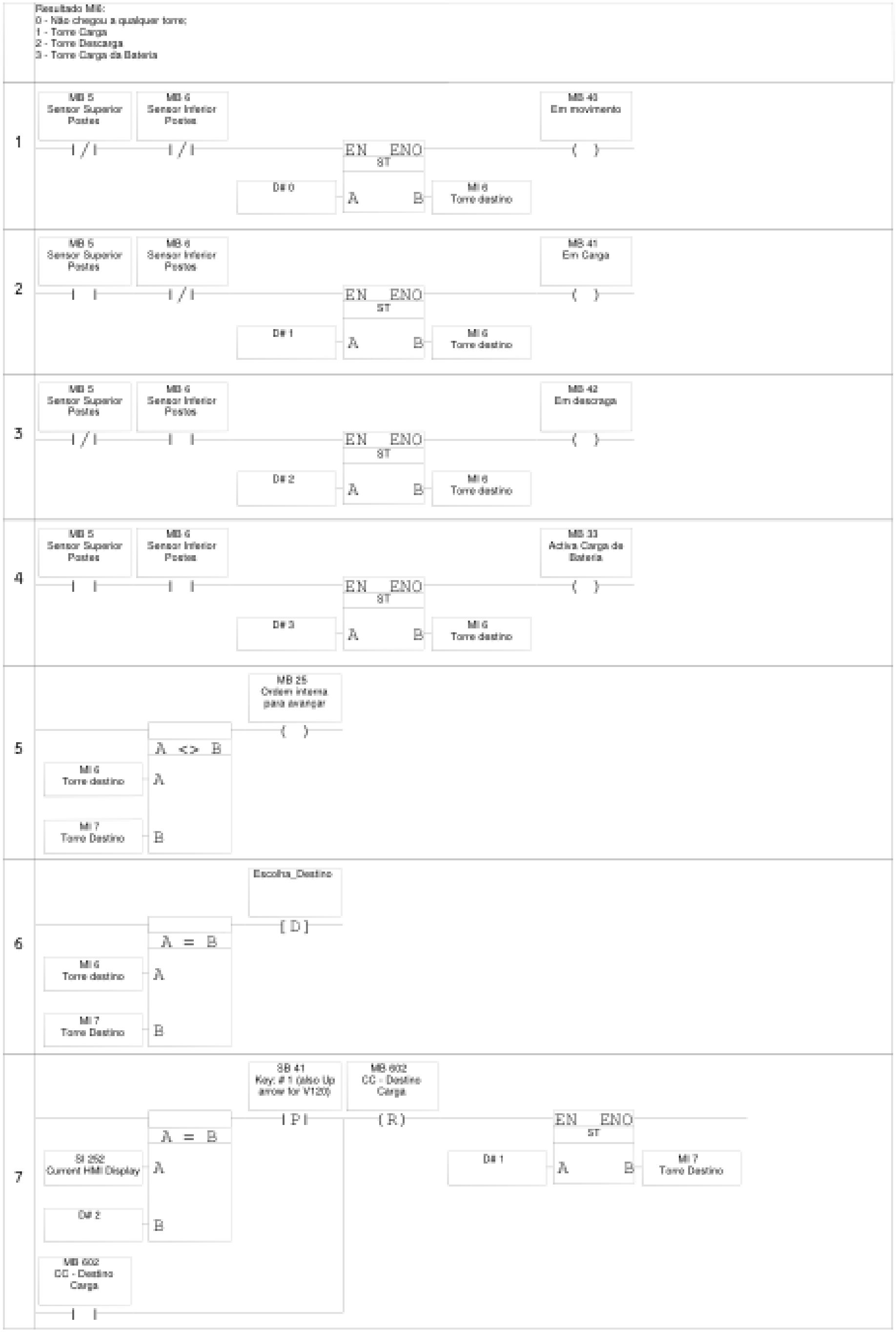
Direção do AGV

O valor de setpoint apenas deve oscilar entre 0 e 250. sendo 250 velocidade mais rapida (25.0%) sem que haja danos no movimentro da direcção

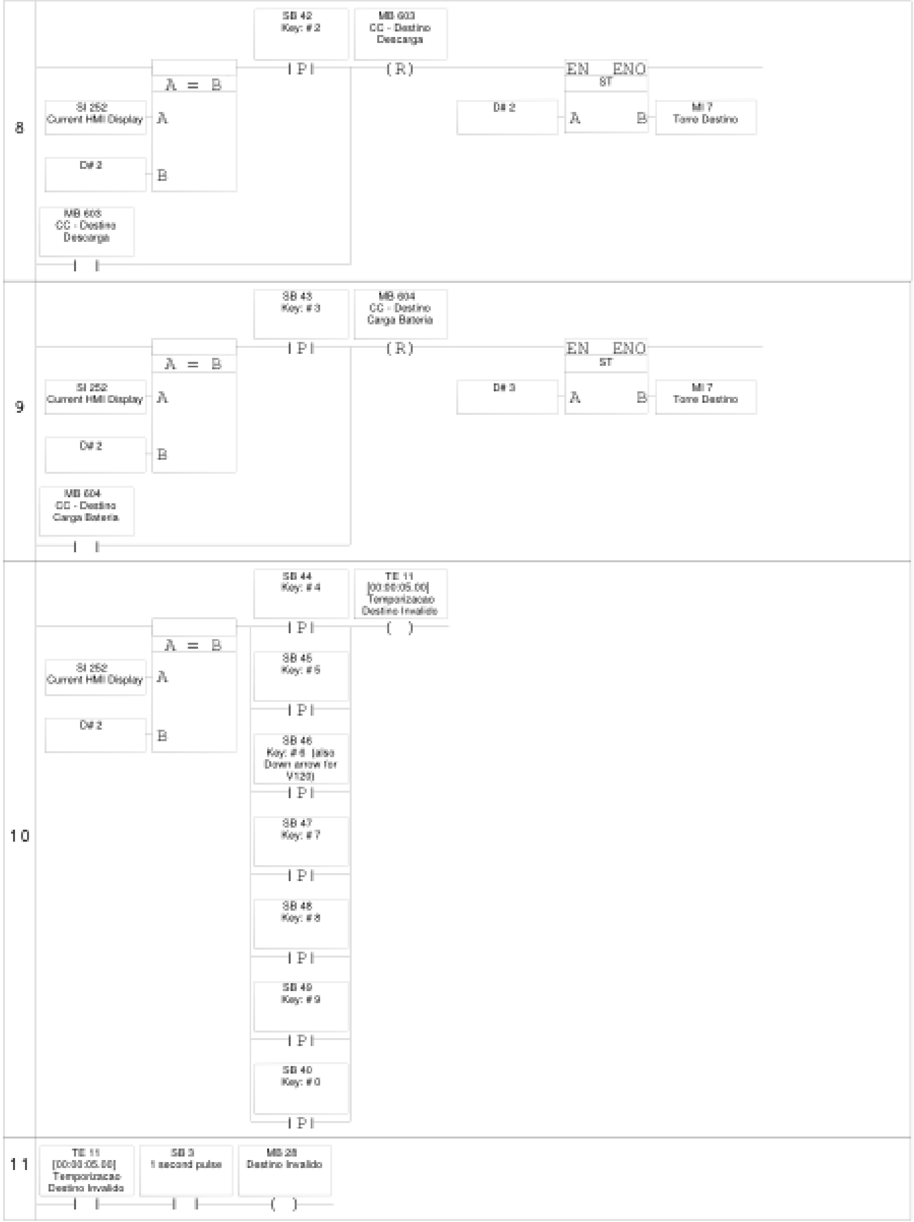
O valor de setpoint apenas deve oscilar entre 0 e 1000. (0% e 100.0%)

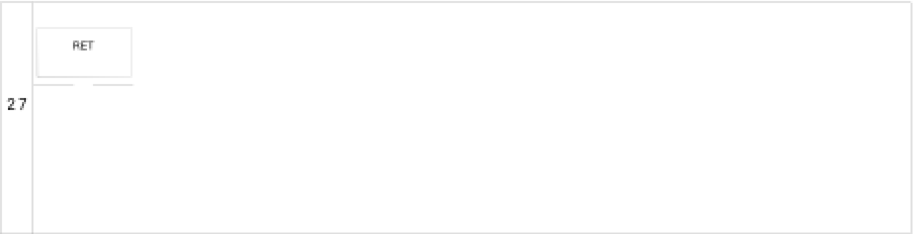

7
MB 12
Saida PWM
Direcção
SB 51
Left Arrow
MB 0
Botao Emergencia
MB 7
Fim de curso
Esquerdo -
Direcção
MB 21
Modela Velocidade
do motor de
Direcção
MB 31
Modo Manual
MB 4
sensor linha
esquerdo
MB 3
sensor linha direito
MB 30
Emergencia Geral
SB 52
Right Arrow
MB 0
Botao Emergencia
MB 8
Fim de curso
Direito - Direcção
MB 31
Modo Manual
MB 3
sensor linha direito
MB 4
sensor linha
esquerdo
MB 30
Emergencia Geral
23
RET

Module: Controlo
Subroutine: Destino

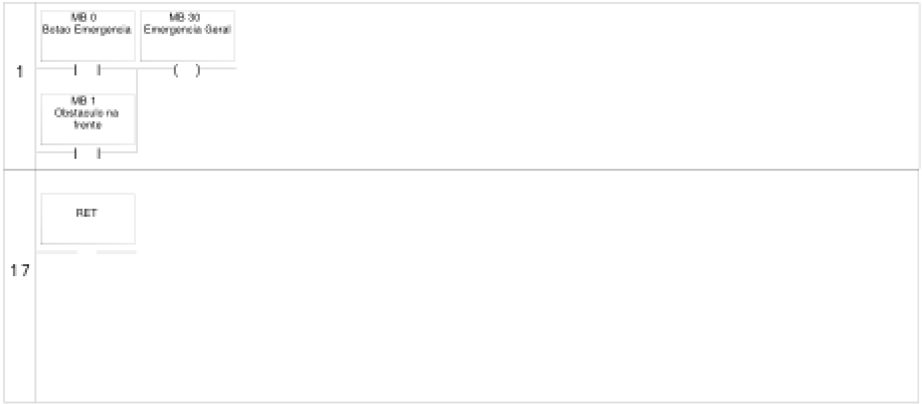


Resultado MI6:
0 - Não chegou a qualquer torre;
1 - Torre Carga
2 - Torre Descarga
3 - Torre Carga da Bateria

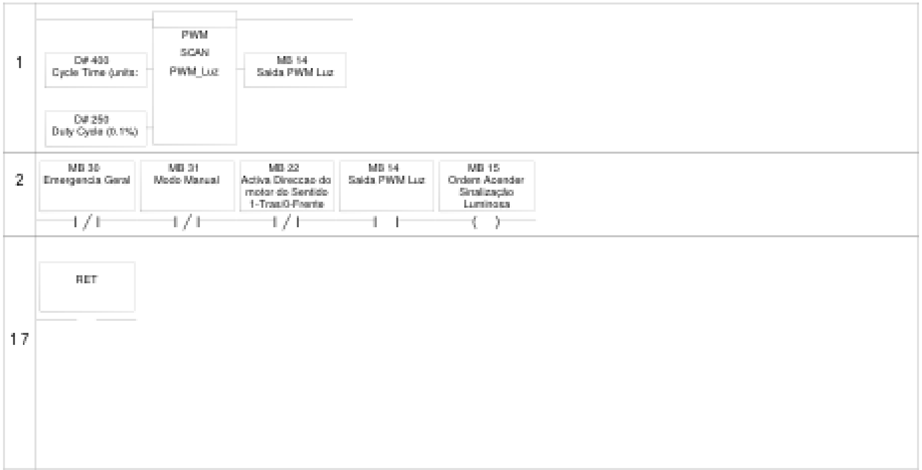
8
SB 42
Key: # 2
MB 603
CC - Destino
Descarga
| P |
(R)
EN
ENO
ST
A = B
SI 252
Current HMI Display
A
D# 2
B
D# 2
A
B
MI 7
Torre Destino
MB 603
CC - Destino
Descarga
9
SB 43
Key: # 3
MB 604
CC - Destino
Carga Bateria
| P |
(R)
EN
ENO
ST
A = B
SI 252
Current HMI Display
A
D# 2
B
D# 3
A
B
MI 7
Torre Destino
MB 604
CC - Destino
Carga Bateria
10
SB 44
Key: # 4
TE 11
[00:00:05.00]
Temporizacao
Destino Invalido
| P |
( )
A = B
SI 252
Current HMI Display
A
D# 2
B
SB 45
Key: # 5
| P |
SB 46
Key: # 6 (also
Down arrow for
V120)
| P |
SB 47
Key: # 7
| P |
SB 48
Key: # 8
| P |
SB 49
Key: # 9
| P |
SB 40
Key: # 0
| P |
11
TE 11
[00:00:05.00]
Temporizacao
Destino Invalido
SB 3
1 second pulse
MB 28
Destino Invalido
( )


RET
27

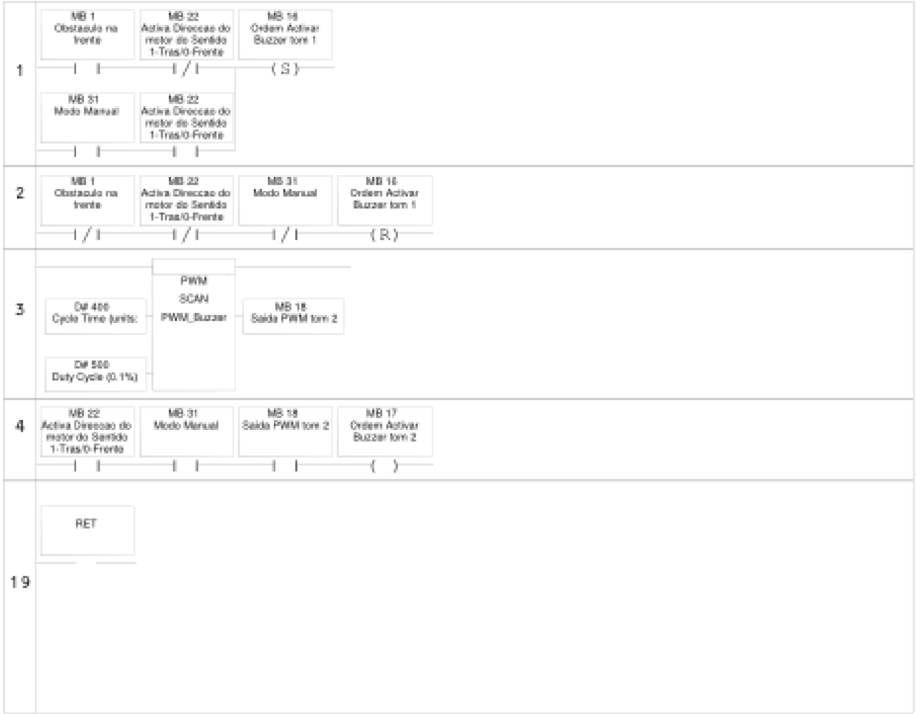
Module: Controlo
Subroutine: Emergencias



Module: Controlo
Subroutine: Luz

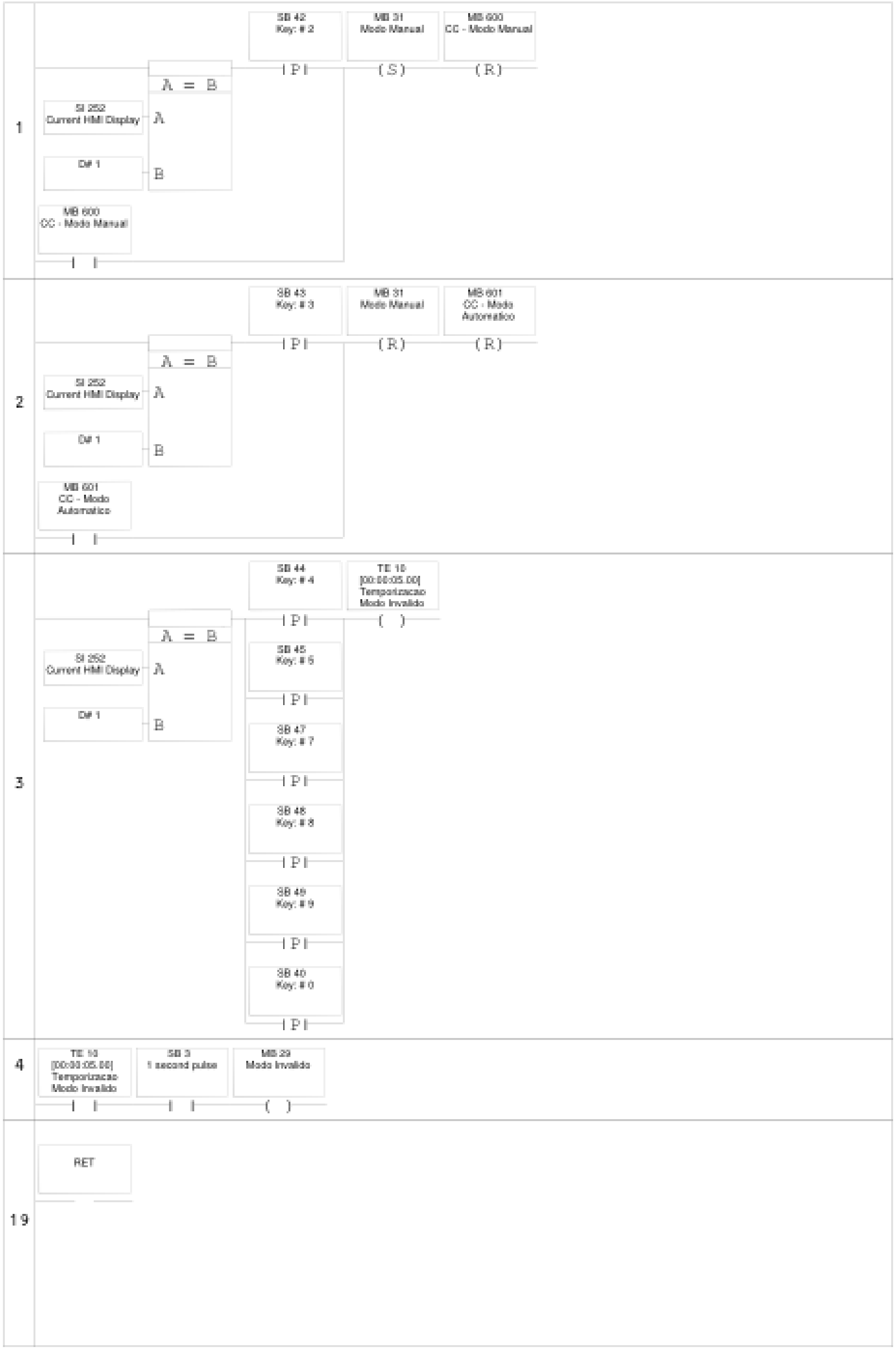


Module: Controlo
Subroutine: Buzzer



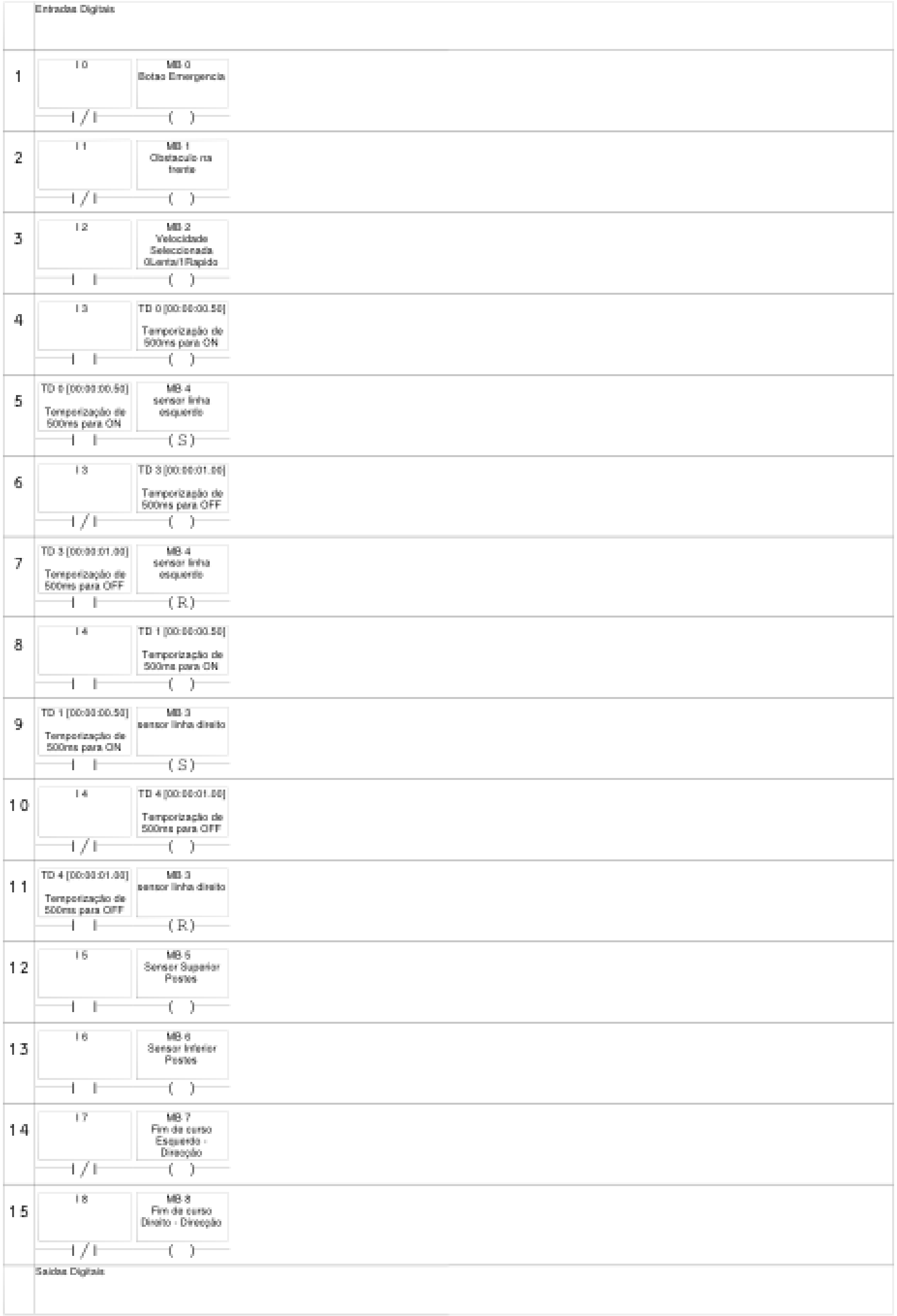
C:\Users\Administrator\Desktop\AGV\Agv_v4.vlp Page 12 of 15 quinta-feira,
22 de Outubro de 2015

Module: Controlo
Subroutine: Modo



C:\Users\Administrator\Desktop\AGV\Agv_v4.vlp Page 13 of 15 quinta-feira, 22 de Outubro de 2015

Module: IO
Subroutine: Interface

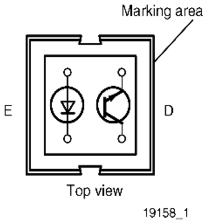


C:\Users\Administrator\Desktop\AGV\Agv_v4.vlp Page 14 of 15 quinta-feira, 22 de Outubro de 2015

C:\Users\Administrator\Desktop\AGV\Agv_v4.vlp Page 15 of 15 quinta-feira, 22 de Outubro de 2015

Anexo J.

