USER MANUAL

ProDAQ Data Acquisition Function Cards

ProDAQ 3940 32-Channel, Relay/Switching Function Card

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PROPRIETARY NOTICE

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Glossary

FC	:	Function Card
FIFO	:	First In First Out Memory
EEPROM	:	Electrically Erasable Programmable Read-Only Memory
MB	:	Motherboard
PCB	:	Printed Circuit Board
PTC	:	Positive Temperature Coefficient
RO	:	Read Only
ROC	:	Read Only, cleared after readout
RW	:	Read / Write
SSR	:	Solid-State Relay
WO	:	Write Only
VXI	:	VME eXtensions for Instrumentation

Reference Documents

Title	Number
ProDAQ 3120 Standard Motherboard Module User Manual	3120-XX-UM-xxxx

1. Introduction

The ProDAQ 3940 relay function card is an add-on card to use together with the ProDAQ Standard Motherboard 3120 or High Performance Motherboard 3150.
The 3940 function card is a switching card with 32 independently controlled 1-Form-A relays. Two relays occupy 3 terminals on the function card front panel connector. This means that they share one common terminal, as it is shown on the Figure 1. Every two relays sharing three pins on the front panel connector are considered as one channel of the 3940 relay function card. This means that the card has 16 independent channels.

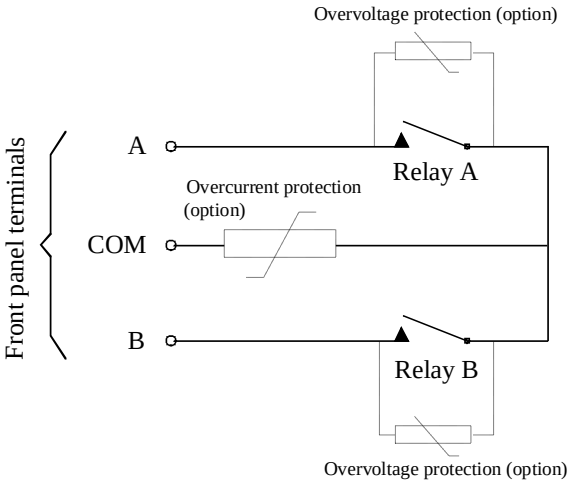

Figure 1: Single channel configuration

Optional, low resistance resettable PTC fuses ensure protection of relays when faulty conditions (overcurrent) occur. After a faulty condition is removed, PTC fuse returns to low resistance state, so device can be still used without costly service intervention. Also optional overvoltage protection of relays is available, which may increase relays lifetime when inductive loads are controlled.
Magnetic screening of electromechanical relays or usage of solid state semiconductor relays (depending on version) allows for dense packing and eliminates problems of magnetic interaction.

2. Installation

2.1 Unpacking and Inspection

1. Before unpacking the ProDAQ 3940 relay function card, check the exterior of the shipping carton for any signs of damage. All irregularities should be noted on the shipping bill.
2. Remove the instrument from its carton, preserving the factory packaging if possible.
3. Inspect the function card for any defect or damage. Immediately notify the carrier if any damage is apparent.
4. Have a qualified person check the instrument for safety before use.

NOTE: Proper ESD handling procedures must always be used when packing, unpacking, or installing any function card. Failure to do so may cause damage to the unit.

2.2 Reshipment Instructions

1. Use the original packing material when returning the function card to Bustec Production for calibration or servicing. The original shipping carton and the instrument's plastic foam will provide the necessary support for safe reshipment.
2. If the original packing material is unavailable, wrap the switching module in plastic sheeting and use plastic spray foam to surround and protect the instrument.
3. Reship in either the original or a new shipping carton.

2.3 Installation

The Function Card is placed into the slot with the SCSI connector facing the front of the module. Then, the extraction tool is used to align the back edge of the card with the pins on the motherboard and the Function Card is gently pressed down onto the pins.
There are two screws and two washers that go through the front panel and lock the front of the Function Card. Additionally, there are three other screws and two washers per screw that go on the top of the card and lock it down.

3. Theory of operation

3.1 Relay types and protection

3.1.1 Board versions

As it was mentioned in chapter 1, two types of relays can be installed on the board. These are reed relays and solid state relays. Choice of a particular relay type depends on the application where the board will be used. Their properties are shortly described in the following chapters.
Additionally, overcurrent and overvoltage protection of relays can be installed. Since not always protection is desirable, because it increases signal path resistance (overcurrent protection) and leakage current (overvoltage protection), various combinations of used relays and installed protection lead to different board version. Four combinations, given in the Table 1 are standard versions of 3940 Relay Function Card. Contact Bustec for availability of other combinations of relay/protection.

No.	Version	Relay type	Overcurrent protection	Overvoltage protection
1	3940-AA	Reed	No	No
2	3940-AB	Reed	Yes	Yes
3	3940-BA	Solid-state	No	No
4	3940-BB	Solid-state	Yes	Yes

Table 1: Standard 3940 relay card versions

3.1.2 Reed relays

Pickering 109P series miniature, 1-Form-A energise to make, high performance ruthenium electro-plated reed relays are used. They are hermetically sealed and offer a very stable, long life relay contact (>10^8 operations, typically 10^9 operations) with very fast ON and OFF times. A ruthenium contact exhibits less wear, and virtually no tendency to cold weld or stick. Their ability of switching low level signals or “cold” switching makes them ideal for ATE applications, where such techniques are often used. Mu-metal magnetic screening eliminates problem of magnetic interaction and allows for dense packing.
Alternative types such as electromechanical armature relays or non-instrumentation grade relays are lower cost but do not offer the consistent contact resistance, long life and fast switching speed.

