Trigger Supervisor Transition Module

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Introduction

The Trigger Supervisor Transition Module is an interface between the Trigger Supervisor (TS) and the front end electronics. The main function of the module is to generate and distribute ADC gates, TDC starts/stops, and control signals to the front end electronics. It is designed specifically to meet the needs of Hall A, but may be flexible enough to be also useful elsewhere (Hall C).

Hall A has two spectrometer arms. Front end electronics (ADCs, TDCs) for the detector systems of an individual arm are located on that arm. A requested mode of operation (especially useful during commissioning) is having each arm running *independently*. This requires separate (local) trigger systems (trigger logic + Trigger Supervisor) for each arm. ADC gates and TDC starts/stops are generated independently for each arm in this mode. These originate from the LEVEL 1 ACCEPT signal of the local TS. The main mode of operation is *paired* mode. In this case the trigger system of one of the arms will be in control of both spectrometer arms. An accepted trigger from the controlling trigger system will result in a set of ADC gates and TDC starts/stops being generated for both arms. These originate from the LEVEL 1 ACCEPT signal of the controlling TS. The Transition Module is designed to easily switch between these two modes of operation.

<u>Figure 1</u> shows the architecture of the system. ‘A’ and ‘B’ represent the two spectrometer arms. The connections between a Transition Module (TR) and its local components (TS = Trigger Supervisor, ADCs, TDCs) are identical for each arm. The two Transition Modules are connected to each other, as well as to a common beam Charge Monitor. <u>Figure 2</u> shows details of the I/O for a Transition Module. <u>Table 1</u> contains important I/O timing information.

When the spectrometer arms are running independently, no communication between the two Transition Modules takes place. Each Transition Module is defined to be in LOCAL mode. In this mode, a Transition Module uses the LEVEL 1 ACCEPT signal from its local TS to generate ADC gates and TDC starts/stops for the local Fastbus crates. Optionally, it will re-time these signals relative to a LEVEL 1 TRIGGER from the local trigger logic. BUSY signals from the local Fastbus crates are collected and sent back to the local TS, and CLEAR signals issued by the local TS are routed to the local Fastbus crates. Local TS control signals GO and LIVE are used to generate signal SCALER GATE that is routed to scalers in local VME crates. Only one of the arms may be enabled to communicate with the Charge Monitor.

When the spectrometer arms are running in paired mode, the trigger system (trigger logic + Trigger Supervisor) of one of the arms must be designated as in control. The Transition Module of the control side is set to be in LOCAL mode. The Transition Module in the other arm is set in REMOTE mode. The Transition Module in LOCAL mode uses the LEVEL 1 ACCEPT signal from its local TS to generate ADC gates and TDC starts/stops for the local Fastbus crates. Optionally, it will re-time these signals relative to a LEVEL 1 TRIGGER from its local trigger logic. The LEVEL 1 ACCEPT signal is also sent to the other arm’s Transition Module. BUSY signals from the local Fastbus crates are collected, ORed with the BUSY from the other arm’s Transition Module, and sent to the local TS. A CLEAR signal issued by the local TS is routed to the local Fastbus crates, and also sent to the other arm’s Transition Module. Local TS control signals GO and LIVE are used to generate signal SCALER GATE that is routed to scalers in local VME crates, and also sent to the other arm’s Transition Module. The Transition Module of the controlling arm is enabled to communicate with the Charge Monitor.

The Transition Module in REMOTE mode ignores its local TS. Instead, it uses the LEVEL 1 ACCEPT signal from the controlling arm’s Transition Module to generate ADC gates and TDC