Reflective Optical Sensor with Transistor Output



DESCRIPTION

The CNY70 is a reflective sensor that includes an infrared emitter and phototransistor in a leaded package which blocks visible light.

FEATURES

- Package type: leaded
- Detector type: phototransistor
- Dimensions (L x W x H in mm): 7 x 7 x 6
- Peak operating distance: < 0.5 mm
- Operating range within > 20 % relative collector current: 0 mm to 5 mm
- Typical output current under test: I_C = 1 mA
- Emitter wavelength: 950 nm
- Daylight blocking filter
- Lead (Pb)-free soldering released
- Material categorization: For definitions of compliance please see www.vishay.com/doc?99912

APPLICATIONS

- Optoelectronic scanning and switching devices i.e., index sensing, coded disk scanning etc. (optoelectronic encoder assemblies).

PRODUCT SUMMARY				
PART NUMBER	DISTANCE FOR MAXIMUM CTR_{rel} (1) (mm)	DISTANCE RANGE FOR RELATIVE I_{out} > 20 % (mm)	TYPICAL OUTPUT CURRENT UNDER TEST (2) (mA)	DAYLIGHT BLOCKING FILTER INTEGRATED
CNY70	0	0 to 5	1	Yes

Notes

(1) CTR: current transfere ratio, I_{out}/I_{in}

(2) Conditions like in table basic charactristics/sensors

ORDERING INFORMATION			
ORDERING CODE	PACKAGING	VOLUME (1)	REMARKS
CNY70	Tube	MOQ: 4000 pcs, 80 pcs/tube	-

Note

(1) MOQ: minimum order quantity

ABSOLUTE MAXIMUM RATINGS (T_{amb} = 25 °C, unless otherwise specified)				
PARAMETER	TEST CONDITION	SYMBOL	VALUE	UNIT
COUPLER				
Total power dissipation	$T_{amb} \leq 25$ °C	P_{tot}	200	mW
Ambient temperature range		T_{amb}	- 40 to + 85	°C
Storage temperature range		T_{stg}	- 40 to + 100	°C
Soldering temperature	Distance to case 2 mm, t £ 5 s	T_{sd}	260	°C
INPUT (EMITTER)				
Reverse voltage		V_R	5	V
Forward current		I_F	50	mA
Forward surge current	$t_p \leq 10$ μs	I_{FSM}	3	A
Power dissipation	$T_{amb} \leq 25$ °C	P_V	100	mW
Junction temperature		T_j	100	°C

ABSOLUTE MAXIMUM RATINGS (T_{amb} = 25 °C, unless otherwise specified)

PARAMETER	TEST CONDITION	SYMBOL	VALUE	UNIT
OUTPUT (DETECTOR)				
Collector emitter voltage		V_{CEO}	32	V
Emitter collector voltage		V_{ECO}	7	V
Collector current		I_C	50	mA
Power dissipation	$T_{amb} \leq 25$ °C	P_V	100	mW
Junction temperature		T_j	100	°C

ABSOLUTE MAXIMUM RATINGS

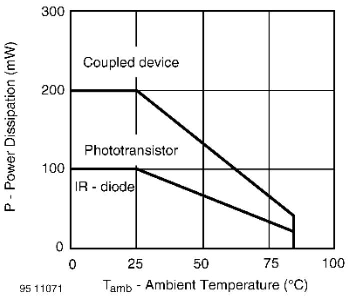


Fig. 1 - Power Dissipation vs. Ambient Temperature

BASIC CHARACTERISTICS (T_{amb} = 25 °C, unless otherwise specified)

PARAMETER	TEST CONDITION	SYMBOL	MIN.	TYP.	MAX.	UNIT
COUPLER						
Collector current	V_{CE} = 5 V, I_F = 20 mA, d = 0.3 mm (figure 1)	I_C (2)	0.3	1.0		mA
Cross talk current	V_{CE} = 5 V, I_F = 20 mA, (figure 2)	I_{CX} (3)			600	nA
Collector emitter saturation voltage	I_F = 20 mA, I_C = 0.1 mA, d = 0.3 mm (figure 1)	V_{CEsat} (2)			0.3	V
INPUT (EMITTER)						
Forward voltage	I_F = 50 mA	V_F		1.25	1.6	V
Radiant intensity	I_F = 50 mA, t_p = 20 ms	I_e			7.5	mW/sr
Peak wavelength	I_F = 100 mA	λ_P	940			nm
Virtual source diameter	Method: 63 % encircled energy	d		1.2		mm
OUTPUT (DETECTOR)						
Collector emitter voltage	I_C = 1 mA	V_{CEO}	32			V
Emitter collector voltage	I_E = 100 µA	V_{ECO}	5			V
Collector dark current	V_{CE} = 20 V, I_F = 0 A, E = 0 lx	I_{CEO}			200	nA

Notes

(1) Measured with the "Kodak neutral test card", white side with 90 % diffuse reflectance

(2) Measured without reflecting medium

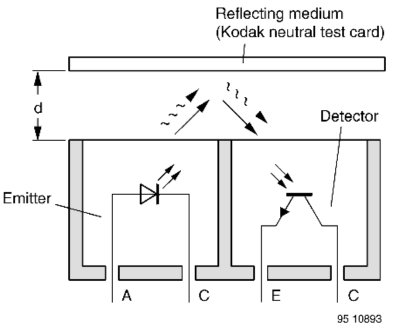


Fig. 2 - Test Condition

BASIC CHARACTERISTICS (T_{amb} = 25 °C, unless otherwise specified)

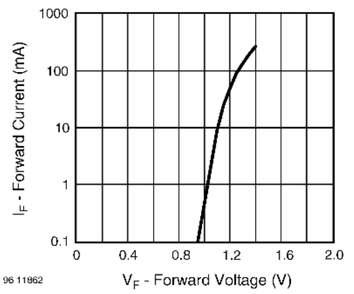


Fig. 3 - Forward Current vs. Forward Voltage

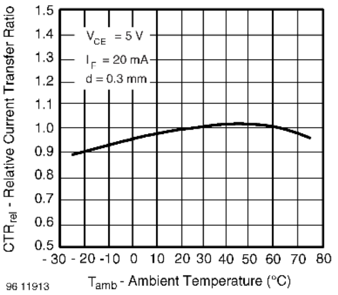


Fig. 4 - Relative Current Transfer Ratio vs. Ambient Temperature

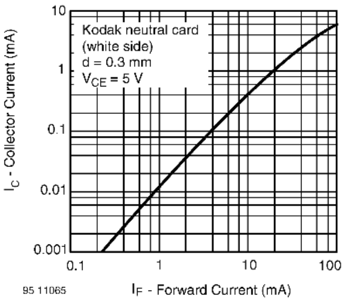


Fig. 5 - Collector Current vs. Forward Current

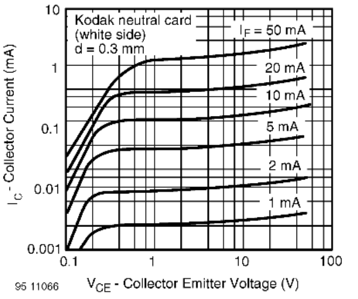


Fig. 6 - Collector Current vs. Collector Emitter Voltage

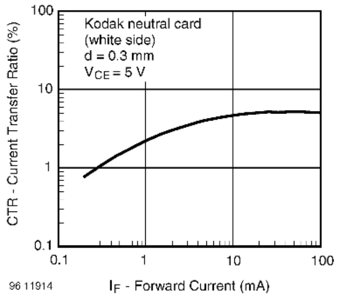


Fig. 7 - Current Transfer Ratio vs. Forward Current

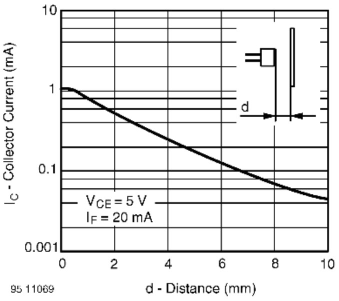


Fig. 9 - Collector Current vs. Distance

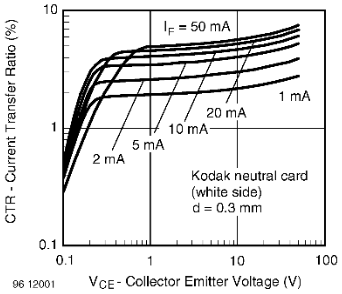


Fig. 8 - Current Transfer Ratio vs. Collector Emitter Voltage

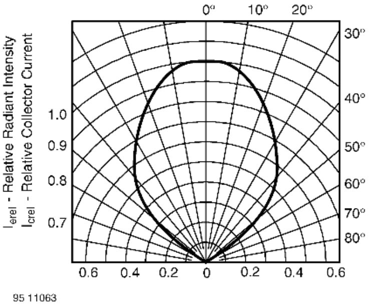


Fig. 10 - Relative Radiant Intensity/Collector Current vs. Angular Displacement

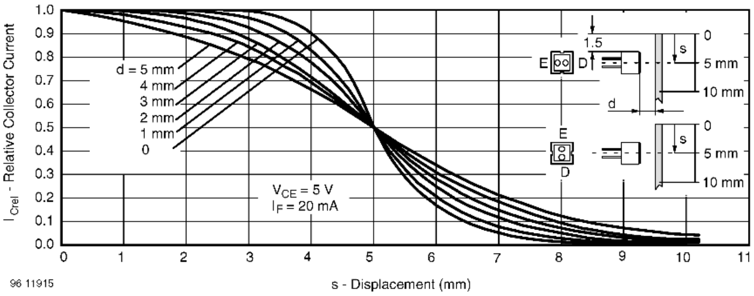
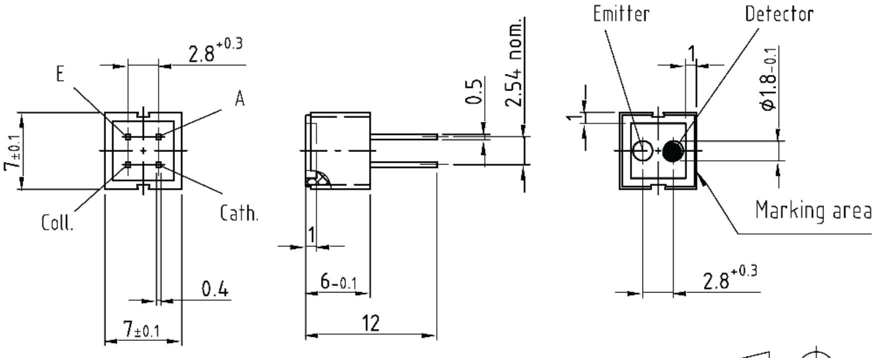


Fig. 11 - Relative Collector Current vs. Displacement

PACKAGE DIMENSIONS in millimeters

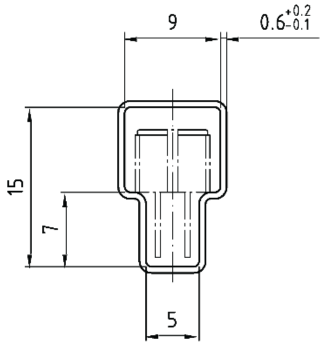


weight: ca. 0.70g

technical drawings
according to DIN
specifications

Drawing-No.: 6.544-5062.01-4
Issue: 6; 03.05.06
95 11345

TUBE DIMENSIONS in millimeters



With rubber stopper
Tolerance: ±0.5mm
Length: 575±1mm

Drawing-No.: 9.700-5097.01-4
Issue: 1; 25.02.00
20291

Packaging and Ordering Information

PART NUMBER	MOQ (1)	PCS PER TUBE	TUBE SPEC. (FIGURE)	CONSTITUENTS (FORMS)
CNY70	4000	80	1	28
TCPT1300X01	2000	Reel	(2)	29
TCRT1000	1000	Bulk	-	26
TCRT1010	1000	Bulk	-	26
TCRT5000	4500	50	2	27
TCRT5000L	2400	48	3	27
TCST1030	5200	65	5	24
TCST1030L	2600	65	6	24
TCST1103	1020	85	4	24
TCST1202	1020	85	4	24
TCST1230	4800	60	7	24
TCST1300	1020	85	4	24
TCST2103	1020	85	4	24
TCST2202	1020	85	4	24
TCST2300	1020	85	4	24
TCST5250	4860	30	8	24
TCUT1300X01	2000	Reel	(2)	29
TCZT8020-PAER	2500	Bulk	-	22

Notes

(1) MOQ: minimum order quantity

(2) Please refer to datasheets

TUBE SPECIFICATION FIGURES

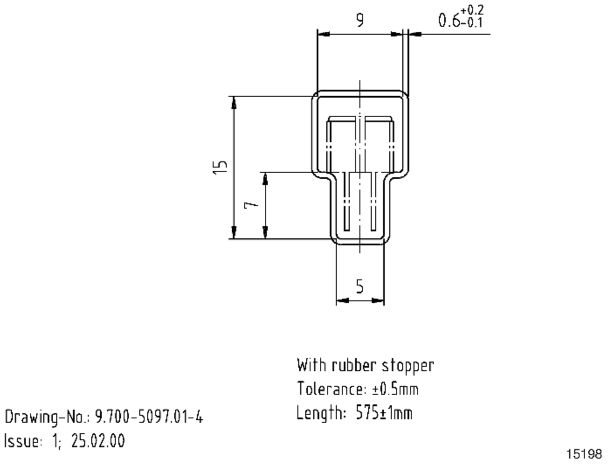


Fig. 1

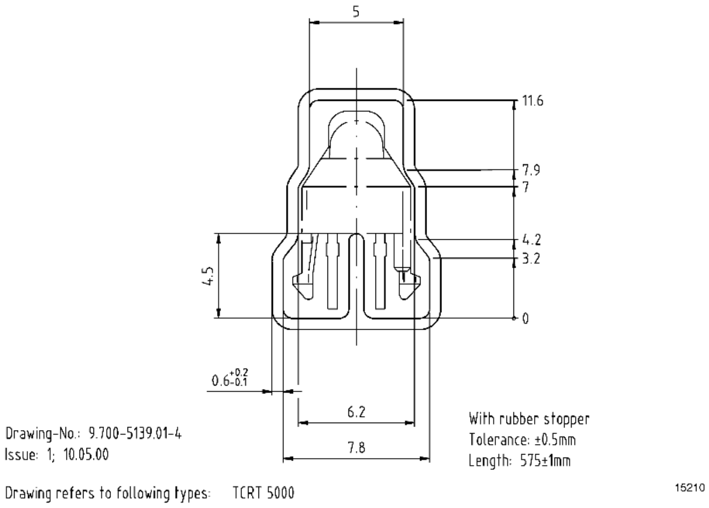

5
11.6
7.9
7
4.2
3.2
0
4.5
0.6+0.2 -0.1
6.2
7.8
Drawing-No.: 9.700-5139.01-4
Issue: 1; 10.05.00
With rubber stopper
Tolerance: ±0.5mm
Length: 575±1mm
Drawing refers to following types: TCRT 5000
15210

Fig. 2

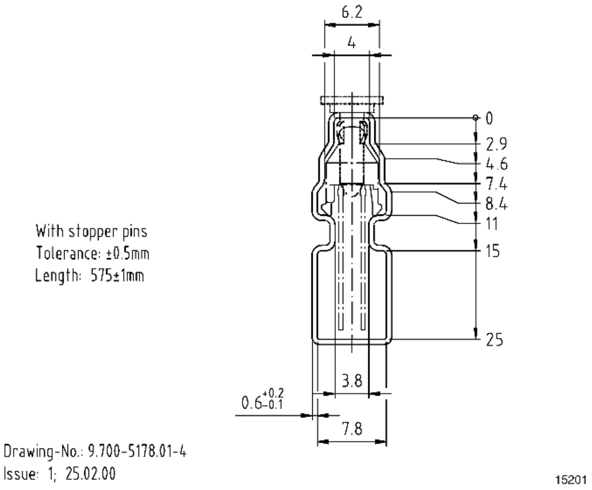

6.2
4
0
2.9
4.6
7.4
8.4
11
15
25
With stopper pins
Tolerance: ±0.5mm
Length: 575±1mm
3.8
0.6+0.2 -0.1
7.8
Drawing-No.: 9.700-5178.01-4
Issue: 1; 25.02.00
15201

Fig. 3

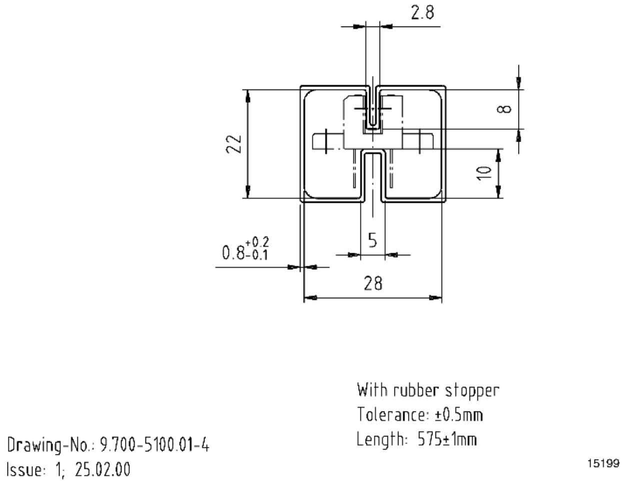

2.8
8
22
10
0.8+0.2-0.1
5
28
With rubber stopper
Tolerance: ±0.5mm
Length: 575±1mm
Drawing-No.: 9.700-5100.01-4
Issue: 1; 25.02.00
15199

Fig. 4

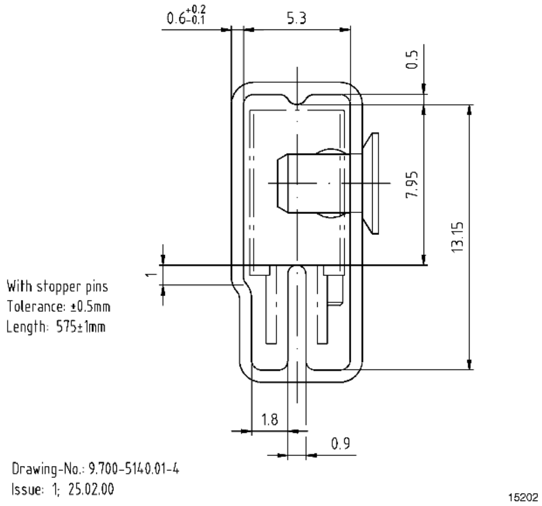

0.6+0.2-0.1
5.3
0.5
7.95
13.15
1
With stopper pins
Tolerance: ±0.5mm
Length: 575±1mm
1.8
0.9
Drawing-No.: 9.700-5140.01-4
Issue: 1; 25.02.00
15202

Fig. 5

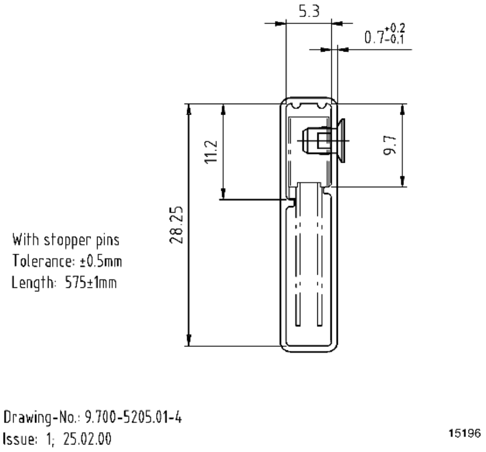

5.3
0.7+0.2 -0.1
11.2
9.7
28.25
With stopper pins
Tolerance: ±0.5mm
Length: 575±1mm
Drawing-No.: 9.700-5205.01-4
Issue: 1; 25.02.00
15196

