7.3 RWC-T24 : GENERAL TTL INTERFACE

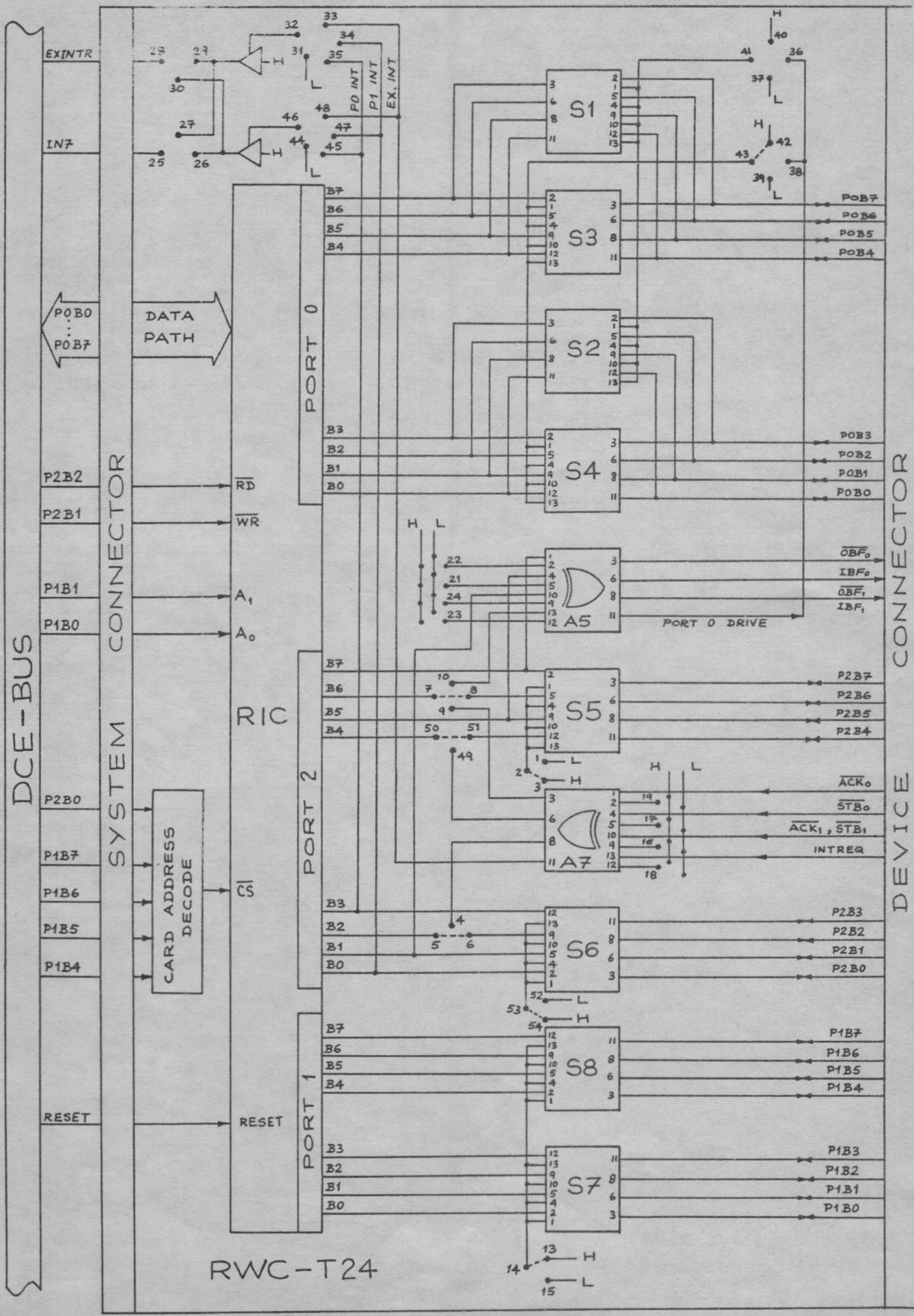
7.3.1 FUNCTIONAL DESCRIPTION

The RWC-T24 Real-World interface module enables all TTL compatible parallel devices to be interfaced to the DCE-BUS, via 24 programmable I/O lines. By insertion of standard TTL buffer/inverter chips or termination, and utilization of jumper options the user can easily configure the card to specific interface requirements. Each card has an identification address defined by a hexadecimal switch, and up to 15 cards may be directly connected to the DCE-BUS.

7.3.2 FEATURES

- three 8-bit ports programmable for simple, handshaking or bidirectional operation.
- automatic generation of handshake signals.
- sockets for standard TTL drive or termination.
- jumper definition of input/output control signals.
- standard hardware and software interface to the DCE-BUS.
- selectable card address.
- single 100 x 160 mm eurocard format.

7.3.3. FUNCTIONAL BLOCK DIAGRAM



7.3.4 SYSTEM DESIGN PARAMETERS

7.3.4.1 Hardware Configuration

The functional block diagram in Section 7.3.3 illustrates the hardware configuration of the RWC-T24 module. The 24 programmable I/O lines from the three RIC ports are brought out to the device connector through a network of sockets. The user must insert into these sockets component carriers with links or termination resistors for input, or standard TTL buffer/inverter devices for output drive and control signal characterization. Connecting links may also be installed for output signals if enhanced drive and inversion are not required.

The following RIC input/output configurations are available on the RWC-T2

Port 0 - may be buffered output, inverted input, terminated input, or buffered bi-directional.

Port 1 - may be buffered output or terminated input.

Port 2 - upper and lower 4-bit groups may each be buffered output or terminated input. Handshake control signals are brought out separately and they may be individually inverted by jumper selection.

One external interrupt request line with optional inversion is provided.

The two interrupt requests associated with input/output handshake control may be gated along with the external interrupt request, to IN7 or EXINTR lines on the DCE-BUS via a jumper network.

The following jumpers are normally connected when the card is shipped to select simple I/O at RIC ports. If the user wishes a different configuration of the card, he must remove the conflicting jumpers and install new ones.

2 - 3 : active high enable for device in socket S5

5 - 6 : PORT 2 Bit 2 connected to device in socket S6

7 - 8 : PORT 2 Bit 6 connected to device in socket S5

13 - 14: active high enable for devices in sockets S7 and S8

42 - 43: active high enable for devices in sockets S3 and S4

50 - 51: PORT 2 Bit 4 connected to device in socket S5

53 - 54: active high enable for device in socket S6

7.3.4.2 Programming Specifications

The RWC-T24 module is addressed via the standard DCE-BUS interface. Programming specifications for driving the DCE-BUS are given in Section 4.1.

The RIC on the RWC-T24 module is the same type of device as the GIC on DCE microcomputer modules. For complete programming specifications, timing diagrams and characteristics of the RIC refer to Section 2 of this manual. The RIC may be configured in all the possible modes specified for the GIC, provided the jumper networks are appropriately connected.

Note that the DCE GIC macros cannot be used with the RIC.