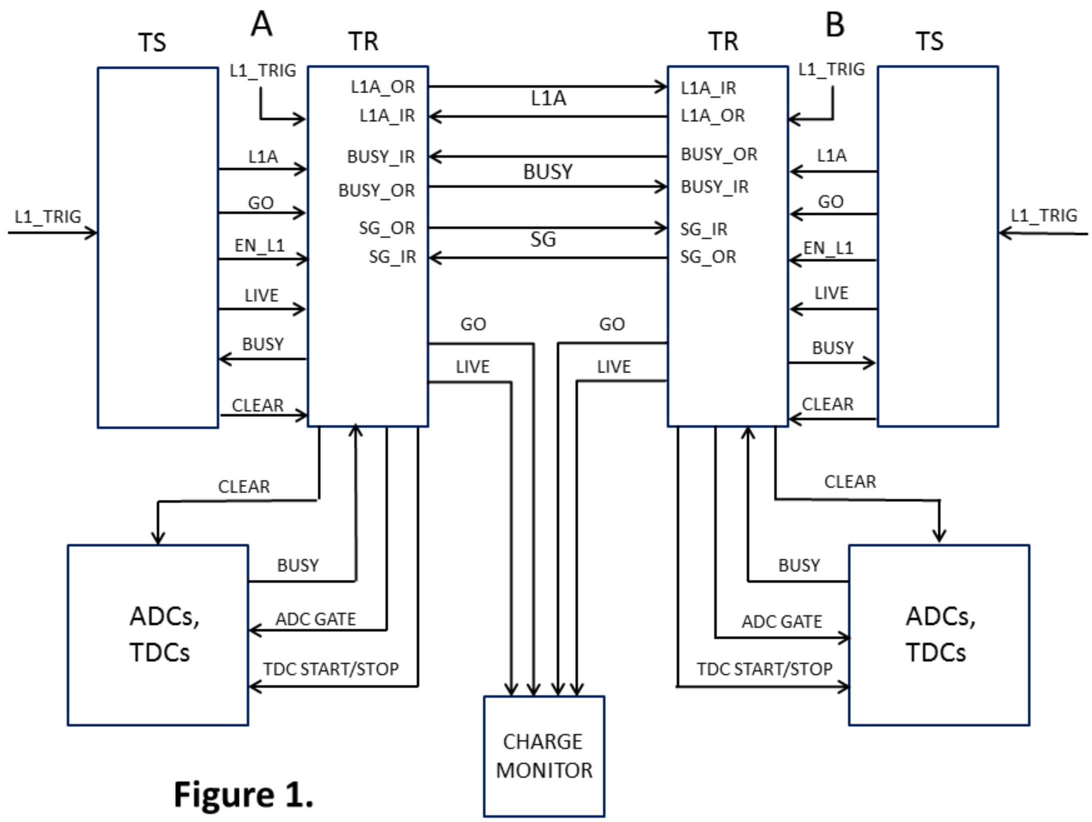


Figure 1.

starts/stops for its local Fastbus crates. Optionally, it will re-time these signals relative to a LEVEL 1 TRIGGER from its local trigger logic. BUSY signals from the local Fastbus crates are collected and sent back to the controlling Transition Module. A CLEAR signal issued by the controlling Transition Module is routed to the local Fastbus crates. The signal SCALER GATE from the controlling arm's Transition Module is routed to scalers in local VME crates. The Transition Module in REMOTE mode should not be enabled to communicate with the Charge Monitor.

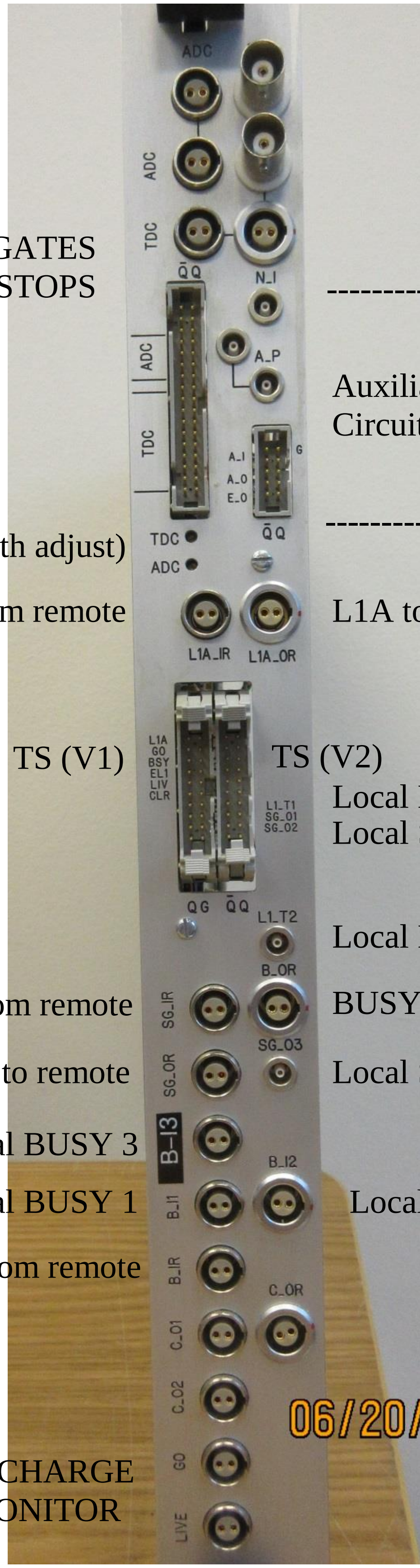
The Transition Module is implemented as a 'D' size VXI module. It can be configured by VME protocols or by DIP switches.