Fig. 6

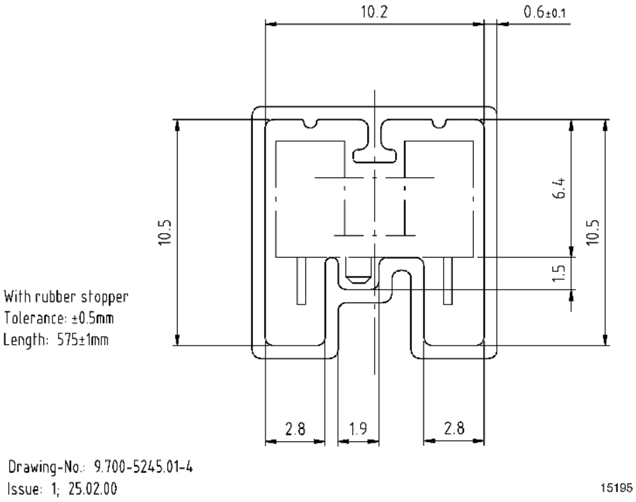

10.2
0.6±0.1
10.5
6.4
10.5
1.5
With rubber stopper
Tolerance: ±0.5mm
Length: 575±1mm
2.8
1.9
2.8
Drawing-No.: 9.700-5245.01-4
Issue: 1; 25.02.00
15195

Fig. 7

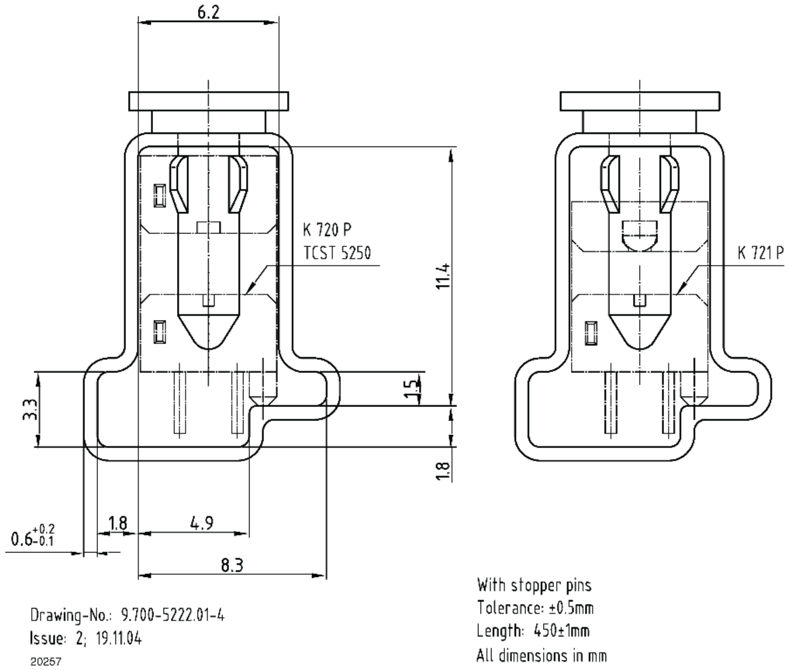

6.2
K 720 P
TCST 5250
K 721 P
11.4
1.5
3.3
1.8
$0.6^{+0.2}_{-0.1}$
1.8
4.9
8.3
Drawing-No.: 9.700-5222.01-4
Issue: 2; 19.11.04
20257
With stopper pins
Tolerance: ±0.5mm
Length: 450±1mm
All dimensions in mm

Fig. 8

Disclaimer

ALL PRODUCT, PRODUCT SPECIFICATIONS AND DATA ARE SUBJECT TO CHANGE WITHOUT NOTICE TO IMPROVE RELIABILITY, FUNCTION OR DESIGN OR OTHERWISE.

Vishay Intertechnology, Inc., its affiliates, agents, and employees, and all persons acting on its or their behalf (collectively, "Vishay"), disclaim any and all liability for any errors, inaccuracies or incompleteness contained in any datasheet or in any other disclosure relating to any product.

Vishay makes no warranty, representation or guarantee regarding the suitability of the products for any particular purpose or the continuing production of any product. To the maximum extent permitted by applicable law, Vishay disclaims (i) any and all liability arising out of the application or use of any product, (ii) any and all liability, including without limitation special, consequential or incidental damages, and (iii) any and all implied warranties, including warranties of fitness for particular purpose, non-infringement and merchantability.

Statements regarding the suitability of products for certain types of applications are based on Vishay's knowledge of typical requirements that are often placed on Vishay products in generic applications. Such statements are not binding statements about the suitability of products for a particular application. It is the customer's responsibility to validate that a particular product with the properties described in the product specification is suitable for use in a particular application. Parameters provided in datasheets and/or specifications may vary in different applications and performance may vary over time. All operating parameters, including typical parameters, must be validated for each customer application by the customer's technical experts. Product specifications do not expand or otherwise modify Vishay's terms and conditions of purchase, including but not limited to the warranty expressed therein.

Except as expressly indicated in writing, Vishay products are not designed for use in medical, life-saving, or life-sustaining applications or for any other application in which the failure of the Vishay product could result in personal injury or death. Customers using or selling Vishay products not expressly indicated for use in such applications do so at their own risk. Please contact authorized Vishay personnel to obtain written terms and conditions regarding products designed for such applications.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document or by any conduct of Vishay. Product names and markings noted herein may be trademarks of their respective owners.

Material Category Policy

Vishay Intertechnology, Inc. hereby certifies that all its products that are identified as RoHS-Compliant fulfill the definitions and restrictions defined under Directive 2011/65/EU of The European Parliament and of the Council of June 8, 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (EEE) - recast, unless otherwise specified as non-compliant.

Please note that some Vishay documentation may still make reference to RoHS Directive 2002/95/EC. We confirm that all the products identified as being compliant to Directive 2002/95/EC conform to Directive 2011/65/EU.

Vishay Intertechnology, Inc. hereby certifies that all its products that are identified as Halogen-Free follow Halogen-Free requirements as per JEDEC JS709A standards. Please note that some Vishay documentation may still make reference to the IEC 61249-2-21 definition. We confirm that all the products identified as being compliant to IEC 61249-2-21 conform to JEDEC JS709A standards.

Anexo K.

74HC14; 74HCT14

Hex inverting Schmitt trigger

Rev. 6 — 19 September 2012 **Product data sheet**

1. General description

The 74HC14; 74HCT14 is a high-speed Si-gate CMOS device and is pin compatible with Low-power Schottky TTL (LSTTL). It is specified in compliance with JEDEC standard No. 7A.

The 74HC14; 74HCT14 provides six inverting buffers with Schmitt-trigger action. It is capable of transforming slowly changing input signals into sharply defined, jitter-free output signals.

2. Features and benefits

- Low-power dissipation
- ESD protection:
  - HBM JESD22-A114F exceeds 2000 V
  - MM JESD22-A115-A exceeds 200 V
- Multiple package options
- Specified from −40 °C to +85 °C and from −40 °C to +125 °C

3. Applications

- Wave and pulse shapers
- Astable multivibrators
- Monostable multivibrators

4. Ordering information

Table 1. Ordering information

Type number	Package			
	Temperature range	Name	Description	Version
74HC14N 74HCT14N	–40 °C to +125 °C	DIP14	plastic dual in-line package; 14 leads (300 mil)	SOT27-1
74HC14D 74HCT14D	–40 °C to +125 °C	SO14	plastic small outline package; 14 leads; body width 3.9 mm	SOT108-1
74HC14DB 74HCT14DB	–40 °C to +125 °C	SSOP14	plastic shrink small outline package; 14 leads; body width 5.3 mm	SOT337-1
74HC14PW 74HCT14PW	–40 °C to +125 °C	TSSOP14	plastic thin shrink small outline package; 14 leads; body width 4.4 mm	SOT402-1
74HC14BQ 74HCT14BQ	–40 °C to +125 °C	DHVQFN14	plastic dual in-line compatible thermal enhanced very thin quad flat package; no leads; 14 terminals; body 2.5 × 3 × 0.85 mm	SOT762-1

5. Functional diagram

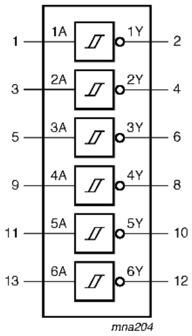


Fig 1. Logic symbol

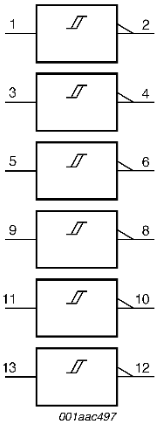


Fig 2. IEC logic symbol

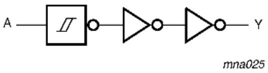


Fig 3. Logic diagram (one Schmitt trigger)

6. Pinning information

6.1 Pinning

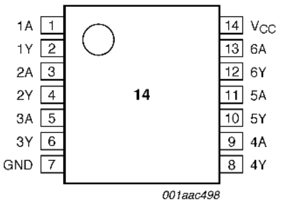
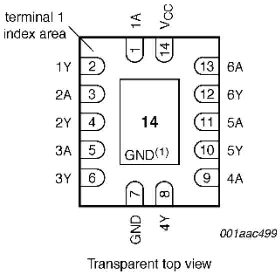


Fig 4. Pin configuration DIP14, SO14 and (T)SSOP14



(1) The die substrate is attached to this pad using conductive die attach material. It cannot be used as a supply pin or input.

Fig 5. Pin configuration DHVQFN14

6.2 Pin description

Table 2. Pin description

Symbol	Pin	Description
1A to 6A	1, 3, 5, 9, 11, 13	data input 1
1Y to 6Y	2, 4, 6, 8, 10, 12	data output 1
GND	7	ground (0 V)
V_{CC}	14	supply voltage

7. Functional description

Table 3. Function table[1]

Input	Output
nA	nY
L	H
H	L

[1] H = HIGH voltage level;
L = LOW voltage level.

8. Limiting values

Table 4. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134). Voltages are referenced to GND (ground = 0 V).

Symbol	Parameter	Conditions		Min	Max	Unit
V_{CC}	supply voltage			-0.5	+7	V
I_{IK}	input clamping current	$V_I < -0.5$ V or $V_I > V_{CC} + 0.5$ V	[1]	-	±20	mA
I_{OK}	output clamping current	$V_O < -0.5$ V or $V_O > V_{CC} + 0.5$ V	[1]	-	±20	mA
I_O	output current	-0.5 V < V_O < V_{CC} + 0.5 V		-	±25	mA
I_{CC}	supply current			-	50	mA
I_{GND}	ground current			-50	-	mA
T_{stg}	storage temperature			-65	+150	°C
P_{tot}	total power dissipation		[2]			
	DIP14 package			-	750	mW
	SO14, (T)SSOP14 and DHVQFN14 packages			-	500	mW

[1] The input and output voltage ratings may be exceeded if the input and output current ratings are observed.

[2] For DIP14 package: P_{tot} derates linearly with 12 mW/K above 70 °C.
For SO14 package: P_{tot} derates linearly with 8 mW/K above 70 °C.
For (T)SSOP14 packages: P_{tot} derates linearly with 5.5 mW/K above 60 °C.
For DHVQFN14 packages: P_{tot} derates linearly with 4.5 mW/K above 60 °C.

9. Recommended operating conditions

Table 5. Recommended operating conditions

Voltages are referenced to GND (ground = 0 V)

Symbol	Parameter	Conditions	74HC14			74HCT14			Unit
			Min	Typ	Max	Min	Typ	Max	
V_{CC}	supply voltage		2.0	5.0	6.0	4.5	5.0	5.5	V
V_I	input voltage		0	-	V_{CC}	0	-	V_{CC}	V
V_O	output voltage		0	-	V_{CC}	0	-	V_{CC}	V
T_{amb}	ambient temperature		-40	+25	+125	-40	+25	+125	°C

10. Static characteristics

Table 6. Static characteristics

At recommended operating conditions; voltages are referenced to GND (ground = 0 V).

Symbol	Parameter	Conditions	T_{amb} = 25 °C			T_{amb} = −40 °C to +85 °C		T_{amb} = −40 °C to +125 °C		Unit
			Min	Typ	Max	Min	Max	Min	Max	
74HC14										
V_{OH}	HIGH-level output voltage	$V_I = V_{T+}$ or V_{T-}								
		I_O = −20 μA; V_{CC} = 2.0 V	1.9	2.0	-	1.9	-	1.9	-	V
		I_O = −20 μA; V_{CC} = 4.5 V	4.4	4.5	-	4.4	-	4.4	-	V
		I_O = −20 μA; V_{CC} = 6.0 V	5.9	6.0	-	5.9	-	5.9	-	V
		I_O = −4.0 mA; V_{CC} = 4.5 V	3.98	4.32	-	3.84	-	3.7	-	V
		I_O = −5.2 mA; V_{CC} = 6.0 V	5.48	5.81	-	5.34	-	5.2	-	V
V_{OL}	LOW-level output voltage	$V_I = V_{T+}$ or V_{T-}								
		I_O = 20 μA; V_{CC} = 2.0 V	-	0	0.1	-	0.1	-	0.1	V
		I_O = 20 μA; V_{CC} = 4.5 V	-	0	0.1	-	0.1	-	0.1	V
		I_O = 20 μA; V_{CC} = 6.0 V	-	0	0.1	-	0.1	-	0.1	V
		I_O = 4.0 mA; V_{CC} = 4.5 V	-	0.15	0.26	-	0.33	-	0.4	V
		I_O = 5.2 mA; V_{CC} = 6.0 V	-	0.16	0.26	-	0.33	-	0.4	V
I_I	input leakage current	$V_I = V_{CC}$ or GND; V_{CC} = 6.0 V	-	-	±0.1	-	±1.0	-	±1.0	μA
I_{CC}	supply current	$V_I = V_{CC}$ or GND; I_O = 0 A; V_{CC} = 6.0 V	-	-	2.0	-	20	-	40	μA
C_I	input capacitance		-	3.5	-	-	-	-	-	pF
74HCT14										
V_{OH}	HIGH-level output voltage	$V_I = V_{T+}$ or V_{T-}; V_{CC} = 4.5 V								
		I_O = −20 μA	4.4	4.5	-	4.4	-	4.4	-	V
		I_O = −4.0 mA	3.98	4.32	-	3.84	-	3.7	-	V
V_{OL}	LOW-level output voltage	$V_I = V_{T+}$ or V_{T-}; V_{CC} = 4.5 V								
		I_O = 20 μA;	-	0	0.1	-	0.1	-	0.1	V
		I_O = 4.0 mA;	-	0.15	0.26	-	0.33	-	0.4	V
I_I	input leakage current	$V_I = V_{CC}$ or GND; V_{CC} = 5.5 V	-	-	±0.1	-	±1.0	-	±1.0	μA
I_{CC}	supply current	$V_I = V_{CC}$ or GND; I_O = 0 A; V_{CC} = 5.5 V	-	-	2.0	-	20	-	40	μA
ΔI_{CC}	additional supply current	per input pin; $V_I = V_{CC} - 2.1$ V; other pins at V_{CC} or GND; I_O = 0 A; V_{CC} = 4.5 V to 5.5 V	-	30	108	-	135	-	147	μA
C_I	input capacitance		-	3.5	-	-	-	-	-	pF

11. Dynamic characteristics

Table 7. Dynamic characteristics

GND = 0 V; C_L = 50 pF; for test circuit see Figure 7.

Symbol	Parameter	Conditions	T_{amb} = 25 °C			T_{amb} = −40 °C to +125 °C		Unit
			Min	Typ	Max	Max (85 °C)	Max (125 °C)	
74HC14								
t_{pd}	propagation delay	nA to nY; see Figure 6 [1]						
		V_{CC} = 2.0 V	-	41	125	155	190	ns
		V_{CC} = 4.5 V	-	15	25	31	38	ns
		V_{CC} = 5.0 V; C_L = 15 pF	-	12	-	-	-	ns
		V_{CC} = 6.0 V	-	12	21	26	32	ns
t_t	transition time	see Figure 6 [2]						
		V_{CC} = 2.0 V	-	19	75	95	110	ns
		V_{CC} = 4.5 V	-	7	15	19	22	ns
		V_{CC} = 6.0 V	-	6	13	15	19	ns
C_{PD}	power dissipation capacitance	per package; V_I = GND to V_{CC} [3]	-	7	-	-	-	pF
74HCT14								
t_{pd}	propagation delay	nA to nY; see Figure 6 [1]						
		V_{CC} = 4.5 V	-	20	34	43	51	ns
		V_{CC} = 5.0 V; C_L = 15 pF	-	17	-	-	-	ns
t_t	transition time	V_{CC} = 4.5 V; see Figure 6 [2]	-	7	15	19	22	ns
C_{PD}	power dissipation capacitance	per package; V_I = GND to V_{CC} − 1.5 V [3]	-	8	-	-	-	pF

[1] t_{pd} is the same as t_{PHL} and t_{PLH}.

[2] t_t is the same as t_{THL} and t_{TLH}.

[3] C_{PD} is used to determine the dynamic power dissipation (P_D in μW):

$P_D = C_{PD} \times V_{CC}^2 \times f_i \times N + \sum (C_L \times V_{CC}^2 \times f_o)$ where:

f_i = input frequency in MHz;

f_o = output frequency in MHz;

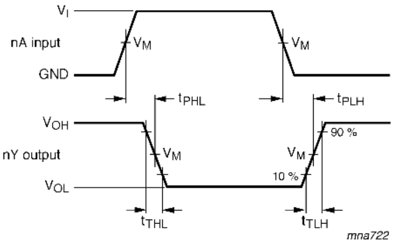
C_L = output load capacitance in pF;

V_{CC} = supply voltage in V;

N = number of inputs switching;

$\sum (C_L \times V_{CC}^2 \times f_o)$ = sum of outputs.

12. Waveforms



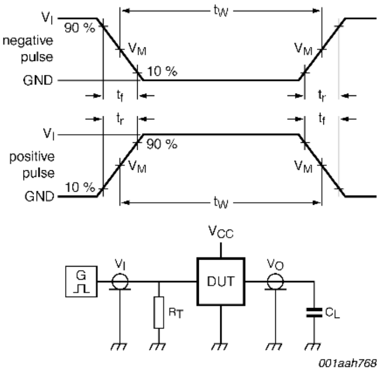
Measurement points are given in Table 8.

V_{OL} and V_{OH} are typical voltage output levels that occur with the output load.

Fig 6. Input to output propagation delays

Table 8. Measurement points

Type	Input	Output		
	V_M	**V_M**	**V_X**	**V_Y**
74HC14	$0.5V_{CC}$	$0.5V_{CC}$	$0.1V_{CC}$	$0.9V_{CC}$
74HCT14	1.3 V	1.3 V	$0.1V_{CC}$	$0.9V_{CC}$



Test data is given in Table 9.

Definitions test circuit:

R_T = termination resistance should be equal to output impedance Z_o of the pulse generator.

C_L = load capacitance including jig and probe capacitance.

Fig 7. Load circuitry for measuring switching times

Table 9. Test data

Type	Input		Load	Test
	V_I	t_r, t_f	C_L	
74HC14	V_{CC}	6.0 ns	15 pF, 50 pF	t_{PLH}, t_{PHL}
74HCT14	3.0 V	6.0 ns	15 pF, 50 pF	t_{PLH}, t_{PHL}

13. Transfer characteristics

Table 10. Transfer characteristics

At recommended operating conditions; voltages are referenced to GND (ground = 0 V); see Figure 8 and Figure 9.

