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SECTION 1 - DESCRIPTION

Introduction

The ScR Direct Address Multiplex (DAM) system is an inexpensive remote control system designed for simplicity of construction and ease of maintenance.

Data MODEMs to CCITT standard are used for transmission (ensuring full compatibility with the telecommunications network), and the use of separate pairs for transmission of controls and indications simplifies fault-finding procedures.

Only three distinct card types are used on the buses. These are of ScR design and care has been taken to use only widely available components in their construction.

LED indications on the cards provide extensive functional information. Consequently, the use of specialised test equipment is not required of first line staff. Maintenance and fault-finding are further facilitated by a low spares requirement.

Incidentally - don't expect to encounter the phrase "Direct Address Multiplexing" elsewhere; this is a term we have introduced to distinguish our system from the more frequently encountered TDM (Time Division Multiplex) systems. It could be argued that DAM is still a TDM system, in the sense that the transmitted data can only contain information on a single bit at any given time; however its principle of operation is so radically different that we have found it beneficial to the process of understanding to adopt a phrase which lays more stress on the essential feature of the system.

The system is asynchronous: the direct addressing and a change-of-state driven interrupt system giving a considerable advantage in response-time over conventional TDM systems. A background scan maintains integrity when the system is quiescent.

If you are familiar with remote control systems, that last paragraph will have conveyed the essence of the system. If you are not, it may have worried you.

This is what it means.

Most remote control systems on the region are Time Division Multiplex (TDM) systems.

These operate by allocating to each input, a proportion of a single long message for transmission. That is, the transmissions are divided up into time "slots" - the state of the carrier during each representing the condition of the input (the frequency of the carrier changes to represent whether the input is "on" or "off" - these changes are called modulations). The system continuously scans its inputs in sequence, modulating the carrier appropriately.

At the end of each scan, the system repeats.

Introduction (cont.)

This, of course, requires that the remote end of the system, if it is to send the data which it decodes from the carrier to the correct output, must correctly divide the carrier into time slots.

This has two major disadvantages:

(1) If an input changes just after its time slot, the change will not be transmitted until the system has completed its scan and returned to the time slot allocated to that input. In a large system this can result in a considerable delay.

(2) The office and field must be synchronised, i.e. both ends must start their scan at the same time and divide the scan into time slots with sufficient accuracy to ensure that the data is correctly allocated. Thus the message must include synchronising codes and, more importantly, the integrity of the system depends on the accuracy of the clock circuits.

Direct Address Multiplexing, as used by the ScR DAM system, avoids these disadvantages. When an input to a DAM system changes, the change is detected immediately, and transmitted to the remote end as part of a message which also identifies the bit.

The inputs and outputs are divided into groups of seven, known as **DATA WORDS**. Each "word" of seven inputs is allocated a unique address, and the corresponding output word at the remote end is allocated the same address.

The transmitted messages consist of two short blocks of data, one containing the address of a single word and the other the condition of the inputs allocated to that word. Thus there is no need for the two ends of the system to be synchronised (since the inclusion of the address in the transmitted data enssures that the data is routed to the correct output).

It might at first sight appear as if this system will be slower, since each block of transmitted signalling data is accompanied by an address block. However since the system is not synchronised, it is not restricted to a time slot, and is free to transmit the data as soon as it changes.

This results in transmission being, by the standards of TDM systems, almost instantaneous.

Most of the time the inputs will be static. The system uses this time to transmit a background scan: i.e. it continuously transmits a stream of data consisting of the address and condition of each word in turn. This ensures that, should the message be corrupted during transmission (and hence rejected by the receiver), the data will be updated reasonably quickly.

Introduction (cont.)

Indeed, since transmission takes considerably longer than reading the cards, and since data is only transmitted for those cards present in the system, even the background scan will usually update data considerably faster than most TDMs.

System Architecture

In the interest of clarity, this section has been written in concise language and makes use of some technical terms which may be unfamiliar. Please persevere. It is in your long term interest to grasp the basic architecture of the system.

WARNING

Not all the information contained here is of equal importance to your initial understanding. Look-up unfamiliar technical terms in the **Glossary** section as you encounter them, but do not let your concern with them disrupt the flow of your reading - familiarity will clarify the concepts eventually as you become aware of their role in the overall structure of the system.

Look at the **System Architecture** drawings whilst reading the description. The architecture is not complicated **but do not expect a complete understanding at a single reading**; be prepared to return to this section as you read through the manual.

NOW READ ON

The system divides naturally into two parts: that located with the control panel and that located with the equipment controlled. As is conventional with remote control systems, we refer to the part of the system local to the control panel as the "office" and to the remote part as the "field". Office and field are identical in concept.

Each consists of two independent bus systems.

(1) **The Multiplexing Bus** - a group of multiplexing cards connected by address and data buses to a control card. The control card obtains information from the relay room via the multiplexing cards and presents it to the modem for transmission.

(2) **The Demultiplexing Bus** - a group of demultiplexing cards connected by a second bus system to a second control card. The control card receives information from the modem and presents it to demultiplexing cards from which it passes into the relay room.

Both buses share a common modem, the multiplexing bus utilising the transmit function and the demultiplexing bus the receive function. Two cable pairs connect office and field MODEMs; one transmitting in each direction.

A conventional V24 interface is used between the modem and the control cards: the TxD connection being with the multiplexing control card and the RxD connection being with the demultiplexing control card.

System Architecture (cont.)

To isolate the electronics from the relay room environment, logic and isolation circuits are powered from separate supplies. The +/-12V power supply for the modem, and for the V24 interface on both control cards, is derived from the logic supply.

All cards and modules of a given type are interchangeable, card indentity being established by backplane wiring.

Operation

In essence, when an input changes, the control card on the multiplexing bus reads the data from the multiplexing card to which that input is connected and transmits it to the remote end. When the control card on the demultiplexing bus at the remote end receives the transmission, it passes the data to the demultiplexing card to which the corresponding output is allocated and hence sets the output.

Let us consider the transmission of a change in the condition of a control switch from office to field.

A contact of the control switch repeater relay (or of the switch itself) is used to complete the return path for one of the isolating circuits on a **MULTIPLEXING CARD**.

These inputs are organised into groups of seven, known as **DATA WORDS**. (There are two data words on each card, and each word can be individually addressed.)

Each multiplexing card stores the current condition of each of its data words and can detect when the condition of its input (and, by implication, of the control switch) changes. The card then generates a change-of-state signal (**COS**) which acts as an interrupt to the multiplexing bus **CONTROL CARD**, causing the control card to leave its background scan routine and enter a rapid scan routine designed to locate quickly the word generating the COS.

In the rapid scan routine the control card examines the output buffer of each card in turn, testing only bit 8 of each word, until it identifies the word which has generated COS (bit 8 of the word latch is set by COS).

The control card then reads the data from the word and, after receiving an acknowledge (**AK**) from the multiplexing card to indicate that the data has been successfully read, transmits a message containing the address of that word, and the new condition of its inputs, to the field equipment. Having initiated the transmission, the control card returns to the background scan at the point at which it was interrupted.

When the message is received (by the demultiplexing bus control card at the field) the receiving control card sets the outputs of the word with the transmitted address to correspond with the condition of the transmitted word (output words are organised on **DEMULTIPLEXING CARDS** as input words are on multiplexing cards).

In the absence of a COS signal the multiplexing bus control card will scan sequentially each of the cards attached to its bus and transmit the condition of each word to the field.

Operation (cont.)