Signal Levels / Connectors

For connections between the Transition Module and existing components (Trigger Supervisor, Fastbus, Level 1 Trigger), compatibility forced the choice of signal levels and connectors used. The Transition Module can be used with either V1 or V2 Trigger Supervisors. Links with the V1 TS employ single-ended ECL levels on 50 ohm coaxial cable, and 2-pin header type connectors. Links with the V2 TS use differential ECL levels on 100 ohm twisted pair cable, and 2-pin header type connectors. Dual input/output sets are provided that are identical in functionality. (See Figure 2 and Front Panel Input and Output sections below.)

The links to a Fastbus crate are through a Fastbus Signal Distribution Module (R.Cuevas). These links utilize differential ECL levels on 100 ohm twin-axial cable, and special LEMO TWINAX

Figure 2.


Local ADC GATES
TDC STARTS/STOPS

Auxiliary
Circuit I/O

(width adjust)
L1A from remote
L1A to remote
TS (V1)
TS (V2)
Local L1 TRIG 1
Local SCALER GATE
Local L1 TRIG 2
SCALER GATE from remote
BUSY to remote
SCALER GATE to remote
Local SCALER GATE
Local BUSY 3
Local BUSY 1
Local BUSY 2
BUSY from remote
To CHARGE
MONITOR

connectors. Also used are single-ended ECL levels on 50 ohm coaxial cables, and standard BNC connectors. The link to the Level 1 Trigger employs differential ECL levels on 100 ohm unshielded twisted pair cable, and a 2-pin header type connector. An additional link to the Level 1 Trigger uses NIM levels on 50 ohm coaxial cable, and a standard LEMO connector.

For connections between the two Transition Modules, the signal levels and connectors used were at our discretion. Because these links are very long (> 400') and some carry precise timing information, we chose differential ECL levels on 100 ohm shielded twin-axial cable (as above). The LEMO TWINAX connector was also used here, partly as an effort to reduce the number of different connector types.

We also defined the links between the Transition Modules and the Charge Monitor, as the latter has not yet been designed (2/97). These links are very long (~ 1000') and have no tight timing requirements. We chose to use RS-485 level signals (differential) on 100 ohm twin-axial cable. The LEMO TWINAX connector was also used here to reduce the number of different connector types.

Re-time Mode

When the Transition Module is in re-time mode, the timing of the ADC gates and TDC starts/stops is set by a local LEVEL 1 TRIGGER in coincidence with the LEVEL 1 ACCEPT signal. A coincidence here is defined as the LEVEL 1 TRIGGER signal's leading edge occurring within a time window started by the LEVEL 1 ACCEPT signal's leading edge. The LEVEL 1 ACCEPT signal may be from the local TS or from the other arm's Transition Module depending on the state of the control bit LOCAL. The duration of coincidence window is adjustable (10-80 ns). See Appendix 2 for information on setting up the window width.

The circuit is designed to trigger only on the first occurrence of a LEVEL 1 TRIGGER within the time window. Note that the leading edge of the LEVEL 1 TRIGGER must be inside the window. A simple overlap of the two signals will not produce an output. The circuit is carefully designed to produce exactly one gate/start/stop per coincidence.

Scaler Gating

Hall A wants the scalers to have the following behavior:

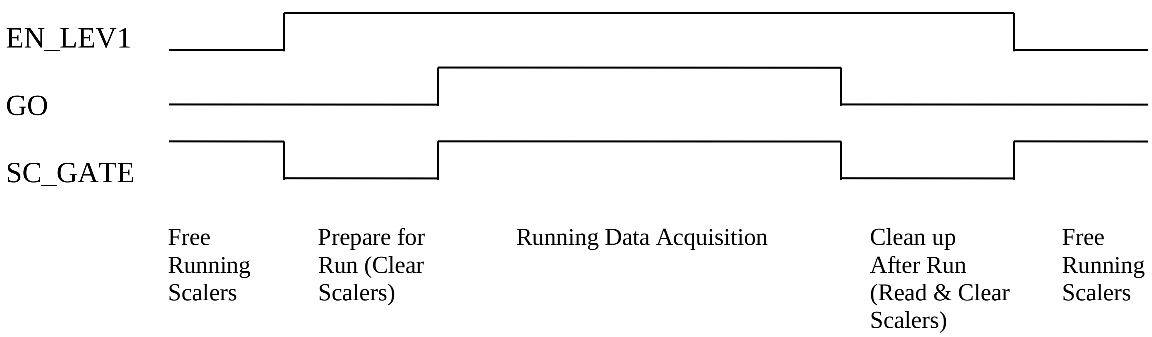
(1) Whenever the experiment is not acquiring data the scalers should be free to count.
(2) Just before starting to acquire data the scalers should be stopped from counting. This allows the scalers to be cleared in preparation of the run.
(3) During the entire data acquisition run the scalers should be free to count.
(4) Just after the data run is completed the scalers should be stopped from counting. This allows the final read out of scalers. After this is done the scalers should be enabled to count.

To achieve this behavior, the Transition Module derives the scaler gate signals from the Trigger Supervisor control signals GO and ENABLE LEVEL 1. The GO signal is automatically asserted during the entire data acquisition run. ENABLE LEVEL 1 is a TS control bit that can be set or reset at any time by the user. We impose the following protocol regarding the use of the ENABLE LEVEL 1 signal:

(1) When the experiment is not preparing to acquire data, ENABLE LEVEL 1 should be held not asserted.

(2) Prior to the start of the run, ENABLE LEVEL 1 should be asserted. Scalers are then cleared. ENABLE LEVEL 1 remains asserted during the entire data acquisition run.
(3) After the data run is completed, the scalers are read out. Then ENABLE LEVEL 1 should be switched to not asserted.

The scaler gates will then behave as shown below.



LEVEL 1 ACCEPT (REMOTE) Output

As discussed earlier, this signal is sent from the controlling Transition Module to the remote Transition Module. Because the long cable run between the modules (> 400') greatly extends the rise/fall time of a signal, we choose to send a *pulse* rather than a copy of the local LEVEL 1 ACCEPT signal to the remote module. The local LEVEL 1 ACCEPT signal remains asserted for the entire 'trigger processing' stage (including front end BUSY time), and is returned to the not asserted state just prior to when the Trigger Supervisor is able to accept another trigger. If the next trigger comes promptly, the duration of the not asserted state of this signal can be very short (~50 ns). What this means after a long cable run is that the rising edge of the LEVEL 1 ACCEPT signal may be sitting atop the (extended) falling edge of the previous trigger's LEVEL 1 ACCEPT, shifting the timing of the rising edge. Since this signal could be used to generate TDC starts/stops, the shift is unacceptable. The argument also applies to differentially transmitted signals, as both Q and /Q are shifted in the same direction (reverse 'rising' & 'falling' for /Q). By sending a pulse triggered by the local LEVEL 1 ACCEPT's rising edge, this condition is avoided. The pulse width of the LEVEL 1 ACCEPT REMOTE output is set by an adjustable resistor R108 on the board (see Figure 3). A value of 200-300 ns should suffice.

Charge Monitor

The Transition Module outputs two signals to the Charge Monitor. Signals GO CHARGE and LIVE CHARGE are logically identical to the GO and LIVE signals input from the Trigger Supervisor. They are driven at RS-485 levels which are suitable for long distance transmission. They are only driven if the CHARGE bit in the Control Register is set. Otherwise the signals are held not asserted.

Programming the Transition Module

The Transition Module can be programmed through the VMEbus if the jumper identified in Figure 3 is in the VME position. When the jumper is installed in the MANUAL position the module is controlled by DIP switches. (See registers below for DIP switch functions.)

The Transition Module is classified as an A16/D16 VMEbus slave. The base address is set with DIP switches identified in Figure 3. There are two 16-bit registers: Control and Status. The Control Register sets the operating mode of the interface. The Status Register allows the user to determine the state of various input signals to the module. When in MANUAL mode, all the Control Register bits are set by DIP switches identified in Figure 3.

The VMEbus address of a register is the module's base address + the register's local address.

Control Register - (local address = 0, READ/WRITE)

(0) LOCAL - selects the source of the LEVEL 1 ACCEPT signal. When LOCAL = 1 (LOCAL mode), a LEVEL 1 ACCEPT signal from the local Trigger Supervisor is used. When LOCAL = 0 (REMOTE mode), the LEVEL 1 ACCEPT signal from a remote Transition Module is used instead.