RIC Device Addresses

The RIC on the RWC-T24 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-T24 module from the DCE-BUS. The following table shows the Device Addresses needed for different communication modes:

DEVICE ADDRESS (HEX)	$\overline{RD}$	$\overline{WR}$	OPERATION
Y0	0	1	RIC Port 0 → DCE Data Bus
Y1	0	1	RIC Port 1 → DCE Data Bus
Y2	0	1	RIC Port 2 → DCE Data Bus
Y3	0	1	Illegal Condition
Y0	1	0	DCE Data Bus → RIC Port 0
Y1	1	0	DCE Data Bus → RIC Port 1
Y2	1	0	DCE Data Bus → RIC Port 2
Y3	1	0	DCE Data Bus → 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. Bits 2 and 3 in the Device Addresses are don't care states.
5. RDRWC and WRRWC software routines provide the $\overline{RD}$ and $\overline{WR}$ signals accordingly.

Table 7.3.1 : Device Address Table for RWC-T24

RIC Configurations

Below is a summary of the different possible modes that can be used to input and output data through the three RIC ports:

GROUP A MODE	PORT 0	PORT 2 (Bits affected)	
0	Output	Output	(4-7)
1	Output	Input	(4-7)
2	Input	Output	(4-7)
3	Input	Input	(4-7)
4	H. S. Output	H. S. C.	(3, 6, 7) Output (4, 5)
5	H. S. Output	H. S. C.	(3, 6, 7) Input (4, 5)
6	H. S. Input	H. S. C.	(3, 4, 5) Output (6, 7)
7	H. S. Input	H. S. C.	(3, 4, 5) Input (6, 7)
8	Bi-directional	H. S. C.	(3, 4, 5, 6, 7)

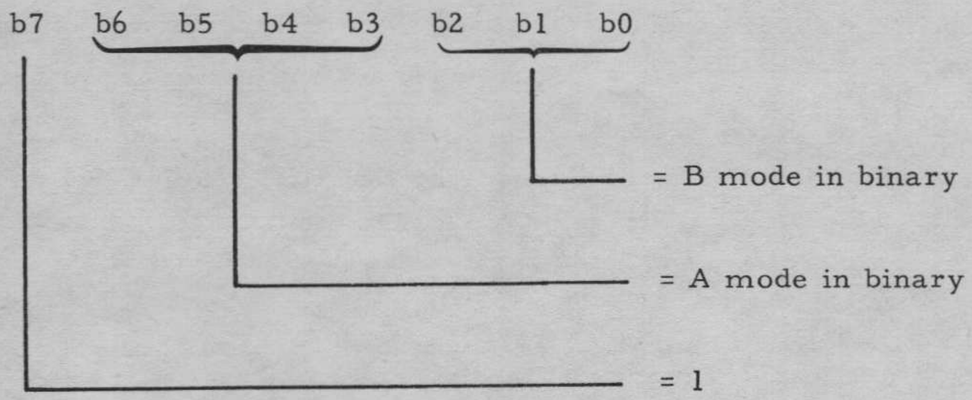
GROUP B MODE	PORT 1	PORT 2 (Bits affected)	
0	Output	Output	(0-3) +
1	Output	Input	(0-3) +
2	Input	Output	(0-3) +
3	Input	Input	(0-3) +
4	H. S. Output	H. S. C.	(0, 1, 2)
6	H. S. Input	H. S. C.	(0, 1, 2)

NOTES: + Bit 3 not affected if Group A in modes 4 through 8.

In the above H. S. = Handshake

H. S. C = Handshake control

The RIC on the RWC-T24 must be first configured in one of the above mode combinations by writing a control word to its Command Register. The bit definitions for this control word are as follows:



A RIC configuration sequence may be followed by a compatible I/O command to RWC-T24 via subroutines 'RDRWC', 'WRRWC' or equivalent.

Ensure that the devices inserted into the sockets correspond to the selected I/O operation.

Format of Data

Output data lines available at the Device Connector pins may be active high or active low, depending on the buffer/inverter devices inserted by the user. Inversion of input data is possible only for Port 0.

Interpretation of Data

Port 2 data lines can be used for normal input/output, except when Port 0 or 1 is functioning in handshaking input or output modes.

RWC-T24 / DCE-BUS Protocol

Each of the three RIC ports may be independently programmed to serve as input or output, with various options. Through selected bits or groups of bits on these ports, the user can input and output data directly to and from a DCE microcomputer via the DCE-BUS. Software controls the selection of data I/O lines and different I/O configuration modes. For handshake input and output modes the handshake control signals are generated automatically by the RIC.

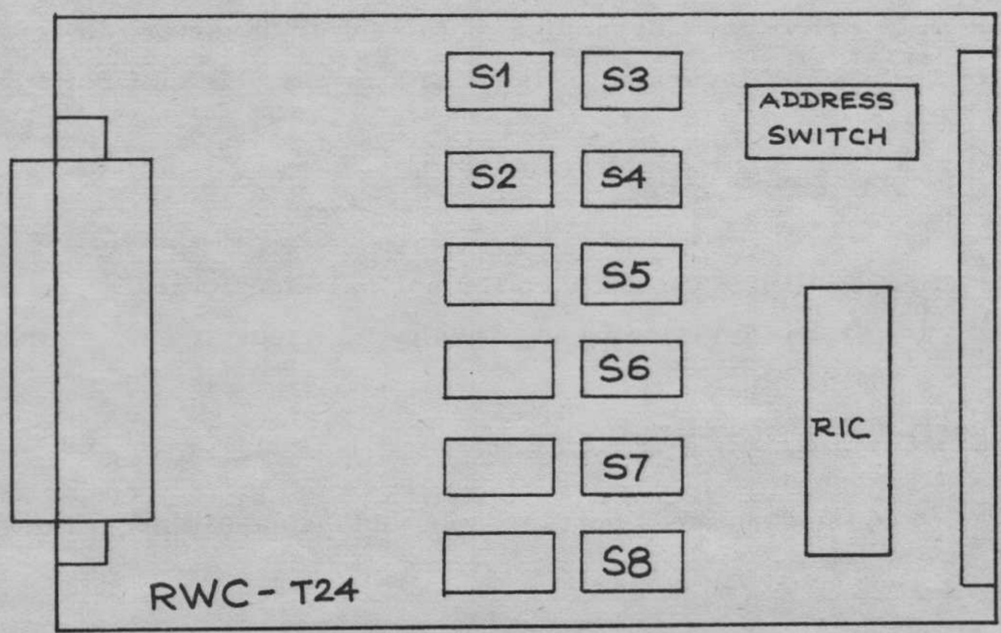
The software sequences for configuring the RIC, reading and writing to it are given in Section 7. 1.

