7.15 RWC-MC/DC : MEDIUM CURRENT D.C. DRIVER

7.15.1 FUNCTIONAL DESCRIPTION

The RWC-MC/DC Real-World interface module provides 24 opto-isolated channels for driving D.C. current up to 300 mA. It enables direct isolated DCE control of medium D.C. current devices such as relays, lamps, small D.C. motors etc. normally found in industrial control environments.

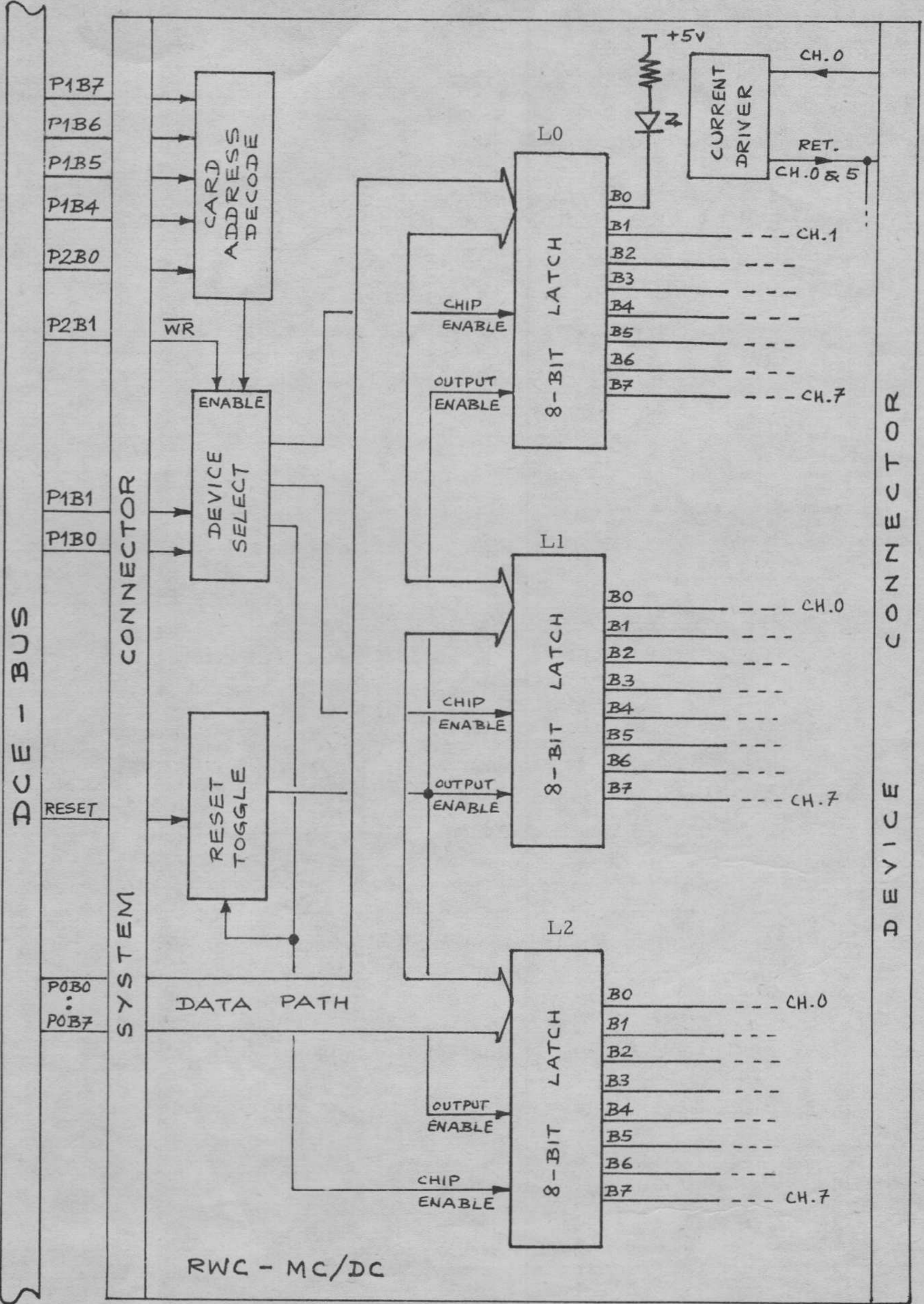
Due to the opto-isolation between the output channels and the DCE system, the RWC-MC/DC module is ideal for precision control environments where industrial noise and ground loops make accurate control difficult. The RWC-MC/DC module can easily be configured as an opto-isolated medium-current D/A converter with one to three channels and 8 to 24-bit resolution, by connecting binary ratioed resistance networks (R:2R:4R:8R:....) externally.

Each module has an identification address defined by the setting of a 4 gang DIP switch. Up to fifteen modules can be directly addressed by the DCE-BUS.

