OEM Manual

APTechnologies
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PhotoniQ

PhotoniQ Series

TPC100AM
Trigger Processing Card

Vertilon

Vertilon Corporation, 66 Tadmuck Road, Westford, MA 01886 / Tel: (978) 692-7070 / Fax: (978) 692-7010 / www.vertilon.com

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Table of Contents

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List of Figures

List of Tables

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General Safety Precautions

Warning – High Voltages

The TPC100AM is mounted to the main board of a Vertilon PhotoniQ multi-channel PMT data acquisition system. This board assembly connects to a Sensor Interface Board (SIB) through a high voltage cable. The TPC100AM, PhotoniQ, Sensor Interface Board, and sensor power cable are energized with potentially harmful high voltages (up to 2000 Volts) during operation.

Use Proper Power Source

The TPC100AM is powered with +5V through the PhotoniQ daughtercard expansion connector. Use with any other power source may result in damage to the product.

Operate Inputs within Specified Range

To avoid electric shock, fire hazard, or damage to the product, do not apply a voltage to any input outside of its specified range.

Electrostatic Discharge Sensitive

Electrostatic discharges may result in damage to the TPC100AM, PhotoniQ and SIB board set. For these reasons, the boards are intended to be operated in a user's conductive instrument enclosure.

Do Not Operate in Wet or Damp Conditions

To avoid electric shock or damage to the product, do not operate in wet or damp conditions.

Do Not Operate in Explosive Atmosphere

To avoid injury or fire hazard, do not operate in an explosive atmosphere.

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Product Overview

The TPC100AM trigger processing card is a circuit board assembly designed for high performance applications requiring capture and synchronization of charge pulse signals. The card accepts a single charge-based input pulse that is signal conditioned and processed to provide the pulse integral and pulse peak on two separate analog outputs. Proprietary circuitry dynamically cancels background current while minimizing baseline drift due to pulse pile-up. Additionally, two user-selectable discriminators, a differential type and a constant fraction type, are available for triggering on the peak of the input pulse. Several user adjustments are included for setting preamp bias, system gain, trigger thresholds, and operational modes. Used in conjunction with a Vertilon PhotoniQ multi-channel PMT data acquisition system, all electrical and mechanical connectivity to the TPC100AM is established through the PhotoniQ daughtercard expansion interface connector. The TPC100AM and PhotoniQ assembly allows developers to easily integrate it with other electronics to build more sophisticated electro-optical instruments.

This guide is intended to be used as a supplement to the PhotoniQ User Manual. It contains information and specifications relating to TPC100AM only. The user should refer to the PhotoniQ User Manual for all other information relating to the operation of the PhotoniQ such as performance specifications, mechanical prints, functionality descriptions, software interfaces, and file formats.

Features

- User-selectable differential or constant fraction type discriminators
- Adjustable input bias
- Dynamic background current cancellation circuitry
- Very low baseline drift, virtually no pulse pile-up
- Pulse integral and pulse peak outputs
- Low delay / low distortion 4th-order noise filter
- On-board non-volatile flash memory for configuration settings
- Programmable thresholds and modes

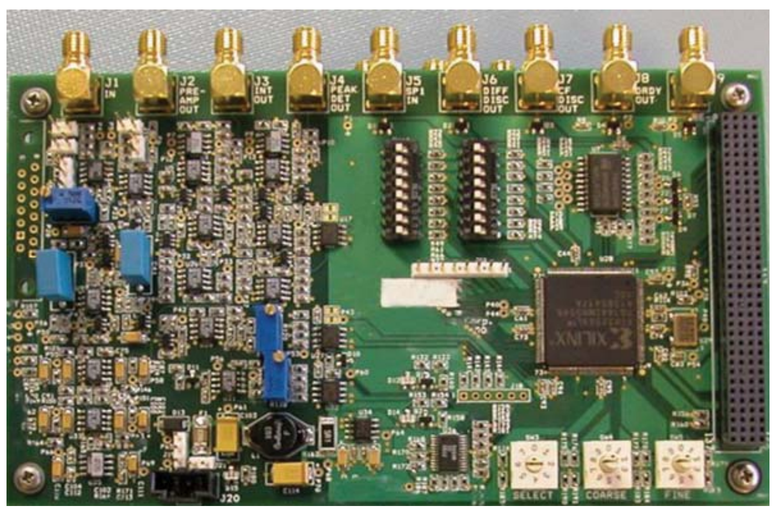

Figure 1: TPC100AM Printed Circuit Board

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Applications

Applications	
▪ Fluorescence Spectroscopy	▪ Bioaerosol Detection and Discrimination
▪ Spatial Radiation Detection	▪ Flow Cytometry
▪ High Speed Spectroscopy	▪ Particle Physics