3.1.3 Photovoltaic relays

As a alternative to reed relays, the PVG612 series photovoltaic, single-pole, normally open solid-state relays (SSR) can be used. They can replace electromechanical relays in many applications. SSRs offer improved system reliability since they have no moving parts or contacts to degrade. They utilize International Rectifier’s proprietary HEXFET power MOSFET as the output switch, driven by an integrated circuit photovoltaic generator of novel construction. The output switch is controlled by radiation from a GaAlAs light emitting diode (LED) which is optically isolated from the photovoltaic generator. These units exceed the performance capabilities of electromechanical relays in operating life, stability of on-resistance, insensitivity to magnetic fields and ruggedess. They can be

successfully used for switching analog signals in test systems, especially where frequent switching is required, and are particularly suited for isolated switching of medium currents (AC or DC) in power distribution systems, since lifetime of electromechanical contacts is reduced when switched current approaches their rated current.
Solid-state relays ensure bounce-free operation, high off-state resistance and linear AC/DC operation and are UL recognized and CSA certified.

3.1.4 Overcurrent protection

An overcurrent is an abnormally high current that has the potential to cause failure in an electrical circuit. An out-of-range condition in the power source or a decrease in load impedance can cause an overcurrent. Used PTC fuses ensures protection of both card relays and external circuitry from damage. They protect circuitry by going from a low-resistance state to a high resistance state in response to an overcurrent, which is called “tripping” the device. This way, the current in the circuit is reduced to the value which can be safely carried by any of the circuit elements. The change of resistance is the result of a rapid increase in the temperature of the device, caused by the generation of heat within the fuse by I^2R heating. A vary narrow temperature range is sufficient for PTC fuse for a sharp change in its resistance, which is graphically shown on Figure 2. After a faulty condition is removed, PTC fuse automatically returns to low resistance state within a few dozen of seconds, so device can be still used without costly service intervention. Usage of overcurrent protection is recommended in power distribution systems, where probability of shortcuts and overloads is significant. Used PTC fuses have recognition of UL, CSA and TÜV agencies.

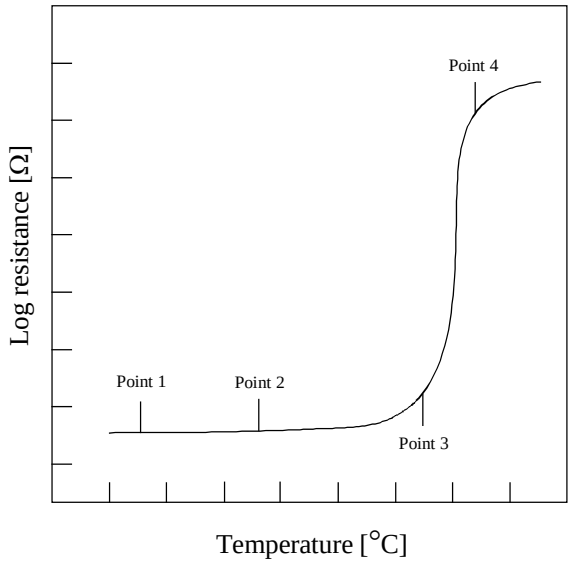

Figure 2: Example of operating curve for PTC fuse (not to scale)

3.1.5 Overvoltage protection

While opening relays, short duration increases in system voltage due to emptying of a circuit energy storage element such as an inductor may appear. These overvoltage transients may have significant impact on lifetime of both reed relays and solid state relays.
When electromechanical relays (including reed relays) are used to control inductive loads, it is often necessary to derate the contacts to 50% of their resistive load rating due to the wear caused by the arcing of the contacts. This arcing is caused by the stored energy in the inductive load. Each time the current in the inductive coil is interrupted by the mechanical contacts, the voltage across the contacts increases until the contacts arc. When the contacts arc, the voltage across the arc decreases and the current in the coil can increase somewhat. The extinguishing of the arc causes an additional voltage transient which can again cause the contacts to arc. It is not unusual for restriking to occur several times with the total energy in the arc several times that which was originally stored in the inductive load. It is this repetitive arcing that is so destructive to the contacts. To prevent initiation of the arc, optional multilayer surge supressors can be installed on the board.
When SSRs are used, any voltage that exceeds the SSR's maximum peak voltage can potentially damage the relay. Again, this may happen when relays are used to control inductive loads. In this case, outputs of SSR require an overvoltage suppression device, like multilayer surge supressors.

3.2 Relays control and synchronous update

For the purpose of relay control, two 16-bit registers RELG1 (group 1, channels 1..8) and RELG2 (group 2, channels 9..16) are available in the board's address space. Each bit in these registers directly controls state of one relay. Write to one of those registers immediately updates relays state.
For applications where simultaneous switching of relays in different groups is required, Synchronous Update mode can be used. When the board is configured to work in this mode, software also writes to registers RELG1 and RELG2, but the state of relays stays unchanged until required conditions (event) are met. As an event updating all relays at a time, write to special UPDATE register or input trigger can be selected.
For more detailed description of board registers refer to chapter 3.4.

3.3 Trigger system

3.3.1 Input trigger

Input trigger is used to update both relay groups synchronously. There are possible three input trigger sources: trigger through the Front Panel connector (FPITRIG), trigger from the switch matrix on the MB and software trigger (SW2ITRIG). More than one source can be selected at a time. The input trigger configuration is shown on the Figure 3.