(1) PAIR - when LOCAL = 1, it determines if BUSY from the remote Transition Module should be included in the total front end BUSY for the system. If PAIR = 1, the remote Transition Module's BUSY is included . If PAIR = 0, only the local BUSY contributes. (When LOCAL = 0 this bit has no effect.)

(2) COINCIDENCE - determines if a re-timing of LEVEL 1 ACCEPT by a local LEVEL 1 TRIGGER signal is implemented. If COINCIDENCE = 1 a re-timing is performed. If COINCIDENCE = 0 the timing is set by LEVEL 1 ACCEPT.

(3) CHARGE - when set, the signals GO CHARGE and LIVE CHARGE are enabled to be driven by the Transition Module to the Charge Monitor. Otherwise the signals are held not asserted.

(4) T1 - when COINCIDENCE = 1, T1 = 1 selects LEVEL 1 TRIGGER Input #1 as the re-timing signal. Otherwise the input is ignored.

(5) T2 - when COINCIDENCE = 1, T2 = 1 selects LEVEL 1 TRIGGER Input #2 as the re-timing signal. Otherwise the input is ignored. (Note: if T1 = T2 = 1, the logical OR of LEVEL 1 TRIGGER Inputs #1 and #2 is used.)

(6) - (7) RESERVED

(8) - (15) NOT USED - (read as 1)

Status Register - (local address = 2, READ only). The state of the following input signals is latched on a READ of this register:

(0) LEVEL 1 ACCEPT (LOCAL)

(1) LEVEL 1 ACCEPT (REMOTE)

(2) BUSY 1 (LOCAL)

(3) BUSY 2 (LOCAL)

(4) BUSY (REMOTE)

(5) LIVE

(6) GO

(7) ENABLE LEVEL 1

(8) SCALER GATE (REMOTE)

(9) - (15) NOT USED - (read as 1)

FRONT PANEL INPUTS

Inputs are considered LOCAL unless followed by the REMOTE tag. In general, REMOTE inputs are ignored when the Transition Module is in LOCAL mode, and LOCAL inputs are ignored when the Transition Module is in REMOTE mode (note exceptions below). See Figure 2 for front panel layout.

LEVEL 1 ACCEPT (**L1A**) **-** from local TS. Both single-ended ECL and differential ECL signals into 2-pin headers on front panel.

LEVEL 1 ACCEPT (REMOTE) (**L1A_IR**) **-** from remote TS Transition Module. Differential ECL signal into LEMO TWINAX connector.

LEVEL 1 TRIGGER (2) (**L1_T1**, **L1_T2**) **-** from local level 1 trigger system. One is differential ECL signal into 2-pin header on front panel. Second is NIM signal into standard LEMO connector. (This signal is used when the Transition Module is in LOCAL or REMOTE mode.)

BUSY (3) **(B_I1**, **B_I2**, **B_I3**) - from local front end electronics crates (Fastbus). All are differential ECL signals into LEMO TWINAX connectors. (This signal is used when the Transition Module is in LOCAL or REMOTE mode.) **(Note: The third local BUSY input replaced the CLEAR (REMOTE) input.)**

BUSY (REMOTE) (**B_IR**) **-** from remote TS Transition module. Differential ECL signal into LEMO TWINAX connector. (If the PAIR control bit is set, the Transition Module will use this remote signal when in LOCAL mode.)

CLEAR (**CLR**) **-** from local TS. Both single-ended ECL and differential ECL signals into 2-pin headers on front panel.

CLEAR (REMOTE) **-** from remote TS Transition Module. Differential ECL signal into LEMO TWINAX connector. **(Replaced by a third local BUSY input.)**

GO (**GO**) - from local TS. Both single-ended ECL and differential ECL signals into 2-pin headers on front panel.

ENABLE LEVEL 1 (**EL1**) **-** from local TS. Both single-ended ECL and differential ECL signals into 2-pin headers on front panel.

LIVE (**LIV**) **-** from local TS. Both single-ended ECL and differential ECL signals into 2-pin headers on front panel.

SCALER GATE (REMOTE) (**SG_IR**) **-** from remote TS Transition module. Differential ECL signal into LEMO TWINAX connector.

FRONT PANEL OUTPUTS

Outputs are considered LOCAL unless followed by the REMOTE tag. In general, REMOTE outputs are driven only when the Transition Module is in LOCAL mode (note exceptions below). See Figure 2 for front panel layout.