Table 1: Applications

Key Specifications

(Typical specifications at room temperature)

Item	Specification	
Typical Pulse Width (FWHM)	Speed Option 010:	10 usec
Minimum Pulse Repetition Time	Speed Option 010:	500 usec
Maximum Input Pulse Amplitude	Input Option 0020: Input Option 0200: Input Option 2000:	20uA 200uA 2000uA
Maximum Background Current	20% of Peak Input Pulse	
Dynamic Range	200:1	
Analog Output Range	+0.10 to +3.00V	
Digital I/O	0 to +5V	
Input Power	+5V	

Table 2: Key Specifications

Ordering Information

The TPC100AM trigger processing card comes in three input pulse size options. Custom speed and input pulse size configurations are also available. Contact Vertilon for details.

Model	Typical FWHM Pulse Width (usec)	Minimum Pulse Repetition Time (usec)	Maximum Input Pulse Height (uA)
TPC100AM-010-2000	10	500	2000
TPC100AM-010-0200	10	500	200
TPC100AM-010-0020	10	500	20
TPC100AM-xxx-xxxx	Specify	Specify	Specify

Table 3: Ordering Information

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Specifications

(V_{supply} = +5.0V, T_A = +25C, speed option -010, Post amplifier gain set low: J14 loaded)

Description	Sym	Option	Min	Typ	Max	Units
CURRENT PREAMP						
Transimpedance Gain	Z	Input Range				V/A
		-0020		75,000		
		-0200		7,500		
		-2000		750		
Gain Adjustment Range	ΔZ		-5.0	0.0	+2.5	dB
Bias	V_{bias}		+0.100	+1.250	+1.970	V
Background Current Cancellation	I_{bg}	Input Range				uA
		-0020	+4			
		-0200	+40			
		-2000	+400			
Threshold Adjustment	I_{th}	Input Range				uA
(at typical pulse width and nominal gain)		-0020	0		+25	
		-0200	0		+250	
		-2000	0		+2500	
Baseline	V_{bl}		+2.4	+2.5	+2.6	V
Signal Swing			V_{bl}		V_{bl} + 1.5	V
Output Impedance				50		Ω
FILTER						
Pulse Gain (for 10 usec FWHM pulse)	A_f		-1.5	-0.8	0.0	dB
Delay				5.6		usec
Attenuation @ 150 KHz				13		dB
Attenuation @ 750 KHz				66		dB
INTEGRATOR						
Gain (from Current Preamp Input)	A_i		61	68	75	uV/pC
Offset	V_{io}		+90	+100	+110	mV
Signal Swing			V_{io}		V_{io} + 3.0	V
Output Impedance				50		Ω
SAMPLING PEAK DETECTOR						
Gain (from Current Preamp Out)	A_{pd}		+1.9	+2.0	+2.1	V/V
Offset	V_{po}		+90	+100	+110	mV
Signal Swing			V_{po}		V_{po} + 3.0	V
Output Impedance				50		Ω

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Description	Sym	Option	Min	Typ	Max	Units
TRACKING PEAK DETECTOR						
Gain (from Current Preamp Out)	A_{pd}		+1.9	+2.0	+2.1	V/V
Offset	V_{po}		+60	+100	+140	mV
Signal Swing			V_{po}		V_{po} + 3.0	V
Output Impedance				50		Ω
POWER						
Supply Voltage	V_{supply}		+4.9	+5.0	+5.1	V
Supply Current	I_{supply}			250		mA
ANALOG OUTPUT TIMING						
Data Ready to Re-Arm Time	t_1			4.0		usec
Integrator Pre-Threshold Time	t_2			0.2		usec
Trigger to Sample Time	t_3		1.0	10	20	usec
Sample to Data Ready Time	t_4			4.0		usec
Data Ready Period	t_{rdy}		2	10	200	usec
DIFFERENTIAL DISCRIMINATOR TIMING						
Pulse Width (FWHM)	t_{pw}		8.0	10	12	usec
Pulse Repetition Time	t_{rep}		500			usec
Discrimination to Trigger Delay (measured over the signal input range of 0dB to -46dB)	t_d		5.5	5.75	6.0	usec
Delay Jitter (measured at -46dB from peak signal input)					400	nsec
CONSTANT FRACTION DISCRIMINATOR TIMING						
Pulse Width (FWHM)	t_{pw}		8.0	10	12	usec
Pulse Repetition Time	t_{rep}		500			usec
Discrimination to Trigger Delay (measured over the signal input range of 0dB to -46dB)	t_d		3.5	5	6.5	usec
Delay Jitter (measured at -46dB from peak signal input)					3.5	usec

Table 4: Specifications

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Theory of Operation

The architecture of the TPC100AM is shown in Figure 2. It consists of several analog processing functions for signal conditioning, discrimination, peak detection, and integration of the input charge pulse as well as programmable digital circuitry to set the operational modes and thresholds for the analog functions and control the system timing.