In this scan the control card will output all the addresses of a full system to the bus, but, since the control card requires an **AK** signal from the card addressed before accepting a word for transmission, transmissions will only be made for those addresses at which a card is present. Thus, since the time taken to address the cards is much less than that required for transmission, the time required for a complete background scan will be determined by the number of cards in the bus.

The field demultiplexing bus control card will pass the information to the relevant demultiplexing card as it arrives.

Message Integrity

One of the main concerns in the design of remote control systems is to ensure that the message transmitted is received unaltered at the remote end. We would not wish a single error among the thousand or so bits transmitted every second to, for example, take off a route on the ground. Unfortunately errors can arise. The message is not, however, left entirely without protection.

Transmissions must at all times conform to a protocol or they will be rejected by the Demultiplexing bus Control card.

The protocol for the DAM is based on the message format, baud rate and the use of parity.

Message Format

Each message consists of two blocks of data.

(1) The address block - a block containing the address of a single data word.

(2) The data block - a block containing the condition of that word.

Each block consists of 11 bits allocated as follows:

(a) One start bit (the leading bit), marking the start of the block.
(b) Eight bits constituting the message.
(c) One parity bit.
(d) One stop bit, marking the end of the block.

As is conventional in serial transmission, the least significant bit of the message follows the start bit, the rest of the message then follows in increasing significance, and the parity bit follows the most significant bit.

The address and data blocks are differentiated by whether the most significant bit of the eight bits constituting the message is set high or low.

High marks the block as an address block.

Low marks the block as a data block.

In the data block the remaining seven bits of the message represent the condition of the data word.

In the address block the most significant of the remaining seven bits is always set high (for reasons associated with the internal operation of the control card), and the remaining six bits represent the address of the data word.

There is a fixed time period (known as a window) following the reception of the address block during which the control card will accept the data block.

If a demultiplexing control card receives a message which does not conform to this format, the message is rejected.

(You may be puzzled when I write of one bit in the message being more "significant" than another. Considered as bits of data this is, I agree, non-sensical: however when I use the term here, I am, for convenience in the description, treating the message as a binary number - see the Glossary: **binary**.)

The Use of Parity

You may know that it is possible effectively to guarantee the integrity of a transmitted message through a technique known as "redundancy". This technique allows the receiving equipment to detect and, given a sufficient degree of redundancy, even to correct, errors in transmission. Without going into detail, the technique consists of adding extra (or "redundant") bits to the message. These inter-relate to the message and to each other in such a way that the transmission as a whole can be processed to extract the message, despite extensive corruption.

The drawback is that the more effective a redundancy scheme is, the more bits it uses and the more processing power is required to encode and decode the message. This is particularly significant in a small remote control system such as the DAM since the extra bits would seriously increase the time required for the background scan, and the encoding/decoding of the message would overload the Control card processor. Given that line safety relies ultimately on the remote interlocking, and hence **the remote control is a non-vital system**, the use of extensive redundancy in this application is not justified.

You will see from the message format that one redundant bit, the **parity** bit has been included. This gives the system the ability to detect any **odd number** of bit errors in the transmission.

In the DAM system, message parity has an additional use, which is to **mark the direction of transmission**.

Odd parity is used for a transmission from office to field **(controls).**

Even parity is used for a transmission from field to office **(indications).**

This has been included as a precaution against crosstalk between the two channels. (Any "controls" message induced on the "indications" channel will be rejected, and vice-versa.)

Maintenance

The system is in effect maintenance free, however it is felt to be important that the technician maintain his familiarity with the equipment. To this end regular visits should be made during which the technicians should:

a) Clean and dust the racks.

b) Check the mechanical integrity of the system.

c) Ensure that the spares are present and functional (i.e. any faulty units have been returned for repair).

d) Measure the supply voltages to be within +/-0.25V of nominal values.

e) Observe the functioning of the system i.e. -
The fault indication LED's on the Control Cards.
Check transmission line levels taking note of any deterioration.

SPARES

It is considered to be adequate that one of each card and module be held at the office site (see site appendix for detailed list). However, to ensure that a spare is available whilst faulty cards and modules are repaired, two spares of each card and module are usually provided.

SECTION 2 - CARDS

Introduction

The buses on the DAM system use only three distinct card types.

(1) The **CONTROL** card. There are four such cards in the system - one card controlling each bus.

On the multiplexing buses it acts as a parallel to serial converter; taking the information in parallel form from the multiplexing cards and passing it to the MODEM in serial form.

On the demultiplexing buses it acts as a serial to parallel converter; taking the information in serial form from the modem and passing it to the demultiplexing cards in parallel form.

In addition, the control card is used in system alarm generation.

(2) The **MULTIPLEXING** card. This card interfaces the system to its inputs from the relay room or control panel. Each card provides fourteen isolated inputs organised as two seven bit data words, and generates a change-of-state signal when the condition of any of these inputs changes.

(3) The **DEMULTIPLEXING** card. This card stores the data on fourteen input conditions transmitted from the remote end, and provides outputs, over the front contacts of fourteen dedicated relays, to interface the system to the relay room or panel functions controlled by those inputs.

Format of all three card types is double eurocard with 2 x 64 way edge connectors.

The cards have been designed with a degree of flexibility which allows them to be used (in different roles) in certain other SES designed systems. The facilities which are not utilised in a DAM system are required for other applications.

This section describes the operation of the cards in sufficient detail to provide an understanding of their function within the DAM system.

<u>Control Card</u> 82SES1 (see drawing)

This card is based on a 48 series micro-computer with support circuits for clock generation, bus control and serial communication. Ancillary circuits handle system alarms (with associated indicators), V24/TTY interfaces, and power-up reset.

Provision is made for I/O expansion.

As programmed for Remote Control System use the card can function in either multiplexing or demultiplexing control mode.

This is determined as follows:

On power up the micro-computer tests the backplane wiring to determine the mode of operation.

If Lc13 is looped to Lc12 the card functions in the **multiplexing** control mode, if Lc13 is looped to Lc14 it functions in the **demultiplexing** control mode.

Lc1 is also tested and, in conjunction with Lc13, determine whether ODD or EVEN PARITY is valid.

Odd parity is used for transmission from office to field.

Even parity is used for transmission from field to office.

Lc1 is wired LOW at FIELD and HIGH at OFFICE.

(This is the usual arrangement, but check the site appendix for variation.)

When functioning as a multiplexing control card,

the card scans sequentially though the multiplexing cards, reading one data word at a time and transmitting the data contained in this word (preceded by its address), before moving on to the next word. This scan can be interrupted by a COS signal from a multiplexing card.

On receipt of COS the card scans the multiplexing cards to determine the origin, and, when located, the associated data word (with address) is immediately transmitted. The control card then checks whether COS is still present, if so, this further change is located: if not, the scan continues from the point at which it was interrupted (re-transmitting the last address and word since the interrupt can occur between transmission of address and word).

Control Card 82SES1 (cont.)

Eight data bits are transmitted, the most significant bit determining whether the transmission is of address or data. The demultiplexing Control Card can thus recognise when it has received data without an address and take no action.

When functioning as a demultiplexing control card,

the card is not scanning but writes directly to the demultiplexing card specified by the received address (after first checking the validity of both address and data).

To ensure that the correct data follows a specific address, a "time window" is created on receipt of a valid address byte. The microcomputer expects to receive the next byte whilst this window is open. If no data byte is received within the window, the address is discarded and the control card waits for the next valid address.

Immediately after determining its mode on power-up (or reset), a demultiplexing control card will write to all addresses on its bus ensuring that all relays are de-energised. This, (together with delay circuits on the demultiplexing cards in the case of power-up), ensures that the system begins from a safe condition.