LEVEL 1 ACCEPT (REMOTE) (**L1A_OR**) **-** to remote TS Transition Module. Differential ECL signal on LEMO TWINAX connector. (Width = 30 - 580 ns).

ADC GATE (2) (**ADC**) **-** to local front end electronics crates (Fastbus). Differential ECL signal on LEMO TWINAX connectors. (Width = 20 - 430 ns).

ADC GATE (5) (**ADC**) **-** to local front end electronics crates (Fastbus). Differential ECL signal on 2-pin front panel header. (Width = 20 - 430 ns).

TDC START/STOP (2) (**TDC**) **-** to local front end electronics crates (Fastbus). Differential ECL signal on LEMO TWINAX connectors. (Width = 20 - 430 ns).

TDC START/STOP (2) (**TDC**) - to local front end electronics crates (Fastbus). Single-ended ECL signal on BNC connectors. (Width = 20 - 430 ns).

TDC START/STOP (10) (**TDC**) - to local front end electronics crates (Fastbus). Differential ECL signal on 2-pin front panel header. (Width = 20 - 430 ns).

BUSY (**BSY**) **-** to local Trigger Supervisor. Both single-ended ECL and differential ECL signals into 2-pin headers on front panel.

BUSY (REMOTE) (**B_OR**) **-** to remote Transition Module. Differential ECL signal on LEMO TWINAX connector. (This signal is driven only when the Transition Module is in REMOTE mode.)

CLEAR (2) (**C_O1, C_O2**) - to local front end electronics crates (Fastbus). Differential ECL signal on LEMO TWINAX connectors.

CLEAR (REMOTE) (**C_OR**) - to remote Transition Module. Differential ECL signal on LEMO TWINAX connector. **(This output is not useful as the CLEAR (REMOTE) input has been reassigned.)**

SCALER GATE (2) (**SG_O1**, **SG_O2**) **-** to local scalers (VME). Differential ECL signals on 2-pin front panel headers.

SCALER GATE (**SG_O3**) **-** to local scalers (VME). NIM signal on standard LEMO connector.

SCALER GATE (REMOTE) (**SG_OR**) **-** to remote Transition Module. Differential ECL signal on LEMO TWINAX connector.

GO CHARGE (**GO**) **-** to beam Charge Monitor. RS-485 signal on LEMO TWINAX connector.

LIVE CHARGE (**LIVE**) - to beam Charge Monitor. RS-485 signal on LEMO TWINAX connector.

SPARE OUTPUTS

These are available at header locations on the board (see Figure 3). They can be put into service by mounting additional connectors on the front panel and wiring them to the board (twisted pair or coax). Including the spare outputs, the Transition Module can support a total of 7 local Fastbus crates.

Outputs are considered LOCAL unless followed by the REMOTE tag. In general, REMOTE outputs are driven only when the Transition Module is in LOCAL mode.

LEVEL 1 ACCEPT (REMOTE) - Differential ECL signal. (Width = 30 - 580 ns).

ADC GATE (5) - Differential ECL signal. (Width = 20 - 430 ns).

TDC START/STOP (5) - Differential ECL signal. (Width = 20 - 430 ns).

TDC START/STOP (5) - Single-ended ECL signal. (Width = 20 - 430 ns).

BUSY - Differential ECL signal.

CLEAR (5) - Differential ECL signal.

SCALER GATE - Differential ECL signal.

SCALER GATE - NIM signal.

AUXILIARY CIRCUIT

A daughter board that does translation, fan out, and pulse generation functions is installed on the Transition Module (see Figures 2, 3).

Inputs

N_I - NIM signal into Lemo connector

A_I (1) - single-ended ECL signal (Q, GND) into 2-pin header (top pair on connector)

A_I (2) - differential ECL signal (Q, /Q) into 2-pin header (2nd pair on connector)

Outputs

A_P - NIM signals out of Lemo connectors (2 signals)

A_O - differential ECL signals (Q, /Q) out of 2-pin headers (3rd and 4th pairs on connector)

E_O - differential ECL signal (Q, /Q) out of 2-pin header (bottom pair on connector)

Functions

N_I → E_O (NIM to differential ECL translation)

[A_I (1) OR A_I (2)] → A_O (single-ended ECL to differential ECL translation, fan out)

[A_I (1) OR A_I (2)] → A_P (leading edge pulse generation, fan out)

(See Figure 3. for A_P width adjustment location.)