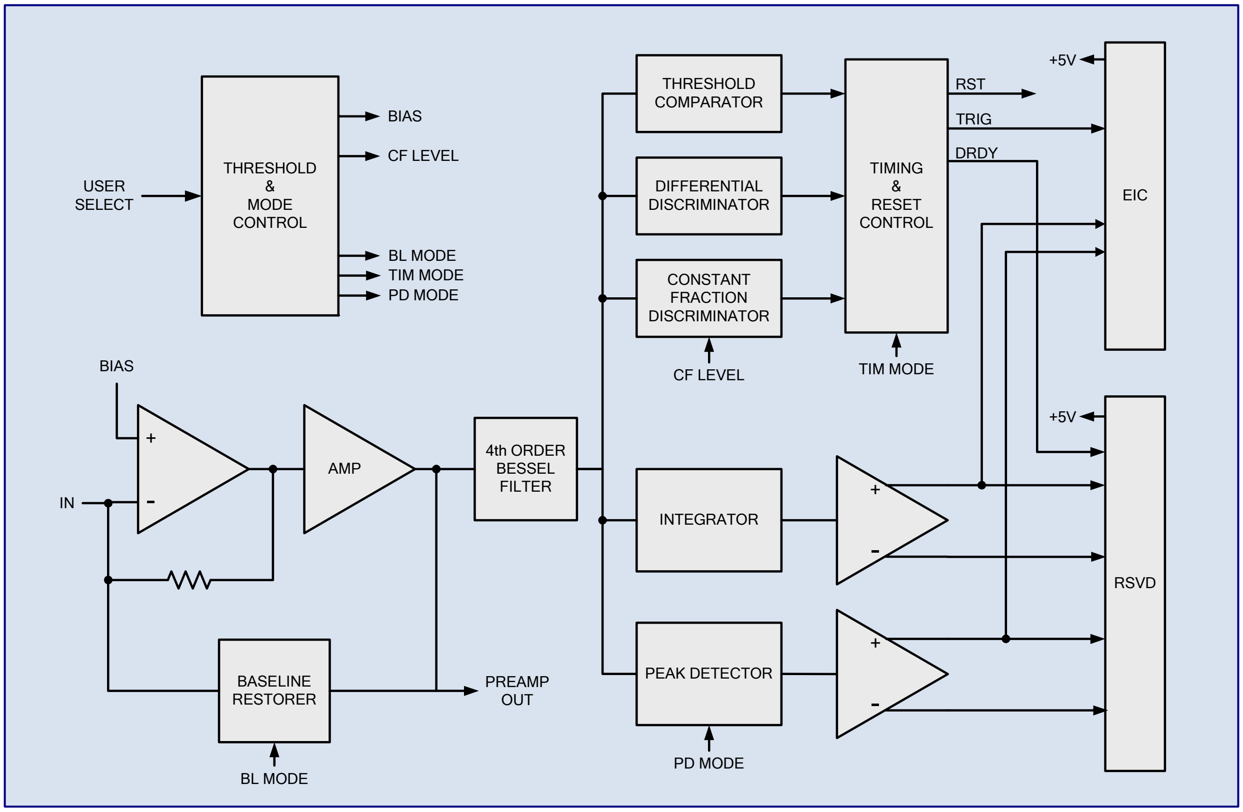

Figure 2: Block Diagram

Current Preamp

The current input signal is amplified by a low noise, high speed transimpedance preamplier followed by a straight voltage amplifier. The high speed of the current preamp preserves the input pulse shape while minimizing delay. The feedback configuration holds the input of the TPC100AM at bias voltage, BIAS.

Baseline Restorer

Fixed background currents are dynamically canceled by the baseline restorer such that the resulting pulse signal is placed on a nearly constant baseline. The proprietary circuit significantly reduces the baseline drift in conditions of large amplitude pulses at high repetition rates (pulse pile-up).