Symbol	Parameter	Conditions	T_{amb} = 25 °C			T_{amb} = −40 °C to +85 °C		T_{amb} = −40 °C to +125 °C		Unit
			Min	Typ	Max	Min	Max	Min	Max	
74HC14										
V_{T+}	positive-going threshold voltage	V_{CC} = 2.0 V	0.7	1.18	1.5	0.7	1.5	0.7	1.5	V
		V_{CC} = 4.5 V	1.7	2.38	3.15	1.7	3.15	1.7	3.15	V
		V_{CC} = 6.0 V	2.1	3.14	4.2	2.1	4.2	2.1	4.2	V
V_{T-}	negative-going threshold voltage	V_{CC} = 2.0 V	0.3	0.52	0.9	0.3	0.9	0.3	0.9	V
		V_{CC} = 4.5 V	0.9	1.4	2.0	0.9	2.0	0.9	2.0	V
		V_{CC} = 6.0 V	1.2	1.89	2.6	1.2	2.6	1.2	2.6	V
V_H	hysteresis voltage	V_{CC} = 2.0 V	0.2	0.66	1.0	0.2	1.0	0.2	1.0	V
		V_{CC} = 4.5 V	0.4	0.98	1.4	0.4	1.4	0.4	1.4	V
		V_{CC} = 6.0 V	0.6	1.25	1.6	0.6	1.6	0.6	1.6	V
74HCT14										
V_{T+}	positive-going threshold voltage	V_{CC} = 4.5 V	1.2	1.41	1.9	1.2	1.9	1.2	1.9	V
		V_{CC} = 5.5 V	1.4	1.59	2.1	1.4	2.1	1.4	2.1	V
V_{T-}	negative-going threshold voltage	V_{CC} = 4.5 V	0.5	0.85	1.2	0.5	1.2	0.5	1.2	V
		V_{CC} = 5.5 V	0.6	0.99	1.4	0.6	1.4	0.6	1.4	V
V_H	hysteresis voltage	V_{CC} = 4.5 V	0.4	0.56	-	0.4	-	0.4	-	V
		V_{CC} = 5.5 V	0.4	0.6	-	0.4	-	0.4	-	V

14. Transfer characteristics waveforms

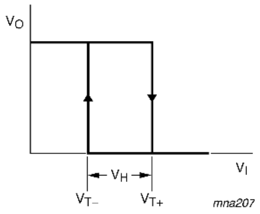


Fig 8. Transfer characteristics

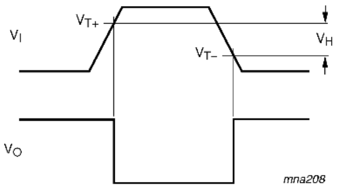
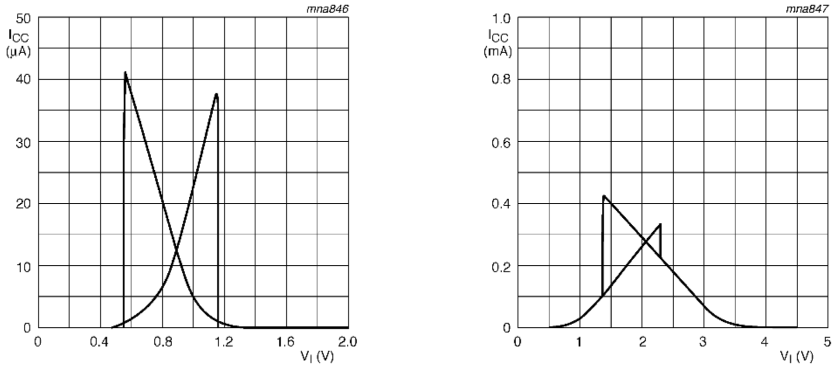
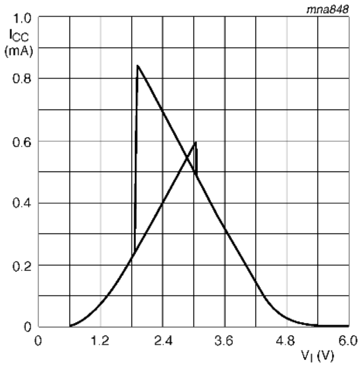


Fig 9. Transfer characteristics definitions



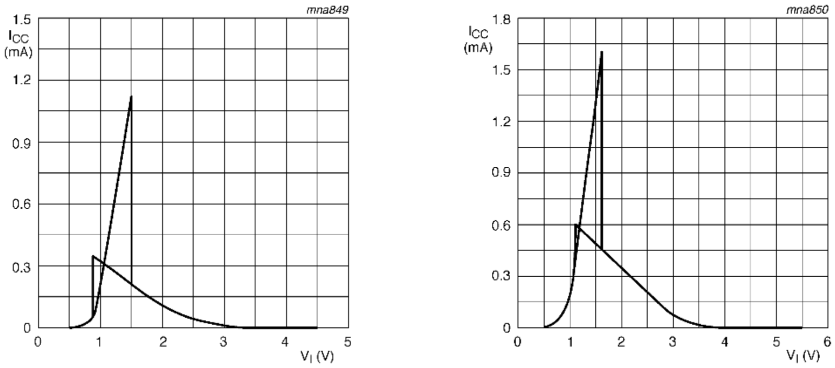
a. V_{CC} = 2.0 V

b. V_{CC} = 4.5 V



c. V_{CC} = 6.0 V

Fig 10. Typical 74HC transfer characteristics



a. V_{CC} = 4.5 V

b. V_{CC} = 5.5 V

Fig 11. Typical 74HCT transfer characteristics

15. Application information

The slow input rise and fall times cause additional power dissipation, this can be calculated using the following formula:

$P_{add} = f_i \times (t_r \times \Delta I_{CC(AV)} + t_f \times \Delta I_{CC(AV)}) \times V_{CC}$ where:

P_{add} = additional power dissipation (μW);

f_i = input frequency (MHz);

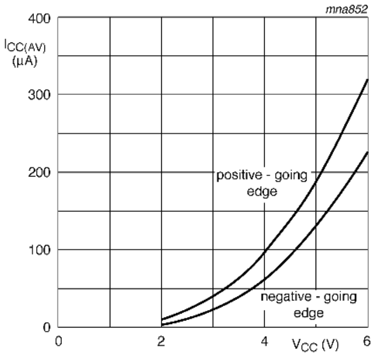
t_r = rise time (ns); 10 % to 90 %;

t_f = fall time (ns); 90 % to 10 %;

$\Delta I_{CC(AV)}$ = average additional supply current (μA).

Average $\Delta I_{CC(AV)}$ differs with positive or negative input transitions, as shown in Figure 12 and Figure 13.

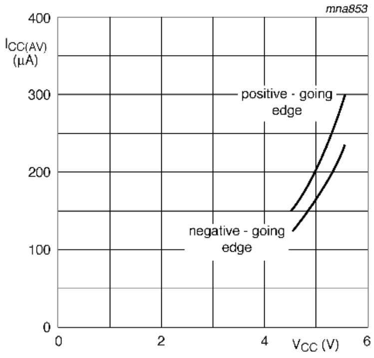
An example of a relaxation circuit using the 74HC14; 74HCT14 is shown in Figure 14.



(1) Positive-going edge.

(2) Negative-going edge.

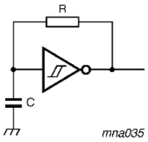
Fig 12. Average additional supply current as a function of V_{CC} for 74HC14; linear change of V_I between $0.1V_{CC}$ to $0.9V_{CC}$.



(1) Positive-going edge.

(2) Negative-going edge.

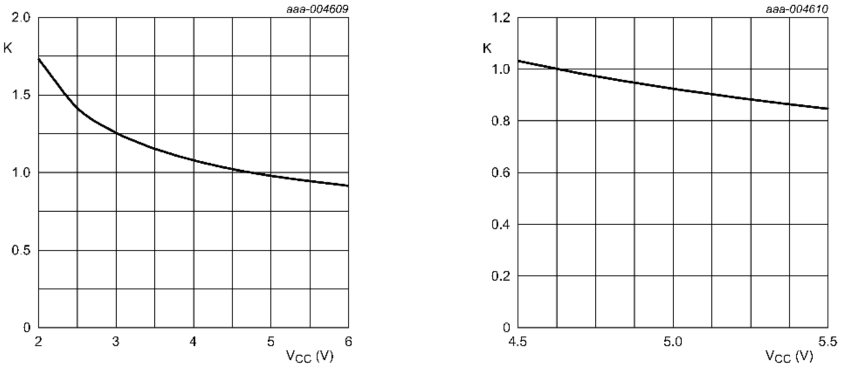
Fig 13. Average additional supply current as a function of V_{CC} for 74HCT14; linear change of V_I between $0.1V_{CC}$ to $0.9V_{CC}$.



For 74HC14 and 74HCT14: $f = \frac{1}{T} \approx \frac{1}{K \times RC}$

For K-factor see Figure 15

Fig 14. Relaxation oscillator



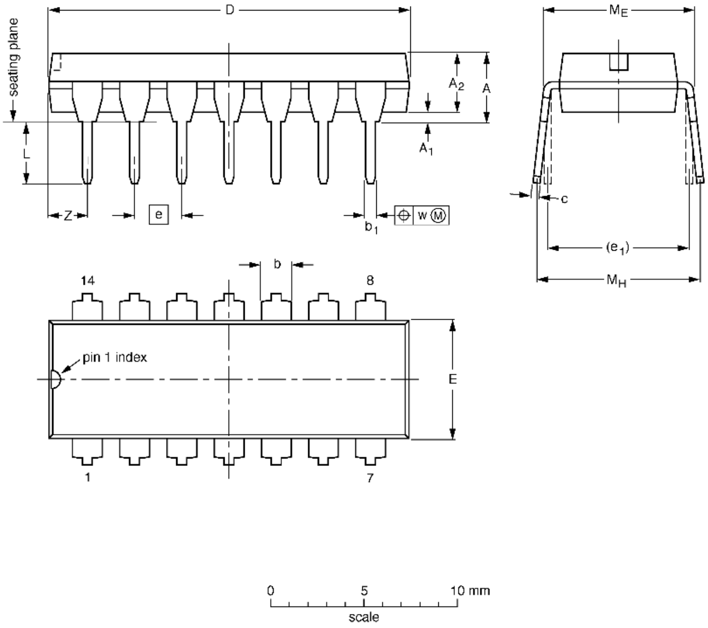
K-factor for 74HC14

K-factor for 74HCT14

Fig 15. Typical K-factor for relaxation oscillator

16. Package outline

DIP14: plastic dual in-line package; 14 leads (300 mil) **SOT27-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A_1 min.	A_2 max.	b	b_1	c	D$^{(1)}$	E$^{(1)}$	e	e_1	L	M_E	M_H	w	Z$^{(1)}$ max.
mm	4.2	0.51	3.2	1.73 1.13	0.53 0.38	0.36 0.23	19.50 18.55	6.48 6.20	2.54	7.62	3.60 3.05	8.25 7.80	10.0 8.3	0.254	2.2
inches	0.17	0.02	0.13	0.068 0.044	0.021 0.015	0.014 0.009	0.77 0.73	0.26 0.24	0.1	0.3	0.14 0.12	0.32 0.31	0.39 0.33	0.01	0.087

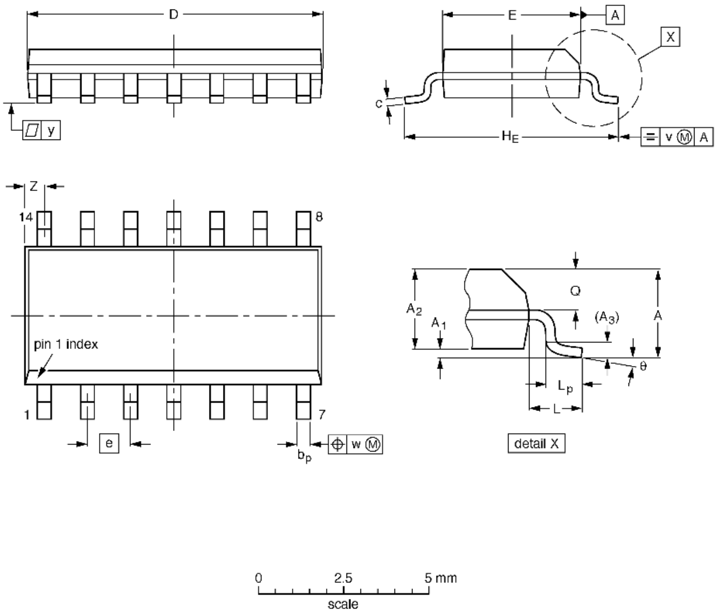
Note

1. Plastic or metal protrusions of 0.25 mm (0.01 inch) maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT27-1	050G04	MO-001	SC-501-14			~~99-12-27~~ 03-02-13

Fig 16. Package outline SOT27-1 (DIP14)

SO14: plastic small outline package; 14 leads; body width 3.9 mm **SOT108-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	$D^{(1)}$	$E^{(1)}$	e	H_E	L	L_p	Q	v	w	y	$Z^{(1)}$	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	8.75 8.55	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8° 0°
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.35 0.34	0.16 0.15	0.05	0.244 0.228	0.041	0.039 0.016	0.028 0.024	0.01	0.01	0.004	0.028 0.012	

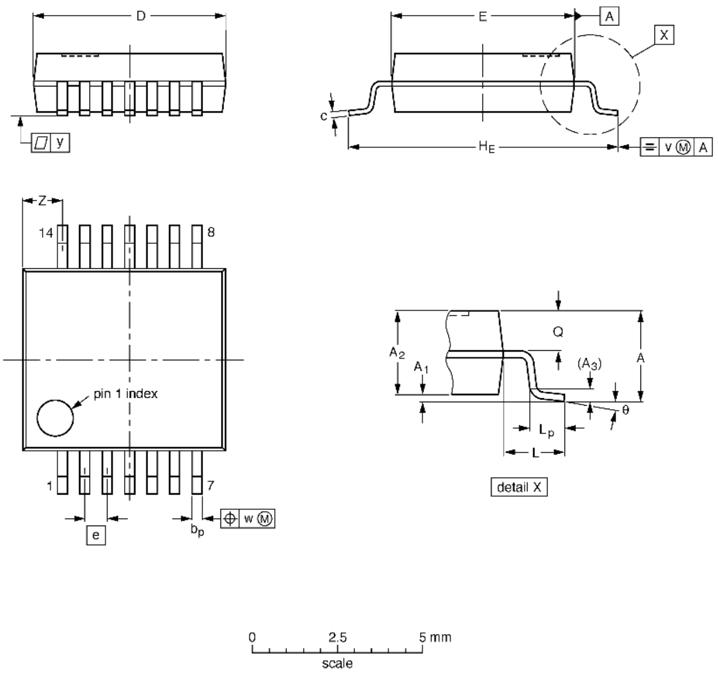
Note

1. Plastic or metal protrusions of 0.15 mm (0.006 inch) maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT108-1	076E06	MS-012				~~99-12-27~~ 03-02-19

Fig 17. Package outline SOT108-1 (SO14)

SSOP14: plastic shrink small outline package; 14 leads; body width 5.3 mm **SOT337-1**



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	D(1)	E(1)	e	H_E	L	L_p	Q	v	w	y	Z(1)	θ
mm	2	0.21 0.05	1.80 1.65	0.25	0.38 0.25	0.20 0.09	6.4 6.0	5.4 5.2	0.65	7.9 7.6	1.25	1.03 0.63	0.9 0.7	0.2	0.13	0.1	1.4 0.9	8° 0°

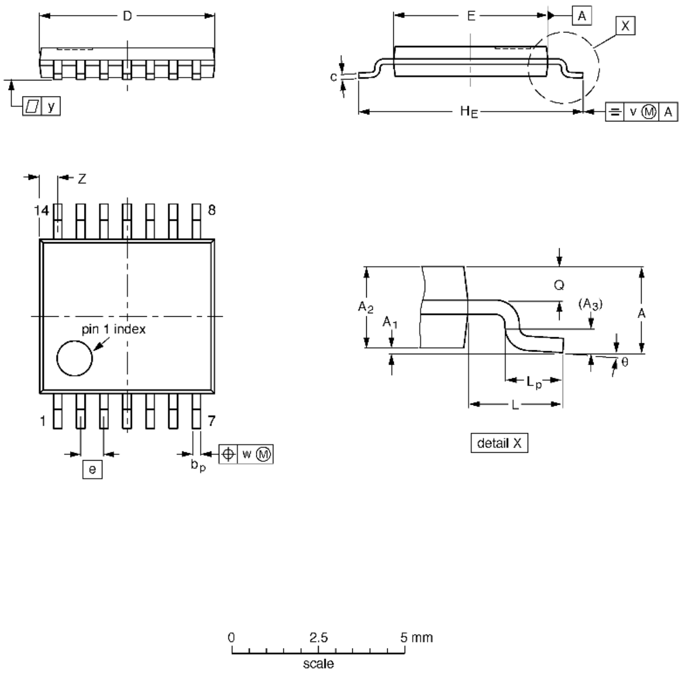
Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT337-1		MO-150				~~99-12-27~~ 03-02-19

Fig 18. Package outline SOT337-1 (SSOP14)

TSSOP14: plastic thin shrink small outline package; 14 leads; body width 4.4 mm **SOT402-1**



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	$D^{(1)}$	$E^{(2)}$	e	H_E	L	L_p	Q	v	w	y	$Z^{(1)}$	θ
mm	1.1	0.15 0.05	0.95 0.80	0.25	0.30 0.19	0.2 0.1	5.1 4.9	4.5 4.3	0.65	6.6 6.2	1	0.75 0.50	0.4 0.3	0.2	0.13	0.1	0.72 0.38	8° 0°

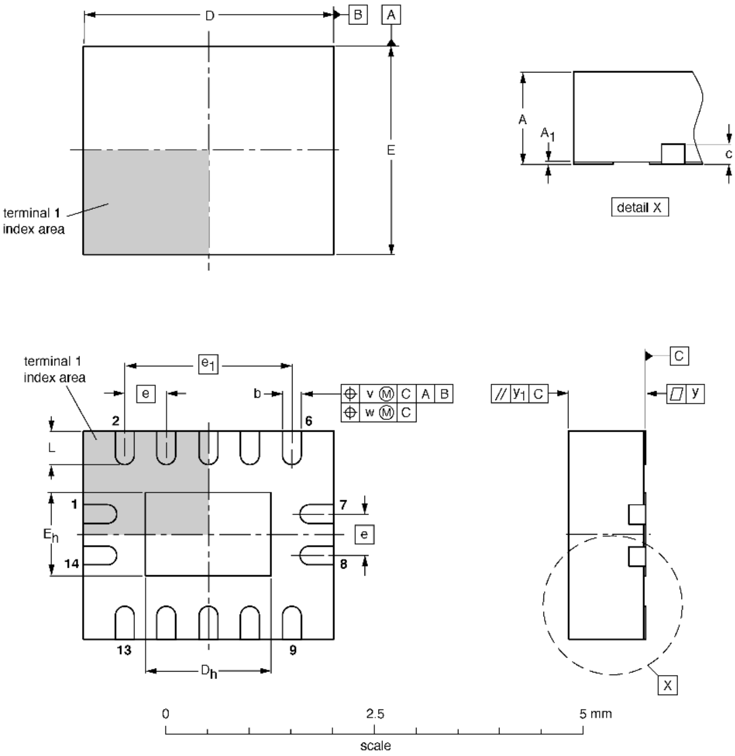
Notes

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic interlead protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT402-1		MO-153				~~99-12-27~~ 03-02-18

Fig 19. Package outline SOT402-1 (TSSOP14)

DHVQFN14: plastic dual in-line compatible thermal enhanced very thin quad flat package; no leads; 14 terminals; body 2.5 x 3 x 0.85 mm **SOT762-1**



DIMENSIONS (mm are the original dimensions)

UNIT	A(1) max.	A_1	b	c	D(1)	D_h	E(1)	E_h	e	e_1	L	v	w	y	y_1
mm	1	0.05 0.00	0.30 0.18	0.2	3.1 2.9	1.65 1.35	2.6 2.4	1.15 0.85	0.5	2	0.5 0.3	0.1	0.05	0.05	0.1

Note

1. Plastic or metal protrusions of 0.075 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT762-1	- - -	MO-241	- - -			~~02-10-17~~ 03-01-27

Fig 20. Package outline SOT762-1 (DHVQFN14)

17. Abbreviations

Table 11. Abbreviations

Acronym	Description
CMOS	Complementary Metal-Oxide Semiconductor
DUT	Device Under Test
ESD	ElectroStatic Discharge
HBM	Human Body Model
LSTTL	Low-power Schottky Transistor-Transistor Logic
MM	Machine Model

18. Revision history

Table 12. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
74HC_HCT14 v.6	20120919	Product data sheet	-	74HC_HCT14 v.5
Modifications:	• Figure 15 added (typical K-factor for relaxation oscillator).			
74HC_HCT14 v.5	20111219	Product data sheet	-	74HC_HCT14 v.4
Modifications:	• Legal pages updated.			
74HC_HCT14 v.4	20110117	Product data sheet	-	74HC_HCT14 v.3
74HC_HCT14 v.3	20031030	Product specification	-	74HC_HCT14_CNV v.2
74HC_HCT14_CNV v.2	19970826	Product specification	-	-

19. Legal information

19.1 Data sheet status

Document status[1][2]	Product status[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL http://www.nxp.com.

19.2 Definitions

Draft — The document is a draft version only. The content is still under internal review and subject to formal approval, which may result in modifications or additions. NXP Semiconductors does not give any representations or warranties as to the accuracy or completeness of information included herein and shall have no liability for the consequences of use of such information.

Short data sheet — A short data sheet is an extract from a full data sheet with the same product type number(s) and title. A short data sheet is intended for quick reference only and should not be relied upon to contain detailed and full information. For detailed and full information see the relevant full data sheet, which is available on request via the local NXP Semiconductors sales office. In case of any inconsistency or conflict with the short data sheet, the full data sheet shall prevail.

Product specification — The information and data provided in a Product data sheet shall define the specification of the product as agreed between NXP Semiconductors and its customer, unless NXP Semiconductors and customer have explicitly agreed otherwise in writing. In no event however, shall an agreement be valid in which the NXP Semiconductors product is deemed to offer functions and qualities beyond those described in the Product data sheet.

19.3 Disclaimers

Limited warranty and liability — Information in this document is believed to be accurate and reliable. However, NXP Semiconductors does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. NXP Semiconductors takes no responsibility for the content in this document if provided by an information source outside of NXP Semiconductors.

In no event shall NXP Semiconductors be liable for any indirect, incidental, punitive, special or consequential damages (including - without limitation - lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Notwithstanding any damages that customer might incur for any reason whatsoever, NXP Semiconductors' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the *Terms and conditions of commercial sale* of NXP Semiconductors.

Right to make changes — NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

Suitability for use — NXP Semiconductors products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of an NXP Semiconductors product can reasonably be expected to result in personal injury, death or severe property or environmental damage. NXP Semiconductors and its suppliers accept no liability for inclusion and/or use of NXP Semiconductors products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

Applications — Applications that are described herein for any of these products are for illustrative purposes only. NXP Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using NXP Semiconductors products, and NXP Semiconductors accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the NXP Semiconductors product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customer(s). Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

NXP Semiconductors does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customer(s). Customer is responsible for doing all necessary testing for the customer's applications and products using NXP Semiconductors products in order to avoid a default of the applications and the products or of the application or use by customer's third party customer(s). NXP does not accept any liability in this respect.

Limiting values — Stress above one or more limiting values (as defined in the Absolute Maximum Ratings System of IEC 60134) will cause permanent damage to the device. Limiting values are stress ratings only and (proper) operation of the device at these or any other conditions above those given in the Recommended operating conditions section (if present) or the Characteristics sections of this document is not warranted. Constant or repeated exposure to limiting values will permanently and irreversibly affect the quality and reliability of the device.

Terms and conditions of commercial sale — NXP Semiconductors products are sold subject to the general terms and conditions of commercial sale, as published at http://www.nxp.com/profile/terms, unless otherwise agreed in a valid written individual agreement. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. NXP Semiconductors hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of NXP Semiconductors products by customer.

No offer to sell or license — Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights.

Export control — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from competent authorities.