7. 3. 4. 3 User Options

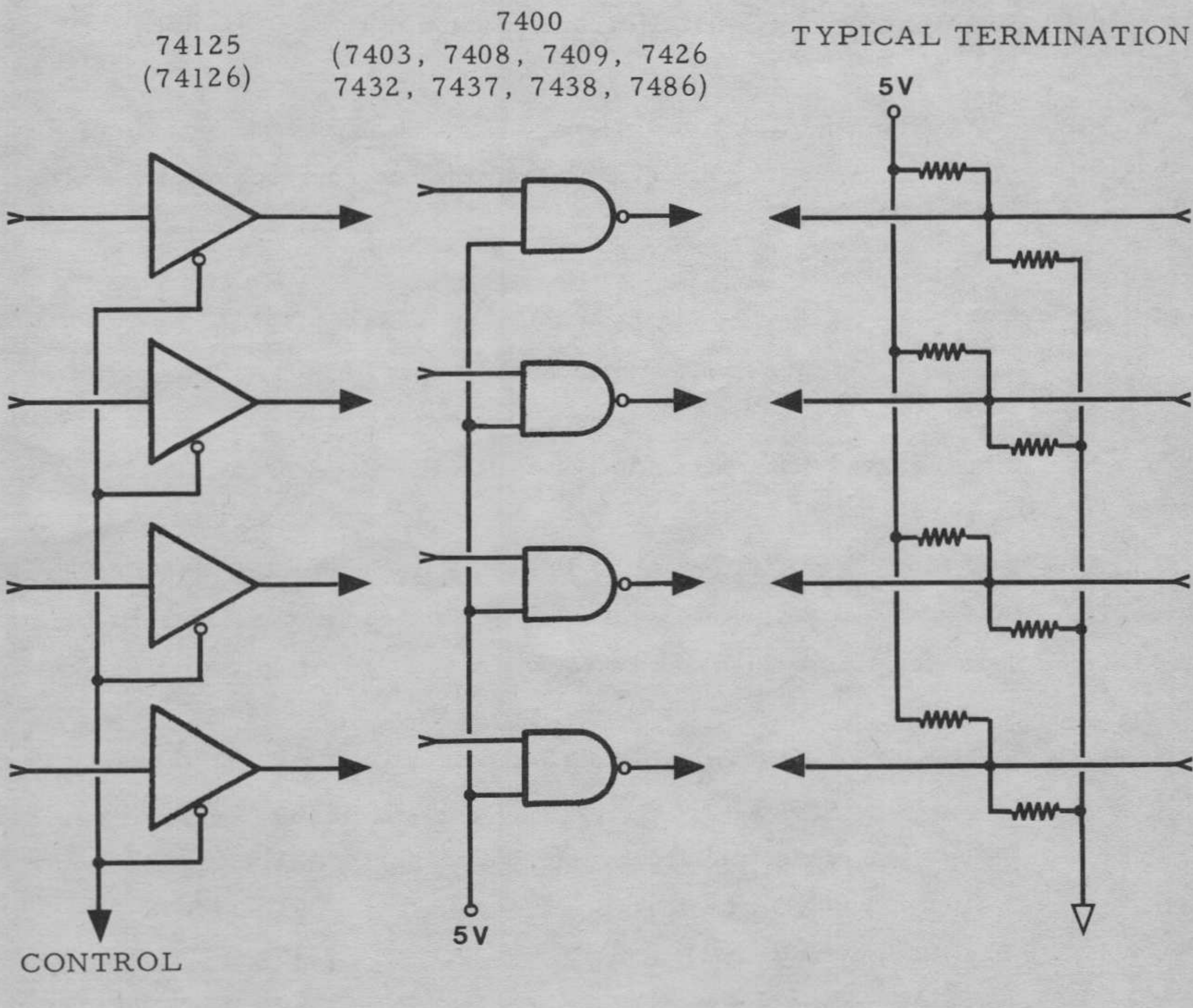
Signal Characterization

Eight 14-pin sockets are provided on the card for the insertion of standard TTL buffer/driver devices, or component carriers with termination resistors or links. By inserting appropriate devices and connecting the relevant jumpers, the user can configure the card to meet specific signal requirements.

The diagram below indicates the physical positioning of sockets S1 to S8 on the RWC-T24 module:



Typical Gates Accepted by Sockets on the RWC-T24 Module :



Some Input - Output Configurations :

For all RIC Ports operating in input mode, install in appropriate sockets component carriers with jumpers or termination resistors across pins 2 - 3, 5 - 6, 8 - 9, 11 - 12 (terminate between ground pin 7 and +5V pin 14 instead, if necessary).

Example: all 3 RIC Ports in input mode

Install in sockets S3, S4, S5, S6, S7, S8, component carriers with jumpers or termination resistors across pins 2 - 3, 5 - 6, 8 - 9, 11 - 12.

Install jumpers between pads 7 - 8, 50 - 51, 5 - 6 (normally pre-connected when shipped).

Program RWC-T24 RIC in mode 3, 3.

For all RIC Ports operating in output mode, install desired TTL drivers in appropriate sockets. For example, use any of the following quadruple 2-input gates or 3-state buffers:

AND (non-inverting)	: 7408, 7409
NAND (inverting)	: 7400, 7403, 7426, 7437, 7438
OR (non-inverting)	: 7432
XOR (selectable inversion)	: 7486
3-state buffers	: 74125 (low enable)
	: 74126 (high enable)

One of the inputs to each AND or NAND gate must be held high, while one of the inputs to each OR gate must be held low, in order to make them act as buffers.

An XOR gate can be made to act as a buffer or an inverter, by holding one of the inputs to the gate low or high respectively.

Example: all 3 RIC Ports in output mode.

Install in sockets S3, S4, S5, S6, S7, S8 desired TTL drivers.

The jumpers needed will depend on the devices selected. If for example 7400 devices are inserted in all above sockets, install jumpers between 2 - 3, 5 - 6, 7 - 8, 13 - 14, 42 - 43, 50 - 51, 53 - 54 (normally pre-connected when shipped).

Program RWC-T24 RIC in mode 0, 0.

If PORT 0 is operating in bi-directional mode, only 3-state buffers can be used in sockets S1, S2, S3, S4. Banks S1, S2 and S3, S4 must have devices with opposite enable signal levels, since they are both enabled by the same signal DRIVE0.

Example: Install 74126 in sockets S1 and S2.
Install 74125 in sockets S3 and S4.

Install jumpers between 7-9-10, 23-L, 36-41, 38-43, 49-50 (remove links 7-8, 42-43, 50-51 if present). Connect also 17, 19, 21 and 22 to L for active low handshake signals.

Program RWC-T24 RIC Amode = 8.

Interrupt Generation Jumpers

The two interrupt requests from Port 2, associated with handshake control for input/output data at Port 0 and 1 may be gated along with the external interrupt request (Device Connector pin 7), to IN7 or EXINTR lines on the DCE-BUS via jumper pads 31 to 35, and 44 to 48. Jumper pads 25-26-27 and 28-29-30 enable the inversion of the two interrupt request signals connected to IN7 and EXINTR.

Jumpers

JUMPER POINTS	ASSOCIATED SOCKETS/DEVICES	PURPOSE
1,2,3	S5	active high or low enable
4,5,6	S6,A7	select PORT 2 Bit 2 as data or handshake signal
7,8,9,10	S5,A5,A7	select PORT 2 Bit 6 as data or handshake signal
13,14,15	S7,S8	active high or low enable for both
16,17,18,19	A7	handshake signal active state selection
21,22,23,24	A5	handshake signal active state selection
25,26,27, 28,29,30	-	EXINTR or IN7 interrupt source selection
31,32,33,34,35	-	interrupt input signal selection external request or either of 2 handshake interrupt request
36,37,38,39 40,41,42,43	S1,S2,S3,S4	bi-directional bus direction con trol, or, active high or low en- able for PORT 0
44,45,46,47,48	-	interrupt input signal selection external request or either of 2 handshake interrupt requests
49,50,51	S5,A7	select PORT 2 Bit 4 as data or handshake signal
52,53,54	S6	active high or low enable

7.3.4.4 Module Connector Definitions

System Connector

See Section 6.1.4 for the pin definitions.