Pulse Filter

The amplified and baseline restored current signal is filtered by a 4th-order Bessel filter that provides very tight noise filtering. This function minimizes pulse distortion and delay resulting in more accurate timing discrimination.

Threshold Comparator

The threshold comparator compares the incoming signal to a user-adjustable threshold to set the noise sensitivity of the TPC100AM. Once the input signal crosses the threshold and fires the threshold comparator (the *threshold point*) the system goes through a complete timing cycle and cannot be re-triggered. For this reason, the threshold level should be set just above the noise level so that the system does not trigger on the noise. The timing cycle can be interrupted by the user by momentarily asserting the RE-ARM external input.

Differential Discriminator

The differential discriminator is one of two types of discriminators selectable by the user. It operates by indicating when the peak of the pulse is detected. This discriminator has a *discrimination point* that occurs at the first zero-slope transition of the input pulse after the *threshold point*. For Gaussian, sinusoidal, and triangular pulses, the *discrimination point* corresponds to the pulse peak. The differential discriminator is very accurate for pulses that are predominantly Gaussian (or uniform) in shape but may not be appropriate for applications where the pulse has several large transitions (ringing). An additional benefit of this type of discriminator is that provided the input pulses are uniform, the *discrimination point* is relatively insensitive to the input pulse width and amplitude.

Figure 3 below illustrates a typical timing cycle for the differential discriminator. The cycle begins with the unit in an armed state where it waits for the signal input to cross the user-adjustable threshold, I_{th}. When the *threshold point* is reached, the BUSY output goes high and the TPC100AM enters a highly sensitive state where it looks for the *discrimination point*. For the differential discriminator, this point is at the pulse peak. After a delay of t_d seconds, the discriminator output, DISC OUT, goes high indicating the *trigger point*. The data ready signal, DRDY OUT, is then asserted after the *trigger point* and remains asserted for duration, t_{rdy}. During this time the integrator and peak detector outputs are available for sampling. Once the data ready period expires and BUSY returns low, the system is re-armed and can again be triggered to capture the next input event.

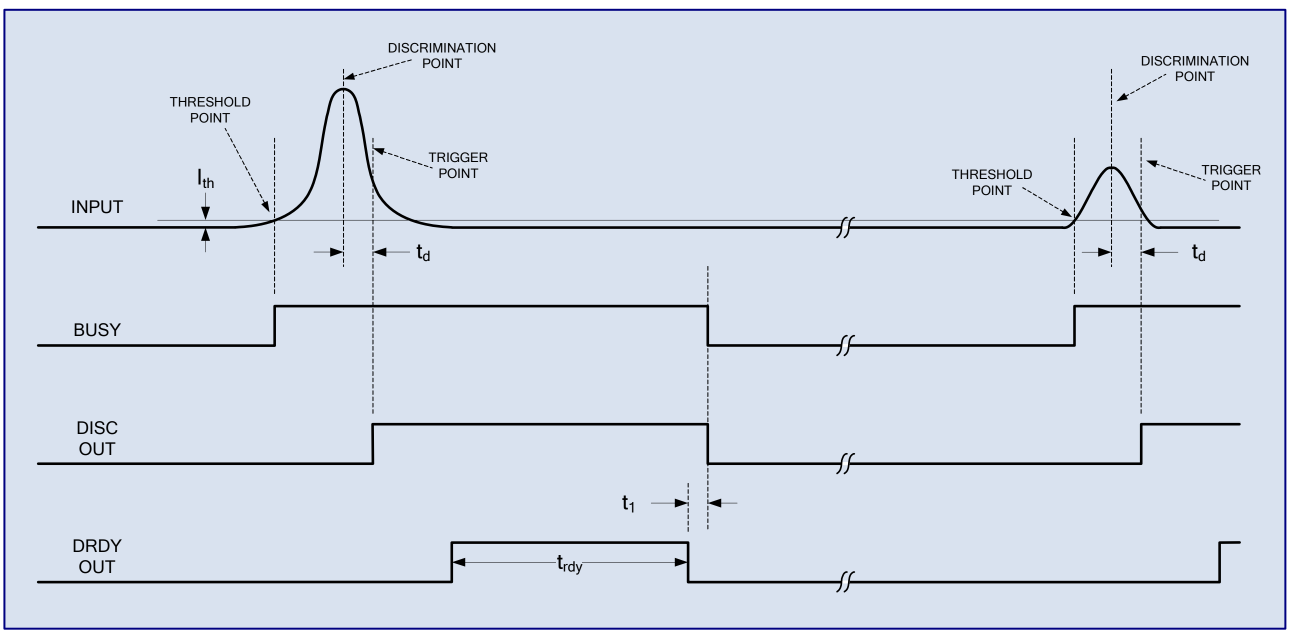

Figure 3: Differential Discriminator Timing

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Constant Fraction Discriminator

