CLIPSAL

C-Bus™

energy management system

TECHNICAL OVERVIEW

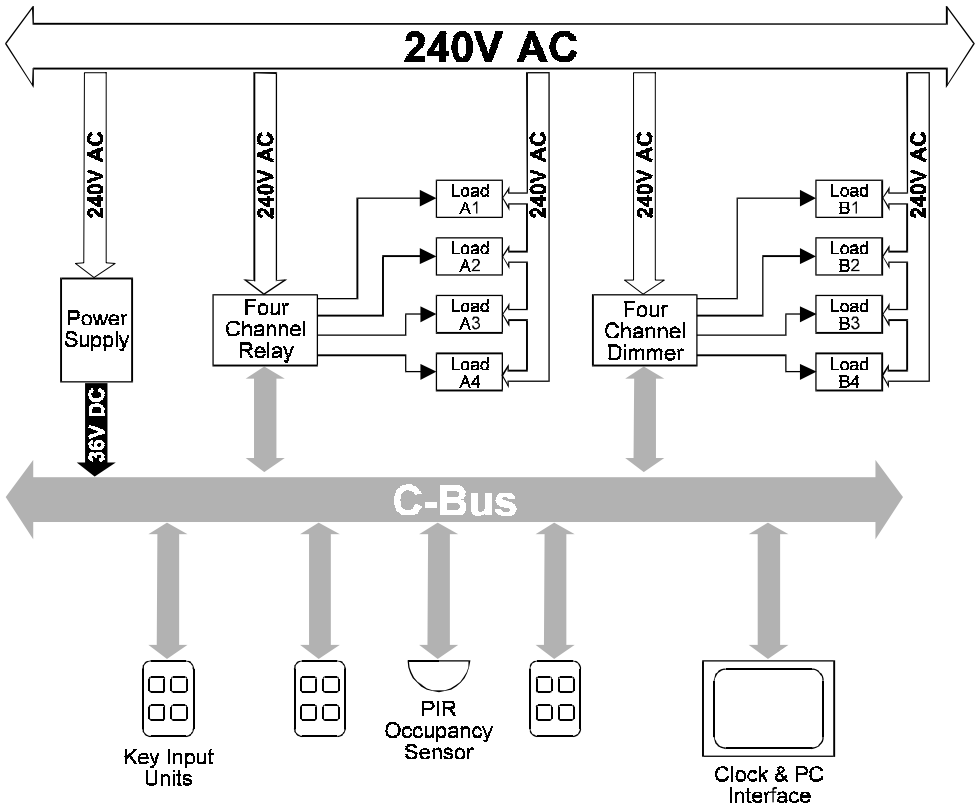
What is C-Bus?

C-Bus is a micro-processor controlled wiring system that uses unshielded twisted pair 'Category 5' data cable as its communication medium to control lighting, air-conditioning, fire detection systems, access control systems, security and other applications in any building.

C-Bus may be integrated as part of an overall energy management system.

The system is highly flexible in the way it operates because each device communicating on the Bus has its own in-built microprocessor. These devices can be programmed to provide optimum energy management conditions in any installation.

Information comes from Input Units such as Keys, Light Level and Passive Infra-red Occupancy Sensors, and messages are sent via the Bus to appropriate Output Units such as Relays and Dimmers. Messages are used to control the loads connected to the Output Units.



Schematic Representation of the Components of the C-Bus System

Why C-Bus?

Electrical wiring practices have not changed significantly since the advent of multi-core insulated cabling. Wiring requirements in commercial buildings, however, have been rapidly changing since that innovation. The addition of security systems, fire and smoke detection systems and energy management systems has placed high demands on electrical installations.

The need for central monitoring and control of these extra systems can also result in massive networks of wires emanating from the control area.

Conventional wiring practices require the current which flows through the load – lights for example – to also flow through the switch controlling the load. This requires heavy conductors to run from the switchboard to the load and from the switchboard and load to the controlling switch or switches.

The C-Bus Network overcomes these problems. It uses a single twisted pair of wires such as standard data cable to communicate signals between light switches and load controlling devices in a building. This method greatly reduces the number of heavy wires required in any given installation. It also enables easy central monitoring and control of all systems, if required.

C-Bus can be expanded to control and monitor all electrical appliances within a building, or part of a building – all from a personal computer. Security, air-conditioning and other systems can be programmed to turn on or off at particular times or with a particular signal, and lighting and temperature can be controlled to vary according to ambient conditions.

Cost Advantages

C-Bus offers an attractive return on investment in the following ways:

- **Energy savings**. By using an intelligent energy control system, the monitoring of various room conditions, ambient light levels and temperature settings can be managed efficiently providing considerable cost savings.

- **Ease of installation**. C-Bus installations are generally easier and take less time than conventional electrical installations.

- **Cost of installation**. Wiring costs are significantly reduced.