Device Connector (37-pin D-type female)

BUFFERED GIC SIGNAL	PIN NUMBER	NOTES
P0B0	34	PORT 0 may be buffered output, terminated input, or buffered / terminated bidirectional.
P0B1	16	
P0B2	35	
P0B3	17	
P0B4	36	
P0B5	18	
P0B6	37	
P0B7	19	
P1B0	23	PORT 1 may be buffered output or terminated input.
P1B1	4	
P1B2	22	
P1B3	3	
P1B4	21	
P1B5	2	
P1B6	20	
P1B7	1	
P2B0	5	PORT 2 upper or lower may be individually buffered outputs or terminated inputs. Control signals are brought out separately below.
P2B1	24	
P2B2	25	
P2B3	6	
P2B4	32	
P2B5	14	
P2B6	33	
P2B7	15	
$\overline{OBF}_0$	12	All control signals may be individually inverted by jumper selection.
$\overline{ACK}_0$	9	
IBF_0	11	
$\overline{STB}_0$	8	
$\overline{OBF}_1$, IBF_1	10	Role depends on mode to which PORT 1 is programmed.
$\overline{ACK}_1$, $\overline{STB}_1$	26	
INT. REQ.	7	May be routed to EXINTR or IN7 by jumper.
GND	13, 27, 28, 29, 30, 31	

7.3.4.5 Operational Requirements

Signal Characteristics

All outputs from the RWC-T24 RIC are capable of driving one standard TTL load. They can drive directly a Darlington configuration (1.5V) and source up to 1mA. This drive capability may be improved by the insertion of standard TTL buffer/inverter devices into the sockets provided.

Power Requirements

The RWC-T24 module uses a single +5volt supply. Typical power consumption, excluding devices inserted by user is :

+5 V : 130 mA

Environmental Requirements

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

Bus Loading

The RWC-T24 module presents 1 unit-load to the DCE-BUS (see Section 4.4).

7.3.5 TEST PROCEDURE

This section defines a simple test configuration and a test program for performing a basic functional test on the RWC-T24 module. Users are advised to carry out such a test procedure when necessary to establish the correct functioning of a module. The test program also provides a good example of RWC-T24 module driver software.

Test Configuration

The test program relates to the following test configuration. A standard RWC-T24 module with connecting links or non-inverting gates in sockets S1 or S3, S2 or S4, S5, S6, S7, S8 is required. Connect a test harness to the device connector with connection links between all the lines of Port 0 and 1, Port 2 upper and Port 2 lower.

The test program outputs data to Port 0 and Port 2 upper bits, reads this data back via Port 1 and Port 2 lower bits respectively, and prints the values for comparison.

```
0000                        ; THIS IS A SIMPLE PROGRAM FOR TESTING THE
0000                        ; STANDARD RWC-T24 MODULE, WITH CARD ADDRESS
0000                        ; SELECT SWITCH SET TO 'E'. A TEST DATA
0000                        ; PATTERN OUTPUT TO PORTS 0 AND 2 UPPER, IS
0000                        ; READ BACK VIA PORTS 1 AND 2 LOWER. THESE
0000                        ; OUTPUT AND INPUT VALUES (12 BITS) ARE
0000                        ; PRINTED AS TWO 3-DIGIT HEX NUMBERS ON THE
0000                        ; CONSOLE, IN THE ABOVE PORT ORDER. THESE
0000                        ; SHOULD BE IDENTICAL.
0000                        ; PROGRAM IS ENTERED FROM DCE UTILITY AND
0000                        ; RETURNS TO THE UTILITY AT THE END. DCE-DM
0000                        ; WITH RESIDENT ASSEMBLER AND VERSION 2.0
0000                        ; UTILITY HAS BEEN USED.
0000                        ;
031E         RDRWC:  EQU    031E
0349         WRRWC:  EQU    0349
061F         TCRLF:  EQU    061F
053A         TSP:    EQU    053A
0602         TBYTE:  EQU    0602
060B         THEX:   EQU    060B
```

```
1000                    ORG     1000
1000                                    ;
1000 3EE3       INIT:   MVI     A,0E3   ; SELECT RIC COMMAND REGISTER
1002 32011C             STGI    1
1005 3E83               MVI     A,83
1007 CD4903             CALL    WRRWC   ; PORTS 0, 2(B4-B7) = OUTPUT
100A                                    ; PORTS 1, 2(B0-B3) = INPUT
100A 16A5               MVI     D,0A5   ; SET UP TEST PATTERN
100C CD1F06             CALL    TCRLF   ; TYPE NEW LINE
100F                                    ;
100F 3EE0       TEST:   MVI     A,0E0   ; SELECT PORT 0
1011 32011C             STGI    1
1014 7A                 MOV     A,D     ; WRITE TEST PATTERN
1015 CD4903             CALL    WRRWC
1018 CD1E03             CALL    RDRWC   ; READ BACK TEST PATTERN AND
101B CD0206             CALL    TBYTE   ;   PRINT AS 2 HEX DIGITS.
101E                                    ;
101E 3EE2               MVI     A,0E2   ; SELECT PORT 2
1020 32011C             STGI    1
1023 7A                 MOV     A,D     ; WRITE TEST PATTERN (B4-B7)
1024 CD4903             CALL    WRRWC
1027 CD1E03             CALL    RDRWC   ; READ BACK TEST PATTERN
102A 0F                 RRC             ; SHIFT B4-B7 INTO B0-B3
102B 0F                 RRC
102C 0F                 RRC
102D 0F                 RRC
102E CD0B06             CALL    THEX    ; TYPE B0-B3 AS A HEX DIGIT
1031 CD3A05             CALL    TSP     ; TYPE A SPACE
1034                                    ;
1034 3EE1               MVI     A,0E1   ; SELECT PORT 1
1036 32011C             STGI    1
1039 CD1E03             CALL    RDRWC   ; READ BACK DATA AND TYPE
103C CD0206             CALL    TBYTE   ;    AS 2 HEX DIGITS.
103F                                    ;
103F 3EE2               MVI     A,0E2   ; SELECT PORT 2
1041 32011C             STGI    1
1044 CD1E03             CALL    RDRWC   ; READ BACK DATA (B0-B3) AN
1047 CD0B06             CALL    THEX    ;    TYPE AS A HEX DIGIT.
104A CD1F06             CALL    TCRLF   ; NEW LINE
104D C9                 RET             ; RETURN TO UTILITY
                        END
```

7.3.6 ORDERING INFORMATION

RWC-T24 : Standard Version

User selectable TTL buffer/inverter devices and component carriers for termination or links are not included.