Table 1 - Timing Information

DELAY - LEVEL 1 ACCEPT Input to GATE/START/STOP Outputs = 14 ns
(no re-timing with LEVEL 1 TRIGGER)

DELAY - LEVEL 1 TRIGGER Input to GATE/START/STOP Outputs = 21 ns
(re-timing with LEVEL 1 TRIGGER)

WIDTH - ADC Gate Outputs = 20 - 430 ns

WIDTH - TDC Start/Stop Outputs = 20 - 430 ns

WIDTH - LEVEL 1 ACCEPT (REMOTE) Output = 30 - 580 ns

WIDTH - Coincidence (Re-timing) Window = 10 - 80 ns

COINCIDENCE CONDITION (Re-time mode) - Defining t = 0 as the occurrence of the LEVEL 1 ACCEPT input's rising edge, the LEVEL 1 TRIGGER input's rising edge must occur during the interval:

+3 ns < t (LEVEL 1 TRIGGER) < Coincidence Window Width

Appendix 1 - Example Configurations

Mode: LOCAL = 1 COINCIDENCE = 0

The LEVEL 1 ACCEPT signal from the local TS is used to generate an ADC gate and a TDC starts/stop. No re-timing is done. The leading edge of the local LEVEL 1 ACCEPT signal sets the timing. The widths of the ADC gate and TDC start/stop are separately adjustable (20 - 430 ns) from the front panel.

Mode: LOCAL = 1 COINCIDENCE = 1

The LEVEL 1 ACCEPT signal from the local TS in coincidence with a local LEVEL 1 TRIGGER signal is used to generate an ADC gate and a TDC start/stop. The leading edge of the LEVEL 1 TRIGGER signal sets the timing. A coincidence is defined as the LEVEL 1 TRIGGER signal's leading edge occurring within a time window started by the local LEVEL 1 ACCEPT signal's leading edge. The duration of this coincidence window is adjustable (10 - 80 ns). The widths of the ADC gate and TDC start/stop are separately adjustable from the front panel.

Mode: LOCAL = 0 COINCIDENCE = 0

The LEVEL 1 ACCEPT signal from the remote Transition Module is used to generate an ADC gate and a TDC starts/stop. No re-timing is done. The leading edge of the remote LEVEL 1 ACCEPT signal sets the timing. The widths of the ADC gate and TDC start/stop are separately adjustable from the front panel.

Mode: LOCAL = 0 COINCIDENCE = 1

The LEVEL 1 ACCEPT signal from the remote Transition Module in coincidence with a local LEVEL 1 TRIGGER signal is used to generate an ADC gate and a TDC start/stop. The leading edge of the LEVEL 1 TRIGGER signal sets the timing. A coincidence is defined as the LEVEL 1 TRIGGER signal's leading edge occurring within a time window started by the remote LEVEL 1 ACCEPT signal's leading edge. The duration of this coincidence window is adjustable. The widths of the ADC gate and TDC start/stop are separately adjustable from the front panel.

Appendix 2 - Adjusting the Coincidence Window Width

There are two methods to set up the coincidence window width for the Transition Module. Consult DAQ group for assistance if necessary.

(A) Using a Fixed Delay - this is an operational method.

(1) Set Transition Module to be in LOCAL & RE-TIME mode with LEVEL 1 TRIGGER #2 enabled by setting bits 0, 2, & 5 in the Control Register (VME access or MANUAL with DIP switches).

(2) Using a common source (pulse generator) and fan out, apply local LEVEL 1 ACCEPT signal and LEVEL 1 TRIGGER #2 (NIM) signal. The LEVEL 1 TRIGGER input should be delayed relative to LEVEL 1 ACCEPT by the desired coincidence window width plus 3 ns.

(3) Observe any ADC gate or TDC start/stop output on an oscilloscope. By turning the screw on adjustable resistor R109 (see Figure 3), find the point at which the output will appear and disappear upon slight adjustment. At this point the coincidence window width is equal to the fixed delay used.

(B) Using Oscilloscope and Probe - this is a straightforward method.

(1) Set Transition Module to be in LOCAL & RE-TIME mode by setting bits 0 & 2 in the Control Register (VME access or MANUAL with DIP switches).

(2) Apply local LEVEL 1 ACCEPT signal (pulse generator).

(3) Set up scope to trigger on a rising edge, with a trigger threshold of -1.3V.

(4) Probe U23, pin 3 (see Figure 3). Signal should be switching between -1.7V and -0.9V (ECL levels).