- **Alterations**. When modifications to the electrical installations or configurations within a building are required due to renovations or changing needs, C-Bus can simply be re-programmed to suit the new layout without the need to re-wire.

How C-Bus Works

The C-Bus method of wiring can provide a low cost alternative to other specialised networks which are currently required to achieve central control. Units on the C-Bus Network each have their own built-in microprocessor, allowing them to operate independently with "distributed intelligence.

C-Bus makes use of commonly available ‘Category 5’ data cable for connecting the units. The C-Bus not only provides the means of communication but also the small amount of power needed to operate the circuitry within each C-Bus unit. The C-Bus is electrically isolated from the mains power, and operates at safe extra low voltage levels, making the switches and sensors on the C-Bus very safe to use.

C-Bus System - Technical Specifications

Cable Type

Unshielded Twisted pair (Category 5) data cable.

Topology

Unrestricted, units are wired in parallel. (i.e. tree, star, combination).

Maximum Distance between Units on a sub-network

1000 metres.

Maximum Total Wire Length per sub-Network

1000 metres.

System Voltage

At any point in the Network, the voltage across a C-Bus unit must be in the range of 15V d.c. to 36V d.c.

Maximum Number of Units per sub-Network

This is limited to 100 C-Bus units due to unit input impedance limitations.

Nominal sub-Network Impedance

For a fully loaded sub-Network with 100 C-Bus units including a PC Interface with Network Burden selected, the a.c. Network impedance is typically 500Ω at communication frequencies.

Communication rate

500 bytes per second. One clock pulse, 8 data bits plus one parity bit per byte

Data rate

Approximately 3500 bits/sec. for data transmission, 64 byte frames

Communication bandwidth

3 kHz to 20 kHz

Addressing capacity

- 255 unique Unit Addresses (per sub-Network)
- 255 unique Area Addresses (per sub-Network)
- 255 unique Group Addresses (per sub-Network)
- 255 unique Application Addresses
- 255 unique Network Addresses

C-Bus Communication protocol

Synchronous Carrier Sense, Multiple Access with Collision Detection, implemented with Collision Avoidance (CSMA/CD-CA).

C-Bus System – Hardware Architecture

Network Configuration

Connection to a C-Bus Network can take on any configuration. From daisy chain, to tree type, or a combination of both.

A maximum number of 255 sub-Networks can be connected to form one complete C-Bus network.

The C-Bus network is made up of one or more sub-Networks. Should either the route length of cable or the number of Units on a sub-Network be exceeded, another sub-Network may be added. Multiple sub-Networks are linked using C-Bus Network Bridges.

Each sub-Network is made up of a combination of Input and Output Units. A maximum of 100 Units may be connected to each C-Bus sub-Network with a route length of cable not exceeding 1000 metres on each sub-Network.

C-Bus Addressing Structure

There are five levels of addressing on the C-Bus system. Each level uses a hexi-decimal method of addressing.

Network Address

The first level of addressing is the Network Address. This can be a 2 digit hexadecimal address from 00 through to FF. Each C-Bus sub-Network must have it's own individual Network Address.

Unit Address

All units on C-Bus have a unique identity code called a Unit Address. This code forms part of the messages sent on the bus so that only one unit corresponding to that address responds. These messages are typically used to program the operating variables of C-Bus.

Application Address

In addition to Unit Addresses, units on C-Bus can be identified by their Application Address. Various units on C-Bus can be grouped together so that Commands issued to that group will not affect other units.

Area Address

An Area Address is used to allow division of the sub-Network into separate, large areas of control. A single Input Unit can issue a Command to Output Units operating on different groupings within the same Area Address.

Group Address

The C-Bus address scheme enables you to define up to 255 different groups of loads on a C-Bus sub-Network, with each group able to be controlled separately.

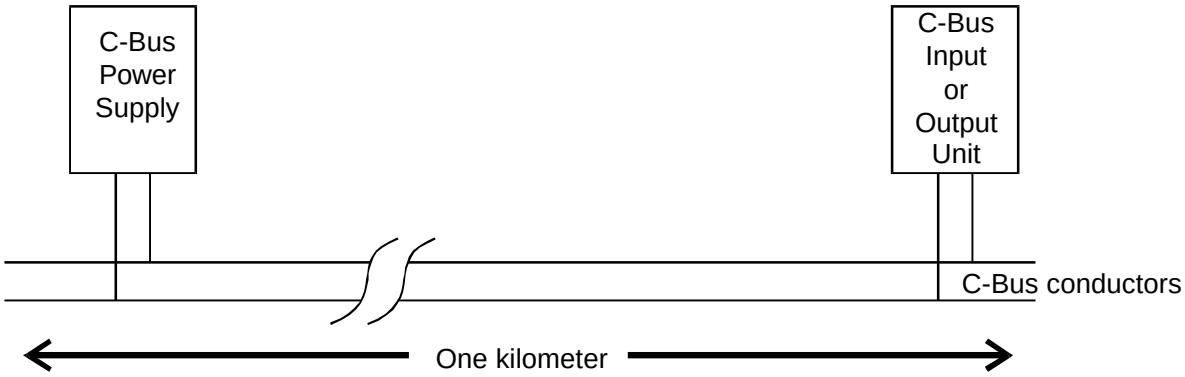
C-Bus System – System Communication Device Details

C-Bus Power Supply units

The C-Bus system operates at a safe extra low voltage level. The minimum voltage required by any device on the bus is 15 volts d.c, so allowing for voltage drops due to cable resistance; the actual potential supplied must be greater than this value.