APPLICATION EXAMPLE: THE RWC-T24 AS DCE - PDP 11 INTERFACE

Two RWC-T24 cards are used to connect the DCE microcomputer to the PDP-11 via its DR11-C General Device Interface Card. One T24 (card 1) handles signals transmitted from the PDP-11 to the DCE, and the other T24 (card 2) handles the DCE output signals as shown on the block diagram of Figure 7.3.1.

The 16-bit output from the PDP-11 is connected to the GIC Port 0 and Port 1 (on card 1) via plug-in termination resistors. These GIC ports are programmed in handshaking input mode. The GIC automatically generates and accepts handshaking signals through Port 2. Exclusive-OR gates for passing the handshake signals are resident on the T24 card. One input of each exclusive-or gate is jumper-wire connected to either +5V to produce an inverting function, or to ground to produce a non-inverting function.

Card 2 handles the DCE output data. The 16-bit output from the DCE is transmitted through Ports 0 and 1 via four 7408 quad 2-input AND gate packages plugged into sockets on card 2. Ports 0 and 1 are configured in handshaking output mode. The ACK (Acknowledge) and OBF (Output Buffer Full) handshake signals are accepted and generated respectively in Port 2.

The PDP-11 output sequence is as follows: The PDP-11 outputs the data to connector 1 of the DR11-C and generates a new-data-ready pulse. This pulse is used to strobe the data to the input buffers of Ports 0 and 1. The resulting input-buffer-full signal for Port 1 pulls the 'REQUEST A' input to the PDP-11 to logical zero. After the DCE software has taken the data from Port 0 and then Port 1, the rising edge of $\overline{IBF}$ interrupts the PDP-11 (via 'REQUEST A') which outputs the next word. The IBF falling edge also generates an interrupt request output from the GIC on card 1. This output can be jumper connected to the external interrupt or auxiliary external interrupt of the DCE, to cause it to read the word received from the PDP-11.

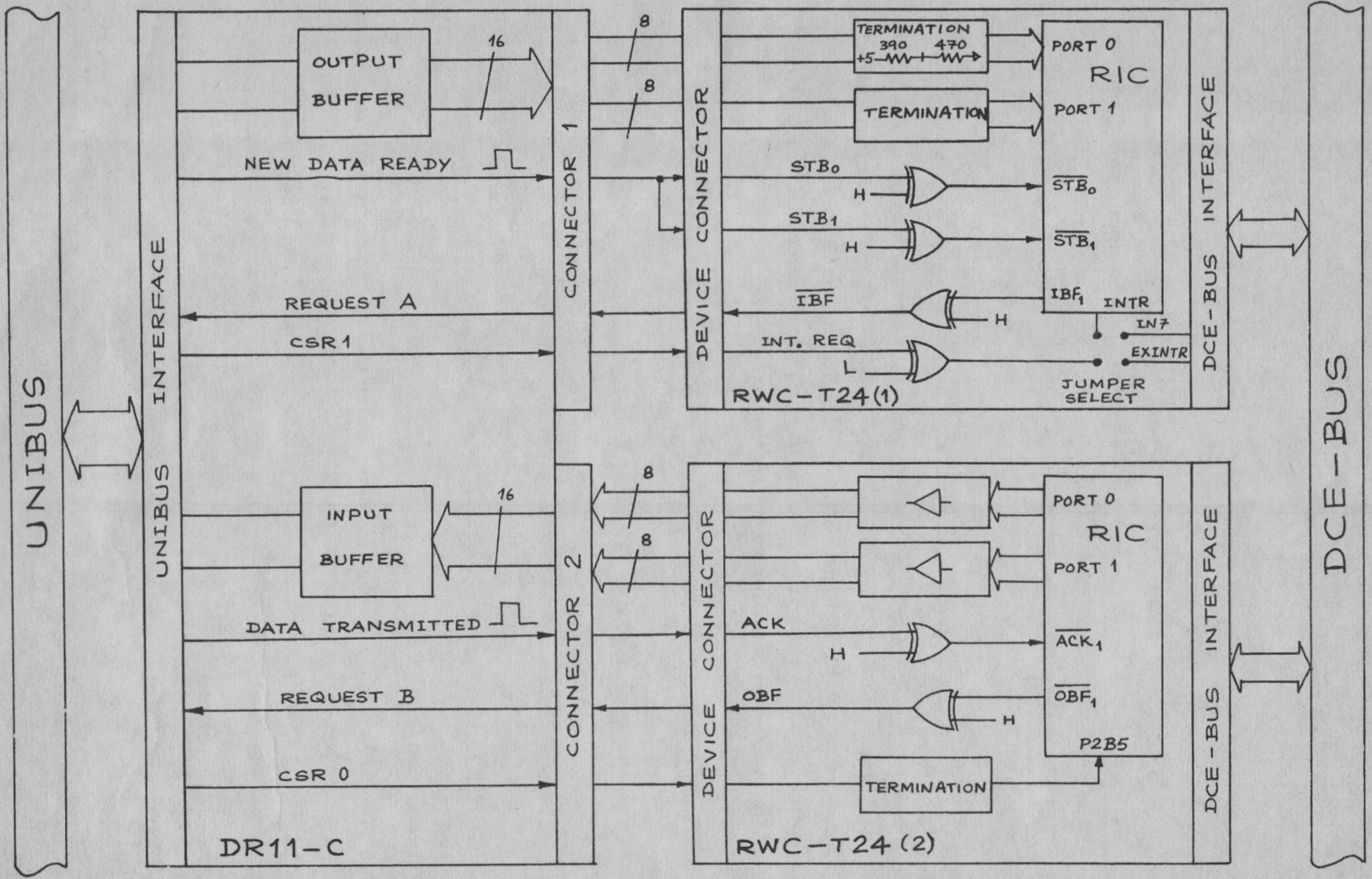


Figure 7.3.1 : DCE - PDP-11 Interface Using Two RWC-T24 and DR11-C.

One can also use the CSR1 output of the PDP-11 to interrupt the DCE. The source of DCE interrupt is jumper wire selectable.

The T24 output sequence starts with the DCE writing the 16-bit word to GIC Ports 0 and 1 on card 2. The resulting $\overline{OBF}$ (Output Buffer Full) signal drives 'REQUEST B' input of the PDP-11 to logical one, causing it to read the data present on connector 2. Acknowledging the data received, the DR11-C outputs a 'DATA TRANSMITTED' pulse, which, if connected to the GIC $\overline{ACK}$ input, triggers an interrupt request pulse. If this pulse is fed to the external interrupt of the DCE, its CPU can be interrupted every time the PDP-11 has taken data from the T24.

I/O PROGRAMMING

Before the RWC-T24 is inserted into the euro-rack, an address for the card must be set on the address switch. Assume the address of card 1 is set to 3H and the address of card 2 is set to 4H.

The program on the DCE must configure the GIC on card 1 (A mode = 7, B mode = 6) and card 2 (A mode = 5, B mode = 4). This is done by writing the control byte BEH to the GIC command register on card 1 (address 33H) and control byte ACH to the GIC command register on card 2 (address 43H). The program segment to accomplish this task is shown below.

```
MVI     A, 33H      set up card 1 command register address
STGI    1
MVI     A, 0BEH     move control byte into accumulator
CALL    WRRWC       call 'write real-world card' routine
MVI     A, 43H      set up card 2 command register address
STGI    1
MVI     A, 0ACH     move control byte into accumulator
CALL    WRRWC       call 'write real-world card' routine
```

After the foregoing program segment is executed, the GIC's on the two T24 cards are configured as required and they will retain this I/O configuration until reconfigured, or power is turned off.