A second type of discriminator called the constant fraction type is available for applications where the input pulse may contain several transitions. This discriminator operates by comparing the integral of the input signal to a (user-adjustable) fraction of the input signal. If the fraction is set to 50% of the integral, the *discrimination point* for Gaussian and other uniformly shaped pulses occurs at the peak of the signal. Quasi-Gaussian pulses with multiple transitions can also be reliably discriminated with the constant fraction discriminator provided that the transitions are small relative to the pulse height. By setting the fraction to less than 50% of the integral, "pre-peak" discrimination is possible. One drawback however is that the *discrimination point* is strongly dependent on the input pulse width. For this reason, the constant fraction discriminator is most useful in applications of fixed pulse width.

A typical event timing cycle for the constant fraction discriminator is shown in Figure 4 below. Like the differential type, the cycle begins with the unit armed and waiting to reach the *threshold point*. When this occurs, BUSY is asserted and the unit goes into a *lockout period*, t_{lo}, where the constant fraction discriminator ignores all potential *discrimination points*. This feature dramatically reduces false triggers under low pulse amplitude conditions. To utilize this feature, the user needs to pre-program the *lockout period*. For 50% *discrimination points*, the lockout period should be set approximately to the FWHM period of the pulse. A certain amount of experimentation is likely to be required.

In most applications the *discrimination point* is set to occur at the peak of the input pulse. While the differential discriminator naturally operates under this condition, the constant fraction discriminator gives the user added flexibility to set the *discrimination point* to be before or after the pulse peak. In the example below it is assumed that the fraction is set to less than half of the integral so that the *discrimination point* precedes the pulse peak. The benefit is that delay, t_d, can be adjusted out so that the *trigger point* coincides exactly with the pulse peak. Once DISC OUT goes high at the *trigger point*, the subsequent timing behaves identically to that of the differential discriminator.