The maximum C-Bus voltage is 36 V d.c. This value optimises power dissipation from any device and voltage drops across the Network.

The resistance of a typical C-Bus twisted-pair conductor is 90 ohms per Km. The maximum current requirement of any one C-Bus device is approximately 18mA. So, if one device is connected to the end of a 1 Km C-Bus, the voltage drop would be $90 \times 18 \times 10^{-3}$ or 1.6 V.



Resistance = 90 Ohms
Current = 18 mA per devices
Voltage drop = 1.6 V per device per km

In an actual installation, the power supplies should be distributed evenly along the C-Bus rather than at the beginning of the 1 Km length in order to minimise the voltage drops in the system.

Output Current Limiting

One of the many advantages of the C-Bus extra low d.c. operating voltages is that connections can be made while the Network is still powered up. Should a short-circuit occur while this is happening, the Power Supply 's output current limiting/overload protection will protect it from damage for an indefinite time period.

DC Output Regulation

To enhance the reliability of the Power Supplies being used on a C-Bus Network, it is desirable that they all contribute equally to the Network's power requirements. Effective positioning of the Power Supplies will help achieve this result.

The Power Supplies have an ability to drop their output voltage under heavy load, which ensures that, given more than one Supply on a Network, they will share the total load current more evenly.

AC Output Impedance

C-Bus messages are voltage pulses, which are superimposed upon the d.c. Power Supply voltage. This requires high AC impedance to be present at the communication frequencies. The Power Supply has a special output stage, which provides this impedance.

Network Bridge

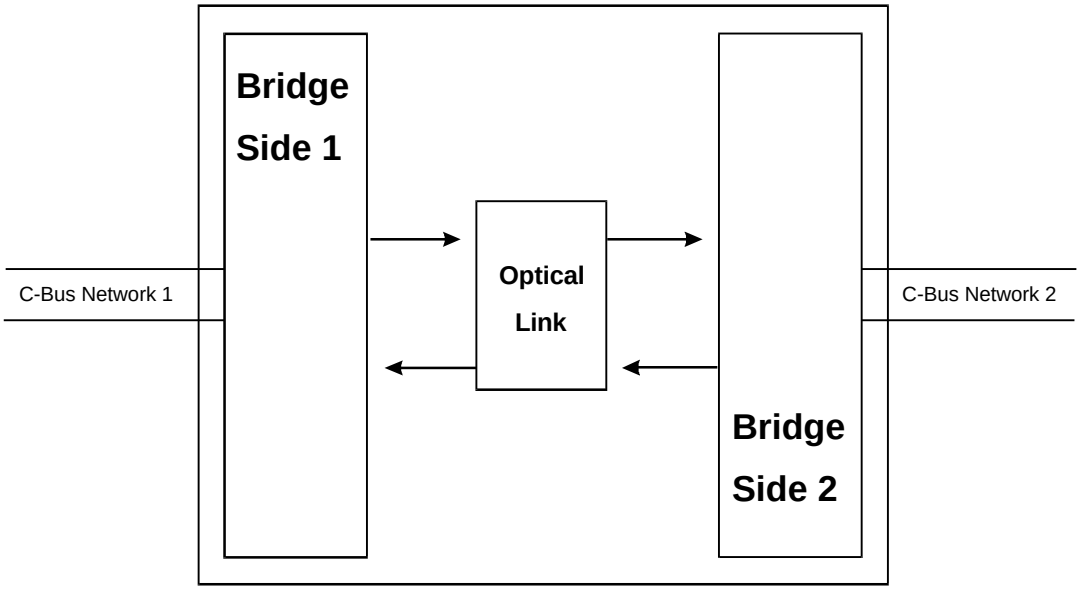
The Network Bridge is a C-Bus unit which allow a communication between two or more C-Bus sub-Networks, while maintaining electrical isolation between them.

The C-Bus Network Bridge facilitates:

- the relaying of messages between sub-Networks, to allow all units on multiple sub-Networks within the one installation to be programmed and monitored from a central location.
- the transmission of ON, OFF and RAMP TO LEVEL Commands, to allow the control of Output Units on one sub-Network by Input Units on another. Units across several sub-Networks can be assigned the same Group Address to provide this high level of control.
- the collection of status information from all units on multiple sub-Networks by a central monitoring tool for Network maintenance.