To illustrate the data input to the DCE, assume that the 16-bit word output from the PDP-11 must be stored in the DCE RAM location 1100H and 1101H. The routine that executes this data transfer can be interrupt driven or it can do an input status check on the input buffer and transfer the data if the buffer is full. The following routine polls the IBF signal to determine if there is data present.

```
RDLP:   MVI     A, 32H      set up card 1, port 2 address
        STGI    1
        CALL    RDRWC       call 'read real-world card' routine
        ANI     02H         mask IBF bit (port 2, bit 1)
        JZ      RDLP        if bit is zero, input buffer is empty
        LXI     H, 1100H    point to low-order RAM store
        MVI     A, 30H      set up card 1, port 0 address
        STGI    1
        CALL    RDRWC       call 'read real-world card' routine
        MOV     M, A        store low-order byte in RAM
        INX     H           point to high-order RAM store
        MVI     A, 31H      set up card 1, port 1 address
        STGI    1
        CALL    RDRWC       call read routine
        MOV     M,A         store high-order byte in RAM
```

The following routine illustrates how to output a word from RAM location 1100H and 1101H. The first routine segment 'STATUS' checks the T24 output buffers to make sure the PDP-11 has taken the previous data word. The program loops until the PDP-11 takes the data.

```
STATUS:  MVI   A, 42H      set up card 2, port 2 address
         STGI  1
         CALL  RDRWC       call read routine
         ANI   02H         mask OBF\ bit (port 2, bit 1)
         JNZ   STATUS      loop until OBF\ is zero
         LXI   H, 1100H    point to low-order RAM store
         MVI   A, 40H      set-up card 2, port 0 address
         STGI  1
         MOV   A, M        move low-order byte to accumulator
         CALL  WRRWC       call write routine
         INX   H           point to high-order RAM store
         MVI   A, 41H      set up card 2, port 1 address
         STGI  1
         MOV   A, M        move high-order byte to accumulator
         CALL  WRRWC       call write routine
```

7.4 RWC-D12 : ISOLATED DIGITAL INTERFACE

7.4.1 FUNCTIONAL DESCRIPTION

The RWC-D12 Real-World interface module allows a DCE micro-computer to read 8 parallel opto-isolated inputs, and to switch medium power loads through 12 reed relays resident on the module. Four additional opto-isolators are wired in series with four of the reed relay contacts, to allow the verification of current flow through these circuits.

Each module has an identification address defined by a hexadecimal switch, and up to fifteen modules may be directly connected to the DCE-BUS.

7.4.2 FEATURES

° 12 reed relay contacts

° 8 opto-isolated inputs

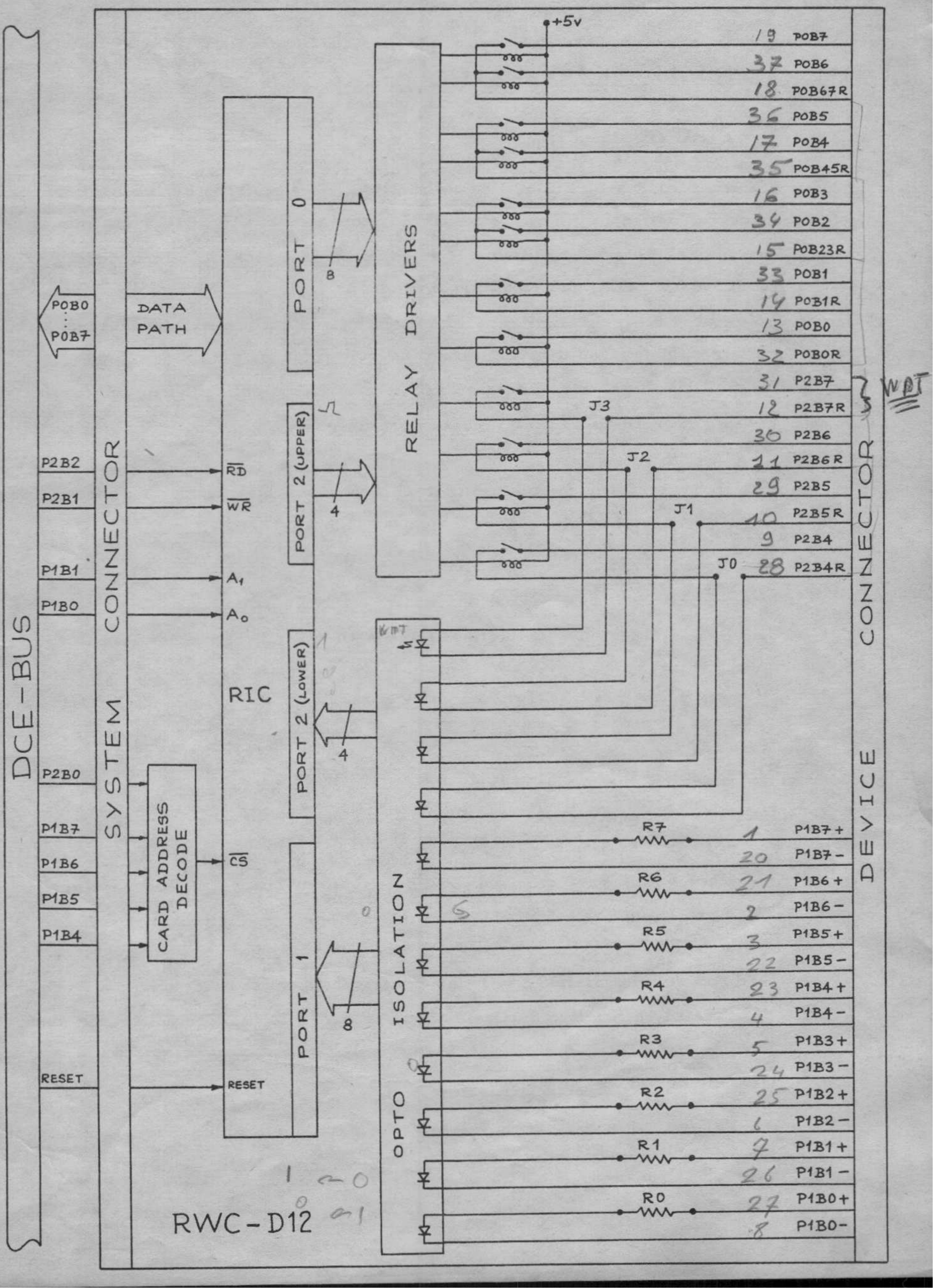
° 4 circuit monitoring inputs

° standard hardware and software interface to the DCE-BUS

° selectable card address

° single 100 x 160 mm eurocard format.