The reset circuit is adjusted such that, if the supply voltage to the card drops below the level at which the correct operation of the micro-computer can be guaranteed, the micro-computer will cease to operate.

When the voltage returns to an acceptable level, operation of the micro-computer will recommence from the beginning of the programme, including power-up routines (see above).

The role of the control card as a DAM system card is determined by the programme installed in the micro-computer as fitted. However certain aspects of its performance remain to be determined by its hardware **configuration**.

Wire-wrap posts select the baud rate and plug-in links select V24 or current loop transmission. In the DAM system, baud rate is set at 1200 and V24 is used in the transmission link to the modem.

The operation of the **alarm circuits**, and the role of the three LEDs mounted on the card edge, are covered under **FAULT INVESTIGATION**.

Multiplexing Card 82SES2 (see drawing)

This card accepts fourteen inputs from the relay room or control panel and presents them in noise free digital form to the multiplexing bus control card. These inputs are organised as two blocks of seven (referred to as DATA WORDS).

The inputs are optically isolated from the logic circuits.

A bit is set by completing a dedicated isolating circuit (e.g. via a closed relay contact). A light emitting diode (LED) in series with each isolating diode is mounted on the card edge such that the condition of any input can be seen at a glance. If the LED is lit, the circuit has been completed.

Each data word is presented at the inputs of an octal latch, the outputs of which are presented at the inputs of gated inverting bus buffers. The outputs of the bus buffers are connected to the **DATA BUS**.

Reading the card

A bus comparitor IC enables the card to accept a READ signal (**RD**) when it detects its identity (five hardwired backplane inputs) on bits 1 to 5 of the **ADDRESS BUS**. Bit 0 of the address selects which of the two data words is to be read.

When a card is addressed, RD clocks the current data for the selected word into the latch and enables the bus buffers, placing the data word onto the data bus.

Reading the word generates an ACKNOWLEDGE pulse (**AK**) which the control card requires as verification before allowing transmission.

The change-of-state interrupt

Two cascaded four bit magnitude comparators compare the word at the latch inputs with the word at the latch outputs. When an input changes the comparators will generate CHANGE OF STATE (COS), triggering a rapid scan.

The comparator output is also presented to bit 8 of the latch. When the rapid scan reaches the word which generated COS, the comparator output will be clocked through onto the bus, thus identifying the data word for transmission.

The latch output will now agree with the input and the COS interrupt will be removed.

Multiplexing Card 82SES2 (cont.)

The SCAN OK indication

A green LED, positioned centrally on the card edge, is driven by a monostable which is triggered whenever the card is read. The time-out period of the monostable is such that the frequency with which the card is read ensures that (given normal operation) the monostable is always retriggered within the time-out period. Consequently its output remains fixed - resulting in the LED remaining lit.

The inverted output of this monostable drives a transistor which is thus maintained in the **off** state. The output of this transistor is connected to the bus.

Should normal operation of the bus be interrupted (i.e should the card fail to recognise its address, or the address or the RD pulses fail to arrive at the card) the monostable will time out.

The LED will then no longer be lit and the transistor will be switched on, pulling the bus wire to which it is connected **low**. Thus, both the external observer (e.g. technician) and the Bus Control Card will be informed of the failure.

The LED is known as **SCAN OK** and the transistor output as SCAN FAIL (SF). (See "FAULT INDICATIONS").

Demultiplexing Card 82SES3 (see drawing)

Each demultiplexing card accepts the information for fourteen outputs from the demultiplexing bus control card and presents it in the form of dedicated relay contacts to the relay room or control panel. These outputs are organised as two blocks of seven (referred to as DATA WORDS).

Each data word is stored in an octal latch the inputs of which are connected to the **DATA BUS**.

Writing to the card

A bus comparator IC enables the card to accept a WRITE signal (**WR**) when it detects its identity (five hardwired backplane inputs) on bits 1 to 5 of the **ADDRESS BUS** - bit 0 of the address selects whichever of the two latches the data is intended for.

The card and latch having been selected by the address, the data is clocked into the latch by WR.

Writing to the card also generates an ACKNOWLEDGE (**AK**) signal, a facility which is not utilised in a non-vital system.

Connecting to the Relay Room

Output from the card is over the front contact of one board mounted relay per data bit - thus isolating the logic circuit from the relay room. The armatures of the seven contacts of each data word are available independently if required, but are usually commoned on the backplane.

Each output is capable of driving a BR SPEC 930 relay directly and is protected against the effects of back EMF by a varistor and series resistor across each output relay contact.

The output relay coils are driven from the latch via a line driver IC.

LED's in series with the relay coils are mounted on the card edge such that the condition of any output can be seen at a glance.

It should be noted that, since a current limiting resistor parallels the relay coil, the LED indicates the state of the driver output; not that of the relay.

The latches constitute stick circuits for the output relays and, should a fault occur which prevents scanning, the relays will remain in the position set by the last data words written to the latches.

Demultiplexing Card 82SES3 (cont.)

Avoiding False Data

The state of the relays is determined by the state in which the outputs of the latches lie.

On power-up, the state in which these outputs will settle when the ICs reach a steady operating voltage cannot be guaranteed. It follows that, to prevent the output of false data on power-up, measures have to be taken to ensures that all relays remain de-energised until the outputs of the latches driving them are valid.

This is achieved by preventing the 12V relay supply from being applied to the coils until a "low" generated by a delay circuit is clocked through bit 8 of the Word B latch.

Through the following process, this ensures that all relays remain de-energised until the outputs of the latches driving them are valid.

On Power-up

The control card is programmed to write rapidly to all B words immediately, thus allowing the initial "high" state of the delay circuit through to the output of bit 8. (This is to counter the possibility of power being applied prematurely to the relays should the Word B latch power up with the output of bit 8 "low".)

The Control card programme, in conjunction with the time delay on Word B bit 8, ensures:

a) That a "low" on bit 8 of Word B of each card will only be allowed to pass through the Word B latch of that card in the company of valid data for that word.

b) That Word A of each card receives valid data prior to the Word B latch of that card transfering a "low" on bit 8 to its output.

Hence the relays on each card are not energised until valid data has been applied to all fourteen drivers on the card.

It follows that it is **ESSENTIAL** that no Demultiplexing Card be inserted in a bus without first ensuring that the Control Card is in place and that the power supply is off.

Demultiplexing Card 82SES3 (cont.)

The SCAN OK Indication

A green LED positioned centrally on the card edge is driven by a monostable which is retriggered whenever the card is written to.

The time-out period of the monostable is such that the frequency with which the card is written to ensures that (given normal operation) the monostable is always retriggered within the time-out period. Consequently its output remains fixed - resulting in the LED remaining lit.

The inverted output of this monostable drives a transistor which is thus maintained in the off state. The output of this transistor is connected to the bus.

Should normal operation of the bus be interrupted (i.e should the card fail to recognise its address, or the address or the WR pulses fail to arrive at the card) the monostable will time out.

The LED will then no longer be lit and the transistor will be switched on, pulling the bus wire to which it is connected low. Thus, both the external observer (e.g. technician) and the Bus Control Card will be informed of the failure.

The LED is known as **SCAN OK** and the transistor output as SCAN FAIL (SF). (See "FAULT INDICATIONS").

SECTION 3 - CONSTRUCTION

<u>The Card Frames</u>

The system is built in standard 19", 6U subracks (DIN 41494, IEC 297) e.g. BICC-VERO KM6.

Rear connector-mounting extrusions with integral busbars (available as an option) are used top and bottom to simplify power distribution, and the least densely populated sub rack at each site is usually fitted with a divider plate - enabling a section of the rack to be used for mounting 3U modules eg power supplies.