Non-automotive qualified products — Unless this data sheet expressly states that this specific NXP Semiconductors product is automotive qualified, the product is not suitable for automotive use. It is neither qualified nor tested in accordance with automotive testing or application requirements. NXP Semiconductors accepts no liability for inclusion and/or use of non-automotive qualified products in automotive equipment or applications.

In the event that customer uses the product for design-in and use in automotive applications to automotive specifications and standards, customer (a) shall use the product without NXP Semiconductors' warranty of the product for such automotive applications, use and specifications, and (b) whenever customer uses the product for automotive applications beyond NXP Semiconductors' specifications such use shall be solely at customer's own risk, and (c) customer fully indemnifies NXP Semiconductors for any liability, damages or failed product claims resulting from customer design and use of the product for automotive applications beyond NXP Semiconductors' standard warranty and NXP Semiconductors' product specifications.

Translations — A non-English (translated) version of a document is for reference only. The English version shall prevail in case of any discrepancy between the translated and English versions.

19.4 Trademarks

Notice: All referenced brands, product names, service names and trademarks are the property of their respective owners.

20. Contact information

For more information, please visit: **http://www.nxp.com**

For sales office addresses, please send an email to: **salesaddresses@nxp.com**

21. Contents

For more information, please visit: http://www.nxp.com
For sales office addresses, please send an email to: salesaddresses@nxp.com
Date of release: 19 September 2012
Document identifier: 74HC_HCT14

Anexo L.

Photoelectric Sensor with Built-in Amplifier with New Connector Options

E3Z

Compact Sensor Offers Long Sensing Distance and Superior Noise-Immunity

- Photo-IC provides long sensing distance: 15 m and 10 m for through-beam, 4 m for retroreflective, and 1 m for diffuse.
- Integrated Photo-IC improves noise immunity to interference from inverters and other inductive loads.
- New injection molding technology assures IP67 rating to withstand water and dust.
- Switch-selectable, Light-ON/Dark-ON operation.
- M8 connector-ready and 2 m, pre-wired models.
- NPN or PNP output models available.

1200 psi washdown rated

Ordering Information

Sensors

Stock Note: Shaded models are normally stocked.

Sensing method	Light source	Appearance	Connection method	Sensing distance	Model	
					NPN output	PNP output
Through-beam	IR/RED		Pre-wired	15 m (IR) 10 m (RED) (See Note 1.)	**E3Z-T61(A)**	**E3Z-T81(A)**
			Connector		**E3Z-T66(A)**	**E3Z-T86(A)**
			Pigtail 3 pin (M8)		**E3Z-T61(A)-M5J**	**E3Z-T81(A)-M5J**
			Pigtail 4 pin (M8)		**E3Z-T61(A)-M3J**	**E3Z-T81(A)-M3J**
			Pigtail 4 pin (M12)		**E3Z-T61(A)-M1J**	**E3Z-T81(A)-M1J**
Polarized retroreflective	RED	(See Note 2.)	Pre-wired	100 mm to 4 m 100 mm to 3 m (See Note 3.)	**E3Z-R61**	**E3Z-R81**
			Connector		**E3Z-R66**	**E3Z-R86**
			Pigtail 3 pin (M8)		**E3Z-R61-M5J**	**E3Z-R81-M5J**
			Pigtail 4 pin (M8)		**E3Z-R61-M3J**	**E3Z-R81-M3J**
			Pigtail 4 pin (M12)		**E3Z-R61-M1J**	**E3Z-R81-M1J**
Diffuse reflective	IR		Pre-wired	5 to 100 mm (wide view)	**E3Z-D61**	**E3Z-D81**
			Connector		**E3Z-D66**	**E3Z-D86**
			Pigtail 3 pin (M8)		**E3Z-D61-M5J**	**E3Z-D81-M5J**
			Pigtail 4 pin (M8)		**E3Z-D61-M3J**	**E3Z-D81-M3J**
			Pigtail 4 pin (M12)		**E3Z-D61-M1J**	**E3Z-D81-M1J**
			Pre-wired	1 m	**E3Z-D62**	**E3Z-D82**
			Connector		**E3Z-D67**	**E3Z-D87**
			Pigtail 3 pin (M8)		**E3Z-D62-M5J**	**E3Z-D82-M5J**
			Pigtail 4 pin (M8)		**E3Z-D62-M3J**	**E3Z-D82-M3J**
			Pigtail 4 pin (M12)		**E3Z-D62-M1J**	**E3Z-D82-M1J**

Note: 1. Model numbers that end with (A) are red LED versions.
2. The Reflector is sold separately. Select the Reflector model most suited to the application.
3. Sensing distance can be extended to 4 meters when the E39-R1S reflector is used. The sensing distance is 3 meters when the E39-R1 reflector is used.

Accessories (order separately)

Stock Note: Shaded models are normally stocked.

Slit for Through-beam Models (E3Z-T□□)

Order a slit for each emitter and receiver.

Slit width	Sensing distance (typical)	Minimum sensing object (typical)	**Model**
0.5 mm dia.	50 mm	0.5 mm dia.	**E39-S65A**
1 mm dia.	200 mm	1 mm dia.	**E39-S65B**
2 mm dia.	800 mm	2 mm dia.	**E39-S65C**
0.5 × 10 mm	1 m	0.7 mm dia.	**E39-S65D**
1 × 10 mm	2.2 m	1.2 mm dia.	**E39-S65E**
2 × 10 mm	5 m	2.4 mm dia.	**E39-S65F**

Reflectors for Retroreflective Models

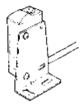
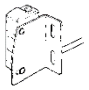
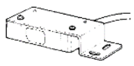
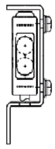
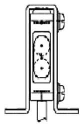
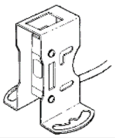
Stock Note: Shaded models are normally stocked.

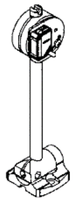
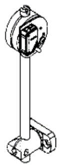
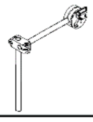
Name	Sensing distance (typical)	**Model**
Reflector	100 mm to 3 m	**E39-R1**
	100 mm to 4 m	**E39-R1S**
	100 mm to 5 m	**E39-R2**
	100 mm to 2.5 m	**E39-R9**
	100 mm to 3.5 m	**E39-R10**
Miniature Reflector	50 mm to 1.5 m	**E39-R3**
Tape Reflector	150 mm to 700 mm	**E39-RS1**
	150 mm to 1.1 m	**E39-RS2**
	150 mm to 1.4 m	**E39-RS3**

Note: The actual sensing distance may be reduced to approximately 70% of the typical sensing distance when using a Reflector other than the E39-R1 or the E39-R1S.

Mounting Brackets

Stock Note: Shaded models are normally stocked.

Appearance	Description	**Model**
	L-bracket, horizontal	**E39-L104**
	L-bracket, vertical	**E39-L44**
	Open top, 20° angle adjustability	**E39-L43**
	Protected top 5° angle adjustability	**E39-L144**
	Compact vertical protective cover bracket	**E39-L142**
	Vertical protective cover bracket	**E39-L98**

Appearance	Description	**Model**
	Adjustable height and angle bracket for sensors; horizontal mounting rotates every 45 degrees Mounted to the aluminum frame rails of conveyors, easily adjustable	**E39-L93FH**
	Adjustable height and angle bracket for sensors; vertical mounting rotates every 45 degrees	**E39-L93FV**
	Adjustable height and angle bracket for sensors; fixed horizontal base mounting	**E39-L93H**
	Adjustable height and angle bracket for sensors; fixed vertical base mounting	**E39-L93V**
	Adjustable height and angle bracket for sensors; free range of X and Y axis positioning; no base included for vertical post	**E39-L93XY**

Note: If a through-beam model is used, order two Mounting Brackets — one for the emitter and one for the receiver.

■ M8 CONNECTORS

Appearance	Cable type		Model
Straight	2 m (6.56 ft)	Four-wire type	**XS3F-M421-402-A**
	5 m (16.40 ft)		**XS3F-M421-405-A**
Right angle	2 m (6.56 ft)		**XS3F-M422-402-A**
	5 m (16.40 ft)		**XS3F-M422-405-A**
Straight	2 m (6.56 ft)	Three-wire type	**Y96E-M833SD2**
	5 m (16.40 ft)		**Y96E-M833SD5**
Right angle	2 m (6.56 ft)		**Y96E-M833RD2**
	5 m (16.40 ft)		**Y96E-M833RD5**

■ M12 CONNECTORS

Appearance	Cable type		Model
Straight	2 m (6.56 ft)	Four-wire type	**Y96E-44SD2**
	5 m (16.40 ft)		**Y96E-44SD5**
Right angle	2 m (6.56 ft)		**Y96E-44RD2**
	5 m (16.40 ft)		**Y96E-44RD5**

Specifications

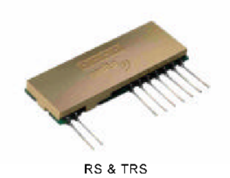
Item	Sensing method	Through-beam	Polarized retroreflective	Diffuse reflective	
	NPN output	E3Z-T61/T66 (A) (Note 3)	E3Z-R61/R66	E3Z-D61/D66	E3Z-D62/D67
	PNP output	E3Z-T81/T86 (A) (Note 3)	E3Z-R81/R86	E3Z-D81/D86	E3Z-D82/D87
Sensing distance		15 m 10 m (A) (Note 3)	100 mm (4 m Note 1) (when using E39-R1S) 100 mm (3 m Note 2) (when using E39-R1)	White paper (100 × 100 mm): 100 mm	White paper (300 × 300 mm): 1 m
Standard sensing object		Opaque: 12 mm (dia. min.)	Opaque: 75 mm (dia. min.)	---	
Hysteresis		---		20% max. of setting distance	
Directional angle		Both emitter and receiver: 3 to 15°	2 to 10°	---	
Light source (wave length)		Infrared LED (870 nm)	Red LED (660 nm)	Infrared LED (860 nm)	
Power supply voltage		12 to 24 VDC ±10% including 10% (p-p) max. ripple			
Current consumption		Emitter: 15 mA Receiver: 20 mA	30 mA max.		
Control output		100 mA max. at 26.4 VDC, open collector output (residual voltage: 2 V max.) < 10 mA (residual voltage: 1 V max.) L-ON/D-ON, switch selectable			
Circuit protection		Load short-circuit, reversed power supply protection, and output reverse protection	Reversed power supply connection, output short-circuit, and mutual interference protection, and output reverse protection		
Response time		1 ms max.			
Sensitivity adjustment		One-turn potentiometer			
Ambient illumination (receiver side)	Incandescent lamp	3,000 ℓ max.			
	Sunlight	10,000 ℓ max.			
Ambient temperature	Operating	−25°C to 55°C (−13°F to 131°F)			
	Storage	−40°C to 70°C (−40°F to 158°F) with no icing or condensation			
Ambient humidity	Operating	35% to 85%			
	Storage	35% to 95% with no condensation			
Insulation resistance		20 MΩ min. at 500 VDC			
Dielectric strength		1,000 VAC, 50/60 Hz for 1 min			
Vibration resistance		10 to 55 Hz, 1.5-mm double amplitude or 300 m/s^2 for 2 hours each in X, Y, and Z axes			
Shock resistance	Destruction	500 m/s^2 3 times each in X, Y, and Z axes			
Enclosure rating		IP67 (IEC60529) 1200 PSI Washdown (NEMA ICS5, ANNEX F)			
Approvals		CE			
Connection method		2 m cable or M8 connector			
Indicator		Operation indicator (orange) Stability indicator (green) Emitter has power indicator (orange) only			
Weight (packed state)	Pre-wired cable (2 m)	Approx. 120 g (4.2 oz)	Approx. 65 g (2.3 oz)		
	Connector	Approx. 30 g (1.1 oz)	Approx. 20 g (0.7 oz)		
Material		Case: PBT (polybutylene terephthalate); Lens: Denatured polyallylate			
Accessories		Instruction manual (Order Reflector and Mounting Bracket separately.)			

Note: 1. Sensing distance can be extended up to 4 meters when the E39-R1S reflector is used.
2. Sensing distance can be extended up to 3 meters when the E39-R1 reflector is used.
3. Sensing distance is 10 meters when using the (A) versions (visible red LED, 660 nm).

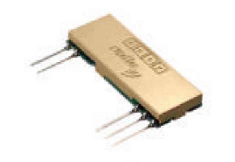
Anexo M.

Endereço Modbus	Texto de função	Designação do canal	Observação
500	Entradas Digital AGV	Emergência	1
501	Entradas Digital AGV	Obstrução	1
502	Entradas Digital AGV	Fim de curso direção - esqueda	1
503	Entradas Digital AGV	Fim de curso direção - direita	1
504	Entradas Digital AGV	Sensor superior infravermelhos	1
505	Entradas Digital AGV	Sensor inferior infravermelhos	1
506	Entradas Digital AGV	Modo Funcionamento Auto/Manual	0/1
507	Entradas Digital AGV	Em movimento	1
508	Entradas Digital AGV	Em carga	1
509	Entradas Digital AGV	Em descarga	1
510	Entradas Digital AGV	A recarregar baterias	1
600	Comando AGV	Comando Manual	1
601	Comando AGV	Comando Automatico	1
602	Comando AGV	Comando destino - carga	1
603	Comando AGV	Comando destino - descarga	1
604	Comando AGV	Comando destino - recarregar bateria	1

Anexo N.



RS & TRS



TS

The Easy-Radio ER400TS Transmitter, ER400RS Receiver and ER400TRS transceiver incorporate 'Easy-Radio' technology to provide high performance, simple to use radio devices that can transfer data over a range of up to 250 metres Line Of Sight (LOS). Furthermore 'Easy-Radio' technology allows frequency, data rate and power output to be optimised for customer specific applications. The embedded software reduces design and development time significantly.

The modules operate on the Pan-European 433 to 434MHz frequency band from a 3.6V supply and are housed in space saving Single-In-Line (SIL) packages.

This data sheet describes the electrical and physical characteristics of the device. Operation of the Easy Radio software and Timing Specifications are described later in this document. Further information is available in the 'Easy-Radio Demonstration Kit & Programming Software' guide, which should be read in conjunction with this data sheet.

Features

Crystal controlled synthesiser for frequency accuracy
High sensitivity receiver – typically -105dBm @ 38.4 Kbps
10mW Transmit Power
Low operating Voltage - 3.6 Volts – Single Lithium Cell
Low power consumption: Receiver – 13mA
Transmitter – 23mA
User programmable: Frequency of operation
Data Rate
Output Power

Applications

Handheld Terminals
Environmental Sense & Control
Vehicle to Base Station Data Transfer
Remote Data Acquisition
Electronic Point of Sale equipment

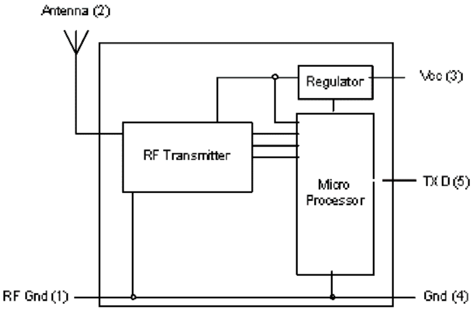
Description

The Easy-Radio ER400TS Transmitter, ER400RS Receiver and ER400TRS Transceiver utilise modern high performance FM (FSK) transmitter and receiver ICs combined with a 'flash' programmable microprocessor and an internal voltage regulator. They are suited for general-purpose remote control and data telemetry applications within the European 433MHz ISM band.

The receiver is provided with a Received Signal Strength Indicator (RSSI) output that can be optionally used to measure received signal levels.

The modules connect to any 50-Ohm antenna such as a whip, helical or PCB loop.

ER400TS Transmitter



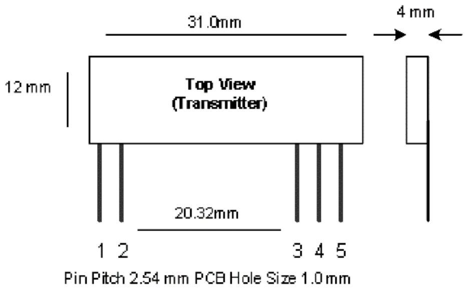


Figure 2 Physical Dimensions

Pin Description

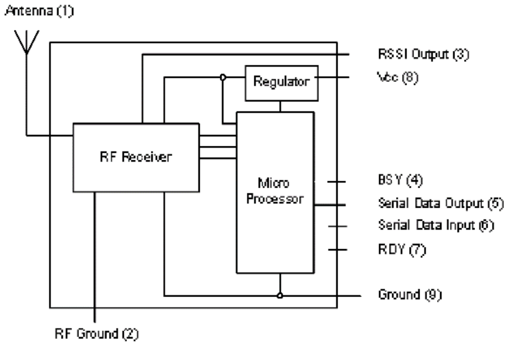
Pin No	Name	Description	Notes
1	RF Gnd	RF ground. Connect to antenna ground (coaxial cable screen braid) and local ground plane. Internally connected to Pin 4	
2	RF Out	50 Ohm RF output. Connect to suitable antenna	See Note
3	Vcc	Positive supply pin. +3.6 to +6.0 Volts. This should be a 'clean' noise free supply with less than 25mV of ripple	
4	Gnd	Supply 0 Volt and Ground Plane	
5	TXD	Transmit Data Digital Input (SDI)	2

Notes

1. The module operates internally from an on board 3.3 Volt low drop regulator.
2. TXD input will be correctly driven by logic operating at 5 Volts (CMOS & TTL logic levels). Input should not be driven by an analogue output.

ER400RS Receiver

The Easy-Radio 400 Receiver is a complete sub-system that combines a high performance low power RF receiver, a 'flash' programmable microcontroller and a voltage regulator (Figure 3). The microcontroller programmes the functions of the RF receiver and provides the interface to the host system via a data output. It also contains programmable EEPROM memory that holds configuration data for the various receiver operating modes. The microcontroller also relieves the host from the intensive demands of searching for signals within the noise, recovering the received data and then presenting it to the host. A Received Signal Strength Indicator output can be optionally used to measure received signal levels. The module connects to a 50 Ohm antenna such as a whip, helical or PCB loop.



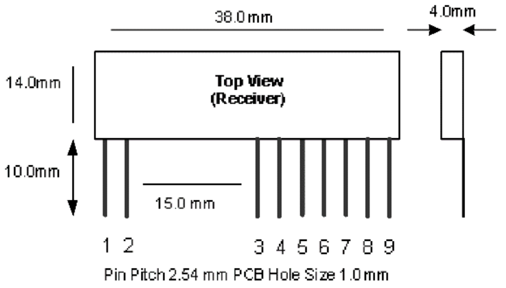


Figure 4 Physical Dimensions

Pin Description

Pin No	Name	Description	Notes
1	Antenna	50 Ohm RF input/output. Connect to suitable antenna.	See Note
2	RF Ground	RF ground. Connect to antenna ground (coaxial cable screen braid) and local ground plane. Internally connected to other Ground pins.	
3	RSSI	Received Signal Strength Indication - Analogue	See Note
4	BSY	Output (Low - Ready for data from Host) (High - Not Ready)	CTS function
5	Data Out	Received Data Output	SDO
6	Data In	ER command Input	SDI
7	RDY	Input (Low – Host Ready to receive data) (High – Not Ready)	RTS function
8	Vcc	Positive supply pin. +3.6 to +5.5 Volts. This should be a 'clean' noise free supply with less than 25mV of ripple.	
9	Ground	Connect to supply 0 Volt and ground plane	

Checklist

1. The module operates internally from an on board 3.3 Volt low drop regulator. The logic levels of the input/output pins are therefore between 0 Volt and 3.3 Volts. (See RS Performance Data).
2. All digital inputs and outputs are intended for connection to low voltage logic devices. Do not connect any of the inputs or outputs directly to an RS232 port. The receiver module may be permanently damaged by the voltages (+/- 12V) present on RS232 signal lines. See Application Circuit (Figure 11) for typical connection to an RS232 port via MAX232 interface IC.
3. Outputs will drive logic operating at 5 Volts.
4. If in handshaking mode, pin (7) of the ER400RS module should be connected directly to GND for data to be delivered.

Application & Operation ER400TS & RS

Figure 5 shows a typical system block diagram comprising hosts (user's application) connected to Easy-Radio Transmitters and Receivers. Host (A) will be monitoring (collecting data) and Host (B) will be receiving and processing this data.

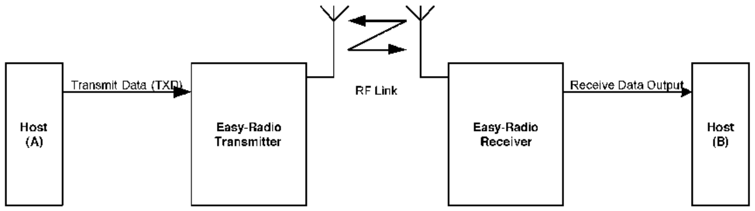


Figure 5 Typical System Block Diagram

The Host (A) should provide the serial data input (up to a maximum 128 characters per packet) to the Easy-Radio transmitter. The data should be sent in 'bursts' therefore allowing adequate time for transmission and reception over the RF link (See Figure 6). The receiver, upon reception and decoding of the RF transmission immediately sends serial data to the Host B.

Data is sent and received in standard 'RS232' serial format (logic level only) and there is no restriction on the characters that may be sent.

A. Host (A) sends serial data to the Easy-Radio Transmitter (A). The data must be continuously streamed at the selected baud rate and it fills an internal transmit buffer until either 128 bytes have been received or a gap of two bytes is detected.
B. After detecting either the 'End of Data' gap or the 'Buffer Full' condition the controller enables RF transmit and sends a fixed 10mS preamble followed by the data in the buffer which is Manchester encoded at 19,200 Baud for efficient transmission across the RF link. Any Easy-Radio receivers within range that 'hear' the transmission will simultaneously lock onto the preamble, decode the data and place it into their receive buffers.
C. After checking the data for integrity the Data within the receive buffer of Easy-Radio Receiver (B) is then sent continuously to the host at the selected baud rate.