7.4.3 FUNCTIONAL BLOCK DIAGRAM



7.4.4 SYSTEM DESIGN PARAMETERS

7.4.4.1 Hardware Configuration

The functional block diagram in Section 7.4.3 illustrates the hardware configuration of the RWC-D12 module. Twelve RIC I/O lines are programmed for output and used for relay control. The other twelve RIC I/O lines are programmed for input and used to read the opto-isolated input signals. The module is supplied with 7417 relay drivers. They could be replaced by inverting buffers if desired. Each of the eight opto-isolated input lines has a current limiting resistor for 10 to 24 volt inputs, nominal.

The four circuit monitoring input photo diodes may be by-passed by links or shunt resistors across pads J0, J1, J2 and J3.

7.4.4.2 Programming Specifications

The RWC-D12 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.

RIC Initialization

The RIC on the RWC-D12 module should be initialized by writing control word 83H to the RIC Command Register. This configures RIC Port 0 and Port 2 Bits 4-7 in output mode for relay control and RIC Port 1 and Port 2 Bits 0-3 in input mode. All output lines will be low after RIC initialization. If non-inverting buffers (eg 7417) are used for relay driving, the relay control bits must be set high immediately after RIC initialization, in order to disable all the relays.

RIC Device Addresses

The RIC on the RWC-D12 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-D12 module from the DCE-BUS. Table 7.4.1 shows the Device Addresses needed for different communication modes.

DEVICE ADDRESS (HEX)	$\overline{RD}$	$\overline{WR}$	OPERATION
Y0	0	1	Invalid Operation
Y1	0	1	RIC Port 1 → DCE Data Bus
Y2	0	1	RIC Port 2 → DCE Data Bus
Y3	0	1	Illegal Condition
Y0	1	0	DCE Data Bus → RIC Port 0
Y1	1	0	Invalid Operation
Y2	1	0	DCE Data Bus → RIC Port 2
Y3	1	0	DCE Data Bus → 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. Bits 2 and 3 in the Device Addresses are don't care states
5. RDRWC and WRRWC software routines provide the $\overline{RD}$ and $\overline{WR}$ signals accordingly.

Table 7.4.1 : Device Address Table for RWC-D12

Format and Interpretation of Data

The output signals used for relay control are all active low. They are obtained from RIC Port 0 Bits 0-7 and Port 2 Bits 4-7. The input signals obtained from RIC Port 1 Bits 0-7 and Port 2 Bits 0-3 are active low. RIC input signal definitions are as follows:

Port 1 :	b0-b7	=	8 external input signals
Port 2 :	b0-b3	=	monitoring inputs from relay circuits activated by Port 2 Bits 4-7 respectively.

RWC-D12 - DCE-BUS Protocol

The RWC-D12 module RIC should first be initialized by writing control word 83H to its Command Register. This will configure RIC Ports 0, 1,2 in the required modes.

After RIC initialization, relay control output operations and signal read operations can be freely carried out by appropriate I/O sequences between the RIC data ports and the DCE-BUS. See Section 7.1 for full details of such input/output sequences.

The following program segment will initialize the RIC:

```
MVI     A,y3    ; y = module select address
STGI    1       ; address the command register
MVI     A,83
CALL    WRRWC   ; write control word
```

To illustrate data I/O, assume that the two relays associated with Port 0 Bits 0 and 3 are to be toggled (ie. close if open, open if closed) without affecting the status of other relays. The program segment below can perform this operation:

```
MVI     A,y0
STGI    1        ; address RIC Port 0
CALL    RDRWC    ; read relay status
XRI     09       ; selective compliment bits 0 and 3
CALL    WRRWC    ; output new relay status
```

The above program segments are written in the format suitable for the DCE resident assembler UAE. Note that the relay control signals must be active low for relay contact closure.!

7.4.4.3 User Options

Circuit Monitoring Inputs

The four circuit monitoring input photo-diodes may be by-passed by connecting links or shunt resistors across pads J0, J1, J2 and J3. If the circuit currents are high, such connections are essential to prevent damage to the photo-diodes on the monitoring input lines.

Input Current Limiting Resistors

The RWC-D12 module is delivered with eight 1.5kΩ 1/4 Watt resistors in positions R0 to R7. They allow inputs of 10 to 24 volts, nominal. If higher voltage signals are to be input, the user must change these resistors accordingly to ensure that the maximum rated forward current through the input photo-diodes is not exceded.

7.4.4.4 Module Connector Definitions

System Connector

See Section 6.1.4 for the pin definitions.

Device Connector

Pin definition of the 37-pin D-type female connector:

PIN	kleur	MNEMONIC	DESCRIPTION
1	WIT	P1B7+	Photo diode inputs
2	BRUIN	P1B6-	(observe polarity)
3	GROEN	P1B5+	
4	GEEL	P1B4-	
5	GRIJS	P1B3+	
6	ROSE	P1B2-	
7	BLAUW	P1B1+	
8	ROOD	P1B0-	
9	ZWART	P2B4	Relay contacts
10	PAARS	P2B5R	
11	GRIJS/ROSE	P2B6R	
12	ROSE/Blauw	P2B7R	
13	wit/groen	P0B0	
14	BRUIN/groen	P0B1R	
15	WIT/geel	P0B23R	(Shared return)
16	geel/Bruin	P0B3	
17	WIT/grijs	P0B4	
18	grijs/BRUIN	P0B67R	(Shared return)
19	wit/ROSE	P0B7	
20	ROSE/BRUIN	P1B7-	Photo diode inputs
21	WIT/BLAUW	P1B6+	(observe polarity)
22	BRUIN/BLAUW	P1B5-	
23	WIT/Rood	P1B4+	
24	BRUIN/Rood	P1B3-	
25	WIT/ZWART	P1B2+	
26	BRUIN/ZWART	P1B1-	
27	GRIJS/groen	P1B0+	
28	geel/grijs	P2B4R	Relay contacts
29	rose/groen	P2B5	
30	geel/Rose	P2B6	
31	groen/bruin	P2B7	
32	geel/blauw	P0B0R	
33	groen/bruin	P0B1	
34	geel/rood	P0B2	
35	groen/zwart	P0B45R	(Shared return)
36	geel/zwart	P0B5	
37	grijs/blauw	P0B6	

7.4.4.5 Operational Requirements

Signal Characteristics

Relay Outputs

Output contact rating	:	10VA max.
		100V DC max.
		500mA max. resistive switching
		1500mA carry load
Dielectric rating	:	250V DC on open contacts
Closing time	:	550 μsec
Release time	:	150 μsec
Max. repetition rate	:	700 Hz
Life expectancy	:	25 million operations at rated load
Min. isolation between coil and contact	:	500V DC or 350V AC at 50Hz

Opto-Isolator Input Diode Ratings

Logic states	:	Logic ONE > 2mA
		Logic ZERO < 100 μA
Max. continuous forward current	:	60 mA
Peak reverse current	:	10 μA
Max. reverse voltage	:	3 V
Rated forward voltage at 20mA	:	1.25 V typical at 25°C
Min. isolation	:	500 V

Power Requirements

The RWC-D12 module uses a single +5 volt supply.
Typical power consumption is:

+5V : 255mA with all relays on.