The cards, which are 160mm depth double eurocard format, are carried in card guides clipped into the subrack and their indirect edge connectors mate with sockets (to DIN 41612) mounted on the rear of the subrack.

The sockets are 64 way a/c format, with wire-wrap posts for those in lower edge-connector positions and either wire-wrap or DIP solder pins for those in upper edge-connector positions.

Before mounting in the subrack, the upper edge connectors are soldered onto a Microbus Backplane PCB (modified for this application by cutting to size with a guillotine) and pull-up resistors are attached to RD and WR conductors.

With the edge connectors in place, wire-wrapping is used to

(a) establish the hard wired identities of multiplexing and demultiplexing card positions

(b) common the output relay armature pins in the demultiplexing position

(c) establish parity and mode at the control card positions

(d) make the ROK/TOFF alarm connections

(e) make 5V power supply connections to each card position from the upper busbar (if wire-wrap upper connectors are used)

(f) make 12V power supply connections to each multiplexing/demultiplexing card position from the lower bus bar

The 20 way backplane header sockets for the Scotchflex connectors can now be mounted on the lower edge connectors in multiplexing and demultiplexing card positions.

Power Supplies

The power supplies required are :- LOGIC (5V)
ISOLATION (12V)
RELAY (12V)
TRANSMISSION (+/-12V)

These share a common 110V AC supply cut through a double pole master switch with neon indicator. The output of each supply should be indicated by a LED. The pattern of supply allocation will vary with site requirements and is shown on the Power Supply Distribution drawing for each site.

Switch mode power supply units (in subrack-mounted modules) are used, simply plugging into DIN 41612 flat pin connectors mounted in the 3U section of the subrack. Spade connections are then made between the connectors and the busbars for all but the transmission supply.

The +/-12V supply connector is wired (via an interface to wire-wrap provided on a PCB mounted on the rear of the rack) to control cards and modem.

MODEM

A modulator/demodulator (MODEM) is used to convert the data signals from the control card to the voice frequency signals suitable for transmission over telecom cable (and vice-versa).

By preference, a one card modem, of single eurocard construction mounted on the subrack (by DIN 41612 connector), will be used. However any CCITT 4 wire modem operating at 1200 Baud is electrically compatible.

Transmission level is -13db and maximum permissible line loss 30db.

Installation

The subrack can of course be mounted in any 19" racking system whether it be a dedicated enclosure or two vertical straps on a relay rack, however if not cabinet mounted, it is advisable to fit the subracks with the optional top and rear covers (to protect the wiring).

With the subracks in position, **KLIPPON RI40** 40 way ribbon/screw interface blocks (1 block for 2 cards) are mounted on standard DIN rail adjacent to the rack, and ribbon cables are run from the lower edge connectors to the blocks.

With the cable cut to length, the backplane connectors are pressed onto the cable at the rack end and the appropriate pairs of cables pressed into 40 way headers at the rail end.

KLIPPON fuse terminals (for 110V connection) and feed-through terminals (for alarm relay connections) are provided on the rail, together with the preferred terminals for transmission lines.

If the transmission medium is not itself protected, surge protection for the line should be provided near the terminals.

If the system is required to operate BR930 relays the installation of additional suppression between terminals and backplane should be considered. This may be required to guard against accidental removal of a demultiplexing card from a working system (the quench circuit is removed with the card and rapid removal will allow a considerable back EMF onto the backplane).

SECTION 4 - FAULT INVESTIGATION

<u>Introduction</u>

Faults on the DAM system fall into two categories.

(1) Bit failures

It is not practicable to raise an alarm for failures of individual bits. Such faults will normally be discovered during investigation of reported signalling control or indication failures.

(2) System faults

These will involve blocks of data and range from complete system failure to a failure involving a single data word (7 bits). Such faults will trigger a system fault alarm on the signalman's panel.

In either case the basic fault correction method is the same - **Substitution.**

Substitution is the main first line fault finding technique on the DAM system. The technician will be required, with the aid of indications available on the card edges, to identify and replace faulty cards and modules. Sufficient spares should be available to allow the technician to identify a faulty unit quickly and easily by replacing it with a unit known to be fault free. **IF THIS METHOD IS TO WORK IT IS IMPORTANT THAT NO FAULTY UNITS ARE KEPT ON SITE AND THAT ALL SUCH UNITS ARE RETURNED IMMEDIATELY FOR REPAIR**.

It is advisable to switch off the 110V supply to the frame before removing cards or modules.

Substitutions should never be random: they must be based on reasoning guided by an understanding of the system. In general, only one component should be substituted at a time and the effect on the system operation evaluated before further substitution takes place.

Since the indications are dependant on the power supplies, all voltages should be measured before following the fault finding procedures. All supplies are indicated on the faceplate of the relevant power supply module.

Failure of the Isolation or Relay supplies will result in the loss of the appropriate bit indications, and failure of the Logic/Transmission supply in the loss of all other card edge indications.

Before replacing a power supply suspected of being faulty the bus fed from that supply should be proven free of short circuit. The switch mode supplies used are short circuit protected and will recover on removal of the short. (When the protection circuit is in operation a high pitched whistle is often audible.) To identify the appropriate power supply bus look at the site appendix Power Distribution Drawing.

Card Indications

All three of the cards in the system have LEDs mounted on the card edge such that they are visible while the card is operating. These have been provided as an aid to fault finding.

The **control card** has three indications:

SD"OK" (Serial Data "OK" - green LED) - This LED is **ON** whenever the communications IC on the card (the UART) is active, indicating that the card is either transmitting or receiving data. Should transmission or reception cease for a 10mS period, the indication would be lost.

Rx FAULT (Receiver Fault - yellow LED) - This LED is switched **ON** by the micro-computer to indicate either that an error has been detected in the protocol of a received message or that a fault (e.g. line discontinuity or low signal level) has been detected in the link.

NOTE - Received messages are rejected if an error has been detected by the Control Card.

FAULT (red LED) - Indicates that a fault resulting in a system alarm has been detected. Either of the above transmission faults, or a bus fault resulting in the control card receiving **SF** (Scan Fail - see below), will trigger a 5 second delay. Should the fault persist when the delay times out, **FAULT** will be lit. **FAULT** will also be lit if the backplane terminal **ROK** is low as part of the alarm sequence.

Multiplexing and demultiplexing cards have two indications:

SCAN OK (green LED) - A monostable is retriggered whenever the card is successfully read from or written to. Should this monostable time out, the signal SF will be output to the alarm circuitry of the appropriate control card and the SCAN OK LED will be switched off, indicating that the card is not being serviced.

It should be clear that the demultiplexing bus is event driven rather than scanned (i.e. only if a valid data word is received is the card written to): the **SCAN OK** nomenclature was chosen to emphasize the relationship between the driving of the bus and the scanning of the corresponding multiplexing bus.

BIT INDICATIONS (14 red LEDs)

On the multiplexing card these are used to indicate whether the contacts fed into the system by that card are open or closed.

On the demultiplexing card they are used to indicate whether the output contacts on the card are open or closed.

In both cases, the LED indicates that the contact is closed.

In a correctly operating system, if a bit indication LED on a multiplexing card is **ON**, the corresponding bit on the remote demultiplexing card with the same address should be **ON**.

Bit Failure

Should a bit failure be suspected, investigation should begin at the multiplexing end.

The **BIT ALLOCATION BOOK** should be used to locate the (Red) LED indicating the bit by **CARD POSITION, WORD** (A or B) and **BIT NUMBER** (0-6).