There is no 'handshaking' provided at either the transmitter or receiver. The user should therefore ensure that sufficient time is allowed for the completion of transmission and reception of data. The Timing Specifications detail these requirements (see page 8). Transmitter Host (A) must allow time for the 'Over Air' transmission and for the receiving Host (B) to unload (and process) the data before sending any more new data. The receiver Host (B) must always be 'ready and waiting' for data to arrive. It should be possible to use fast response 'interrupts' without any loss of data.

With such a 'one-way' (simplex) system there is no confirmation of the satisfactory reception of the data and for added reliability it is recommended that the data be sent, perhaps, repetitively several times. For increased reliability the use of transceivers (which can acknowledge packet reception) is recommended. Easy-Radio services do not provide automatic acknowledgement (or re-tries) but these can be provided by the users application.

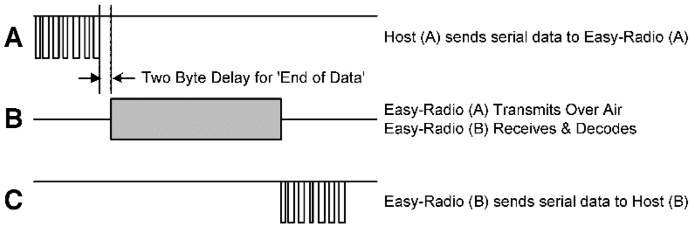
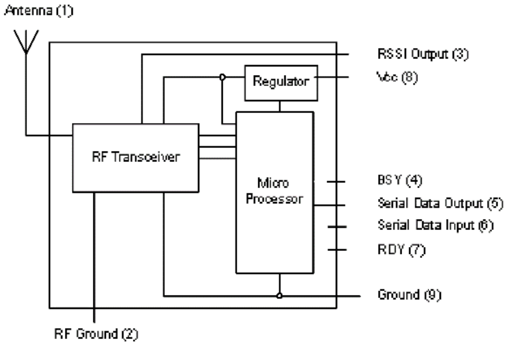


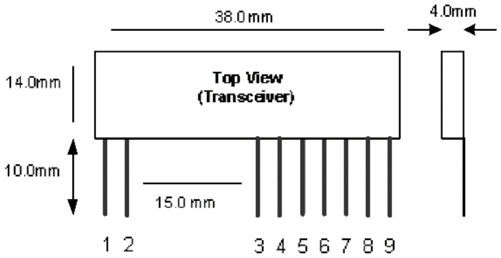
Figure 6 Serial Data

ER400TRS Transceiver Description

The Easy-Radio 400 Transceiver is a complete sub-system that combines a high performance very low power RF transceiver, a microcontroller and a voltage regulator (Figure 7).

.





Pin Pitch 2.54 mm PCB Hole Size 1.0mm

Figure 8 Physical Dimensions

Pin Description

Pin No	Name	Description	Notes
1	Antenna	50 Ohm RF input/output. Connect to suitable antenna.	See Note
2	RF Ground	RF ground. Connect to antenna ground (coaxial cable screen braid) and local ground plane. Internally connected to other Ground pins.	
3	RSSI	Received Signal Strength Indication	See Note
4	Busy Output	Digital Output to indicate that transceiver is ready to receive serial data from host.	CTS function
5	Serial Data Out	Digital output for received data to host	
6	Serial Data In	Digital input for serial data to be transmitted	
7	Host Ready Input	Digital Input to indicate that Host is Ready to receive serial data from transceiver	RTS function
8	Vcc	Positive supply pin. +3.6 to +5.5 Volts. This should be a 'clean' noise free supply with less than 25mV of ripple.	
9	Ground	Connect to supply 0 Volt and ground plane	

Checklist

1. The module operates internally from an on board 3.3 Volt low drop regulator. The logic levels of the input/output pins are therefore between 0 Volt and 3.3 Volts. (See specifications/performance data).
2. The serial inputs and outputs are intended for connection to a UART or similar low voltage logic device. Do not connect any of the inputs or outputs directly to an RS232 port. The transceiver module may be permanently damaged by the voltages (+/- 12V) present on RS232 signal lines. See Application Circuit (Figure 11) for typical connection to an RS232 port via MAX232 interface IC.
3. The 'Host Ready Input' should be tied to 0 Volt (Ground) if not used.
4. The 'Serial Data In' should be tied to Vcc if not used. (Receive mode only).
5. Outputs will drive logic operating at 5 Volts and inputs will be correctly driven by logic operating at 5 Volts (CMOS & TTL logic levels).

Application & Operation ER400TRS

Figure 9 shows a typical system block diagram comprising hosts (user's application) connected to Easy-Radio Transceivers. The hosts (A & B) will be monitoring (collecting data) and/or controlling (sending data) to some real world application.

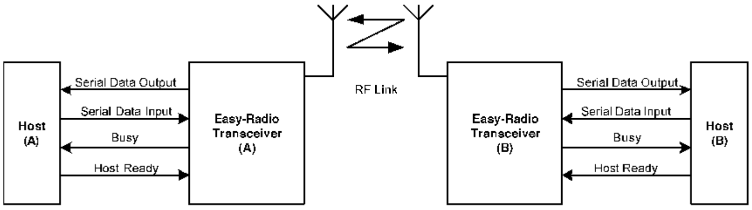


Figure 9 Typical System Block Diagram

The hosts provide serial data input and output lines and two 'handshaking' lines that control the flow of data to and from the Easy-Radio Transceivers. The 'Busy' output line, when active, indicates that the transceiver is undertaking an internal task and is not ready to receive serial data. The 'Host Ready' input is used to indicate that the host is ready to receive the data held in the buffer of the Easy-Radio Transceiver.

The host should check before sending data that the 'Busy' line is not high, as this would indicate that the transceiver is either transmitting or receiving data over the radio link. It should also pull the 'Host Ready' line low and check that no data appears on the Serial Data Output line.

Detailed operation of interfacing, handshaking (including timing) is described in the 'Easy-Radio Software Guide'.

Timing Specifications – Applies to all Easy-Radio Modules.

Parameters	Min	Units	Notes
Host Serial Input/Output	2400, 4800, 9600, 19200, 38400	baud	1
Host Character Format	1 Start, 8 Data, No Parity, 1 Stop	Bits	2
End of Data Delay	2 x BAUD BYTE Duration	mS	3
RF Transmit	13.2 + (n Bytes X 0.8)	mS	4
Buffer Size	1-128	Bytes	5

Notes

1. Data is inverted i.e. Start Bit is logic low. The inputs are intended for direct connection to a microcontroller UART or to RS232 inputs and outputs via an RS232 Level translator such as a Maxim MAX232 which invert the logic of the RS232 signals. This allows direct connection to, for example a PIC UART. The data rate is user programmable (Default 19200 baud) and may differ between individual units within a system. (See Application Circuit diagram for logic level to RS232 interface figure 11, page 13).
2. 1 start, 8 data, 1 stop = 10 bits @ 104uS/bit = 0.52mS/character at 19200 Baud. (Default)
3. The 'End of Data' delay is fixed at twice the character time.
4. A fixed package overhead of 13.2mS is added to all packets.
5. The buffer size is limited to 128 bytes. Sending more than 128 bytes will cause loss of data.

Absolute Maximum Ratings ER400TS, ER400RS and ER400TRS

Operating Temperature Range	-20° C to +65° C (Commercial)
Storage Temperature Range	-20° C to +75° C
Vcc	- 0.3 to + 6.0 Volts
All Other Pins (N.B.)	- 0.3 to 3.3 Volts
Antenna	50V p-p @ < 10MHz

Performance Data: ER400TS Transmitter Supply +5.0 Volt ± 5%, Temperature 20° C

DC Parameters	Pin	Min	Typical	Max	Units	Notes
Supply Voltage (Vcc)	3	3.6	5.0	5.5	Volts	
Supply current	3		23		mA	1
Interface Levels						
Data Input Logic 1		2.0			Volts	
Data Input Logic 0				0.2	Volts	
Input Impedance			100		K Ohm	
RF Parameters	**Pin**	**Min**	**Typical**	**Max**	**Units**	**Notes**
Antenna Impedance	2		50		Ohms	
RF Frequency			433-4		MHz	See ER Configuration Command set Page 12
RF Power Output	2		+10		dBm	50 Ohm load
Frequency accuracy			±50		ppm	Overall
FM deviation			64		kHz	
Harmonics		-43			dB	Below fundamental
Data Rate		2.4	19.2 (Default)	38.4	Kbps	76.8k available on request
Logic Timing	**Pin**	**Min**	**Typical**	**Max**	**Units**	**Notes**
Power Up Time			7		mS	2
Mechanical						
Size		31 x 12 x 4		mm		
Pin Pitch			2.54		mm	Standard 0.1 Inch
Weight			2.5		gms	

Notes

1. Contact the Sales Office for details of special low power variants. RF power output can be programmed at the factory.
2. Time required to 'lock' synthesiser from power up.

Performance Data: ER400RS Receiver Supply +5.0 Volt ± 5%, Temperature 20° C

DC Parameters	**Pin**	**Min**	**Typical**	**Max**	**Units**	**Notes**
Supply Voltage (Vcc)	8	3.6	5.0	5.5	Volts	
Receive supply current	8		12.5		mA	
Quiescent supply current	8		2		mA	1
Interface Levels						
Data Output Logic 1			3.1		Volts	10k load to +Vcc supply
Data Output Logic 0			0.1		Volts	10k load to +Vcc supply
Logic Output Current				25	mA	
Data Input Logic 1		2.0		3.6	Volts	
Data Input Logic 0				0.2	Volts	
Input Pull-ups			100		K Ohm	
Antenna Impedance	1		50		Ohms	
RF Frequency			433-4		MHz	See ER Configuration Command set Page 12
Receiver						
Receive Sensitivity			-105		dBm	BER = 10^{-3}
LO leakage			-60		dBm	Meets EN 300 220-3
Data Rate		2.4	19.2	38.4	Kbps	76.8 on Request
RSSI Output	3	0		1.2	Volt	See Figure 10
Logic Timing	**Pin**	**Min**	**Typical**	**Max**	**Units**	**Notes**
Initial Power Up Time			7.5		mS	2,3
Mechanical						
Size		38 x 14 x 4		mm		
Pin Pitch			2.54		mm	Standard 0.1 Inches
Weight			3.5		gms	

Notes

1. Processor running at full speed. Contact the Sales Office for details of special low power variants.
2. When power is first applied to the module the processor retrieves 'calibration' data for the RF section that compensates for temperature and power supply voltage variations. The receiver will then be ready to receive. It would normally be left in this powered state ready to receive data.
3. Contact the Sales Office for special 'fast' versions that can incorporate internal 'duty cycling' to further reduce quiescent power consumption for battery powered applications. Also for variants in frequency etc.

Performance Data: ER400TRS transceiver Supply +5.0 Volt ± 5%, Temperature 20° C

DC Parameters	Pin	Min	Typical	Max	Units	Notes
Supply Voltage (Vcc)	8	3.6	5.0	5.5	Volts	
Transmit supply current	8		23		mA	
Receive supply current	8		17.0		mA	
Quiescent supply current	8		2		mA	1
Interface Levels						
Data Output Logic 1			3.1		Volts	10k load to +Vcc supply
Data Output Logic 0			0.1		Volts	10k load to +Vcc supply
Logic Output Current				10	mA	
Data Input Logic 1		2.0			Volts	
Data Input Logic 0				0.2	Volts	
Input Pull-ups			100		K Ohm	2
RF Parameters	**Pin**	**Min**	**Typical**	**Max**	**Units**	**Notes**
Antenna Impedance	1		50		Ohms	
RF Frequency			433-4		MHz	See ER Configuration Command set Page 12
Transmitter						
RF Power Output	1		+10		dBm	50 Ohm load
Frequency accuracy			±50		ppm	Overall
FM deviation			-30		kHz	
Harmonics			-25		dBc	
Over Air Data rate			19200		bps	Manchester Encoded
Receiver						
Receive Sensitivity			-105		dBm	BER = 10^{-3}
LO leakage			-60		dBm	Meets EN 300 220-3
Serial Data Rate		4.8	19.2	38.4	Kbps	Host interface. 6
RSSI Output	3	0		1.2	Volt	See Figure 10
Logic Timing	**Pin**	**Min**	**Typical**	**Max**	**Units**	**Notes**
Initial Power Up Time			7.5		mS	3,4
Standby Power Up Time			TBA			5
Mechanical						
Size		38 x 14 x 4		mm		
Pin Pitch			2.54		mm	Standard 0.1 Inches
Weight			3.5		gms	

Notes

1. Processor running at full speed. Contact the Sales Office for details of special low power variants.
2. The 'Host Ready Input' and the 'Serial Data Input' have 'weak' internal pull-ups enabled. These inputs should not however be left 'floating' but should be tied to either Vcc or Ground 0 Volts.
3. When power is first applied to the module the processor retrieves 'calibration' data for the RF section that compensates for temperature and power supply voltage variations. The transceiver will then be ready to receive (default) or transmit. It would normally be left in this powered state ready to receive data.
4. During power up the Busy Output line goes high.
5. Contact the Sales Office for special 'fast' versions that can incorporate internal 'duty cycling' to further reduce quiescent power consumption for battery powered applications.
6. Serial data rate up to 38.4k standard but 76.8k available on request.

Easy-Radio Configuration Command Set

The programming software sends 'text messages' to the modules and this action can be performed by the terminal software or User's own PIC using the following list of commands:

Command	Function	Value	Notes
ER_CMD#U1	UART Data Rate	2400	
ER_CMD#U2		4800	
ER_CMD#U3		9600	
ER_CMD#U4		19200	
ER_CMD#U5		38400	
ER_CMD#P0	RF Power Output	1mW	
ER_CMD#P1		2mW	
ER_CMD#P2		3mW	
ER_CMD#P3		4mW	
ER_CMD#P4		5mW	
ER_CMD#P5		6mW	
ER_CMD#P6		7mW	
ER_CMD#P7		8mW	
ER_CMD#P8		9mW	
ER_CMD#P9		10mW	
ER_CMD#C0	Channel 0	433.23	MHz
ER_CMD#C1	Channel 1	433.30	MHz
ER_CMD#C2	Channel 2	433.45	MHz
ER_CMD#C3	Channel 3	433.55	MHz
ER_CMD#C4	Channel 4	433.68	MHz
ER_CMD#C5	Channel 5	433.83	MHz
ER_CMD#C6	Channel 6	433.88	MHz
ER_CMD#C7	Channel 7	434.00	MHz
ER_CMD#C8	Channel 8	434.15	MHz
ER_CMD#C9	Channel 9	434.35	MHz
ER_CMD#R1	Default Settings		Factory Default
ER_CMD#T1	Carrier Only	XX	Test Mode 1
ER_CMD#T2	Constant Preamble	XX	Test Mode 2
ER_ERR#01	Invalid Command Parameter		Error command
ER_ERR#02	EEPROM is reset to defaults		

Notes

The commands should be sent exactly as shown (case sensitive) with no spaces between characters. The ACK command is sent as three ASCII characters, ACK in sequence. 'A"C"K' .Note that the TS (transmitter) devices send data 'over air' as they are not equipped with a serial data out or handshake pins. This takes approximately 20mS and time should be taken in to account before sending the 'ACK' sequence

Notes

RSSI Output

The Receiver/Transceiver has a built in RSSI (Received Signal Strength Indicator) that provides an analogue output voltage that is inversely proportional to the RF energy present within the pass band of the receiver. It ranges from 0 Volt (maximum signal, –50dBm) to 1.2 Volts (minimum signal, -105bBm) and has a slope of approximately 50dB/Volt. This analogue output signal should only be connected to a high impedance load (>100k Ohms) and can be used to provide a measure of the signal strength and any interfering signals (noise) within band during the installation and operation of systems.

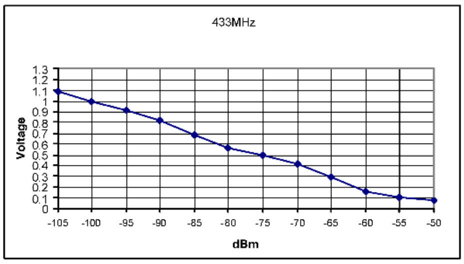


Figure 10 RSSI Output

Application Notes

MAX232 Application

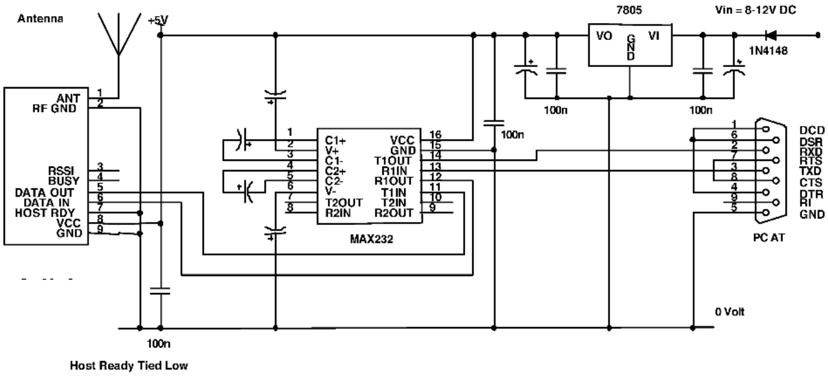


Figure 11 MAX232 Application Circuit

Compatibility

The ER400TS, ER400RS & ER400TRS use crystal controlled synthesisers to accurately define transmit and receive frequencies incorporating RS232 protocols, and so should not be used in connection with Non-Easy Radio RF modules.

Encoding/Decoding

Easy-Radio technology allows the transport of simple encoder/decoder code formats or more sophisticated schemes. Please contact sales/applications for further technical advice.

PCB Layout

The Ground (0 Volt) pins of the receiver should be connected to a substantial ground plane (large area of PCB copper) connected to 0 Volt. It is suggested that a double sided PCB be used with one layer being the ground plane.

Power Supply

The supply used to power the receiver should be 'clean' and free from ripple and noise (<20mV p-p total). It is suggested that 100nF ceramic capacitors be used to de-couple the supply close to the power pins of the receiver. The use of 'switch mode' power supplies should be avoided as they can generate both conducted and radiated high frequency noise that can be very difficult to eliminate. This noise may considerably reduce the performance of any radio device that is connected or adjacent to the supply.

Antennas

The receiver can be used with the various common types of antenna that match the 50 Ohm RF Input/Output such as a monopole (whip), helical or PCB/Wire loop antennas.

Monopole antennas are resonant with a length corresponding to one quarter of the electrical wavelength ($\lambda/4$). They are very easy to implement and can simply be a 'piece of wire' or PCB track which at 434MHz should be 16.4 cms in length. This should be straight, in 'free space' (kept well away from all other circuitry) and should be connected directly to the Antenna pin of the receiver. If the antenna is remote it should be connected via a 50 Ohm coaxial feeder cable or transmission line. A 50 Ohm transmission line can be constructed on FR4 board material by using a 3mm wide PCB track over a ground plane. This should be kept as short as possible.

Helical antennas are also resonant and generally chosen for their more compact dimensions. They are more difficult to optimise than monopole antennas and are critical with regard to surrounding objects that can easily 'de-tune' them. They operate most efficiently when there is a substantial ground plane for them to radiate against.

Wire or PCB Loop antennas are the most compact antennas but are less effective than the other types. They are also more difficult to design and must be carefully 'tuned' for best performance.

The Internet can provide much useful information on the design of Short Range Device (SRD) Antennas.

Product Order Codes

Name	Description	Order Code
Easy-Radio 400 Transmitter	UK/European Transmitter Module on 433 MHz	ER400TS
Easy-Radio 400 Receiver	UK/European Receiver Module on 433 MHz	ER400RS
Easy-Radio 400 Transceiver	UK/European Transceiver Module on 433 MHz	ER400TRS

Please contact the sales office for availability and other variants of the standard product. The software interface can be customised to specific requirements for high volume applications.

Easy-Radio Module Firmware Version

Version	Date	Revision
1.02	March 2003	

Document History

Issue	Date	Revision
1.1	March 2004	

Copyright

Disclaimer

LPRS
LOW POWER RADIO SOLUTIONS
"Making radio work..for YOU"

For further information or technical assistance please contact:

Tel: +44 (0)1993 709418
Fax: +44 (0)1993 708575
Web: http://www.lprs.co.uk
Email: info@lprs.co.uk

Web: http://www.easy-radio.co.uk

The above address is a dedicated web site for Easy-Radio

Low Power Radio Solutions Ltd
Two Rivers Industrial Estate
Station Lane
Witney
Oxon
OX28 4BH
England

easy radio

End of Data Sheet

Anexo O.