7.15.2 FEATURES

- 24 identical simultaneous independent current output channels
- up to 300 mA D.C. current output per channel
- total opto-isolation between each pair of outputs and DCE system
- can be configured as an opto-isolated,medium current D/A converter
- standard hardware and software interface to the DCE-BUS
- selectable module address
- single 100 x 160 mm eurocard format.

7. 15. 3 FUNCTIONAL BLOCK DIAGRAM



Each output can be protected against overvoltage by installing a suitable zener diode between the component pads located on the card for this purpose. See section 7. 15. 4. 1.

7.15.4 SYSTEM DESIGN PARAMETERS

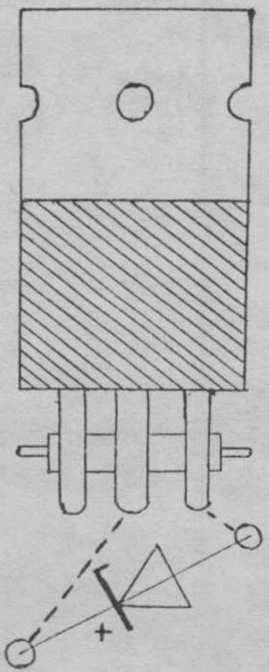
7.15.4.1 Hardware Configuration

The functional block diagram in Section 7.15.3 illustrates the hardware configuration. The RWC-MC/DC does not use a RIC device for interfacing to the DCE-BUS. External power sources are required by the current drivers (separate or combined).

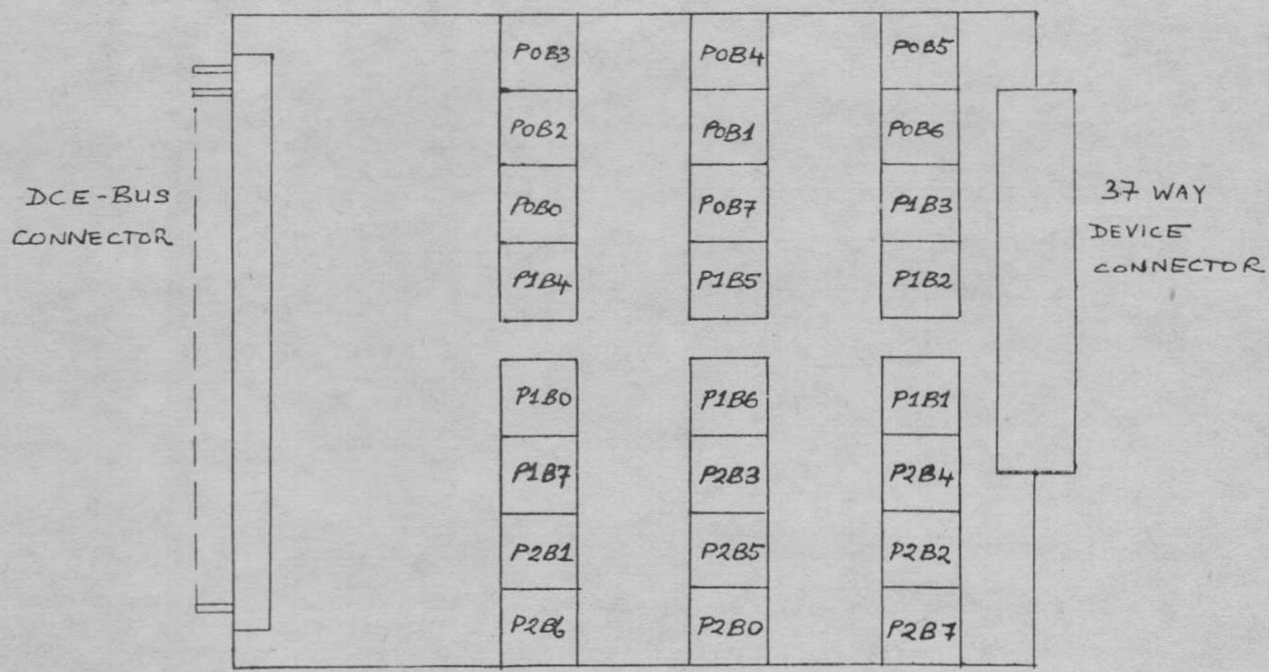
The RWC-MC/DC has three 8-bit latches for the 24 channel-switching control signals. In normal operation, the outputs of each latch follow the data input from the DCE-BUS Data Path while its chip-enable signal is active. DCE-BUS address lines P1B0 and P1B1 are decoded to produce one of three chip-enable signals for the three latches while the $\overline{WR}$ signal is active and the module is correctly addressed. Latching occurs when the corresponding chip-enable signal becomes inactive.

Each latch has an output-enable signal which when inactive disables and thereby switches off all the eight current outputs. The three output-enable signals for the latches are commonly derived from the reset toggle logic, which has the DCE-BUS Reset signal and the chip enable signal for latch L2 as the two inputs. This feature ensures that all the output currents are switched off at power-on or any subsequent system reset. After reset, the outputs from the three latches are simultaneously enabled when latch L2 recieves an active chip-enable signal.