Shorting the KLIPPON terminal allocated to the bit (identified from the bit allocation book) to the block common, the technician should satisfy himself that the LED lights. Failing this, the card should be changed. If the bit LED still does not light the ribbon cable connecting card to terminal is suspect.

If the LED lights when the terminal is shorted there is a fault external to the system, either in the contact to be multiplexed or in the wiring between the contact and the klippon block.

When the bit is considered to be being multiplexed correctly the investigation should move to the corresponding demultiplexing card.

Here the bit indication should be observed to follow that of the multiplexed bit. If it does not do so replace the demultiplexing card.

If the indication is following that of the multiplexed bit but the fault has not cleared, the relay contact should be tested by checking for continuity between the allocated KLIPPON terminal and the word common. Should the continuity not follow the transmitted bit the card should be changed.

If changing the card makes no difference the ribbon cable is suspect.

If the fault persists with the continuity at the demultiplexing KLIPPON block following the multiplexed bit, the failure is external to the system.

It should be noted that the back EMF from a BR930 relay is sufficient to interfere with the operation of the microcomputer, causing temporary bus failure. Should such a failure occur associated with the operation of a particular relay the quench circuit associated with that bit will have failed and, in those systems where the quench circuit is mounted on the demultiplexing card, the card should be changed.

Since on most systems the quench circuit is removed with the card it is inadvisable to remove a demultiplexing card from a working system - switch off first.

The Alarm System

Major failures on the DAM system will result in an alarm on the control panel. This alarm is triggered by a relay (external to the system) driven by the **FAULT** indication circuit on one of the control cards. The relay, known as the "**SYSTEM OK**" relay, is normally energised, but, should a fault develop, the drive will be removed and the relay will drop.

Most faults which can develop on a bus will result in a **FAULT** indication on the appropriate bus control card. By linking the fault indication circuits of all the control cards in the system, an alarm can be raised should a fault develop on any bus. The wiring which links the control cards is known as the **ROK/TOFF** wiring.

Three signals on each control card are involved in this wiring. These are **ROK, TOFF** and **ROK/TOFF.**

ROK switches **FAULT** ON when pulled low, overriding any 5 second delay in progress.

TOFF disables the V24 interface when pulled low (preventing the card from transmitting).

ROK/TOFF is an output which is driven low when **FAULT** is ON.

Effectively duplicating ROK/TOFF is an isolated transistor labelled **RELAY DRIVE**. As might be expected, this is provided to allow the FAULT condition to be indicated by picking an external relay, and it is one such output which drives the "SYSTEM OK" relay.

The ROK/TOFF wiring varies according to site requirements but the following examples should serve to illustrate the principles involved.

Simple ROK/TOFF Wiring (see drawing)

At the office

The "SYSTEM OK" relay is energised via the isolated transistor of the **demultiplexing bus control card**. A FAULT indication on this card will switch off the transistor and trigger the alarm. Any major fault on the demultiplexing bus will give rise to such an indication.

Also, ROK/TOFF of the **multiplexing** bus control card is connected to ROK on the **demultiplexing** bus control card and would immediately trigger FAULT on the demultiplexing bus control card (and hence the alarm), should a fault develop on the **multiplexing bus**.

At the field station

ROK/TOFF of the **demultiplexing** bus control card is connected to ROK of the **multiplexing** bus control card. Thus a FAULT indication on the **demultiplexing** bus control card will immediately trigger FAULT on the **multiplexing** bus control card.

ROK/TOFF of the **multiplexing** bus control card is connected to TOFF on the same card.

It follows that FAULT on **either** field control card will prevent transmission from field to office. This would lead to the **office** demultiplexing control card losing **SD OK** and, after 5 sec, a FAULT indication would turn off the drive to the "SYSTEM OK" relay and trigger the alarm.

This simple method of ROK/TOFF wiring would prove over restrictive in practise (since a control fault disables transmission of indications) and a method whereby a field demultiplex fault is transmitted as data to the office is more commonly used.

Practical ROK/TOFF Wiring (see drawing)

The alarm system most commonly used is of a less restrictive type which allows indications to be received despite the presence of a failure on the control channel.

This is accomplished by keeping seperate the alarm circuits for the two buses at the field end. The state of the demultiplexing bus alarm circuit is transmitted back to the office as an indication bit known as "Receiver OK".

The isolated transistor on the demultiplexing bus is used to switch the multiplexing card input allocated to the "Receiver OK" bit, and the corresponding output at the office is incorporated into the "System OK" relay circuit.

No connection is made between ROK/TOFF on the demultiplexing bus and ROK on the multiplexing bus. Otherwise the ROK/TOFF wiring is as in the previous example. Consequently, faults on either of the two office buses, or on the field multiplexing bus, trigger the alarm in the same manner as in the previous example.

The alarm system works as follows:

The B50 feed to the alarm relay is over the contact of the "Receiver OK" indication relay, and the return to N50 is via the isolated transistor on the office demultiplexing bus control card.

Should a fault at the field cause the loss of the "Receiver OK" indication, or should the isolated transistor on the office demultiplexing bus control card be turned off (whether by a fault on the bus or via the ROK/TOFF wiring) the system alarm will sound.

A failure of the field demultiplexing bus will result in the loss of "Receiver OK" indication at the office and trigger the system alarm.

Failure of any other bus will trigger the system alarm by turning of the isolated transistor on the office demultiplexing bus control card via the ROK/TOFF wiring.

Locating a System Fault

If the alarm is due to a fault on the DAM system it will have been triggered either by the loss of the "Receiver OK" bit or by the transistor associated with the FAULT indication circuit on the office demultiplexing bus control card turning off.

Both have a visual indication.

The **FAULT** LED on the demultiplexing bus control card will be ON if the alarm has been triggered by a fault on this bus or on one of those connected via the ROK/TOFF wiring.

The **bit-indicating** LED on the appropriate demultiplexing card will be OFF if the loss of "Receiver OK" has triggered the alarm.

Should neither of these indications show a fault - check the fuse feeding the alarm relay. (If you are convinced that the DAM system is at fault then the alarm circuit itself should be investigated.)

Using the card indications and the site drawings, the technician should follow the ROK/TOFF sequence in reverse and thus determine which control card has initiated the system alarm. This will be the card furthest back in the sequence to be showing a **FAULT** LED (Red).

It should be noted that, if the fault condition has been transmitted as an indication bit from the remote end, the control card driving the system alarm relay will not show **FAULT**.

Locating the originating control card identifies the bus (and associated transmission equipment) where the investigation should continue.

Locating a System Fault (cont.)

"Receiver OK" indication bit OFF

This condition is intended to indicate that the demultiplexing bus at the field station is faulty, however there are some alternative causes which should be borne in mind.

At the field station, the isolated transistor associated with the **FAULT** indication circuit on the demultiplexing bus control cardswitches "Receiver OK", an indication bit on one of the multiplexing cards. In this way, the condition of the field station receiver (demultiplexing bus) is transmitted to the office via the multiplexing bus.

This results in any condition which will trigger **FAULT** on the demultiplexing bus control card (or inhibit transmission of the allocated bit) indicating a fault condition on the demultiplexing bus. These include:

(a) A fault on the field station demultiplexing bus.
(b) A transmission fault on the "controls" pair between office and field.
(c) A failure of the individual bit used to transmit the indication.
(d) A failure of the alarm circuit at the field station.
(e) A failure of either office bus.

Condition (b) may be due to a faulty MODEM at the office and hence some time may be saved by listening to the transmit pair at the office for the sound of data transmission.

Condition (e) will result in loss of "SYSTEM OK" at the office, and in this instance, investigation should start at the office. Otherwise, faults accompanied by the loss of "Receiver OK" are best investigated at the field station.