55 Series - General purpose relays 7 - 10 A

Features

Printed circuit mount, general purpose 2, 3 & 4 Pole relays

55.12 - 2 Pole 10 A
55.13 - 3 Pole 10 A
55.14 - 4 Pole 7 A

- AC coils & DC coils
- Cadmium Free contacts
- Contact material options
- RT III (wash tight) option available

55.12

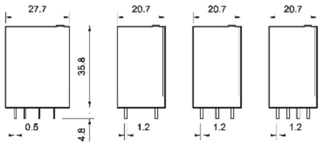
- 2 pole, 10 A
- PCB mount

55.13

- 3 pole, 10 A
- PCB mount

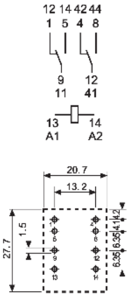
55.14

- 4 pole, 7 A
- PCB mount

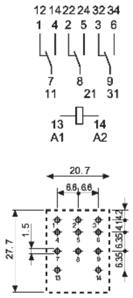


55.12 55.13 55.14

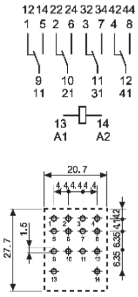
For UL ratings see:
"General technical information" page V



Copper side view



Copper side view



Copper side view

		55.12	55.13	55.14
Contact specification				
Contact configuration		2 CO (DPDT)	3 CO (3PDT)	4 CO (4PDT)
Rated current/Maximum peak current	A	10/20	10/20	7/15
Rated voltage/Maximum switching voltage	V AC	250/400	250/400	250/250
Rated load AC1	VA	2,500	2,500	1,750
Rated load AC15 (230 V AC)	VA	500	500	350
Single phase motor rating (230 V AC)	kW	0.37	0.37	0.125
Breaking capacity DC1: 30/110/220V	A	10/0.25/0.12	10/0.25/0.12	7/0.25/0.12
Minimum switching load	mW (V/mA)	300 (5/5)	300 (5/5)	300 (5/5)
Standard contact material		AgNi	AgNi	AgNi
Coil specification				
Nominal voltage (U_N)	V AC (50/60 Hz)	6 - 12 - 24 - 48 - 60 - 110 - 120 - 230 - 240		
	V DC	6 - 12 - 24 - 48 - 60 - 110 -125 - 220		
Rated power AC/DC	VA (50 Hz)/W	1.5/1	1.5/1	1.5/1
Operating range	AC	$(0.8...1.1)U_N$	$(0.8...1.1)U_N$	$(0.8...1.1)U_N$
	DC	$(0.8...1.1)U_N$	$(0.8...1.1)U_N$	$(0.8...1.1)U_N$
Holding voltage	AC/DC	$0.8\ U_N/0.5\ U_N$	$0.8\ U_N/0.5\ U_N$	$0.8\ U_N/0.5\ U_N$
Must drop-out voltage	AC/DC	$0.2\ U_N/0.1\ U_N$	$0.2\ U_N/0.1\ U_N$	$0.2\ U_N/0.1\ U_N$
Technical data				
Mechanical life AC/DC	cycles	$20 \cdot 10^6/50 \cdot 10^6$	$20 \cdot 10^6/50 \cdot 10^6$	$20 \cdot 10^6/50 \cdot 10^6$
Electrical life at rated load AC1	cycles	$200 \cdot 10^3$	$200 \cdot 10^3$	$150 \cdot 10^3$
Operate/release time	ms	10/5	10/5	11/3
Insulation between coil and contacts (1.2/50 μs)	kV	4	4	4
Dielectric strength between open contacts	V AC	1,000	1,000	1,000
Ambient temperature range	°C	–40…+85	–40…+85	–40…+85
Environmental protection		RT I	RT I	RT I
Approvals (according to type)		ANCE CCC SA EAC PCT Lloyd's Register RINA c UL us VDE		

55 Series - General purpose relays 7 - 10 A

Features

Plug-in mount, general purpose 2, 3 & 4 Pole relays

55.32 - 2 Pole 10 A
55.33 - 3 Pole 10 A
55.34 - 4 Pole 7 A

- Lockable test button and mechanical flag indicator as standard on 2 & 4 pole types
- AC coils & DC coils
- UL Listing (certain relay/socket combinations)
- Cadmium Free contacts
- Contact material options
- 94 series sockets
- Coil EMC suppression
- Timer accessories 86 series
- European Patent

55.32

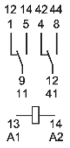
- 2 pole, 10 A
- Plug-in 94 series sockets

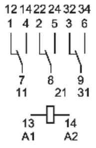
55.33

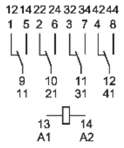
- 3 pole, 10 A
- Plug-in 94 series sockets

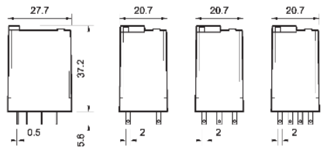
55.34

- 4 pole, 7 A
- Plug-in 94 series sockets

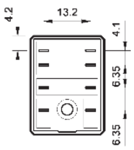


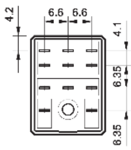


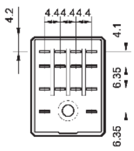




55.32 55.33 55.34







For UL ratings see:
"General technical information" page V

	55.32	55.33	55.34
Contact specification			
Contact configuration	2 CO (DPDT)	3 CO (3PDT)	4 CO (4PDT)
Rated current/Maximum peak current A	10/20	10/20	7/15
Rated voltage/Maximum switching voltage V AC	250/400	250/400	250/250
Rated load AC1 VA	2,500	2,500	1,750
Rated load AC15 (230 V AC) VA	500	500	350
Single phase motor rating (230 V AC) kW	0.37	0.37	0.125
Breaking capacity DC1: 30/110/220 V A	10/0.25/0.12	10/0.25/0.12	7/0.25/0.12
Minimum switching load mW (V/mA)	300 (5/5)	300 (5/5)	300 (5/5)
Standard contact material	AgNi	AgNi	AgNi
Coil specification			
Nominal voltage (UN) V AC (50/60 Hz)	6 - 12 - 24 - 48 - 60 - 110 - 120 - 230 - 240		
V DC	6 - 12 - 24 - 48 - 60 - 110 - 125 - 220		
Rated power AC/DC VA (50 Hz)/W	1.5/1	1.5/1	1.5/1
Operating range AC	$(0.8\ldots1.1)U_N$	$(0.8\ldots1.1)U_N$	$(0.8\ldots1.1)U_N$
DC	$(0.8\ldots1.1)U_N$	$(0.8\ldots1.1)U_N$	$(0.8\ldots1.1)U_N$
Holding voltage AC/DC	$0.8\ U_N/0.5\ U_N$	$0.8\ U_N/0.5\ U_N$	$0.8\ U_N/0.5\ U_N$
Must drop-out voltage AC/DC	$0.2\ U_N/0.1\ U_N$	$0.2\ U_N/0.1\ U_N$	$0.2\ U_N/0.1\ U_N$
Technical data			
Mechanical life AC/DC cycles	$20 \cdot 10^6/50 \cdot 10^6$	$20 \cdot 10^6/50 \cdot 10^6$	$20 \cdot 10^6/50 \cdot 10^6$
Electrical life at rated load AC1 cycles	$200 \cdot 10^3$	$200 \cdot 10^3$	$150 \cdot 10^3$
Operate/release time ms	10/5	10/5	11/3
Insulation between coil and contacts (1.2/50 μs) kV	4	4	4
Dielectric strength between open contacts V AC	1,000	1,000	1,000
Ambient temperature range °C	–40…+85	–40…+85	–40…+85
Environmental protection	RT I	RT I	RT I
Approvals (according to type)	CE ANCE EAC Lloyd's Register RINA c UL us		

VI-2015, www.findernet.com

Ordering information

Example: 55 series plug-in relay, 4 CO (4PDT), 12 V DC coil, lockable test button and mechanical indicator.

A B C D
5 5 . 3 4 . 9 . 0 1 2 . 0 0 4 0

Series

Type
1 = PCB
3 = Plug-in

No. of poles
2 = 2 pole, 10 A
3 = 3 pole, 10 A
4 = 4 pole, 7 A

Coil version
8 = AC (50/60 Hz)
9 = DC

Coil voltage
See coil specifications

A: Contact material
0 = Standard AgNi
5 = AgNi + Au

B: Contact circuit
0 = CO (nPDT)

D: Special versions
0 = Standard
1 = Wash tight (RT III) for 55.12, 55.13 and 55.14 only

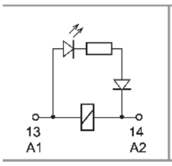
C: Options
0 = None
1 = Lockable test button
2 = Mechanical indicator
3 = LED (AC)
4 = Lockable test button+mechanical indicator
5 = Lockable test button + LED (AC)
54 = Lockable test button + LED (AC) + mechanical indicator
6* = Double LED (DC non-polarized)
7* = Lockable test button + double LED (DC non-polarized)
74* = Lockable test button + double LED (DC non-polarized) + mechanical indicator
8* = LED + diode (DC, polarity positive to pin A1/13)
9* = Lockable test button + LED + diode (DC, polarity positive to pin A1/13)
94* = Lockable test button + LED + diode (DC, polarity positive to pin A1/13) + mechanical indicator

* Option not available for the 220 V DC version.

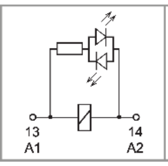
Selecting features and options: only combinations in the same row are possible.
Preferred selections for best availability are shown in **bold.**

Type	Coil version	A	B	C	D
55.32/34	AC-DC	0 - 5	0	0	0
	AC	**0** - 5	**0**	2 - 3 - **4** - 5	**0**
	AC	0 - 5	0	54	/
	DC	**0** - 5	**0**	2 - **4** - 6 - 7 - 8 - 9	**0**
	DC	0 - 5	0	74 - 94	/
55.33	AC-DC	**0** - 5	**0**	**0**	**0**
	AC	0 - 5	0	1 - 3 - 5	0
	DC	0 - 5	0	1 - 6 - 7 - 8 - 9	0
55.12/13/14	AC-DC	**0** - 5	**0**	**0**	**0** - 1

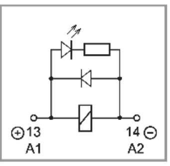
Descriptions: options and special versions



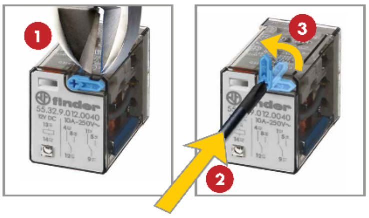
C: Option 3, 5, 54
LED (AC)



C: Option 6, 7, 74
Double LED
(DC non-polarized)



C: Option 8, 9, 94
LED + diode (DC, polarity positive to pin A1/13)



Lockable test button and mechanical flag indicator (0010, 0040, 0050, 0054, 0070, 0074, 0090, 0094)

EUROPEAN PATENT EUROPEAN

The dual-purpose Finder test button can be used in two ways:

Case 1) The plastic pip (located directly above the test button) remains intact. In this case, when the test button is pushed, the contacts operate. When the test button is released the contacts return to their former state.

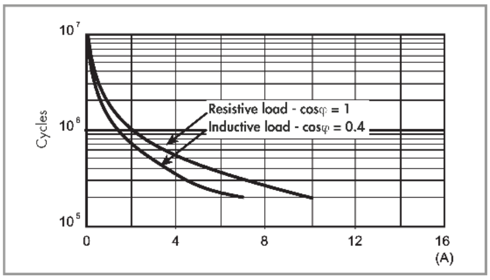
Case 2) The plastic pip is broken-off (using an appropriate cutting tool). In this case, (in addition to the above function), when the test button is pushed and rotated, the contacts are latched in the operating state, and remain so until the test button is rotated back to its former position. In both cases ensure that the test button actuation is swift and decisive.

Technical data

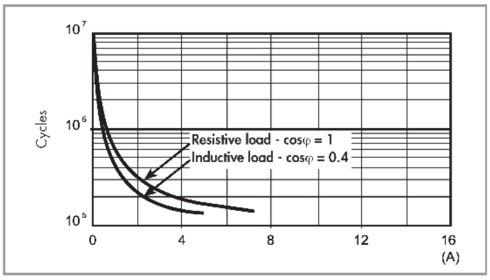
Insulation according to EN 61810-1		2 pole - 3 pole	4 pole
Nominal voltage of supply system	V AC	230/400	230
Rated insulation voltage	V AC	400	250
Pollution degree		2	2
Insulation between coil and contact set			
Type of Insulation		Basic	Basic
Overvoltage category		III	III
Rated impulse voltage	kV (1.2/50 µs)	4	4
Dielectric strength	V AC	2,000	2,000
Insulation between adjacent contacts			
Type of insulation		Basic	Basic
Overvoltage category		III	II
Rated impulse voltage	kV (1.2/50 µs)	4	2.5
Dielectric strength	V AC	2,000	2,000
Insulation between open contacts			
Type of disconnection		Micro-disconnection	Micro-disconnection
Dielectric strength	V AC/kV (1.2/50 µs)	1,000/1.5	1,000/1.5
Conducted disturbance immunity			
Burst (5...50)ns, 5 kHz, on A1 - A2		EN 61000-4-4	level 4 (4 kV)
Surge (1.2/50 µs) on A1 - A2 (differential mode)		EN 61000-4-5	level 4 (4 kV)
Other data			
Bounce time: NO/NC	ms	1/3	
Vibration resistance (5...55)Hz: NO/NC	g	15/15	
Shock resistance	g	16	
Power lost to the environment without contact current	W	1	
with rated current	W	3 (2 pole) 4 (3 pole)	3 (4 pole)
Recommended distance between relays mounted on PCB	mm	≥ 5	

Contact specification

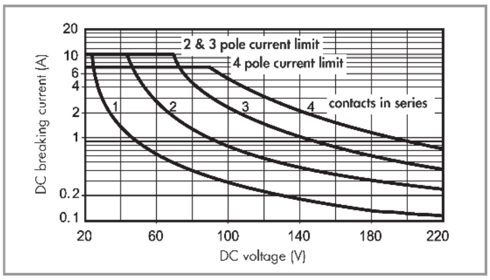
F 55 - Electrical life (AC) v contact current
2 and 3 pole relays



F 55 - Electrical life (AC) v contact current
4 pole relay



H 55 - Maximum DC1 breaking capacity



- When switching a resistive load (DC1) having voltage and current values under the curve, an electrical life of ≥ 100·10^3 can be expected.
- In the case of DC13 loads, the connection of a diode in parallel with the load will permit a similar electrical life as for a DC1 load. Note: the release time for the load will be increased.

Coil specifications

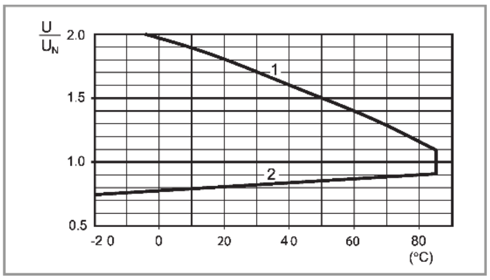
DC coil data

Nominal voltage U_N	Coil code	Operating range U_{min}	Operating range U_{max}	Resistance R	Rated coil consumption I at U_N
V		V	V	Ω	mA
6	**9**.006	4.8	6.6	40	150
12	**9**.012	9.6	13.2	140	86
24	**9**.024	19.2	26.4	600	40
48	**9**.048	38.4	52.8	2,400	20
60	**9**.060	48	66	4,000	15
110	**9**.110	88	121	12,500	8.8
125	**9**.125	100	138	17,300	7.2
220	**9**.220	176	242	54,000	4

AC coil data

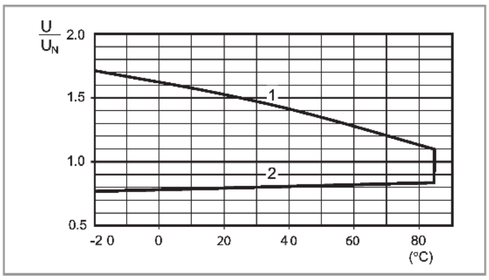
Nominal voltage U_N	Coil code	Operating range U_{min}	Operating range U_{max}	Resistance R	Rated coil consumption I at U_N (50Hz)
V		V	V	Ω	mA
6	**8**.006	4.8	6.6	12	200
12	**8**.012	9.6	13.2	50	97
24	**8**.024	19.2	26.4	190	53
48	**8**.048	38.4	52.8	770	25
60	**8**.060	48	66	1,200	21
110	**8**.110	88	121	4,000	12.5
120	**8**.120	96	132	4,700	12
230	**8**.230	184	253	17,000	6
240	**8**.240	192	264	19,100	5.3

R 55 - DC coil operating range v ambient temperature



1 - Max. permitted coil voltage.
2 - Min. pick-up voltage with coil at ambient temperature.

R 55 - AC coil operating range v ambient temperature



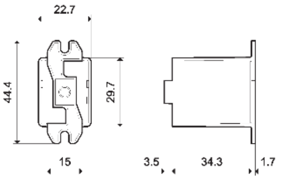
1 - Max. permitted coil voltage.
2 - Min. pick-up voltage with coil at ambient temperature.

Accessories

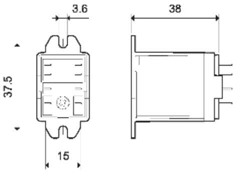

056.25


056.25 with relay

Top flange mount adaptor for 55.32, 55.33, 55.34	056.25



056.25

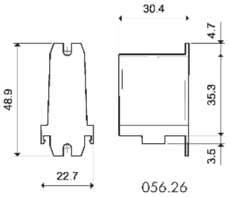


056.25 with relay

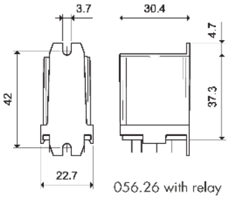

056.26


056.26 with relay

Rear flange mount adaptor for 55.32, 55.33, 55.34	056.26



056.26

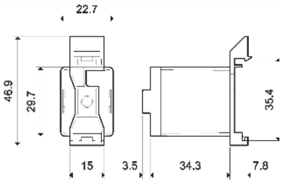


056.26 with relay

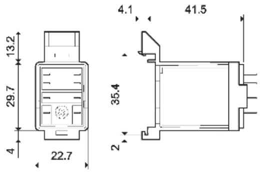

056.27


056.27 with relay

Top 35 mm rail (EN 60715) adaptor for 55.32, 55.33, 55.34	056.27



056.27



056.27 with relay

Anexo P.

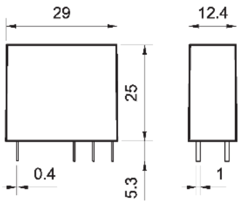
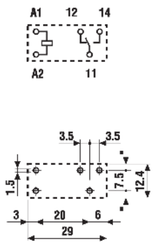
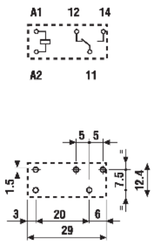
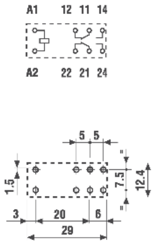
40 Series - Miniature PCB/Plug-in relays 8 - 10 - 16 A

Features

1 & 2 Pole relay range
40.31 - 1 Pole 10 A (3.5 mm pin pitch)
40.51 - 1 Pole 10 A (5 mm pin pitch)
40.52 - 2 Pole 8 A (5 mm pin pitch)

PCB mount
- direct or via PCB socket
35 mm rail mount
- via screw and screwless sockets

- DC coils (standard or sensitive) & AC coils
- Cadmium Free contact material
- 8 mm, 6 kV (1.2/50 µs) isolation, coil-contacts
- UL Listing (certain relay/socket combinations)
- Flux proof: RT II standard, (RT III option)
- 95 series sockets
- Coil EMC suppression
- Timer accessories 86 series

	40.31	40.51	40.52
			
	• 3.5 mm contact pin pitch • 1 Pole 10 A • PCB or 95 series sockets	• 5 mm contact pin pitch • 1 Pole 10 A • PCB or 95 series sockets	• 5 mm contact pin pitch • 2 Pole 8 A • PCB or 95 series sockets
			
For UL Horsepower and Pilot Duty ratings *See "General technical information" page V*	Copper side view	Copper side view	Copper side view

		40.31	40.51	40.52
Contact specification				
Contact configuration		1 CO (SPDT)	1 CO (SPDT)	2 CO (DPDT)
Rated current/Maximum peak current	A	10/20	10/20	8/15
Rated voltage/Maximum switching voltage	V AC	250/400	250/400	250/400
Rated load AC1	VA	2,500	2,500	2,000
Rated load AC15 (230 V AC)	VA	500	500	400
Single phase motor rating (230 V AC)	kW	0.37	0.37	0.3
Breaking capacity DC1: 30/110/220 V	A	10/0.3/0.12	10/0.3/0.12	8/0.3/0.12
Minimum switching load	mW (V/mA)	300 (5/5)	300 (5/5)	300 (5/5)
Standard contact material		AgNi	AgNi	AgNi
Coil specification				
Nominal voltage (U_N)	V AC (50/60 Hz)	6 - 12 - 24 - 48 - 60 - 110 - 120 - 230 - 240		
	V DC	5 - 6 - 7 - 9 - 12 - 14 - 18 - 21 - 24 - 28 - 36 - 48 - 60 - 90 - 110 - 125		
Rated power AC/DC/sens. DC	VA (50 Hz)/W/W	1.2/0.65/0.5	1.2/0.65/0.5	1.2/0.65/0.5
Operating range	AC	(0.8…1.1)U_N	(0.8…1.1)U_N	(0.8…1.1)U_N
	DC/sens. DC	(0.73…1.5)U_N/(0.73…1.75)U_N	(0.73…1.5)U_N/(0.73…1.75)U_N	(0.73…1.5)U_N/(0.73…1.75)U_N
Holding voltage	AC/DC	0.8 U_N /0.4 U_N	0.8 U_N /0.4 U_N	0.8 U_N /0.4 U_N
Must drop-out voltage	AC/DC	0.2 U_N /0.1 U_N	0.2 U_N /0.1 U_N	0.2 U_N /0.1 U_N
Technical data				
Mechanical life AC/DC	cycles	10 · 10^6/20 · 10^6	10 · 10^6/20 · 10^6	10 · 10^6/20 · 10^6
Electrical life at rated load AC1	cycles	200 · 10^3	200 · 10^3	100 · 10^3
Operate/release time	ms	7/3 - (12/4 sensitive)	7/3 - (12/4 sensitive)	7/3 - (12/4 sensitive)
Insulation between coil and contacts (1.2/50 µs)	kV	6 (8 mm)	6 (8 mm)	6 (8 mm)
Dielectric strength between open contacts	V AC	1,000	1,000	1,000
Ambient temperature range	°C	–40…+85	–40…+85	–40…+85
Environmental protection		RT II**	RT II**	RT II**
Approvals (according to type)		SA D FI PC Lloyd's Register N RINA S c RU us NF VDE		

** See general technical information "Guidelines for automatic flow solder processes" page II .

1

40 Series - Miniature PCB/Plug-in relays 8 - 10 - 16 A

Features

40.61 - 1 Pole 16 A (5 mm pin pitch)
40.xx.6 - Bistable versions of the 40.31, 40.51, 40.52 & 40.61 relays

PCB mount
- direct or via PCB socket
35 mm rail mount
- via screw and screwless sockets

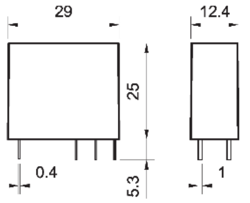
- DC coils & AC coils
- Cadmium Free option available
- 8 mm, 6 kV (1.2/50 μs) isolation, coil-contacts
- UL Listing (certain 40.61 relay/socket combinations)
- Flux proof: RT II standard, (RT III option)
- 95 series sockets
- Coil EMC suppression
- Timer accessories 86 series

40.61

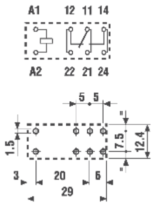
- 5 mm contact pin pitch
- 1 Pole 16 A
- PCB or 95 series sockets

40.xx.6

- Bistable (single coil) versions of 40.31/51/52/61
- PCB or 95 series sockets



For UL Horsepower and Pilot Duty ratings
See "General technical information" page V



Copper side view

Bistable version (1 coil) types:

40.31.6...
40.51.6...
40.52.6...
40.61.6...