The 24 current output channels are grouped as 12 pairs, with each pair sharing a common return. These 12 pairs are opto-isolated from each other and from the DCE system. Overvoltage protection can be fitted by the user if necessary. The component pads for this are commonly located as illustrated below.



LOCATION OF PROTECTIVE ZENER DIODE. (VIEW FROM PRINT SIDE).



LOCATION OF INDIVIDUAL DRIVERS, WITH PROGRAMMING REFERENCES. (COMPONENT SIDE)

7.15.4.2 Programming Specifications

The RWC-MC/DC module is addressed via the standard DCE-BUS interface. Programming specifications for driving the DCE-BUS are given in Section 4.1 of this manual.
The card address is defined by the setting of the 4 pole DIP switch. The setting of this switch is compared to P1B4 through P1B7 address lines. Closure of any switch causes logic 1 comparison. P1B7 is defined by the switch nearest to the DCE-BUS connector. Likewise, P1B6,5 and 4 are defined in order.

Since the module does not use the $\overline{RD}$ signal from the DCE-BUS, software Read operations are not recognised by it.

After power-on or system reset, all 24 current channels will be switched OFF automatically, and no software initialization is necessary. After a system reset, the outputs of all three latches will remain disabled until latch L2 is enabled by a Write operation to it. A Write operation to L2 will cause the data on the DCE-BUS Data Path to be latched at L2, and enable the outputs of all three latches.

Format and Interpretation of Data

After the outputs of the three latches are enabled by the first Write operation to L2 the latched output signals control the 24 current outputs from the module. The 24 latched output signals are all active high.
The latched output signal definitions are as follows:

Latch L0 : b0 - B7 = control signals for Channels L0C0-L0C7
(0 = current OFF)
(1 = current ON)

Latch L1 : b0 - B7 = control signals for Channels L1C0-L1C7
(0 = current OFF)
(1 = current ON)

Latch L2 : b0 - b7 = control signals for Channels L2C0-L2C7
(0 = current OFF)
(1 = current ON)

Latch Addresses

The DCE-BUS Data Path is channelled to one of the three 8-bit latches depending on the address received by the RWC-MC/DC module from the DCE-BUS. Table 7.15.1 shows the Device Addresses associated with the three latches L0, L1 and L2.

Device Address (Hex)	$\overline{RD}$	$\overline{WR}$	Operation
Y0	1	0	DCE Data Bus → Latch L0
Y1	1	0	DCE Data Bus → Latch L1
Y2	1	0	DCE Data Bus → Latch L2, and enable output status batch
YN	1	0	Invalid condition. May change latch outputs.
YX	0	1	Invalid condition.
ZX	X	X	Data bus in 3-state

Notes:

1. Y is the card address select switch setting in hex (1 to F).
2. Z is any number other than Y.
3. X means don't care.
4. N means any number other than 0, 1 or 2.
5. Bits 2 and 3 in the Device Addresses are don't care states.
6. WRRWC software routine provides the $\overline{WR}$ signal accordingly.

Table 7.15.1 : Device Address Table for RWC-MC/DC

Special Considerations

If the 24 current output channels are to be enabled simultaneously, appropriate data must be written to latches L0 and L1 before writing to latch L2. After the first software Write operation to L2, all 24 channels will be enabled and be under control of the 24 latched output signals. The output channels can then be switched ON or OFF as necessary by writing appropriate data to the three latches in any desired sequence

A system Reset will disable all the current outputs, but will not change the 24 latched output control signals. L2 must be written to in order that the current outputs are re-enabled.

RWC-MC/DC DCE-BUS Protocol

Channel switching is carried out by writing the appropriate control words to the three latches in the RWC-MC/DC module. For example, the following sequence will switch channels L2C7, L2C6 and L3C1 ON simultaneously after a system reset (module address switch set to 'E' hex) :

```
MVI     A,0E0H      bits 7-4 = module address;  3-0 = address of L0
STGI    1           select L0 of RWC-MC/DC
XRA     A
CALL    WRRWC       all L0 outputs to OFF state
MVI     A,0E1H
STGI    1           select L1 of RWC-MC/DC
MVI     A,0C0H
CALL    WRRWC       b6 and b7 outputs of L1 to ON state
MVI     A,0E2H
STGI    1           select L2 of RWC-MC/DC
MVI     A,02H
CALL    WRRWC       b1 output of L2 to ON state; enable all 24
                    current channels simultaneously
```

7.15.4.3 Module Connector Definitions

System Connector

See Section 6.1.4 for the pin definitions.