(5) Adjust width to desired value by turning the screw on adjustable resistor R109 (see Figure 3).

(Note: Differential ECL versions of inputs LEVEL 1 ACCEPT & LEVEL 1 TRIGGER may be used in the above. (See section **Signal Levels / Connectors** and Figure 2).

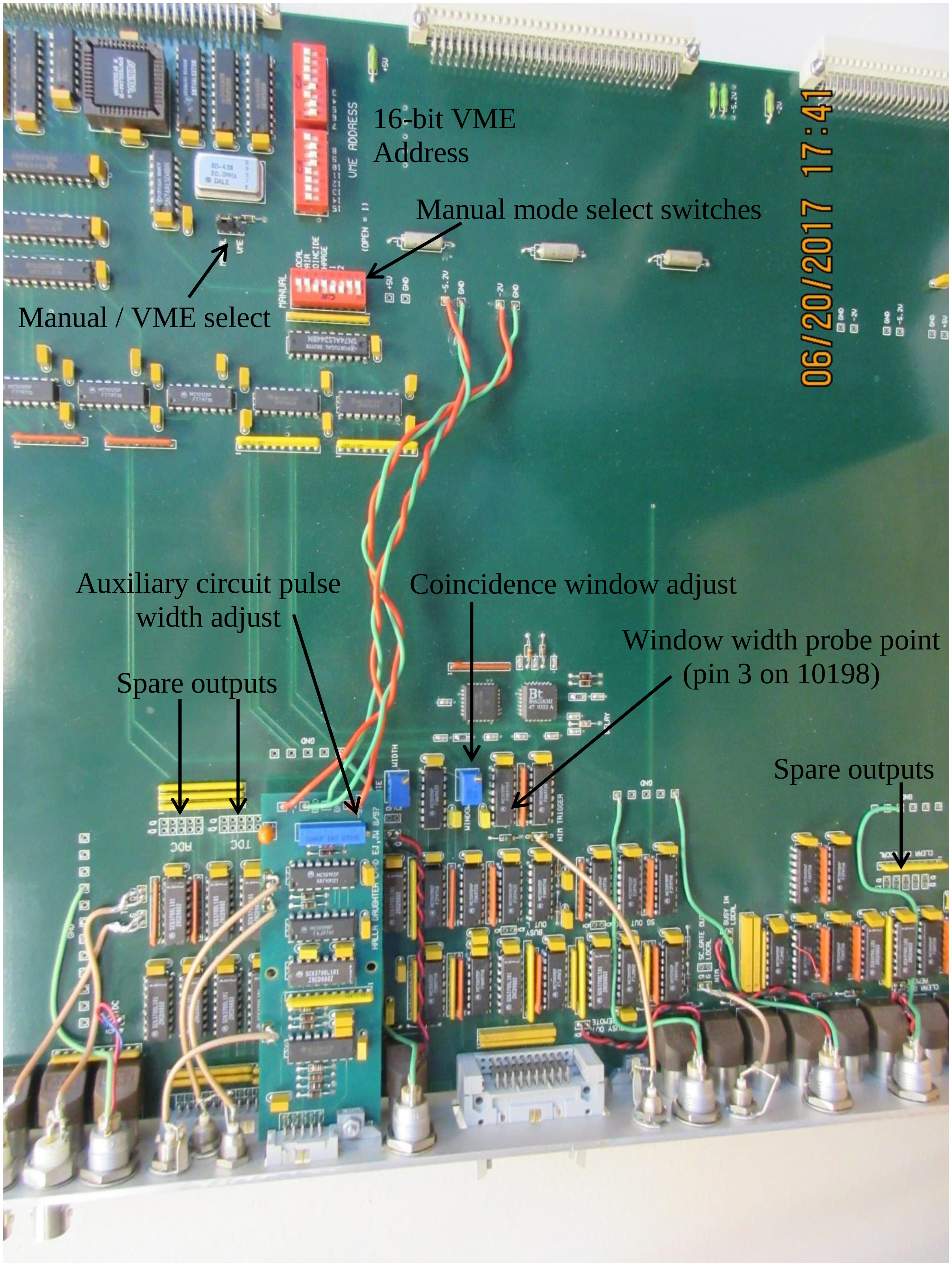

16-bit VME
Address
Manual mode select switches
Manual / VME select
06/20/2017 17:41
Auxiliary circuit pulse
width adjust
Coincidence window adjust
Window width probe point
(pin 3 on 10198)
Spare outputs
Spare outputs

Figure 3.