The C-Bus Network Bridge consists of two functionally and electrically independent systems. Each system consists of a communication interface together with an associated micro-controller, which is powered by the safe extra low C-Bus voltage from each of the two sub-Networks to which it is connected.

The Network Bridge functions as a system clock on the C-Bus Network or can act as a redundant clock generator if one is already present.



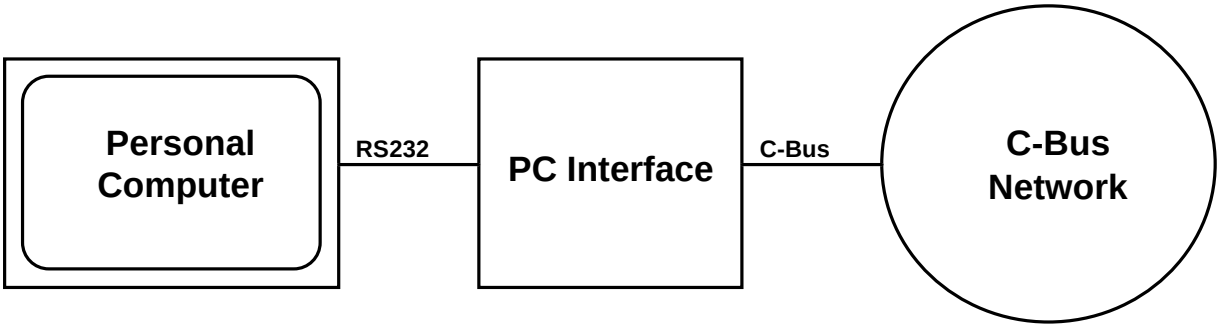
Each Network Bridge provides optically isolated communication between sub-networks, so that introducing bridges will not impair the reliability of the overall system.

PC Interface

The PC interface is designed to provide an isolated communication path between a personal computer/modem and a C-Bus Network.

The C-Bus PC Interface facilitates:

- programming of the C-Bus units
- issuing Commands to the C-Bus units
- C-Bus Network monitoring/logging
- generates system clock for synchronised data transmissions
- provides a Network Burden required by the C-Bus Network



C-Bus Status Report updating

In order to ensure that the overall reliability of the system is not less than that of conventional wiring systems, a Status Report is communicated between all units within any Application on a regular basis. This Status Report is coordinated by the last Input Unit which issued a Command, or, failing this, any other Input Unit operating in the Application concerned.

The Status Report gathers information from all Output Units and sends this to all Input Units so that if any state disagreement exists, the Input Units can adjust. Disagreements between units may result from the intentional disconnection of one or more units from a Network, or from a power failure of the overall system in some cases.

In response to a state disagreement within a Status Report, Input Units may reassign their internal state, or may transmit a Command to ensure that all Output Units are set to the same state as the Input Unit.

C-Bus Power Failure issues

Each unit on C-Bus incorporates a microprocessor and non-volatile memory, operating independently from any central control. All programmed parameters are stored in non-volatile memory allowing them to retain their settings in the event of power failure. In this way, when power is restored the entire Network can resume operating as if power were always available. Units can also be programmed to reset to a predetermined state in the event of temporary loss of power.

Power Surges

C-Bus side

The C-Bus Network connection of every C-Bus unit incorporates transient protection circuitry to safeguard against the effects of unintentionally induced Network voltages. During transient conditions, information may be lost, however the C-Bus system incorporates a mechanism to recover from such losses.

Mains side

The mains voltage must be limited to the range specified for any unit which is mains powered. Each unit incorporates transient protection circuitry, and additional external power surge protection devices may be used (e.g. Clipsal 970) to enhance system immunity to power surges.

Megger Testing

Megger testing of an electrical installation, which has C-Bus units connected, will not cause any damage to the C-Bus units. Since C-Bus units contain electronic components, the installer should interpret megger readings with due regard to the nature of the circuit connection.

C-Bus System – Input Units

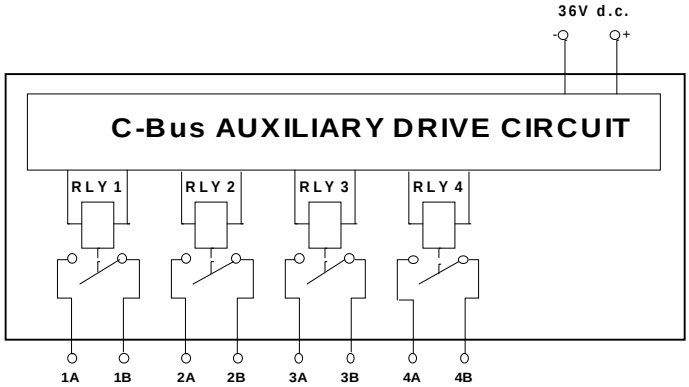
Key Input Units

The types of Input Units are 1, 2, and 4 Key Input Units, each requiring only a 2 wire connection to other units on the network. Key Input Units are fully programmable and can be used to control relay, dimmer or Analogue Output Units.