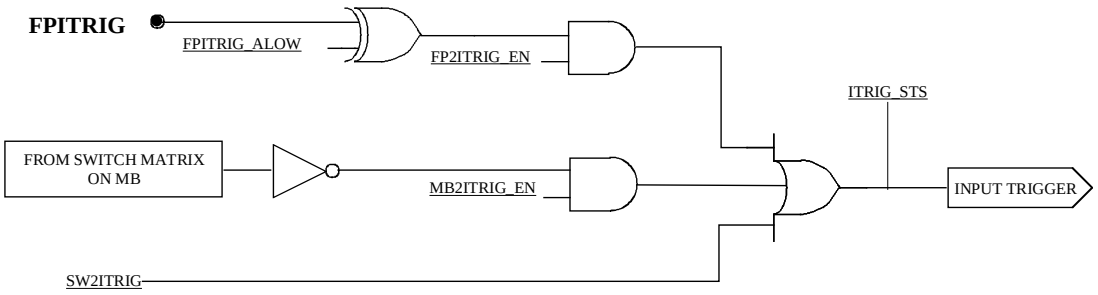

Figure 3: The input trigger configuration

Note that the state of the relays is updated only when input trigger becomes active (card must be earlier configured to work in Synchronous Update mode). There are two consequences of such behaviour:

- when one of the input trigger sources is already active, no event updating relays is generated if another input trigger source becomes active
- to generate series of events updating relays with software trigger, software has to write to SW2ITRIG bit zeros and ones alternately.

3.3.2 Output trigger

The output trigger is located on the MB-FC connector and it goes to the MB switch matrix. Then it can be directed to any trigger line connected to the switch matrix. There is only one output trigger source – input trigger signal generated internally. The output trigger system can generate the pulse or the level. If the level has been selected, the output trigger stays active as long as the source of the trigger is active. If the pulse is selected, pulse of 125 ns width is generated when output trigger source signal becomes active.
The output trigger configuration scheme is shown on the Figure 4.

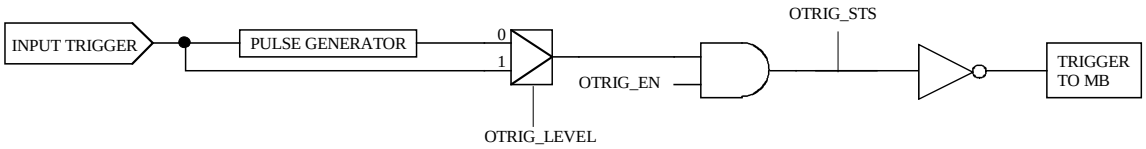

Figure 4: The output trigger configuration

Output trigger is especially useful when input trigger through the Front Panel connector (FPITRIG) is used in the system. It can inform the host (for example through interrupt) that input trigger arrived and an action, like write new values to relay configuration registers RELG1 and/or RELG2, must be taken.

3.4 Register description

3.4.1 Address map and registers

All addresses are given in hexadecimal notation. FC_ADR is address in FC address space. VXI_ADR is address in VXI address space. The appropriate address offset depends on the function card position on the motherboard (refer to the motherboard manual).

FC_ ADR	VXI_ ADR	Register Name	Access	Function
FPGA internal registers				
0	0	FCID	RO	FC ID register
1	4	FCVER	RO	FC version register
2	8	FCCSR	RW	Function card Control and Status Register
3	C	FCLEN	RO	Size of installed FIFO
4	10	reserved		
5	14	OTRI	RW	Output trigger control register
6	18	ITRI	RW	Input trigger control register
7	1C	TEST	RW	Test register
8	20	UPDATE	WO	Update register
9	24	RELG1	RW	Relay group 1 control register
A	28	RELG2	RW	Relay group 2 control register
FB	3EC	FCEPC	RW	EEPROM Control register (for factory usage only)
FC	3F0	FCSUB	RO	Function Card sub-type register
FE	3F8	FCSERH	RO	Upper 16-bit of the serial number of the function card
FF	3FC	FCSERL	RO	Lower 16-bit of the serial number of the function card

3.5 Register Details

3.5.1 FCID

FC_ADR=0H, *VXI_ADR=0H*

FCID register contains identification number of function card type. Readout should give value of 3940H.

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Operation	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Initial	0	0	1	1	1	0	0	1	0	1	0	0	0	0	0	0
Content	FC identification number = 3940H															

3.5.2 FCVER

FC_ADR=1H, *VXI_ADR=4H*

This is FC version register. Readout from this register gives information about board revision and firmware version.

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Operation	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Initial	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Content	major				minor				major				minor			
	FPGA version								PCB version							

3.5.3 FCCSR

FC_ADR=2H, *VXI_ADR=8H*

Control and Status register allows to switch board into Synchronous Update mode and to select event which will update all relays.

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Operation	RW	RW														WO
Initial	0	0														0
Content	SYNCUPDT	SYNCSRC	Not used													RESET

RESET This bit resets all relays to their default state (open) and resets configuration bits to initial state.

Write

0: Has no effect

1: Resets all relays and configuration bits in FCCSR, ITRI and OTRI registers to their initial state.

Read

Always gives '0'.

SYNCSRC This bit selects the source of a synchronous update signal.

Write

0: write to UPDATE register updates state of all relays

1: input trigger updates state of all relays

Read

Gives the last written value

USAGE

- Synchronous Update must be selected with SYNCUPDT bit
- If input trigger signal is used to update relays, one of the input trigger sources must be enabled in ITRI register

SYNCUPDT This bit switches board to Synchronous Update mode, in which all relays can be updated synchronously.

Write

0: Synchronous Update mode is OFF

1: Synchronous Update mode is ON

Read

Gives the last written value

3.5.4 FCLEN

FC_ADR=3H, *VXI_ADR=CH*

This is register containing information about size of installed FIFO. Readout should always give 0000H because no FIFO is used on this card.

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Operation	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Initial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Content	Size of installed FIFO = 0000H															

3.5.5 OTRI

FC_ADR=5H, *VXI_ADR=14H*

Output trigger register allows to control whether the output trigger will be sent to the MB and whether output trigger will be generated as a level or pulse. There is only one output trigger source – input trigger signal generated internally.