Device Connector

Pin definitions for the 37-pin D-type female connector are as follows :

Pin Number	Signal
1	+L0C0
2	+L0C7
3	+L1C3
4	-L1C2, L1C3
5	+L1C4
6	+L1C5
7	+L1C2
8	-L1C5, L0C7
9	-L1C4, L0C0
10	-L1C7, L1C0
11	-L2C3, L1C6
12	+L1C0
13	+L1C6
14	+L1C7
15	+L1C1
16	-L2C4, L1C1
17	+L2C3
18	+L2C4
19	+L2C1
20	-L0C2, L0C3
21	-L0C1, L0C4
22	+L0C6
23	+L0C1
24	+L0C2
25	-L0C5, L0C6
26	+L0C5
27	+L0C4
28	+L0C3
29	not used
30	-L2C6, L2C1
31	-L2C5, L2C0
32	+L2C7
33	-L2C7, L2C2
34	+L2C6
35	+L2C0
36	+L2C2
37	+L2C5

The 24 return (-) connections are grouped into 12 pairs as shown in the table.

Pin connections for the 24 current channels are as follows:

L0C7	+ 2	- 8
L0C6	+ 22	-25
L0C5	+ 26	-25
L0C4	+ 27	-21
L0C3	+ 28	-20
L0C2	+ 24	-20
L0C1	+ 23	-21
L0C0	+ 1	- 9
L1C7	+ 14	-10
L1C6	+ 13	-11
L1C5	+ 6	- 8
L1C4	+ 5	- 9
L1C3	+ 3	- 4
L1C2	+ 7	- 4
L1C1	+ 15	-16
L1C0	+ 12	-10
L2C7	+ 32	-33
L2C6	+ 34	-30
L2C5	+ 37	-31
L2C4	+ 18	-16
L2C3	+ 17	-11
L2C2	+ 36	-33
L2C1	+ 19	-30
L2C0	+ 35	-31

7.15.4.4 Operational Requirements

Signal Characteristics

Output Current Channels :

Maximum supply voltage = 60v

Peak current = 5A for 1 msec

Recommended maximum continuous current at 25°C ambient (free-air cooling) = 300 mA

Recommended maximum continuous current at 25°C ambient (forced cooling) = 500 mA

Reverse energy rating = 50 mJ

Overvoltage protection 6 - 60V.

Power Requirements

The RWC-MC/DC requires a single +5v power supply from the DCE-BUS. A typical power requirement in the quiescent state is given below. Active state value is typically 20% higher.

+5v : 170 mA

Environmental Requirements

Operating temperature	:	0°C to 55°C
Storage temperature	:	-25°C to +85°C
Relative humidity	:	up to 95% non condensing

Bus Loading

The RWC-MC/DC module presents 3.5 unit-loads to the DCE-BUS (see section 4.4)

7.15.5 ORDERING INFORMATION

RWC-MC/DC : Standard Version

7.16 RWC-PTM : POSITION AND TEMPERATURE MEASUREMENT

7.16.1 FUNCTIONAL DESCRIPTION

The RWC-PTM Real-World interface module enables constant current driven variable resistance parameter measurements, such as with platinum resistance thermometers, displacement potentiometers, position transducers etc.