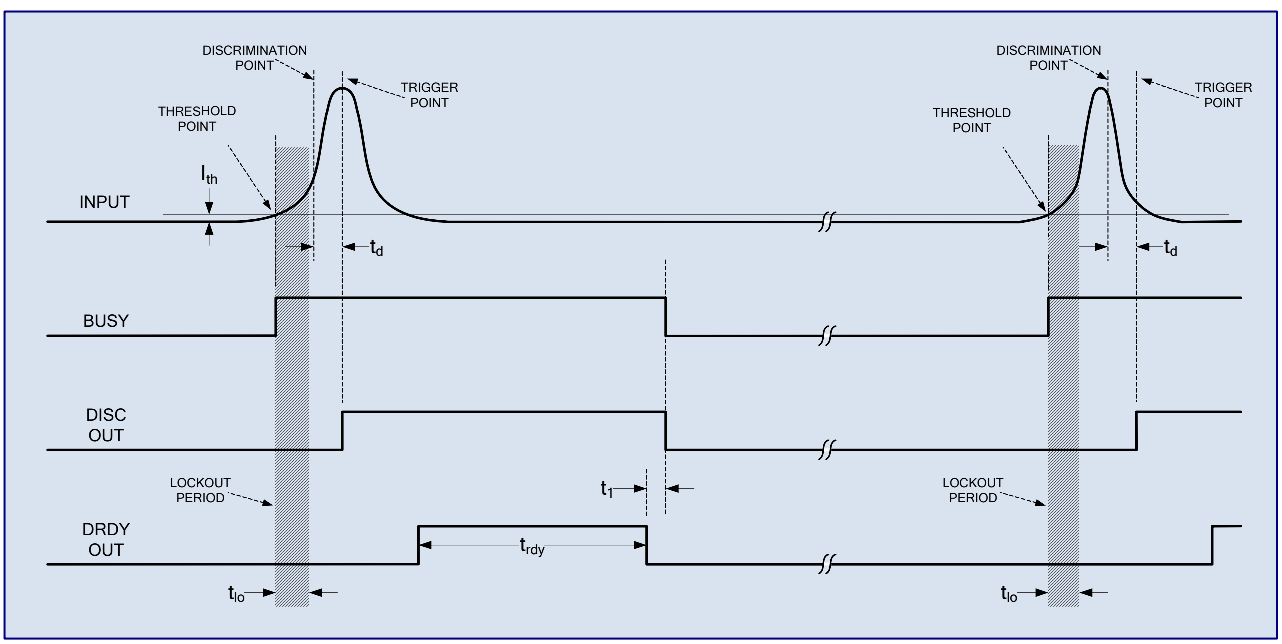

Figure 4: Constant Fraction Discriminator Timing

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Pulse Integrator Timing

The pulse integrator computes the integral of the input pulse within a fixed time window positioned relative to the pulse *trigger point*. The result is output in single-ended form on the expansion interface connector (EIC) and in differential form on the reserved connector (RSVD). The TPC100AM is designed to start integrating the triggering pulse just prior in time to the *threshold point*. This is denoted in by time t_2 in Figure 5. Integration continues for t_3 seconds after the *trigger point* with the resulting integrated signal ready for external sampling t_4 seconds after the end of the integration period. The data ready period, t_{rdy}, is indicated by DRDY OUT in the high state. At the end of this period, the integrator is reset.

Pulse Peak Detector Timing

The pulse peak detector determines the peak of the input pulse within the same time window used by the integrator. Two peak detection modes are available. In *tracking* mode, the peak detector continuously follows the input pulse and holds the peak value when reached. An alternative mode called *sampling* mode operates by sampling the pulse at the *trigger point*. Because the peak detector operates on a delayed version of the input pulse, the effective sampling point of the pulse occurs t_d seconds prior to the *trigger point*. When using the differential discriminator this has the advantage of placing the peak detector sampling point very near the peak of the pulse. It is recommended that the *sampling* mode be used with the differential discriminator and the *tracking* mode with the constant fraction discriminator. The output from the peak detector is available in single-ended form on the expansion interface connector (EIC) and in differential form on the reserved connector (RSVD). Like the pulse integrator, the data ready signal indicates when the peak detector result is ready for sampling. The peak detector is also reset after the data ready signal is de-asserted.