The output trigger can be used to generate an interrupt to the host computer after input trigger arrived.

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Operation	RO														RW	RW
Initial	0														0	0
Content	OTRIG_STS	Not used													OTRIG_LEVEL	OTRIG_EN

OTRIG_EN This bit is the output trigger enable bit. If this bit is cleared no output trigger will be sent to MB. If this bit is set output trigger to MB will be generated if trigger source becomes active.

Write

0: output trigger disabled

1: output trigger enabled

Read

Gives the last written value

USAGE

- Output trigger enabling bit

OTRIG_LEVEL This bit is for selection of the output trigger generating mode:

Pulse – after a rising edge of a trigger source pulse of 125 ns width will be generated independently of trigger source high level duration

Level – after a rising edge a trigger source output trigger level will follow the level of trigger source.

Write

0: output trigger generating mode set to pulse

1: output trigger generating mode set to level

Read

Gives the last written value

USAGE

- When working with interrupts to the host the level mode should be set

OTRIG_STS The state of the output trigger line.

Write

No effect

Read

0: output trigger inactive

1: output trigger active

USAGE

- When working with interrupts to the host this bit should be used by the interrupt routing to determine the interrupt source

3.5.6 ITRI

FC_ADR=6H, *VXI_ADR=18H*

The register allows selection of the trigger source which will be used to update state of all relays simultaneously in Synchronous Update mode and/or will be sent as an output trigger to MB.

These are the three possible input trigger sources:

- trigger through the Front Panel connector (FPITRIG)
- trigger from the switch matrix on the MB
- software trigger

To be able to use input trigger to update state of all relays simultaneously, board must be properly configured:

- Synchronous Update mode must be selected (bit SYNCUPDT in FCCSR register set to '1')
- Input trigger register must be selected as a source of update signal (bit SYNCSRC in FCCSR register set to '1')

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Operation	RO	ROC											RW	RW	RW	RW
Initial	0	0											0	0	0	0
Content	ITRIG_STS	TRIGCOME	Not used										SW2ITRIG	MB2ITRIG_EN	FP2ITRIG_EN	FPITRIG_ ALOW

FPITRIG_ ALOW This bit sets the active level of the external trigger coming from the Front Panel (ALOW stands for **A**ctive **LOW**).
Write
0: active level high
1: active level low
Read
Gives the last written value

FP2ITRIG_EN This bit enables the external trigger through the Front Panel connector (FPITRIG) as a source of input trigger.
Write
0: external trigger disabled
1: external trigger enabled
Read
Gives the last written value
USAGE
- The active level of external trigger can be set using FPITRIG_ALOW bit

MB2ITRIG_EN This bit enables the MB trigger as a source of input trigger.
Write
0: MB trigger disabled
1: MB trigger enabled
Read
Gives the last written value

SW2ITRIG This bit sets the software-generated input trigger.
Write
0: inactive state of the software-generated input trigger
1: active state of the software-generated input trigger
Read
Gives the status of software-generated input trigger
USAGE
- To generate series of events updating relays with software trigger, software has to write to SW2ITRIG bit zeros and ones alternately.

TRIGCOME This bit gives information if input triggers arrived since last readout of ITRI register.
Write
Has no effect
Read
1: Trigger arrived after last readout of ITRI register.
0: No trigger arrived after last readout of ITRI register.
USAGE
- To check whether trigger arrived without using interrupts
- Readout from ITRI register clears TRIGCOME bit

ITRIG_STS Current state of the input trigger. The status shows OR function of all enabled sources of input trigger.
Write
Has no effect
Read
0: input trigger inactive
1: input trigger active

3.5.7 TEST

FC_ADR=7H, *VXI_ADR=1CH*

Test register is Read/Write register dedicated to be used during production test.

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Operation	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW
Initial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Content	Read/Write test register															

3.5.8 UPDATE

FC_ADR=8H, *VXI_ADR=20H*

This register is used in Synchronous Update mode. Write to this register (written data doesn't matter) updates state of all relays simultaneously. To achieve that, board must be properly configured:

- Synchronous Update mode must be selected (bit SYNCUPDT in FCCSR register set to '1'),
- write to UPDATE register must be selected as a source of update signal (bit SYNCSRC in FCCSR register set to '0')

In opposite to synchronous update with software trigger, every write to UPDATE register generates event updating relays (there is no need to write zeros and ones alternately to generate series of updates).

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Operation	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO	WO
Initial	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Content	UPDATE register															

3.5.9 RELG1

FC_ADR=9H, *VXI_ADR=24H*

This register controls state of relays in group 1 (channels 1..8).

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Operation	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW
Initial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Content	RLB8	RLA8	RLB7	RLA7	RLB6	RLA6	RLB5	RLA5	RLB4	RLA4	RLB3	RLA3	RLB2	RLA2	RLB1	RLA1

RLAx These bits control state of relay A in channel x.

Write

0: Relay is OFF (doesn't conduct current)

1: Relay is ON (conducts current)

Read

Gives actual state of the relay (not the last written value)

0: Relay is OFF (doesn't conduct current)

1: Relay is ON (conducts current)

USAGE

- State of corresponding relays is updated immediately if board is not switched to Synchronous Update mode.
- In Synchronous Update mode the state of relays stays unchanged until required conditions (event) are met. As an event updating all relays at a time either write to UPDATE register or input trigger can be selected.

- Information written to RELG1 register and read back may differ when board is in Synchronous Update mode and after write to this register no update event took place

RLBx These bits control state of relay B in channel x.