Locating a System Fault (cont.)

FAULT LED on office demultiplex bus control card ON

Presuming the less restrictive form of alarm circuitry, this indicates a fault on any of the following three buses:

(1) the office demultiplexing bus.
(2) the office multiplexing bus.
(3) the field multiplexing bus.

NOTE that when I refer to a bus, this should be taken to mean both the backplane wiring of the bus and **all** cards on the bus (including the control card).

Both the **field multiplexing bus** and the **office multiplexing bus** operate the alarm by triggering FAULT on the office demultiplexing bus control card.

The field multiplexing bus control card does this by inhibiting transmission from the field and hence causing the loss of "serial data OK" on the office demultiplexing control card.

The office multiplexing bus control card does this by means of the office ROK/TOFF wiring.

If an alarm has been triggered from the office demultiplexing control card, check whether FAULT is showing on the **office multiplexing bus** control card, and if so, start the investigation there.

If the alarm has not originated on the office multiplexing bus, check **SD OK** on the office demultiplexing control card, if this is not lit the fault may be best investigated at the field station; however it is **worth listening to the receive pair at the office for the sound of data transmission** (the control card, or MODEM, may be at fault).

Identifying a Fault

Once the bus which has initiated a system alarm has been identified, the LEDs on the cards can be used to determine the nature of the fault. This process should begin with the bus control card.

The normal state of the control card indications is

FAULT (Red LED)______________ OFF

Rx FAULT (Yellow LED)_________OFF (The keen observer may notice the ocassional flash. This can occur when the UART is re-programmed every 30 seconds and does not indicate a fault.)

SD OK (Green LED)_____________ON and flashing at a rate determined by the number of cards on the bus.

Under fault conditions the **FAULT** LED will be **ON.**

FAULT is switched **ON** by either **SD OK OFF** or **Rx FAULT ON** and also by **SF** - a signal presented to the control card when one of the cards on the bus has not been serviced for a one second period.

If **Rx FAULT** or **SD OK** have triggered **FAULT** on a demultiplexing bus, the fault is probably transmission related. (It should be clear that neither is to be expected on a multiplexing bus, and that **Rx FAULT** in particular, if encountered, would indicate that the card itself is faulty.)

If **SF** has triggered **FAULT** then the fault is internal to the bus.

SCAN OK (green LED), mounted centrally on multiplexing and demultiplexing cards, is associated with **SF.** If a card is not being serviced, **SCAN OK** will go **OFF** and the card will output **SF**.

Thus, if **FAULT** on the control card has been triggered by SF, the card on which the signal originated will have its **SCAN OK** LED **OFF**.

Bus Faults

On a multiplexing bus each card is scanned in sequence. If a card is not being scanned the most likely fault is in the address decoding. The card should be replaced by the spare.

If the fault persists it could originate in the address generation by the control card, however this would be likely to affect more than one card. If changing the control card does not remove the fault, then the hardwired identity is suspect.

If the cards on the demultiplexing bus are not being written to, the possible causes are as for the multiplexing bus but, in addition, it should be remembered that this bus is **not** scanned and therefore the possibility exists that the corresponding multiplexing card (at the remote end) is not being scanned or is not present in the system.

If the ROK/TOFF wiring is such that a fault on the demultiplexing bus disables the multiplexing bus control card (via TOFF), removing the faulty card from the demultiplexing bus will allow transmission to resume.

Should a fault condition arise in which a card responded to addresses other than its own, the card's **SCAN OK** LED would remain **ON**. However the fault should be detectable via the bit indications which would be erratic.

Transmission/Reception Faults

SD OK on the control card (Green LED) is maintained by the flow of data between MODEM and UART.

Rx FAULT (Yellow LED) is switched ON by the processor when the UART detects any of five conditions:-

PARITY ERROR	- Generated by corruption of the received message.
FRAME ERROR	- Generated by incorrect formation of the received message.
OVERRUN ERROR	- Generated when the rate of received messages is higher than the rate at which the processor can deal with them.
BREAK DETECT	- Generated when the transmission lines are broken, when the link between Control Card and Modem is broken, or when the received signal level is too low to be accepted by the Modem.
UART FAILURE	- Generated when the UART continues to produce an interrupt signal after being serviced by the microcomputer.

It will be clear that **Rx FAULT** should only appear in a **demultiplexing** control card, also that if **Rx FAULT** is **ON** for BREAK DETECT, **SD OK** will be **OFF**.

SD OK **OFF** on a **multiplexing** control card when the bus is being scanned implies a fault on the card.

Reception faults indicated on a demultiplexing control card can originate not only on the card itself, but also:-

a) in its associated MODEM
b) in the transmission lines, and
c) in the multiplexing control card and MODEM at the transmitting end.

For such faults the transmitting control card should be investigated first.

Transmission/Reception Faults (cont.)

The transmitted signal is audible on a telephone earpiece connected across the lines. When attached to the lines by two pieces of wire and two crocodile clips, the earpiece can tell the experienced technician as much as a battery of expensive signal analysing devices.

Obtain an earpiece and listen to the lines of a fully functional link. With this experience you will be able to listen to a suspect link and determine the following.

(a) Is the MODEM carrier present?

(b) Is some illegal carrier present?

(c) Is the carrier suffering breakup or being modulated by a corrupting signal?

(d) Is the signal level adequate?

(e) Is the carrier modulated when (and **only** when) the system is transmitting?

Using this technique both MODEM and lines can be tested.

It is also possible to use the earpiece to test for the presence of the V24 signal between MODEM and control card - **however I should warn you not to put your ear too close to the earpiece when doing so as this signal is extremely loud!**

The MODEM will often be fitted with diagnostic LEDs indicating aspects of performance such as whether data is being transmitted or received. The use of these LEDs (if present) is covered in the site appendix since it will depend on the particular MODEM fitted.

Before replacing MODEMs the lines should be checked with the MODEMs disconnected.

SECTION 6 - GLOSSARY AND INDEX OF TERMS

NOTE: In what follows "**device**" can refer to a card, module, or other system component according to context.

acknowledge - A control signal used to indicate to a device that an attempted communication has been successful (see 1-6, 2-4 & 2-6).

address - The binary code used by the system to select a device.

AK - Shorthand for **acknowledge**.

asynchronous - Not synchronous. Synchronous communication between devices relies on the devices carrying out complimentary operations at the same time. Each device carries out a predetermined sequence of operations at a set rate and in a set order. The sequence must start and finish at the same time in both devices. Communication between synchronous devices relies on the receiving device being at the point in its sequence when it reads data in, at the same time as the transmitting device is at the point in its sequence when it outputs data. That is, the operation of the devices must be synchronised. In asynchronous communication the transmitting device is free to send data at any time. The start and end of each word in the message will be marked as specified by the transmission protocol. The receiving device will either respond to an interrupt generated by the incoming message, or test its receiving circuits for a message at intervals of less than the transmission time for the shortest possible message.

backplane - The cards and modules of the system plug into edge connectors mounted in the card frame. The terminal pins of these connectors, which are accessible from the rear of the card frame, are known as the backplane.

backplane wiring - This is the wiring terminated on the pins of the edge connectors constituting the backplane. It includes both point to point wire wrapping and PCB or ribbon cable bussing, and connects together the devices which constitute the system.

baud rate - The rate at which information passes down a communication channel. In a serial transmission link the baud rate will correspond to the number of bits passing over the link in one second. However, the baud rate is not equivalent to data bits per second. However, the number of data bits passed per second will be less when Start and Stop bits are taken ito account.