Environmental Requirements

Operating temperature	:	0°C to 55°C
Storage temperature	:	-25°C to +85°C
Relative humidity	:	95% non condensing (isolation may be reduced with high humidity)

Bus Loading

The RWC-D12 module presents 1 unit-load to the DCE-BUS (see Section 4.4).

7.4.5 TEST PROCEDURE

This section defines a simple test configuration and a test program for performing a basic functional test on the RWC-D12 module. Users are advised to carry out such a test procedure when necessary to establish the correct functioning of a module. The test program also provides a good example of RWC-D12 module driver software.

Test Configuration

The test program relates to the following test configuration. It requires a standard RWC-D12 module, four 1.5kΩ resistors, +12V and -5V power supplies (may be taken from the DCE-BUS). The 12 relay outputs are fed back through the 12 opto-isolated inputs, and compared. Relay circuits controlled by Port 0 Bits 0-7 are fed back into Port 1 Bits 0-7 respectively. Relay circuits controlled by Port 2 Bits 4-7 are monitored via Port 2 Bits 0-3 respectively.

The following connections are needed at the Device Connector:

pins 18, 35, 15, 14, 32	to +12V
pins 20, 2, 22, 4, 24, 6, 26, 8	to -5V
pins 31, 30, 29, 9	to +12V
pins 12, 11, 10, 28 via $1.5\,k\Omega$ resistors	to -5V

connect pin pairs 19-1, 37-21, 36-3, 17-23, 16-5, 34-25, 33-7, 13-27.

```
0000                    ; THIS IS A SIMPLE PROGRAM FOR TESTING THE
0000                    ; STANDARD RWC-D12 MODULE WITH CARD ADDRESS
0000                    ; SELECT SWITCH SET TO 'E'. A TEST DATA
0000                    ; PATTERN IS WRITTEN TO CONTROL THE RELAY
0000                    ; OUTPUTS, AND THESE ARE READ BACK AS 12
0000                    ; INPUTS. THE RELAY OUTPUT AND DATA INPUT
0000                    ; VALUES (12 BITS) ARE PRINTED AS TWO 3-DIGIT
0000                    ; HEX NUMBERS ON THE CONSOLE. PORT 0 AND
0000                    ; PORT 2 UPPER RELAY OUTPUTS ARE PRINTED
0000                    ; FIRST, FOLLOWED BY DATA INPUTS FROM
0000                    ; PORT 1 AND PORT 2 LOWER. THESE 2 VALUES
0000                    ; SHOULD BE IDENTICAL (RELAY OUTPUTS AND
0000                    ; DATA INPUTS ARE ALL ACTIVE LOW).
0000                    ; PROGRAM IS ENTERED FROM DCE UTILITY AND
0000                    ; RETURNS TO THE UTILITY AT THE END. DCE-DM
0000                    ; WITH RESIDENT ASSEMBLER AND VERSION 2.0
0000                    ; UTILITY HAS BEEN USED.
0000                    ;
031E          RDRWC:  EQU     031E
0349          WRRWC:  EQU     0349
061F          TCRLF:  EQU     061F
053A          TSP:    EQU     053A
0602          TBYTE:  EQU     0602
060B          THEX:   EQU     060B
```

```
1000                    ORG     1000
1000                                    ;
1000 3EE3       INIT:   MVI     A,0E3   ; SELECT RIC COMMAND REGISTER
1002 32011C             STGI    1
1005 3E83               MVI     A,83
1007 CD4903             CALL    WRRWC   ; PORTS 0, 2(B4-B7) = OUTPUT
100A                                    ; PORTS 1, 2(B0-B3) = INPUT
100A 16A5               MVI     D,0A5   ; SET UP TEST PATTERN
100C CD1F06             CALL    TCRLF   ; TYPE NEW LINE
100F                                    ;
100F 3EE0       TEST:   MVI     A,0E0   ; SELECT PORT 0
1011 32011C             STGI    1
1014 7A                 MOV     A,D     ; WRITE TEST PATTERN
1015 CD4903             CALL    WRRWC
1018 CD1E03             CALL    RDRWC   ; READ BACK TEST PATTERN AND
101B CD0206             CALL    TBYTE   ;   PRINT AS 2 HEX DIGITS.
101E                                    ;
101E 3EE2               MVI     A,0E2   ; SELECT PORT 2
1020 32011C             STGI    1
1023 7A                 MOV     A,D     ; WRITE TEST PATTERN (B4-B7)
1024 CD4903             CALL    WRRWC
1027 CD1E03             CALL    RDRWC   ; READ BACK TEST PATTERN
102A 0F                 RRC             ; SHIFT B4-B7 INTO B0-B3
102B 0F                 RRC
102C 0F                 RRC
102D 0F                 RRC
102E CD0B06             CALL    THEX    ; TYPE B0-B3 AS A HEX DIGIT
1031 CD3A05             CALL    TSP     ; TYPE A SPACE
1034                                    ;
1034 3EE1               MVI     A,0E1   ; SELECT PORT 1
1036 32011C             STGI    1
1039 CD1E03             CALL    RDRWC   ; READ BACK DATA AND TYPE
103C CD0206             CALL    TBYTE   ;    AS 2 HEX DIGITS.
103F                                    ;
103F 3EE2               MVI     A,0E2   ; SELECT PORT 2
1041 32011C             STGI    1
1044 CD1E03             CALL    RDRWC   ; READ BACK DATA (B0-B3) AND
1047 CD0B06             CALL    THEX    ;    TYPE AS A HEX DIGIT.
104A CD1F06             CALL    TCRLF   ; NEW LINE
104D C9                 RET             ; RETURN TO UTILITY
                        END
```

7.4.6 ORDERING INFORMATION

RWC-D12 : Standard Version
includes current limiting resistors for 10 to 24 volt inputs.

7.4.7 RWC-D12/WDT : ISOLATED DIGITAL INTERFACE WITH WATCH-DOG TIMER.

Functional Description

The RWC-D12/WDT is a special version of the RWC-D12 module, with one of the reed relays adapted to perform a system watch-dog function. This relay is controlled by a watch-dog timer circuit on the module. The timer must be triggered at regular intervals by the DCE microcomputer software to maintain the watch-dog relay contacts closed. If the timer is not re-triggered within a preset time (0.5 to 10 seconds) due to a system or power failure, the relay contact will open as a signal of system failure. This can be used to sound an alarm or initiate an orderly shut-down of the system being controlled. The preset time interval for the trigger can be manually adjusted to be from 0.5 to 10 seconds.

The relay circuit controlled by RIC Port 2 Bit 7 is the watch-dog relay. It is connected to Pins 12 & 31 at the device connector. The watch-dog timer is triggered by a software pulse to RIC Port 2 Bit 7, which can be generated by writing 0,1,0 in sequence to that line. The preset time can be adjusted to any value in the range 0.5 to 10 seconds by using the potentiometer mounted near the device connector. The periodic re-triggering of the timer may be assigned to the service routine of one of the TICC timers. When the timer is re-triggered correctly, the contacts of the relay performing the watch-dog function will remain closed.

The RWC-D12/WDT is connected to be functionally identical to the normal RWC-D12 module when shipped. The watch-dog function can be enabled by removing jumper links 2-3 and 5-6, and installing jumper links 1-2 and 4-5.