Complicated wiring systems (multiway switching) can be easily achieved using a C-Bus system, as each Key Input Unit need only be wired with a single UTP cable. Each "key" is capable of controlling one or more loads via a Group Address thus allowing up to four loads to be controlled. Status indicators (LED's) are included in each key to confirm the state of the load. These indicators can be set up for a number of different conditions and are programmed via the C-Bus software.

Auxiliary Key Input Unit

The Four Channel Auxiliary Switch Input permits voltage free switches to be used on C-Bus. Being an input device it transmits messages to output devices to control load states. Each input is capable of controlling a combination of loads, associated with a Group Address, allowing up to four groups of loads to be controlled. Combinations of inputs can be programmed to the same Group Address and



therefore control the same loads, perhaps in different ways.

The remote switches are electrically isolated from the C-Bus by the use of transformers on each channel input, located on the Auxiliary Switch Input Unit. There is no restriction on cable type between remote switches and the unit. A standard toggle switch mechanism such as a 30M or a 30MBP momentary push button switch would be examples of these mechanisms.

As with other C-Bus units, the Auxiliary Key Input Unit can be programmed to set their unique identification and the mode of operation on the C-Bus network.

PIR Occupancy Sensor

The Passive Infra-red (PIR) Occupancy Sensor is a C-Bus accessory that senses the natural thermal (infra-red) radiation emitted by any warm body. It is used as an automatic switching device in lighting applications by detecting and responding to changes in infra-red levels. The PIR Occupancy Sensor is an Input Unit, and thus can control any loads which share the Group Addresses.

Two types of sensors are available, one outdoor model, which is fully weather protected, and one model intended for indoor use only. Both models incorporate PIR, Light Level, Sunset Switch and Security modes of operation, all of which are selectable via the C-Bus software.

When a warm body moves in front of the sensor, the unit sends a message to the C-Bus and any loads having the same Group Address respond in a pre-programmed way. The PIR Occupancy Sensor can be used to control both switched and dimmed loads on corresponding Output Units. Control of the units is as per the description for Key Input Units.

The C-Bus PIR Occupancy Sensor Type 'SENSOR' consists of a light level sensor as well as the infra-red sensor. Light level sensing is used to produce different behaviour in response to infra-red activity depending on the ambient light level in the area under observation. The light level sensor threshold can be manually adjusted.

Type 'SENPIRSS' C-Bus PIR Occupancy Sensor has a facility to use the device as a sunset switch, automatically turning loads on for a pre-defined period conditional on ambient light conditions. The sensor also incorporates a security facility which detects motion independent of light conditions. A built in light emitting diode can be programmed to indicate when movement has been detected providing a valuable aid during installation and commissioning.

As with other C-Bus units, the PIR Occupancy Sensors must be programmed to set their unique identification and the mode of operation in the C-Bus Network.

Light Level Sensor

The Light Level Sensor is a transducer which measures ambient light levels and converts this information into messages sent across the C-Bus to be interpreted by appropriate Output Units. The Light Level Sensors continually measure the illuminance level in their vicinity. Output Units use this light level information to regulate light levels in a working area.

The Light Level Sensor is capable of measuring ambient light in the range of 20 to 3000 Lux. The sensor converts the light level logarithmically into a value between 0 and 100 %, and compares this value with the Brightness setting. If the sensor determines that the measured illumination differs from the Brightness setting by more than the Margin, it will issue a Ramp To Level message (to output units whose Group Addresses are the same as the Sensor' s Level Group Address) to attempt to correct the situation.

Any Output Units programmed to respond to the nominated Group Address will respond to the Ramp To Level command and will change the intensity of the lights that they control. In this way, lamps can maintain a constant level of illumination across a pre-determined area.

If the natural ambient light level is such that extra illumination is not necessary, an OFF message is transmitted across the Network to Output Units programmed to respond to the same Group Address.

Temperature Sensor

The Temperature Sensor is a transducer that measures ambient temperature and converts this information into messages sent across the C-Bus to be interpreted by appropriate Output Units. This information is also displayed in a panel within the GUI Template and in the icon caption when the Template is minimised.

The unit is capable of measuring ambient temperature within the range of 0 to 50 ^{0}C with an accuracy of approximately half a degree.

The Temperature Sensor monitors the surrounding temperature, and can be used to control either heating, or cooling equipment in order to maintain a comfortable working temperature.

The Sensor incorporates adjustable hysteresis, so that the installer can define the maximum and minimum temperature limits for regulation. The minimum hysteresis for the Temperature Sensor is 2 degrees. By allowing for greater hysteresis, the number of On/Off cycles are reduced. The Temperature Sensor incorporates an adjustable, selectable offset temperature of up to 30 degrees, used to achieve an “economy” temperature setting which can be enabled or disabled by any other C-Bus Input Unit.