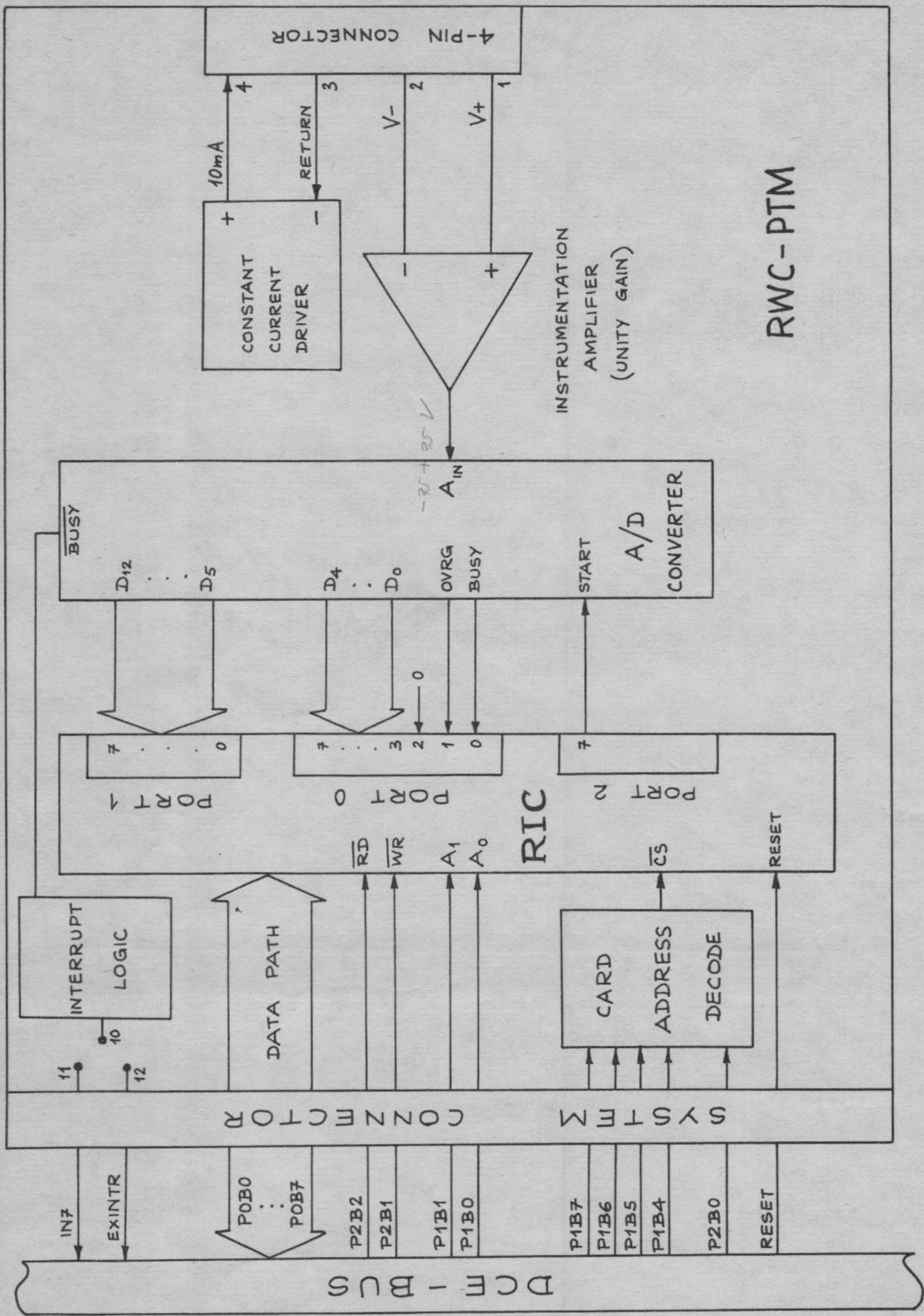
The RWC-PTM has a fully compensated 10 mA constant current source, and a differential analog voltage input channel for measuring the resulting voltage across the variable resistance element. The analog input is converted to a digital value of 13 bits including sign by a quad-slope A/D converter It provides maximum noise rejection with a conversion time of 80 milliseconds. A jumper choice enables the generation of an interrupt via the DCE-BUS at the end of a conversion. Each card has an identification address defined by a hexadecimal switch.

The RWC-PTM has a 4-pin device connector and is intended for use with one or more RWC-MUX multiplexer modules (see section 7.17).

7.16.2 FEATURES

- $\pm$ 2.5v full scale; 13 bit result including sign with full resolution
- 10 mA constant current generator with temperature-compensated high-precision reference
- Unity-gain instrumentation amplifier for differential voltage input and noise rejection
- Uses standard DCE-BUS power supplies
- Standard hardware and software interface to the DCE-BUS
- Selectable card address
- Single 100 x 160 mm eurocard format

7.16.3 FUNCTIONAL BLOCK DIAGRAM



7.16.4 SYSTEM DESIGN PARAMETERS

7.16.4 1 Hardware Configuration

The functional block diagram in Section 7.16.3 illustrates the hardware configuration of the RWC-PTM module.

The 4-pin device connector on the RWC-PTM carries the constant current output to, and receives the voltage input from the selected channel on the RWC-MUX multiplexer modules. Each RWC-MUX module provides 16 multiplexed channels, and upto 14 can be directly connected to a RWC-PTM. Each RWC-MUX has a 4-pin connector and a 4-wire flat cable so that they can be directly linked to each other and to the RWC-PTM.

Before performing an analog to digital conversion, system software must select one of the RWC-MUX modules and enable one of the 16 channels on it. The conversion is then started by a software signal to the A/D converter. The end of a conversion can be detected by the generation of an interrupt, or by software scanning of the BUSY output of the A/D converter. The digital result is then read from the A/D converter by the DCE processor via the DCE-BUS.

7.16.4.2 Programming Specifications

The RWC-PTM module is addressed via the standard DCE-BUS interface. Programming specifications for driving the DCE-BUS are given in Section 4.7 of this manual.

RIC Initialisation

The RIC on the RWC-PTM module should be initialised by writing the control word 92H to the RIC Command Register. This configuration provides a 16-bit data path from the A/D converter device to the DCE-BUS via RIC port 0 and 1; and a start signal to the A/D converter via RIC Port 2 Bit 7.

The 16-bit data path is used for 13 bits of data representing the digital value of the selected analog channel, and 2 control bits from the A/D converter.

RIC Device Addresses

The RIC on the RWC-PTM module has 3 data ports and a command register. Different modes of communication between RIC Ports 0, 1, 2 and the DCE-BUS data path are established depending on the Device Address received by the RWC-PTM module from the DCE-BUS. The following table shows the Device Addresses needed for the different communication modes.