Write

0: Relay is OFF (doesn't conduct current)

1: Relay is ON (conducts current)

Read

Gives actual state of the relay (not the last written value)

0: Relay is OFF (doesn't conduct current)

1: Relay is ON (conducts current)

USAGE

- State of corresponding relays is updated immediately if board is not switched to Synchronous Update mode.
- In Synchronous Update mode the state of relays stays unchanged until required conditions (event) are met. As an event updating all relays at a time either write to UPDATE register or input trigger can be selected.
- Information written to RELG1 register and read back may differ when board is in Synchronous Update mode and after write to this register no update event took place.

3.5.10 RELG2

FC_ADR=AH, *VXI_ADR=28H*

This register controls state of relays in group 2 (channels 9..16).

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Operation	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW
Initial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Content	RLB16	RLA16	RLB15	RLA15	RLB14	RLA14	RLB13	RLA13	RLB12	RLA12	RLB11	RLA11	RLB10	RLA10	RLB9	RLA9

RLAx These bits control state of relay A in channel x.

Write

0: Relay is OFF (doesn't conduct current)

1: Relay is ON (conducts current)

Read

Gives actual state of the relay (not the last written value)

0: Relay is OFF (doesn't conduct current)

1: Relay is ON (conducts current)

USAGE

- State of corresponding relays is updated immediately if board is not switched to Synchronous Update mode.
- In Synchronous Update mode the state of relays stays unchanged until required conditions (event) are met. As an event updating all relays at a time either write to UPDATE register or input trigger can be selected.
- Information written to RELG2 register and read back may differ when board is in Synchronous Update mode and after write to this

register no update event took place.

RLBx These bits control state of relay B in channel x.

Write

0: Relay is OFF (doesn't conduct current)

1: Relay is ON (conducts current)

Read

Gives actual state of the relay (not the last written value)

0: Relay is OFF (doesn't conduct current)

1: Relay is ON (conducts current)

USAGE

- State of corresponding relays is updated immediately if board is not switched to Synchronous Update mode.
- In Synchronous Update mode the state of relays stays unchanged until required conditions (event) are met. As an event updating all relays at a time either write to UPDATE register or input trigger can be selected.
- Information written to RELG2 register and read back may differ when board is in Synchronous Update mode and after write to this register no update event took place.

3.5.11 FCSUB

FC_ADR=FCH, *VXI_ADR=3F0H*

This is function card sub-type register useful for software to distinct between versions of the board. This register is automatically loaded during board initialisation with contents of on-board EEPROM chip, which takes approximately 10ms after power-up or deasserting reset signal from motherboard.

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Operation	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Initial	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Content	First letter (ASCII)								Second letter (ASCII)							
	Function card sub-type (e.g. "AA")															

3.5.12 FCSERH

FC_ADR=FEH, *VXI_ADR=3F8H*

This register contains the upper 16-bit of the serial number of the function card. This register is automatically loaded during board initialisation with contents of on-board EEPROM chip, which takes approximately 10ms after power-up or deasserting reset signal from motherboard.

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Operation	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Initial	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Content	Upper 16-bit of serial number															

3.5.13 FCSERL

FC_ADR=FFH, *VXI_ADR=3FCH*

This register contains the lower 16-bit of the serial number of the function card. This register is automatically loaded during board initialisation with contents of on-board EEPROM chip, which takes approximately 10ms after power-up or deasserting reset signal from motherboard

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Operation	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
Initial	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Content	Lower 16-bit of serial number															

4. Software Utilities

4.1 Introduction

The ProDAQ 3940 VXI*plug&play* compatible driver package encompasses the instrument driver, soft front panel, documentation and examples. The VXI*plug&play* soft front panel is a graphical user interface application developed for the instrument. It is used to verify the instrument operation and functionality when the instrument is first integrated into a system. It provides instrument control in a user-friendly environment, being both Windows 95 and NT framework compatible. The soft front panel application uses the installed driver to control and operate the instrument.

4.2 Soft Front Panel

After the start of the Soft Front Panel application, the user will be presented with a dialog box showing all available ProDAQ 3940 instruments in a system, allowing the selection of one instrument, which will be operated. Due to imposed limitations, there is no possibility to control simultaneously two or more instruments fitted to the same motherboard. If there is only one instrument available, this dialog box will not appear and this instrument will be automatically selected for operation. In order to run the soft front panel for the chosen 3940, select the appropriate position from the list and press OK button.

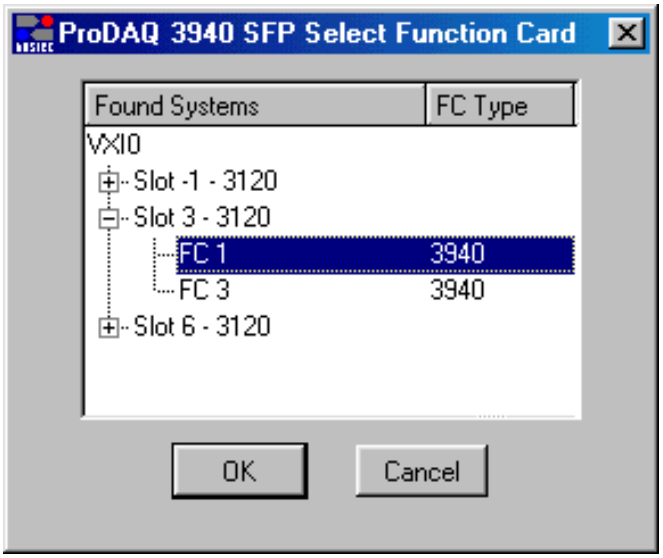

Figure 5: Function Card selection

This will invoke the main Soft Front Panel window as shown in Figure 6.