A programmable indicator (LED) is included on the front plate of the unit. This indicator can be used to monitor the current state of the heating, or cooling equipment, or can be used to indicated when the “economy” mode is selected.

In addition to control, the ambient temperature measured by the Temperature Sensor can be read by other devices connected to the C-Bus Network via a PC Interface, for monitoring or logging purposes.

2 Channel, 7 Day Clock Module

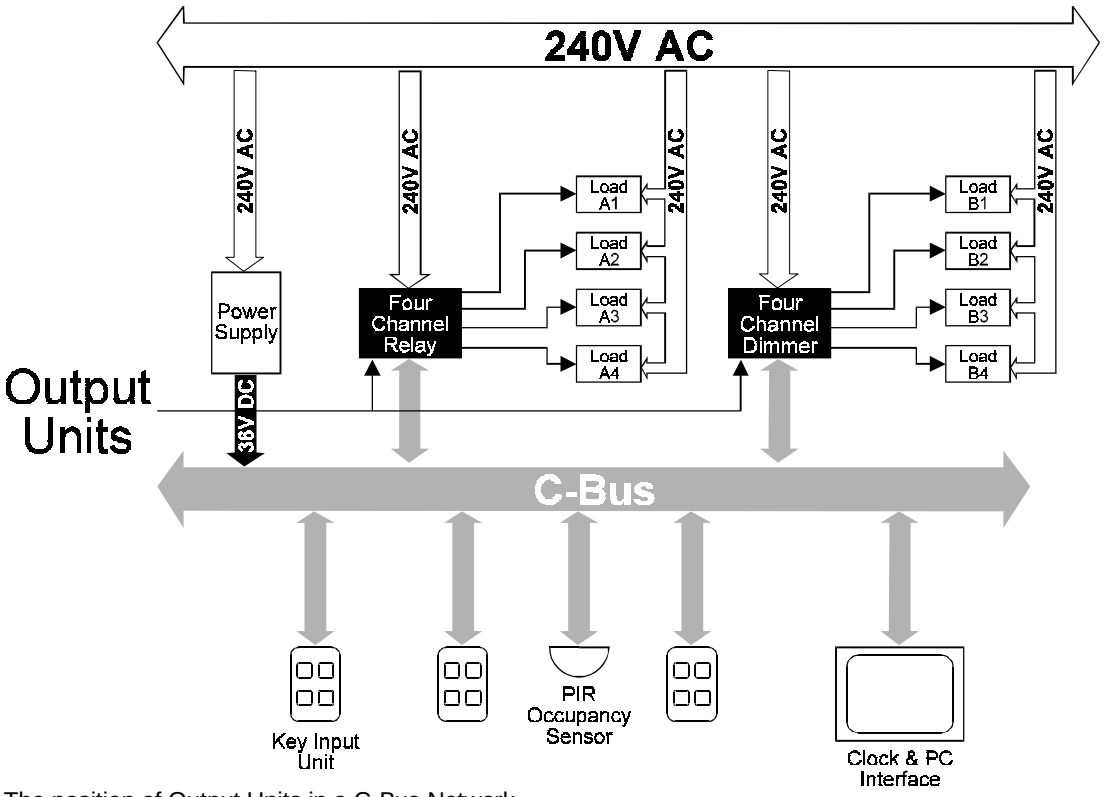
The Clock Module is a 2 channel input device with a maximum cycle time of 7 days. Events may be programmed on the C-Bus with a minimum repetition rate of 1 day and maximum rate of 7 days. The Clock Module uses a real time clock to keep an accurate measure of time. In the event of power loss, the clock function is maintained for up to 24 hours.

Programmed events are entered via a key pad located on the front of the unit where a LCD display of the current time is also displayed. Up to eight On/Off events may be programmed on each channel. Two channels provide the flexibility for up to 4 Group Addresses to be assigned to the unit.
A facility to adjust for daylight savings is incorporated on the unit.

C-Bus System – Output Units

C-Bus Output Units control external devices connected to it in a manner determined by instructions received across the C-Bus from the respective Input Unit.