For wiring diagrams see page 8

		40.61	40.xx.6
Contact specification			
Contact configuration		1 CO (SPDT)	
Rated current/Maximum peak current	A	16/30*	
Rated voltage/Maximum switching voltage	V AC	250/400	See relays
Rated load AC1	VA	4,000	40.31
Rated load AC15 (230 V AC)	VA	750	40.51
Single phase motor rating (230 V AC)	kW	0.55	40.52
Breaking capacity DC1: 30/110/220 V	A	16/0.3/0.12	40.61
Minimum switching load	mW (V/mA)	500 (10/5)	
Standard contact material		AgCdO	
Coil specification			
Nominal voltage (U_N)	V AC (50/60 Hz)	6-12-24-48-60-110-120-230-240	5 - 6 - 12 - 24 - 48 - 110
	V DC	***See table	5 - 6 - 12 - 24 - 48 - 110
Rated power AC/DC/sens. DC	VA (50 Hz)/W/W	1.2/0.65/0.5	1.0/1.0/—
Operating range	AC	$(0.8...1.1)U_N$	$(0.8...1.1)U_N$
	DC/sens. DC	$(0.73...1.5)U_N/(0.8...1.5)U_N$	$(0.8...1.1)U_N$/—
Holding voltage	AC/DC	0.8 U_N /0.4 U_N	—
Must drop-out voltage	AC/DC	0.2 U_N /0.1 U_N	—
Technical data			
Mechanical life AC/DC	cycles	$10 \cdot 10^6/20 \cdot 10^6$	See relays
Electrical life at rated load AC1	cycles	$100 \cdot 10^3$	40.31
Operate/release time	ms	7/3 - (12/4 sensitive)	40.51
Insulation between coil and contacts (1.2/50 μs)	kV	6 (8 mm)	40.52
Dielectric strength between open contacts	V AC	1,000	40.61
Ambient temperature range	°C	–40...+85	Min. impulse duration
Environmental protection		RT II**	≥ 20 ms
Approvals (according to type)		RINA	

* With the $AgSnO_2$ material the maximum peak current is 120 A - 5 ms on normally open contact.

*** Nominal voltage (U_N):
5 - 6 - 7 - 9 - 12 - 14 - 18 - 21 - 24 - 28 - 36 - 48 - 60 - 90 - 110 - 125 V DC

** See general technical information "Guidelines for automatic flow solder processes" page II.

40 Series - Miniature PCB/Plug-in relays 8 - 10 - 16 A

Features

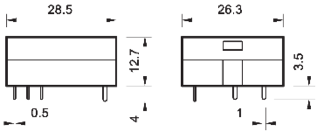
1 Pole relay range

40.11	**- 1 Pole 10 A (Flat pack)**
40.11-2016	**- 1 Pole 16 A (Flat pack)**
40.41	**- 1 Pole 10 A (Vertical)**

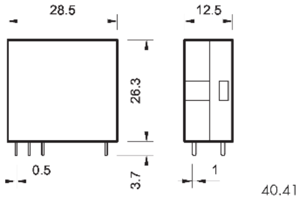
PCB mount

- direct or via PCB socket (40.41 version)

- DC coils
- Cadmium Free option available
- 8 mm, 6 kV (1.2/50 μs) isolation, coil-contacts
- 40.41 - NO version available



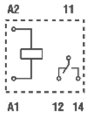
40.11

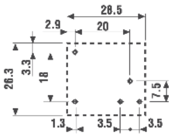


For UL Horsepower and Pilot Duty ratings
See "General technical information" page V

40.11

- 1 Pole 10 A
- Flat pack
- PCB mount

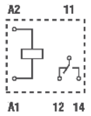


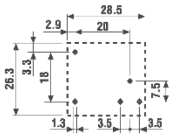


Copper side view

40.11-2016

- 1 Pole 16 A
- Flat pack
- PCB mount

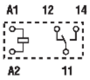


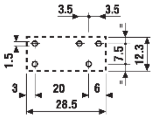


Copper side view

40.41

- 1 Pole 10 A
- Vertical
- PCB or 95 series socket





Copper side view

		40.11	40.11-2016	40.41
Contact specification				
Contact configuration		1 CO (SPDT)	1 CO (SPDT)	1 CO (SPDT)
Rated current/Maximum peak current	A	10/20	16/30	10/20
Rated voltage/Maximum switching voltage	V AC	250/400	250/400	250/400
Rated load AC1	VA	2,500	4,000	2,500
Rated load AC15 (230 V AC)	VA	500	750	500
Single phase motor rating (230 V AC)	kW	0.37	0.55	0.37
Breaking capacity DC1: 30/110/220 V	A	10/0.3/0.12	16/0.3/0.12	10/0.3/0.12
Minimum switching load	mW (V/mA)	300 (5/5)	500 (10/5)	300 (5/5)
Standard contact material		AgCdO	AgCdO	AgCdO
Coil specification				
Nominal voltage (U_N)	V AC (50/60 Hz)	–	–	–
	V DC	6 - 12 - 24 - 48 - 60	6 - 12 - 24 - 48	6 - 12 - 24 - 48 - 60
Rated power AC/DC/sens. DC	VA (50 Hz)/W/W	–/–/0.5	–/–/0.5	–/–/0.5
Operating range	AC	–	–	–
	DC/sens. DC	–/(0.73…1.75)U_N	–/(0.73…1.5)U_N	–/(0.73…1.75)U_N
Holding voltage	AC/DC	–/0.4 U_N	–/0.4 U_N	–/0.4 U_N
Must drop-out voltage	AC/DC	–/0.1 U_N	–/0.1 U_N	–/0.1 U_N
Technical data				
Mechanical life AC/DC	cycles	–/20 · 10^6	–/20 · 10^6	–/20 · 10^6
Electrical life at rated load AC1	cycles	200 · 10^3	50 · 10^3	200 · 10^3
Operate/release time	ms	12/4	12/4	12/4
Insulation between coil and contacts (1.2/50 μs)	kV	6 (8 mm)	6 (8 mm)	6 (8 mm)
Dielectric strength between open contacts	V AC	1,000	1,000	1,000
Ambient temperature range	°C	–40…+70	–40…+70	–40…+70
Environmental protection		RT I	RT I	RT I
Approvals (according to type)		РС c UL us VDE		

Ordering information

Example: 40 series PCB relay, 2 CO (DPDT), 230 V AC coil.

A B C D

4 0 . 5 2 . 8 . 2 3 0 . 0 0 0 0

Series

Type
1 = PCB - 3.5 mm pinning, flat
3 = PCB - 3.5 mm pinning
4 = PCB - 3.5 mm pinning
5 = PCB - 5 mm pinning
6 = PCB - 5 mm pinning

No. of poles
1 = 1 pole
for: 40.11, 10 A/16 A
40.31, 10 A
40.41, 10 A
40.51, 10 A
40.61, 16 A
2 = 2 pole
for: 40.52, 8 A

Coil version
6 = AC/DC bistable
7 = Sensitive DC
8 = AC (50/60 Hz)
9 = DC

Coil voltage
See coil specifications

A: Contact material
0 = Standard AgNi
for 40.31/51/52,
AgCdO for 40.61
2 = AgCdO (standard
for 40.11/41)
4 = AgSnO$_2$
5 = AgNi + Au (5 μm)

B: Contact circuit
0 = CO (nPDT)
3 = NO (nPST)

D: Special versions
0 = Standard
1 = Wash tight (RT III)
3 = High temperature (+ 125 °C) wash tight

C: Options
0 = None
16 = With rated current 16 A (for 40.11)

Selecting features and options: only combinations in the same row are possible.
Preferred selections for best availability are shown in **bold.**

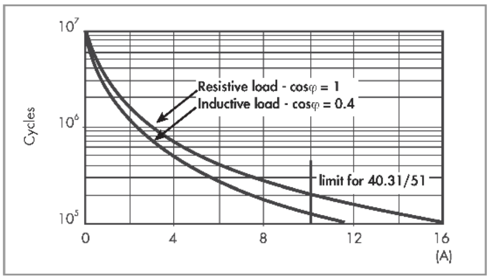
Type	Coil version	A	B	C	D
40.11	sensitive DC	**2** - 4	**0**	**0**	**0**
40.11	sensitive DC	**2** - 4	0	16	/
40.41	sensitive DC	0 - **2**	**0** - 3	**0**	**0**
40.31/51	AC-sens. DC	**0** - 2 - 5	**0** - 3	**0**	**0** - 1
40.31/51	DC	**0** - 2 - 5	**0** - 3	**0**	**0** - 1 - 3
40.52	AC-sens. DC	**0** - 2 - 5	**0** - 3	**0**	**0** - 1
40.52	DC	**0** - 2 - 5	**0** - 3	**0**	**0** - 1 - 3
40.61	AC-sens. DC	**0** - 4	**0** - 3	**0**	**0** - 1
40.61	DC	**0** - 4	**0** - 3	**0**	**0** - 1 - 3
40.31/51/52/61	bistable	**0**	**0**	**0**	**0**

Technical data

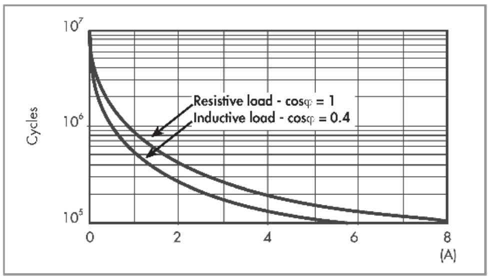
Insulation according to EN 61810-1					
		1 pole		**2 pole**	
Nominal voltage of supply system	V AC	230/400		230/400	
Rated insulation voltage	V AC	250	400	250	400
Pollution degree		3	2	3	2
Insulation between coil and contact set					
Type of insulation		Reinforced (8 mm)		Reinforced (8 mm)	
Overvoltage category		III		III	
Rated impulse voltage	kV (1.2/50 µs)	6		6	
Dielectric strength	V AC	4,000		4,000	
Insulation between adjacent contacts					
Type of insulation		—		Basic	
Overvoltage category		—		II	
Rated impulse voltage	kV (1.2/50 µs)	—		2.5	
Dielectric strength	V AC	—		2,000	
Insulation between open contacts					
Type of disconnection		Micro-disconnection		Micro-disconnection	
Dielectric strength	V AC/kV (1.2/50 µs)	1,000/1.5		1,000/1.5	
Conducted disturbance immunity					
Burst (5...50)ns, 5 kHz, on A1 - A2		EN 61000-4-4		level 4 (4 kV)	
Surge (1.2/50 µs) on A1 - A2 (differential mode)		EN 61000-4-5		level 3 (2 kV)	
Other data					
Bounce time: NO/NC	ms	2/5			
Vibration resistance (5…55)Hz: NO/NC	g	10/4 (1 changeover)		15/3 (2 changeover)	
Shock resistance	g	13			
Power lost to the environment without contact current	W	0.6			
with rated current	W	1.2 (40.11/31/41/51)		2 (40.61/52/40.11-2016)	
Recommended distance between relays mounted on PCB	mm	≥ 5			

Contact specification

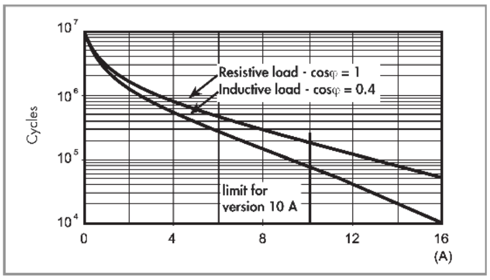
F 40 - Electrical life (AC) v contact current
Types 40.31/51/61



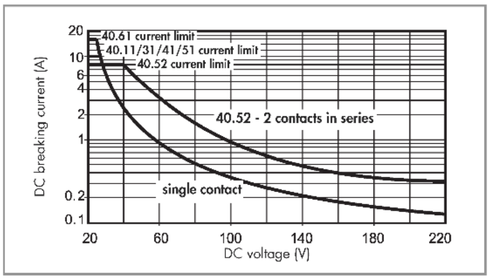
F 40 - Electrical life (AC) v contact current
Type 40.52



F 40 - Electrical life (AC) v contact current
Types 40.11/41



H 40 - Maximum DC1 breaking capacity



- When switching a resistive load (DC1) having voltage and current values under the curve, an electrical life of ≥ 100·10^3 can be expected.
- In the case of DC13 loads, the connection of a diode in parallel with the load will permit a similar electrical life as for a DC1 load.
  Note: the release time for the load will be increased.

Coil specifications

DC coil data - 0.65 W standard (types 40.31/51/52/61)

Nominal voltage	Coil code	Operating range		Resistance	Rated coil consumption
U_N		U_{min}	U_{max}	R	I at U_N
V		V	V	Ω	mA
5	9.005	3.65	7.5	38	130
6	9.006	4.4	9	55	109
7	9.007	5.1	10.5	75	94
9	9.009	6.6	13.5	125	72
12	9.012	8.8	18	220	55
14	9.014	10.2	21	300	47
18	9.018	13.1	27	500	36
21	9.021	15.3	31.5	700	30
24	9.024	17.5	36	900	27
28	9.028	20.5	42	1,200	23
36	9.036	26.3	54	2,000	18
48	9.048	35	72	3,500	14
60	9.060	43.8	90	5,500	11
90	9.090	65.7	135	12,500	7.2
110	9.110	80.3	165	18,000	6.2
125	9.125	91.2	188	23,500	5.3

DC coil data - 0.5 W sensitive (types 40.31/51/52/61)

Nominal voltage	Coil code	Operating range		Resistance	Rated coil consumption
U_N		U_{min}*	U_{max}**	R	I at U_N
V		V	V	Ω	mA
5	7.005	3.7	8.8	50	100
6	7.006	4.4	10.5	75	80
7	7.007	5.1	12.2	100	70
9	7.009	6.6	15.8	160	56
12	7.012	8.8	21	300	40
14	7.014	10.2	24.5	400	35
18	7.018	13.2	31.5	650	27.7
21	7.021	15.4	36.9	900	23.4
24	7.024	17.5	42	1,200	20
28	7.028	20.5	49	1,600	17.5
36	7.036	26.3	63	2,600	13.8
48	7.048	35	84	4,800	10
60	7.060	43.8	105	7,200	8.4
90	7.090	65.7	157	16,200	5.6
110	7.110	80.3	192	23,500	4.7
125	7.125	91.2	219	32,000	3.9

*U_{min} = 0.8 U_N for 40.61 **U_{max} = 1.5 U_N for 40.61

DC coil data - 0.5 W sensitive (types 40.11/41)

Nominal voltage	Coil code	Operating range		Resistance	Rated coil consumption
U_N		U_{min}	U_{max}*	R	I at U_N
V		V	V	Ω	mA
6	7.006	4.4	10.5	75	80
12	7.012	8.8	21	300	40
24	7.024	17.5	42	1,200	20
48	7.048	35	84	4,600	10.4
60	7.060	43.8	105	7,200	8.3

*U_{max} = 1.5 U_N for 40.11-2016

AC coil data (types 40.31/51/52/61)

Nominal voltage	Coil code	Operating range		Resistance	Rated coil consumption
U_N		U_{min}	U_{max}	R	I at U_N (50Hz)
V		V	V	Ω	mA
6	8.006	4.8	6.6	21	168
12	8.012	9.6	13.2	80	90
24	8.024	19.2	26.4	320	45
48	8.048	38.4	52.8	1,350	21
60	8.060	48	66	2,100	16.8
110	8.110	88	121	6,900	9.4
120	8.120	96	132	9,000	8.4
230	8.230	184	253	28,000	5
240	8.240	192	264	31,500	4.1

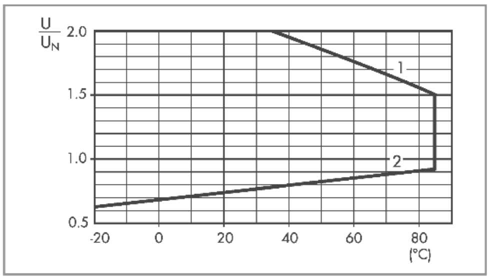
AC/DC coil data - bistable (types 40.31/51/52/61)

Nominal voltage	Coil code	Operating range		Resistance	Rated coil consumption	DC: Release resistance**
U_N		U_{min}	U_{max}	R	I at U_N	R_{DC}
V		V	V	Ω	mA	Ω
5	6.005	4	5.5	23	215	37
6	6.006	4.8	6.6	33	165	62
12	6.012	9.6	13.2	130	83	220
24	6.024	19.2	26.4	520	40	910
48	6.048	38.4	52.8	2,100	21	3,600
110	6.110	88	121	11,000	10	16,500

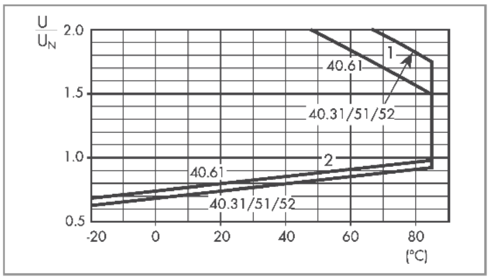
** R_{DC} = Resistance in DC, R_{AC} = 1.3 x R_{DC} 1W

Coil specifications

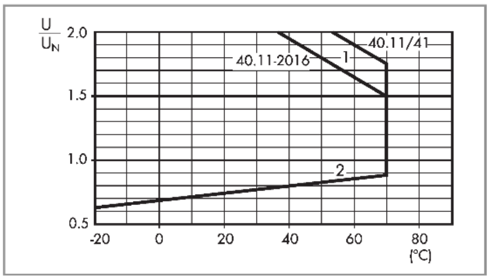
R 40 - DC coil operating range v ambient temperature
Standard coil



R 40 - DC coil operating range v ambient temperature
Sensitive coil, types 40.31/51/52/61

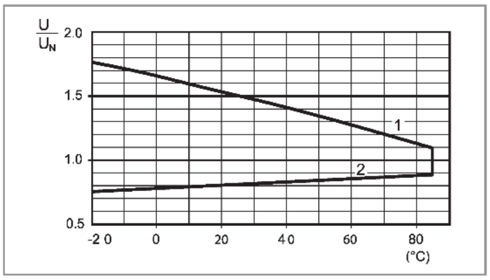


R 40 - DC coil operating range v ambient temperature
Sensitive coil, types 40.11/41



1 - Max. permitted coil voltage.
2 - Min. pick-up voltage with coil at ambient temperature.

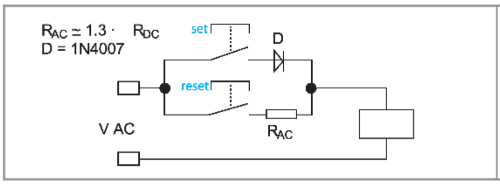
R 40 - AC coil operating range v ambient temperature



1 - Max. permitted coil voltage.
2 - Min. pick-up voltage with coil at ambient temperature.

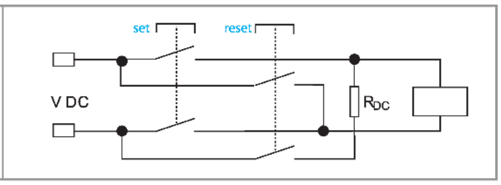
Wiring diagram for 40 series bistable coil version

AC Operation



On momentary closure of the SET switch the relay is magnetised through the diode and the relay contacts transfer to the set position and remain in this position.
On momentary closure of the RESET switch the relay is demagnetised through limiting resistor (R_{AC}) and the contacts return to the reset position.

DC Operation



On momentary closure of the SET switch the relay is magnetised and the relay contacts transfer to the set position and remain in this position.
On momentary closure of the RESET switch the relay is demagnetised through limiting resistor (R_{DC}) and the contacts return to the reset position.

Notes: The minimum SET or RESET impulse time is 20 ms. The maximum time can be continuous. In practice, always ensure that the SET and RESET contacts cannot be operated simultaneously.

Histórico

- 1 de Outubro de 2015, Versão 1.0, mailto:ranginha@gmail.com