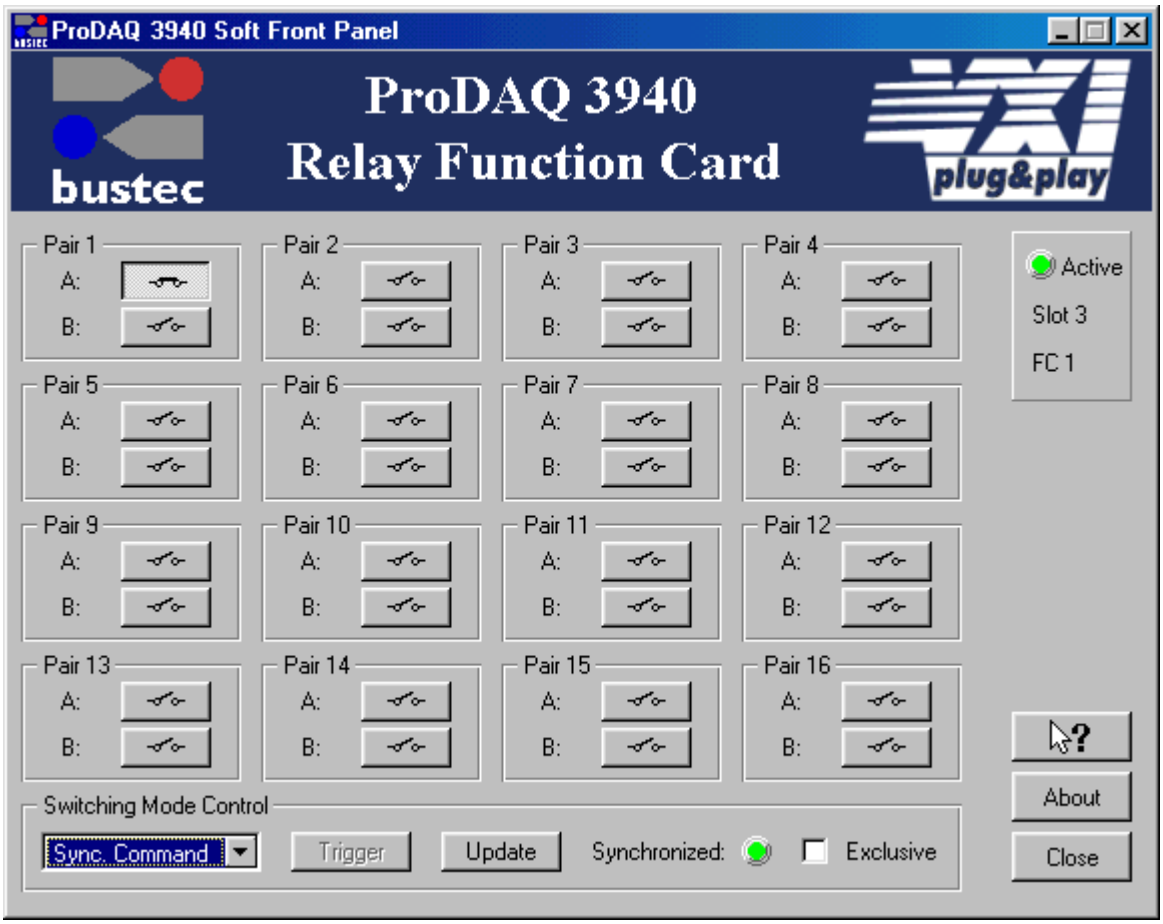

Figure 6: Main panel

The main panel of the soft front panel shows the relays grouped in pairs as they are arranged on the function card. The relays within the pairs can be operated separately or, when exclusive mode is selected, in dependence of the state of the other relay in the pair. The soft front panel allows selecting an update mode as asynchronous or synchronous. In latter case the “Trigger” or “Update” buttons are activated, according to the selected synchronisation mechanism.
While working in synchronous mode the “Synchronized” LED control signals the relay update state, a green colour means that the state is up to date, read colour means that the relays state has changed in registers but it awaits update command or trigger in order to be switched. When the LED is green the buttons state on the main panel reflects the relays state.

4.3 Programming Concepts

4.3.1 Instrument Driver Overview

To use the instrument driver for the Relay Function Card, one ProDAQ Motherboard, e.g. the 3120 or 3150, has to be used. In new 2.x version of drivers, a common interface library was implemented to act as an intermediate layer between the motherboard hardware and the driver, handling the communication to the different motherboards in a transparent way. In turn now every function card driver acts as a standalone VXIplug&play compatible driver, using its own instrument handle to communicate to the instrument. There is no longer the need to have a driver for the motherboard installed, although this is recommended. The common library is included to the installation package for every ProDAQ VXIplug&play driver.

The Instrument driver for the ProDAQ 3940 provides the following functionality:

Figure 7: Instrument Driver function tree

A full description of the instrument driver functions can be found in the driver help file.

4.3.2 Error/Status Information

Every instrument driver function has the same return type format. Returning either a completion code or an error code.

```
ViStatus _VI_FUNC bu3940_functionName ( Parameters… );
```

In order to identify the successful operation of any function these codes can be used. The following example illustrates this principle.


```
ViSession vi;
ViStatus error;
ViChar msg[512];
   :
   :
error = bu3940_reset(vi);
if(error < VI_SUCCESS)
{
   bu3940_error_message (vi, error, msg);
   /* stop execution */
}
else if(error > VI_SUCCESS)
{
   bu3940_error_message (vi, error, msg);
   /* print a warning and continue execution */
}
```

If an error occurs, a value less than VI_SUCCESS is returned. The function bu3940_error_message converts the error code into a readable string. All driver functions operate along the same principles, so any errors in hardware access are easily determined.
If a warning occurs, a value greater than VI_SUCCESS is returned. The same function bu3940_error_message can be used to convert the warning code into readable string.