Output Units are programmable in order to behave in a way that suits the needs of that particular installation



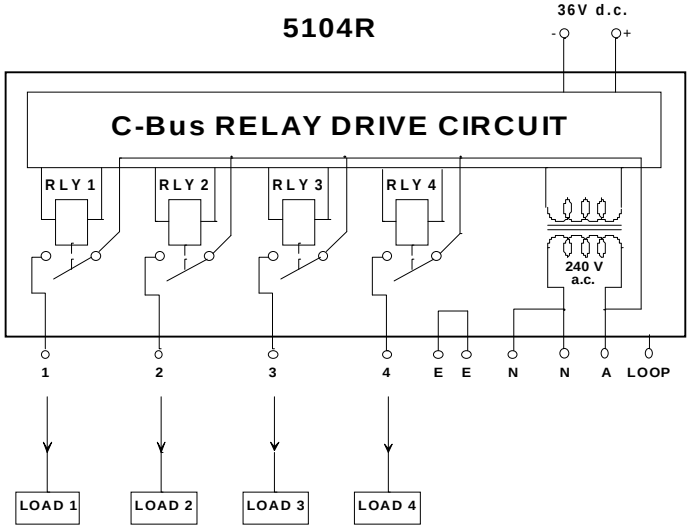
The position of Output Units in a C-Bus Network

Output Unit Types

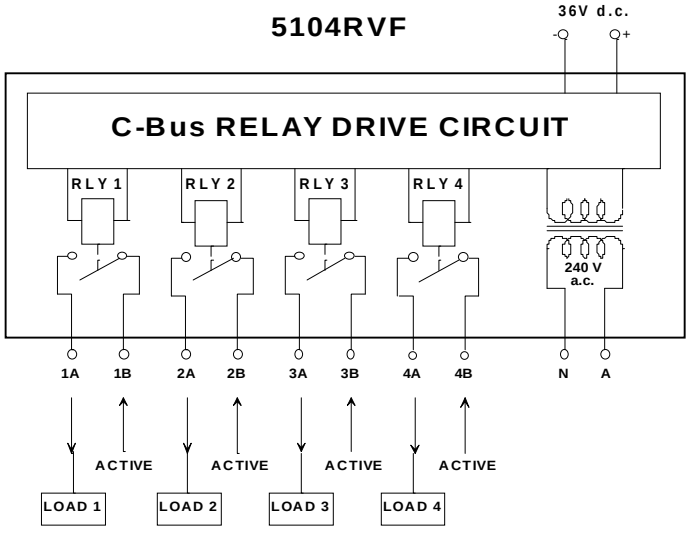
Relay Units

The 5104R is an output device used to switch resistive and inductive loads. The unit has a total load capacity of 20A, while each channel is capable of switching a maximum of 10A. The 5104R provides four switched active output connections. All loads are on the same phase.

The 5104RVF is an output device used to switch resistive and inductive loads. The unit has a total capacity of 40A, while each channel is capable of switching a maximum of 10A, with no de-rating for power factor corrected fluorescent loads. The 5104RVF has four voltage free contacts offering more flexible switching options. ie. Switching for 3 phase applications.



The Four Channel Relay Unit, 5104R Switches Mains Power to the Load



The Four Channel Relay Unit, 5104RVF Voltage Free Relay

Options on the 5104R and 5104RVF

The Four Channel Relay Units will, by default, revert all the outputs to the On state if C-Bus power is lost. This maybe changed by setting the on the Printed Circuit Board. The jumper settings offer the user to have the C-Bus outputs in the Off state if the C-Bus power is lost.

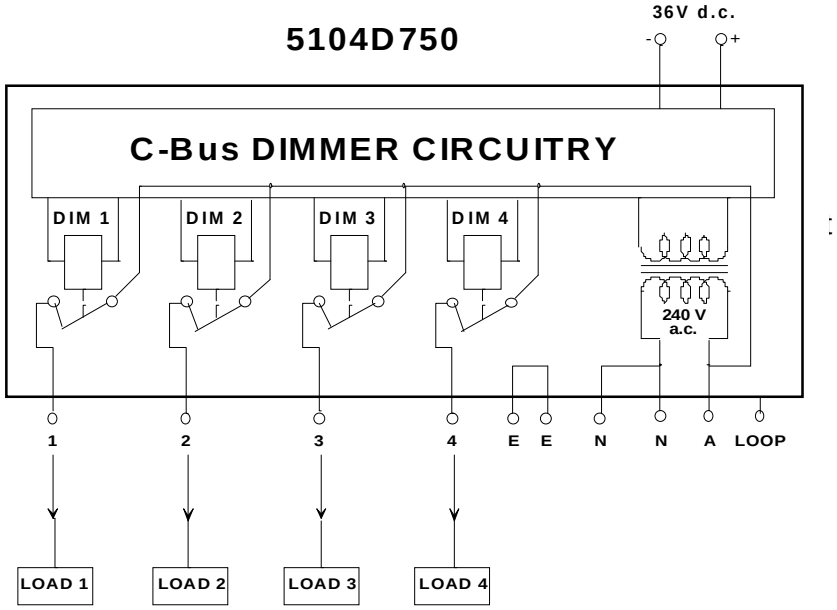
Four Channel Dimmer 5104D750

The Four Channel Dimmer is an output device used to dim incandescent as well as dimmable fluorescent lamps with correct ballasts fitted. The dimmer is suitable to regulate the speed of inductive motors, such as exhaust fans and to provide dimming control for transformers as used in low voltage lighting.