BICC-VERO - A manufacturer of racking systems.

binary - The system of counting to the base 2. In the decimal system we count to the base 10 and each of the digits can represent 10 numbers.
e.g. In the decimal number "25" the LSD (least significant digit) "5" represents one of the ten possible "unit" numbers (0-9), and the MSD (most significant digit) "2" represents one of the ten possible "tens" numbers (0x10-9x10). Each increase in significance of a digit multiplies its value by ten.
In the binary system, each digit can represent one of only two numbers (0 or 1), and each increase in significance of a digit multiplies its value by two. Thus the decimal number 25 is equivalent to the binary number 11001.

i.e. binary	decimal
1	1
0x2	0
0x2x2	0
1x2x2x2	8
1x2x2x2x2	16
1 1 0 0 1	25

The number 25, which requires two digits to express it in decimal, requires five digits to express it in binary. However, binary has the advantage of being easy to represent electrically. - The two numbers of each digit can be represented by the two states of an electric circuit (ON and OFF). In practice, the circuit is switched to the potential of one of its (5V) power supply rails; 5V being taken to represent the condition of the binary digit represented above by 1, and 0V being taken to represent the condition of the binary digit represented above by 0. The condition (1) represented by 5V is also referred to as **HIGH**: and the condition (0) represented by 0V is also referred to as **LOW**.

bit - Single element of a byte - see **byte**.

BR 1810 - A specification issued by the D of S&T detailing the protocol to be followed in communications between electronic systems used by the S&T. - The purpose being to ensure compatibility and ease the assimilation of individual systems into any future Integrated Electronic Control Centre.

buffer - A circuit providing for the temporary storage of data passing between two devices. One of the devices will place the data in the buffer and set a control bit indicating that the buffer is full. The second device will test the control bit and, when appropriate, take the data from the buffer.

bus - You get on a bus to travel between areas of the town: data gets on a bus to travel between areas of the system. A bus is a group of conductors with a common purpose connecting together devices in the system. The conductors may be ribbon cable, wire wrap or PCB tracks. The bus will have associated conductors carrying signals which control access to the bus.

busbar - A heavy conductor used for distributing power to the system. Individual devices tap onto the busbar at any convenient point.

byte - The smallest block of data with which a computer (in this case the control card) works. The microcomputer used has 8 bit buses for the passage of internal data; hence in this system a byte is a group of 8 bits. A byte is often referred to as a **word**, this is to be avoided, since this term has a more specific meaning in the context of the DAM system.

carrier - A signal, at a fixed frequency, which is present on a MODEM communication link when no data is passing over the link (see **MODEM**).

cascaded - A group of identical circuits, connected such as to be able to implement the circuit's function on larger bytes than is possible for the component circuit, is said to have its individual circuits cascaded.

CCITT - An international committee charged with establishing standards for data communication.

clock - A signal which controls the rate at which a circuit operates. Each time clock goes high (or low) the circuit is free to change state; clock goes alternately high and low at a fixed rate.

comparitor - A circuit which compares two bytes of data and gives an output indicating which byte has the greater binary value, or, if such be the case, that they are of equal binary value. It will be appreciated that this later indication is of considerable convenience in decoding address data.

configuration - Cards used in ScR systems are designed with a considerable degree of flexibility. The cards can be combined in several ways to produce systems with differing capabilities, and some of the cards have circuit options built in to allow them to perform different tasks within the system. Once the system has been designed, the cards will have been combined in a particular way, and their role in the system, and hence their circuit options, will have been decided. - The circuit and cards are then said to be "configured" in a particular way. The combination of cards is known as the system configuration; and the circuit options chosen for the individual cards are known as the cards' configurations.

corruption - When the data in the system changes in a way not controlled by the programme, perhaps through power supply noise or radio interference, it is said to have been "corrupted". This phenomenon is known as corruption.

current-loop - A serial transmission method using the presence or absence of a 20mA current in the transmission pair to indicate a 1 or 0. This method is less susceptible to interference than V24 and can be used over greater distances.

COS - **C**hange **O**f **S**tate. A signal originating on a multiplexing card and indicating that an input on that card has undergone a change since the card was last read. (see 1-6)

DAM - **D**irect **A**ddress **M**ultiplex. (see 1-2)

data - This is what it's all about! Data is what information is known as when it's inside a computer system. The job of the remote control is to take information from the
signalling system at one relay room and pass it into the signalling system at another relay room. To accomplish this it translates the information from one relay room into a binary pattern of 1s and 0s, and transmits this pattern to the other relay room where it is retranslated into signalling information. - More specifically, the binary pattern of 1s and 0s within the system is the data.

demultiplexing - The process of distributing the data from a single channel to many destinations.

DIL - **D**ual **I**n-**L**ine (Package). A form of packaging in which the component lead-out pins are arranged in two rows of pins set at a pitch of 0.1". In the most commonly used integrated circuit package these rows are set 0.3" apart.

DIP - See **DIL**.

DIN - The initials of the institute which sets the standards to which German electronic equipment must comply. As you might expect of the Germans, these standards are very comprehensive and widely complied with. The edge connectors and racking system we use are to the DIN standards; these being by far the worst widely adopted in
this country for equipment of this nature.

duplex - The term used to describe a two-way transmission system. Simplex is transmission in one direction only between two devices: duplex is transmission in both directions between two devices. A full-duplex system is capable of transmitting in both directions at the same time: a half-duplex system must wait for transmission in one direction to stop before transmitting in the other direction. The system links are configured as 4 wire full-duplex systems. 2 wire full-duplex is possible, however we have chosen not to use it since fault-finding on the link then becomes rather difficult.

eurorack - The name in common use for racks to the DIN standard to which those used to contain the system are built.

event-driven - A system which is inactive unless an external occurrence requires it to operate is said to be event-driven.

fault - A hypothetical condition which ScR designed systems never enter.

FDM - **F**requency **D**ivision **M**ultiplex. A multiplexing system in which the individual signals to be multiplexed are allocated one of a range of frequencies within a group which can be transmitted simultaneously. Since each signal is communicated solely by the modulation of its own carrier all signals can be transmitted continuously.

FM - **F**requency **M**odulation. The method of encoding data on a carrier signal by altering its frequency.

full-duplex - see **duplex**.

header - The receptacle into which an insulation displacement connector plugs.

HIGH - see **binary**.

HP - The unit in which the width of a eurorack is measured, and hence, the unit in which the width of the components fitted to it are specified.

IC - **I**ntegrated **C**ircuit. A package containing part of the logic circuit. It will contain several logic gates, some of which can be tested individually, but all of which have to be replaced together due to the packaging. The ICs used in the system are usually "74 series" circuits, and the number printed on the package, following the series identifier, identifies the logic elements present in the circuit.

IDC - **I**nsulation **D**isplacement **C**onnector. A type of connector the electrical contact of which relies for its mechanical integrity on a system of twin blades which cut through the insulation around the conductor and bite into the conductor to establish an electrical connection.

interface - As a noun: the junction between two devices or systems. As a verb: to link two devices or systems.

isolation supply - The system is connected to the interlocking and panel indication circuits via opto-isolators and relays. To maintain the integrity of this isolation, a separate power supply is required on the input side of the opto-isolators. This supply is known as the isolation supply.

La - The system uses double-eurocard format PCBs each of which has two indirect edge connectors fitted, which, when the board is fitted in the rack, can be thought of as an upper edge connector and a lower edge connector. "L" refers to the lower of these edge connectors. The pins of these edge connectors are in two vertical rows: "a" refers to the righthand row (when viewed from the rear) and "c" to the lefthand row. Hence La10 is the tenth pin down in the righthand row of the lower edge connector.