4.3.3 Connecting to the instrument

A typical initialization sequence is as following:

```
bu3940_init ("VXI::1::INSTR", VI_TRUE, VI_TRUE, &viSession);
bu3940_fcSelect (viSession, 2);  /*use function card in pos.2 */
```

The call of function `bu3940_fcSelect` is obligatory and has to be issued after `bu3940_init()` function but before calling any other `bu3940_` function. Although, for convenience, another function is provided which encompasses the functionality of those two function calls:

```
bu3940_paramInit ("VXI::1::INSTR", 2, VI_TRUE, VI_TRUE, &viSession);
```

There is a strong requirement that function `bu3940_close` should be called when the instrument is no longer used. Each ProDAQ driver obtains a lock to the motherboard resource, which is released by `bu3940_close` function afterwards. This also means that it is not possible to access two function cards, either the same or different located on the same motherboard, from two separate system processes, since they would use the same resource descriptor but different instances of common library DLL. Therefore, the unmatched `bu3940_close` call can lock the resource as long as common interface library is loaded.

4.3.4 API Layout

API functions are logically divided into groups, which provide different functionality. Apart from functions which establish session with the instrument and utility functions defined by VISA standard, there are control and configuration groups which provide actual functionality. The Output Control class contains functions which operate on relays both in asynchronous and synchronous mode. The Configure Functions class contains functions to configure

4.3.5 Programming instrument

Next few paragraphs discuss step by step instrument setup to operate relays in asynchronous or synchronous mode. All functions are fully described in the driver help file.

After initialization process the instrument is in asynchronous mode and can be operated using bu3940_switchRelay() or bu3940_switchABPair() functions.

```
bu3940_switchRelay (viSession, 3, VI_TRUE);
bu3940_switchABPair (viSession, 2, bu3940_A_ON);
```

The two function calls in the code snippet above simply switch the relay third on. The second call additionally switches fourth relay off as it operates on pair of relays.
Following sample shows instrument operation in synchronous mode using software command to release relays state change.

```
ViBoolean relaysSet[32] = {0, 1, 1, 0, 0, 1, 0, 0, 0, 1, 1, 0};
ViInt32 i;              /*1  2  3  4  5  6  7  8  9 10 11 12*/

bu3940_setSwitchingMode (viSession, bu3940_SWITCH_SYN_CMD,
                                    bu3940_ITRIG_NONE);
for(i=0; i<32; i++)
    bu3940_switchRelay (viSession, i+1, VI_FALSE);
for(i=0; i<12; i++)
    bu3940_switchRelay (viSession, i+1, relaysSet[i]);

bu3940_updateRelaysState (viSession);
```

First of all the switching mode is set to be synchronous with software command to release change, as the input trigger is irrelevant here it is disabled – the third parameter selected as `bu3940_ITRIG_NONE`. The first ‘for’ loop switches all relays off and the second loop sets relays state according to the ‘relaysSet’ array values, the first twelve relays are in use only.
Finally after setting the relays to desired state software issues update command to make relays switched, as we are in synchronous mode the switching takes place only after synchronization event – in this case software command.
When input trigger is used as a synchronization event bu3940_getTriggerStatus() function can be use to determine the event occurrence. Another way to notice the input trigger

arrival is to install an interrupt service routine which would react on output trigger signal. The bu3940_enableOutputTrigger() function installs user interrupt service routine for that purpose.

5. Technical Specification

ITEM		SPECIFICATION
Number of Relays		32 (16 independent channels)
-AA	**Relay Type**	Ruthenium-plated Reed Relays
	On-path Resistance	< 0.3 Ω (initial)
	Switch Current	0.5 A max.
	Carry Current[1]	1.0 A max. (per common terminal)
	Switch Voltage	24 V max.
	Switch Power Rating	10 W max.
	Insulation Resistance	> 10^{12} Ω
	Turn-On Time	< 0.5 msec
	Turn-Off Time	< 0.25 msec
	Expected Relay lifetime[2]	10^9 operations
	Current Consumption	300 mA (+5V)
-AB	**Relay Type**	Ruthenium-plated Reed Relays
	Overcurrent Protection	PTC Resettable Fuse
	Overvoltage Protection	Multilayer Transient Voltage Surge Supressor Leakage Current 10μA
	On-path Resistance	< 0.6 Ω (initial)
	Switch Current	0.5 A max.
	Carry Current[1]	0.5 A max.
	Switch Voltage	24 V max.
	Switch Power Rating	10 W max.
	Insulation Resistance	> 10^{12} Ω
	Turn-On Time	< 0.5 msec
	Turn-Off Time	< 0.25 msec
	Expected Relay lifetime[2]	10^9 operations
	Current Consumption	300 mA (+5V)
-BA	**Relay Type**	Solid State Relays
	On-path Resistance	< 0.7 Ω
	Off-path Resistance	> 10^8 Ω
	Switch Current	0.9 A max.
	Carry Current[1]	0.9 A max.
	Switch Voltage	24 V max.
	Insulation Resistance	> 10^{12} Ω
	Turn-On Time	< 2.0 msec
	Turn-Off Time	< 0.5 msec
	Expected Relay lifetime	Unlimited
	Current Consumption	500 mA (+5V)
-BB	**Relay Type**	Solid State Relays
	Overcurrent Protection	PTC Resettable Fuse
	Overvoltage Protection	Multilayer Transient Voltage Surge Supressor Leakage Current 10μA
	On-path Resistance	< 1.0 Ω
	Switch Current	0.5 A max.
	Carry Current[1]	0.5 A max.
	Switch Voltage	24 V max.
	Insulation Resistance	> 10^{12} Ω
	Turn-On Time	< 2.0 msec
	Turn-Off Time	< 0.5 msec
	Expected Relay lifetime	Unlimited
	Current Consumption	500 mA (+5V)