The 5104D750 is rated at 3000VA total, with each channel rated at 750VA. All loads are on the same phase.

The Dimmer Units are used to dim both incandescent and low voltage lighting. The dimmer unit can also be used to regulate the speed of exhaust and ceiling sweep fans.

It is not recommended however that a C-Bus dimmer be used to control compact fluorescent lamps, miniature fluorescent lamps or extra low voltage dichroic lamps with electronic ballasts.



Options on the Four Channel Dimmer Unit

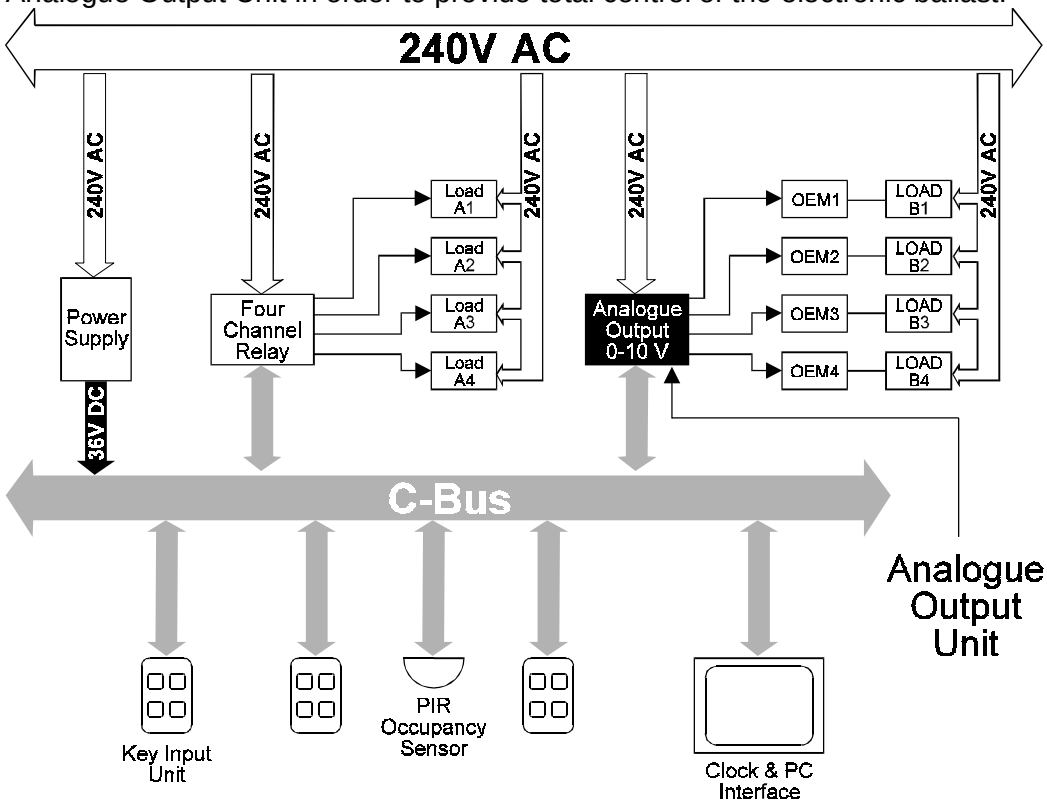
The Four Channel Dimmer Unit will, by default, revert all the outputs to the On state if C-Bus power is lost. This maybe changed by setting the on the Printed Circuit Board. The jumper settings offer the user to have the C-Bus outputs in the Off state if the C-Bus power is lost.

Analogue Output, 0-10V

The Analogue Output unit receives the digital signal from such Input Units as the Key Input Unit and converts it into an analogue control voltage. The control voltage value is determined by the level set from the digital input signal, and can be used to interface the C-Bus to any original equipment manufacturers products compatible with a 0-10 V signal.

Four analogue outputs per unit provide the capability to control up to four separate devices from the one point. The unit safely isolates the mains power from the low voltage C-Bus Network.

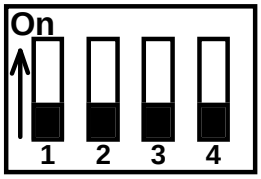
When used with particular solid state electronic ballasts the ballast output may still be active even with the analogue control off. In this case a C-Bus Relay Unit can be used in conjunction with the Analogue Output Unit in order to provide total control of the electronic ballast.



The Analogue Output unit can either source or sink current to equipment which it is interfaced with, refer to the product specification for output ratings. (i.e. 0 - 10 volt or 10 - 0 volt)

Available on the printed circuit board is a 4 way DIP Switch which provides the ability to invert the output of the Analogue Unit. Switch On indicates that the channel is inverted, hence when output is On the voltage is approximately 0V and when output is Off the voltage is approximately 10V.

The default settings are all switches in the Off position.



DIP Switch located on printed circuit board