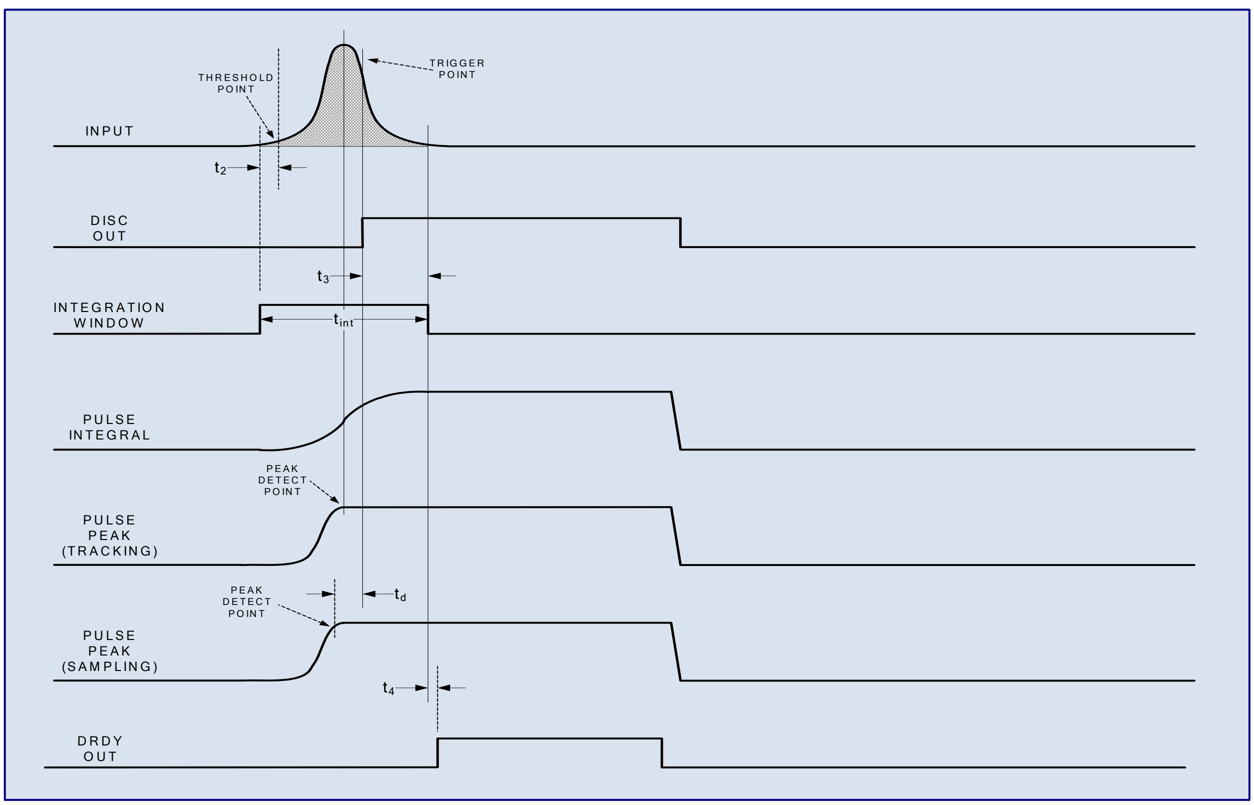

Figure 5: Analog Output Timing Diagram

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Timing Generator

Timing to the integrator and peak detector is derived from the programmable timing generator. It consists mainly of the integration and peak detection windows as well as reset control.

Re-Arm

The RE-ARM input allows the user to interrupt the timing cycle of the TPC100AM and return it to an armed state. It is most useful in applications where the analog outputs are unused or are sampled very quickly. By applying a re-arm signal to the unit during the data ready period, the TPC100AM cycle time can be minimized and as a result the time between successive events can be reduced. The figure below illustrates operation with an external re-arm signal.

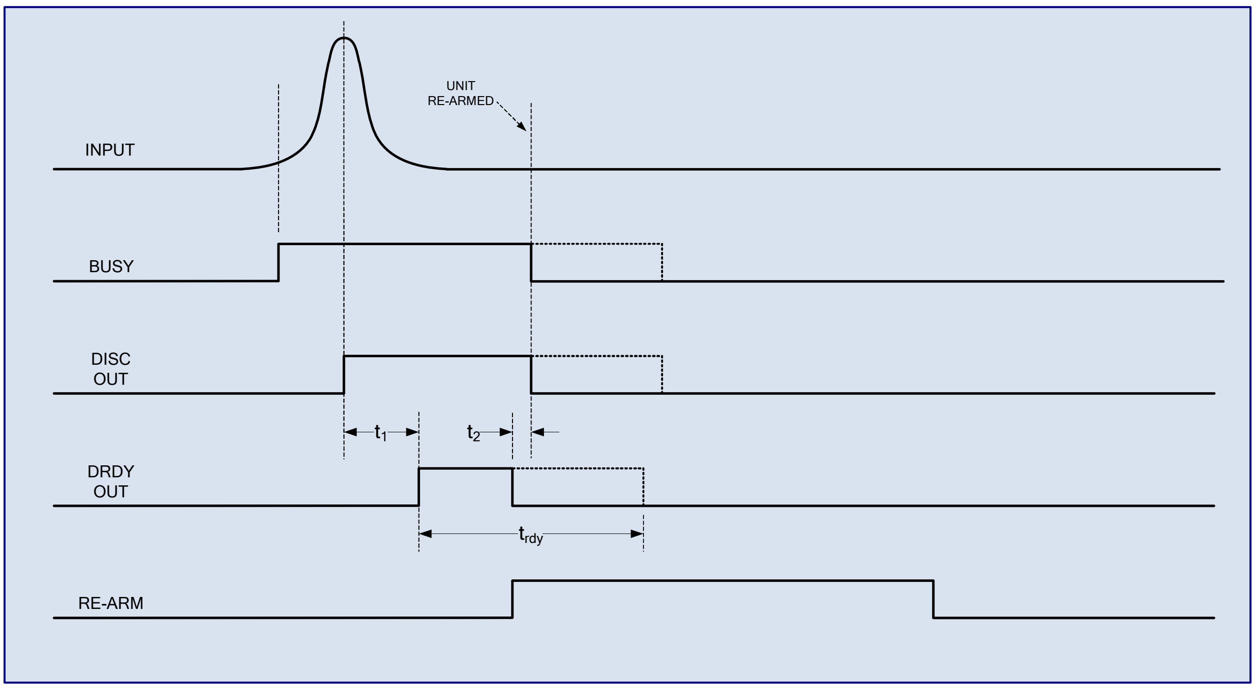

Figure 6: Re-Arm Timing

Expansion Interface Connector (EIC)

The expansion interface connector on the TPC100AM is used as the main electrical connectivity path to the PhotoniQ main board. Power to the TPC100AM is provided from the PhotoniQ on this connector. Depending on which discriminator type is selected by the user, the TPC100AM passes either the differential or constant fraction discriminator output through the EIC to trigger the PhotoniQ. The integrator and peak detector outputs also pass through the EIC to the PhotoniQ. Display and logging of these signal is currently unsupported in the PhotoniQ.