Lc - see **La**.

latch - A storage device into which data can be written and in which data will remain until cleared.

LED - Light Emitting Diode. A semiconductor which has the usual properties of a diode, but which in addition emits light of a fixed wavelength when forward biased.

LSB - **L**east **S**ignificant **B**it. In a binary code, the LSB is the bit with the lowest numerical significance (see **binary**).

LOW - see **binary**.

mark - see **MODEM**.

MSB - **M**ost **S**ignificant **B**it. In a binary code, the MSB is the bit with the highest numerical significance (see **binary**).

MOD - Shorthand for modification. This appears after the SES number identifying the card on some of the cards used in the system. It distinguishes small variations in the build characteristics of the card. The number following "MOD" identifies the exact variation. Cards with higher MOD numbers have extra facilities but are interchangeable with any card bearing the same SES number.

MODEM - **MOD**ulator/**DEM**odulator. A device used to transmit serial data over long distances in a comparatively interference-free form. It works by transmitting a fixed frequency known as the carrier when no data is present and shifting to one of two other frequencies (known as mark and space), one either side of the carrier frequency,
to represent the two binary states of the data.

monostable - A circuit the output of which has one stable state. A control signal can change the state of the circuit for a fixed length of time, after which it returns to the stable state.

multiplexing - The process of combining data from many sources into a form suitable for transmission down a single channel.

NSB - **N**ext **S**ignificant **B**it. In a binary code, the bit next in numerical significance, either more or less, to one previously identified (see **LSB** & **MSB**).

opto-isolator - A device consisting of an LED and a photo-sensitive transistor encapsulated in a light-proof package. It is used to provide electrical isolation between two signals. One signal switches the light from the LED on and off, thus turning the photo-transistor on and off. The transistor controls the second signal and hence the first signal effectively controls the second without any electrical connection existing between the two.

parity - A system of protecting against the acceptance of corrupt data by including an extra bit in each message. This bit is set high or low as appropriate to ensure that the binary sum of all the bits in the message (including parity) is always either odd (for odd parity) or even (for even parity). A transmission system operating with odd parity will reject any messages received with even parity (and vice-versa).

PCB - **P**rinted **C**ircuit **B**oard. A fibre-glass board carrying a pattern of copper tracking on its surface. This tracking forms the electrical connection between circuit elements.

processor - The part of the computer which does all the work. The processor takes each programme instruction in turn and carries out the logical operation required by that instruction, on the data specified by that instruction, before moving on to the next instruction.

programme - A list of instructions for the processor to carry out. The programmer's skill lies in picking the sequence of instructions which will produce the required results from the input data.

protocol - The rules governing communication between two devices or systems. The protocol will specify the handshaking, message format, baud rate etc.. It will be obvious that, to avoid the data being misinterpreted, the protocol must be strictly adhered to. Data which does not conform to the protocol will be ignored.

quench circuit - A circuit intended to protect a device from the excess voltage generated by the release of the energy stored in the coil of a relay driven by that device, when the feed is removed. It operates by limiting the discharge rate of the stored energy.

RD - **R**ea**D**. A control pulse issued by one device to obtain data from another.

ribbon cable - A flat multi-core cable with the cores running parallel to each other at a fixed spacing in a single plane, with the insulation of each attached to that of its neighbours. This format makes the cable ideal for use with multi-way IDC systems.

ROK - An input on the control card, used in the alarm circuits. (see 4-5)

ROK/TOFF - an output on the control card, used in the alarm circuits. (see 4-5)

RS 232 - An internationally accepted communications interfacing standard, originating from America, based on a 3 wire communication channel with voltage polarity changes of the Rx and Tx wires (relative to the 3rd wire reference voltage) representing mark and space. RS232 also specifies the handshaking signals used and the pin allocations of the interfacing connector. V24 is essentially the same standard as defined by a -european standards authority. The SES has adopted the convention of referring to RS 232 when the link under discussion uses the complete specification and to V24 when only the polarity changing principle has been used: This is incorrect usage but it does come in handy!

Rx - shorthand for receive.

scan - to examine sequentially. For example, on receiving COS the control card scans the output buffers of the Multiplexing cards, examining bit 8 of each in turn to determine whether the COS originated on that card. Also used to refer to a complete "run-through" of the programme: i.e. from start instruction to start instruction.

SES - **S**ystems **E**ngineering **S**ection. At the time of writing, a section within Signalling Control U.K. (formally Signalling Electronics of the D of S&TE).

simplex - One way data transmission (see duplex).

space - see **MODEM**.

tri-state - A type of logic, mainly used in circuits connected to a bus, which can assume, in addition to the binary logic levels, a third state which presents a high impedance to the bus; allowing other devices to use the bus without electrically stressing either circuit.

switch mode - A type of power supply in which the incoming mains voltage is first rectified, then used to power a high frequency invertor, the output of which is rectified and regulated to produce the required low voltage DC output. This method produces a compact and cost effective supply (the step-down transformer, now operating at high frequency, can be considerably smaller) and also has advantages in tolerance of mains fluctuations.

TDM - **T**ime **D**ivision **M**ultiplex. (see 1-1)

TOFF - An input on the control card, used in the alarm circuits. (see 4-5)

Tx - shorthand for transmit.

U - The unit in which the height of a eurorack is measured, and hence, the unit in which the height of the components fitted to it are specified. Note, however, that a 6U card is more than twice the height of a 3U card since it includes the height which, when two 3U racks are stacked, is occupied by the upper rail of the lower rack and the lower rail of the upper rack.E

Ua - The system uses double-eurocard format PCBs each of which has two indirect edge connectors fitted, which, when the board is fitted in the rack, can be thought of as an upper edge connector and a lower edge connector. "U" refers to the upper of these edge connectors. The pins of these edge connectors are in two vertical rows: "a" refers to the righthand row (when viewed from the rear) and "c" to the lefthand row. Hence Ua10 is the tenth pin down in the righthand row of the upper edge connector.

UART - **U**niversal **A**synchronous **R**eceiver **T**ransmitter. A communications IC designed to simplify the transmission and reception of serial data. In the multiplexing control card, the UART is acting as a transmitter. The microcomputer passes the data to be transmitted to the UART in parallel form. The UART adds the framing and parity bits required to form the complete message block, and passes the data to the MODEM in serial form. In the demultiplexing control card, the UART is acting as a receiver. The data arrives at the UART, from the MODEM, in serial form. The UART checks the framing and parity bits for errors and strips them from the data. The UART then informs the microcomputer of the arrival of the data and, when requested to, presents it, together with notification of any errors detected in parallel form. In short, the UART handles the time consuming tasks of serial transmission; freeing the microcomputer to perform other tasks.

UPS - **U**ninterruptable **P**ower **S**upply - a power unit whose output voltage does not vary with input voltage.

Uc - see **Ua**.

V24 - see **RS232**.

varistor - A component which, below a set voltage, presents an extremely high resistance: above that voltage the resistance decreases rapidly. The effect of including this component in a parallel circuit is to "clamp" the voltage of the circuit slightly above the varistors set voltage.

wire-wrap - A system of wire termination which has largely replaced soldering in backplane wiring. The termination pins are square in cross-section with sharp edges. A special tool is used to wrap the wire tightly around the pin such that the edges of the pin bite into the wire; forming a firm electrical connection.

word - A group of seven inputs or outputs (see 1-2). The seven inputs of a word are transmitted together as one block of data. (see also **byte**)

WR - **WR**ite. A control pulse used by a transmitting device to transfer data to a receiving device.