ITEM	SPECIFICATION
Overcurrent protection characteristics	
Type	Ressetable PTC fuse
Hold current	0.75 A @ 25°C, 0.61 A @ 50°C
Trip current	1.5 A
Time to trip	0.3 s (max.) @ 8.0 A
Maximum voltage	24V
Reset time	< 120s
Resistance	0.29 Ω (max.)
Dissipated power[3]	0.6W
Overvoltage protection characteristics	
Type	Multilayer transient voltage surge supressor
Non-repetitive surge current (8/20 μs)	30A (max.)
Non-repetitive surge energy (10/1000 μs)	0.1 J
Leakage current	10 μA (max.)
Response time	< 5.0 ns
Typical capacitance	75 pF
Trigger Input	
Maximum input voltage	5V
Input type	Schmitt trigger
Negative threshold	1.5 V (typ.)
Positive threshold	2.5 V (typ.)
Histeresis	1.0V (typ.)
Active Polarity	Software selectable
Connectors	50-pin SCSI female
Dimensions	230 x 52.6 mm
PCB construction	6-layer PCB
Weight	<100g
Operating temperature	0 °C to 50 °C
Storage temperature	-40 °C to 70 °C

NOTES:

[1] If both relays in particular channel are open, current in common path must not exceed 1A. Actual maximum current is limited by PTC fuse to its hold current value if it is installed.

[2] The life of the relay depends entirely upon load condition

[3] Dissipated power is useful for calculating whether automatic reset condition for PTC fuse is met. The device will automatically reset, when $\frac{V^2}{4R_L} < P_D$

where: V = operating voltage of the circuit, R_L= Load resistance, P_D = dissipated power

6. Front Panel Connector and Signal Assignments

A high density, 50 pin, female SCSI type (Harting 60010505132) connector is used. Bustec offers matching cable assemblies, product number 8010-AA (0.5 Meter SCSI-Connector Cable) and 8010-AB (1 Meter SCSI-Connector Cable).

As it was shown on Figure 1, every channel of 3940 FC has three terminals: one common terminal (x-COM), and terminals connecting to relay A (x-A) and relay B (x-B) ('x' stands for the channel number). Layout of those terminals on the Front Panel connector is given on Figure 8. Additionally, also input trigger (FPITRIG) and ground (DGND) terminals are available on the front panel connector.

Signal	Pin	Pin	Signal
DGND	1	26	FPITRIG
16-COM	2	27	16-B
15-B	3	28	16-A
15-A	4	29	15-COM
14-COM	5	30	14-B
13-B	6	31	14-A
13-A	7	32	13-COM
12-COM	8	33	12-B
11-B	9	34	12-A
11-A	10	35	11-COM
10-COM	11	36	10-B
9-B	12	37	10-A
9-A	13	38	9-COM
8-COM	14	39	8-B
7-B	15	40	8-A
7-A	16	41	7-COM
6-COM	17	42	6-B
5-B	18	43	6-A
5-A	19	44	5-COM
4-COM	20	45	4-B
3-B	21	46	4-A
3-A	22	47	3-COM
2-COM	23	48	2-B
1-B	24	49	2-A
1-A	25	50	1-COM

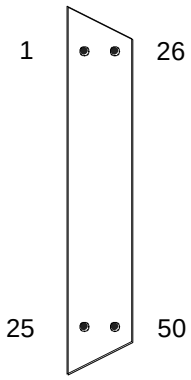

Figure 8: Front panel SCSI connector – front view when 3940 relay card is fitted on ProDAQ module in VXI chassis.

To simplify connection of field wiring to 3940 relay function card, together with a SCSI cable we recommend using Signal Conditioning Unit 5010-AA with Terminal Block Card 5421-AA. To determine which terminal block connects to a particular channel of 3940 function card, use the following table:

Terminal Block no.	Terminal Block pin	3940 signal	SCSI Pin
		–	
TB25	IN	FPITRIG	26
	OUT	DGND	1
	GND	–	
TB24	+	16-B	27
	-	16-COM	2
	GND	–	
TB23	+	16-A	28
	-	15-B	3
	GND	–	
TB22	+	15-COM	29
	-	15-A	4
	GND	–	
TB21	+	14-B	30
	-	14-COM	5
	GND	–	
TB20	+	14-A	31
	-	13-B	6
	GND	–	
TB19	+	13-COM	32
	-	13-A	7
	GND	–	
TB18	+	12-B	33
	-	12-COM	8
	GND	–	
TB17	+	12-A	34
	-	11-B	9
	GND	–	
TB16	+	11-COM	35
	-	11-A	10
	GND	–	
TB15	+	10-B	36
	-	10-COM	11
	GND	–	
TB14	+	10-A	37
	-	9-B	12
	GND	–	
TB13	+	9-COM	38
	-	9-A	13

SCSI Pin	3940 signal	Terminal Block pin	Terminal Block no.
25	1-A	-	
50	1-COM	+	TB1
	–	GND	
24	1-B	-	
49	2-A	+	TB2
	–	GND	
23	2-COM	-	
48	2-B	+	TB3
	–	GND	
22	3-A	-	
47	3-COM	+	TB4
	–	GND	
21	3-B	-	
46	4-A	+	TB5
	–	GND	
20	4-COM	-	
45	4-B	+	TB6
	–	GND	
19	5-A	-	
44	5-COM	+	TB7
	–	GND	
18	5-B	-	
43	6-A	+	TB8
	–	GND	
17	6-COM	-	
42	6-B	+	TB9
	–	GND	
16	7-A	-	
41	7-COM	+	TB10
	–	GND	
15	7-B	-	
40	8-A	+	TB11
	–	GND	
14	8-COM	-	
39	8-B	+	TB12
	–	GND	

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