DEVICE ADDRESS (HEX)	$\overline{RD}$	$\overline{WR}$	OPERATION
Y0	0	1	RIC Port 0 → DCE-BUS Data Path
Y1	0	1	RIC Port 1 → DCE-BUS Data Path
Y2	0	1	Invalid Operation
Y3	0	1	Illegal Condition
Y0	1	0	Invalid Operation
Y1	1	0	Invalid Operation
Y2	1	0	DCE-BUS Data Path → RIC Port 2
Y3	1	0	DCE-BUS Data Path → RIC Command Register
ZX	X	X	RIC Data Bus in 3-state

Notes:

1. Y is the card address select switch setting in hex (1 to F).
2. Z is any number other than Y.
3. X means don't care.
4. RDRWC and WRRWC software routines provide the $\overline{RD}$ and $\overline{WR}$ signals accordingly.
5. Bits 2 and 3 in the low-order byte of the Device Addresses are don't care states.

Table 7.16.1 : Device Address Table for RWC-PTM

Format of Data

The digital output from the A/D converter corresponding to a selected multiplexed analog channel signal is input to the DCE-BUS via RIC Ports 0 and 1. The digital result from the converter consists of 13 bits. 2 of the bits of RIC Port 0 are used for status signals from the A/D converter. Input signal allocation for RIC Port 0 and 1 bits are as follows :

Port 0 :	b0	=	A/D converter busy flag indicating when a conversion is in progress
	b1	=	A/D converter over-range flag indicating that the analog voltage input is outside specified range
	b2	=	not used
	b3 - b7	=	A/D output data bits 0 - 4
Port 1 :	b0 - b7	=	A/D output data bits 5 - 12

The START signal to the A/D converter is sent from the DCE-BUS to RIC Port 2. Bit allocation is as follows :

Port 2 :	b0 - b6	=	not used
	b7	=	START : start pulse to the A/D converter to initiate the conversion

Interpretation of Data

The A/D converter on the RWC-PTM module gives a 13-bit digital result in two's complement form, where the most significant bit acts as the sign bit. If this bit is set, the result is negative (0 to -2. 5V analog input); if it is clear, the result is positive (0 to +2. 5V analog input). When the sign bit is set, the actual value of the negative result is given by the remaining 12-bits in two's complement form.

When the sign bit is clear, the value of the positive result is given by the remaining 12 bits in the normal form. This is illustrated in the figure below:

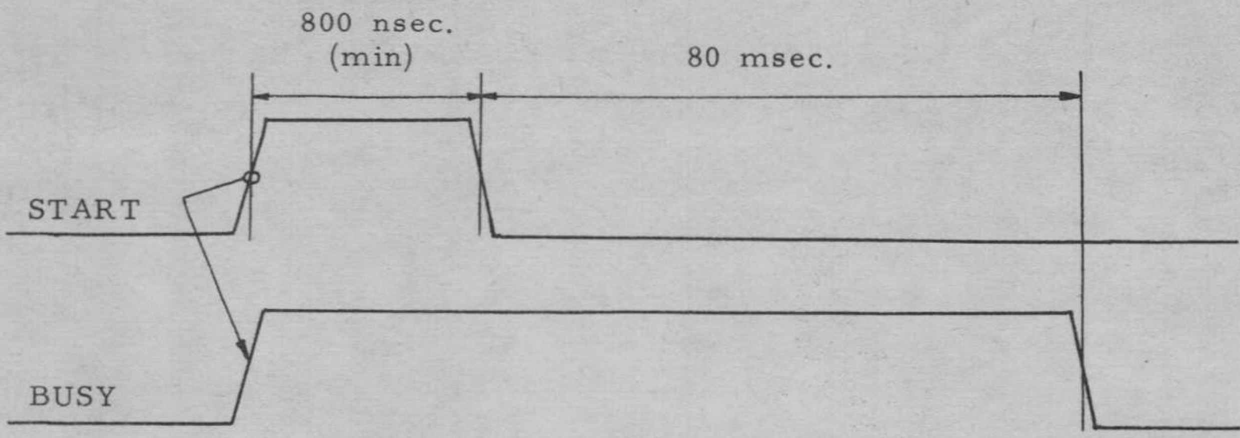
ANALOG INPUT		13-BIT DIGITAL OUTPUT
+2.5V	←——→	0 111111111111
.		.
.		.
.		.
0V	←——→	0 000000000000
.		1 111111111111
.		.
.		.
.		.
-2.5V	←——→	1 000000000000

The digital output in its normal form is suitable for performing arithmetic operations etc. where a sign capability is needed. However, it can be interpreted to suit specific requirements.

For example, by complementing the sign bit (by software) it is possible to have a range of all zeros to all ones in the digital result, corresponding to the analog input range of -2.5V to +2.5V. In such a case the 13th bit in the result also becomes a data bit giving a range of digital values from 13 zeros to 13 ones.

Special Considerations

The analog to digital conversion procedure is initiated by giving a START pulse to the A/D converter (via RIC Port 2 bit 7). The timing diagram on the next page shows the sequence of operation:



The rising edge of the START signal produces the BUSY output signal from the A/D converter. However, the actual conversion does not commence until the falling edge of the START signal. BUSY is a status signal which when high indicates that a conversion is in progress. The RWC-PTM module design allows this BUSY signal to be used as a software polled flag (via RIC Port 0 bit 0), or as an interrupt request generator at the end of a conversion. Interrupt driven operation of the RWC-PTM module allows the DCE processor to carry out other functions while an A/D conversion is in progress.

The A/D converter provides an over-range flag OVRG via RIC Port 0 bit 1. This when true indicates that the analog input signal was outside the specified range ($\pm$ 2.5V).

The digital result read from the RWC-PTM module is valid only if both BUSY and OVRG signals are low.

In order to minimise the heating effects of the 10mA constant current on the variable resistance being measured, the current must be present during the A/D conversion only. This is achieved by enabling the required multiplex channel on the selected RWC-MUX only during the conversion process. Such a procedure will minimise the heating effects of the current to negligible proportions.

RWC-PTM RIC / DCE-BUS Protocol

Initialisation

The RWC-PTM module RIC should first be initialised by writing control word 92H to its Command Register. This will configure RIC Ports 0, 1, 2 in the required modes and disable the Start signal. The A/D converter does not have a RESET input; therefore, it may start-up with a random conversion in progress. One way to clear the A/D converter is to perform a dummy conversion as described below, and to wait till the BUSY line goes low. The RWC-PTM is then ready for normal operation.

A/D Conversion

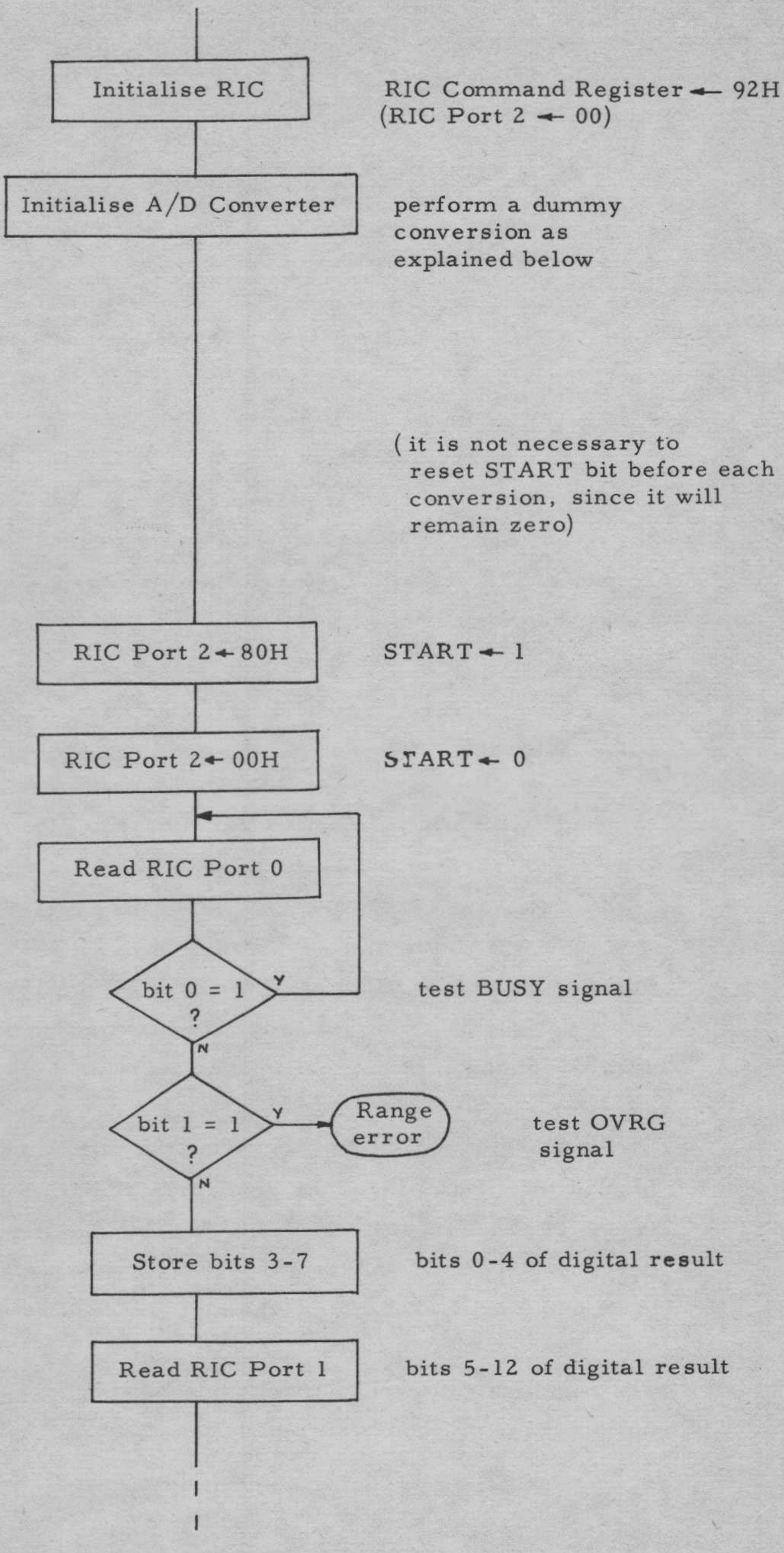
In order to initiate an A/D conversion, select the required analog input by addressing one of the RWC-MUX modules and enabling one channel on it (see Section 7. 17). Start the conversion procedure by writing a word with bit 7 = 0 (START bit) to RIC Port 2. Do two more operations to RIC Port 2 with bit 7 = 1 and then 0. This sequence will pulse the START input to the A/D converter and initiate the conversion for the selected multiplexed channel.

The conversion will be finished when the BUSY line goes low. Therefore, after sending the START pulse, scan RIC Port 0 until bit 0 becomes zero. Next test the OVRG flag (bit 1). If zero, the conversion results are correct and the low-order 5 bits have already been read from RIC Port 0. Then read the high-order 8 bits from RIC Port 1.

The complete software controlled conversion sequence is given on the next page.

Initialisation:

Example of a conversion sequence:



If the RWC-PTM module is configured by a jumper connection to generate an interrupt when BUSY goes low at the end of a conversion, the interrupt service routine should test the OVRG flag.

7.16.4.3 User Options

Interrupt Generation Jumpers

Jumper network 10 - 11 - 12 alows the user to connect the $\overline{\text{BUSY}}$ output signal of the A/D converter to interrupt request lines EXINTR (10 - 12) or IN7 (10 - 11) on the DCE-BUS.

7.16.4.4 Module Connector Definitions

System Connector

See Section 6.1.4 for the pin definitions.

Device Connector

The constant current output and the voltage input signals are provided via a 4-pin connector. Pin definitions are as follows :

1 : input voltage (+ve)
2 : input voltage (-ve)
3 : 10mA current return
4 : 10mA current output

Note: When the RWC-PTM is held with the component side up and the system connector to the left side, the top end of the 4-pin connector corresponds to pin 4 and the bottom end corresponds to pin 1.

These connections are automatically taken care of by the 4-wire cable connection from the RWC-MUX modules.

7.16.4.5 Operational Requirements

Signal Characteristics

Constant Current Source :

temperature coefficient	=	0.002% per °C
long-term stability	=	40 ppm
warm-up time to 0.05%	=	10 seconds typical at 25°C

Power Requirement

The RWC-PTM requires three power supplies from the DCE-BUS. The values given below are for the quiescent state. Active state values are typically 20% higher.

+12V	:	75mA
+ 5V	:	175mA
- 5V	:	60mA

Environmental Requirements

Operating temperature	:	0°C to 55°C
Storage temperature	:	-25°C to +85°C
Relative humidity	:	95% noncondensing

Bus Loading

The RWC-PTM module presents 1 unit-load to the DCE-BUS (see Section 4. 4).

7. 16. 5 TEST PROCEDURE

This section defines a simple test configuration and procedure for performing a basic functional test on the RWC-PTM module. Users are advised to carry out such a test procedure when necessary to establish the correct functioning of a module. The test program is similar to that for the RWC-AI modules (see Section 7. 6. 5), except that RIC Port 2 Bits 0-6 are not used on the RWC-PTM.

Test Configuration

The test requires a variable resistance to be connected across the V+ and V- inputs of the RWC-PTM. The 10mA output and V+ are connected to one end of the resistance, and the current ground and V- to the other end. Varying the resistance will produce different digital conversion values, which can be read by the test program. A 50Ω 1/4W limiting resistor in series with a 200Ω variable resistance is recommended.

Note : The RWC-AI/16S test program (Section 7. 6. 5) can be easily modified to repeat whenever a key on the console is pressed. This is done by changing the last few instructions as follows :

Existing program :

```
        -
        -
        -
        1068    CD1F06    PR:    CALL    TCRLF
        106B    CDFD05           CALL    TADDR
        106E    C9               RET
                                 END
```

Modification to repeat when any key on console is pressed :

```
                          CI:    EQU     054C
        -
        -
        -
        1068    CD1F06    PR:    CALL    TCRLF
        106B    CDFD05           CALL    TADDR
        106E    CD4C05           CALL    CI     ;press any key to repeat
        1071    C30E10           JMP     CONV ;repeat conversion
                                 END
```

7. 16. 6 <u>ORDERING INFORMATION</u>

RWC-PTM : Standard version