Reserved Connector (RSVD)

This connector is reserved for expansion.

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Electrical Interface

The photo below shows the TPC100AM mated to PhotoniQ. All electrical connections to the PhotoniQ are made through the expansion interface connector (EIC). The TPC100AM is mechanically mounted to the PhotoniQ at each of its four corners using a captive 5/8" long spacer and a one inch long #4-40 machine screw.

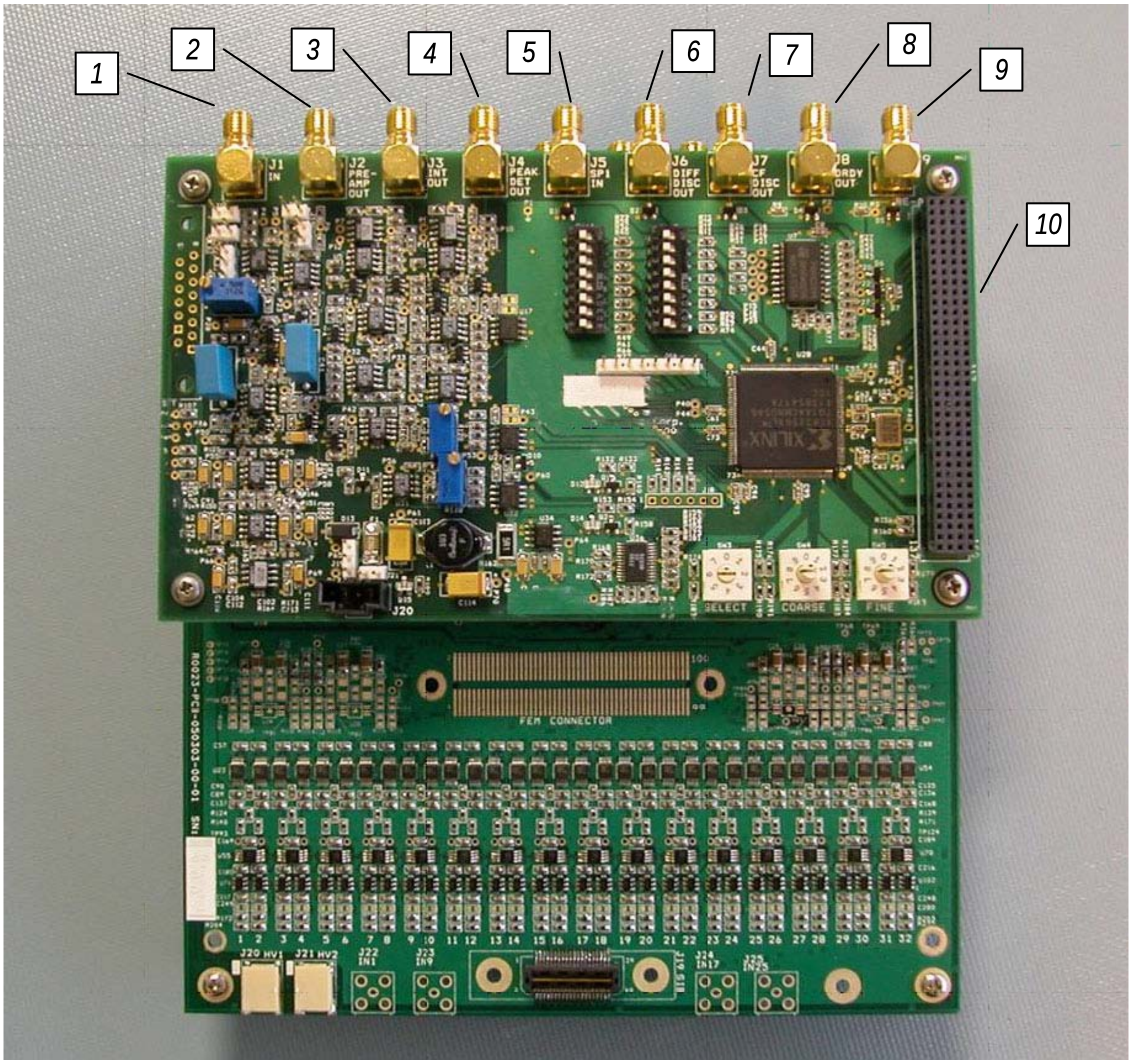

Figure 7: PhotoniQ / TPC100AM System

1. Current Input (J1)
2. Preamp Monitor Output (J2)
3. Integrator Output (J3)
4. Peak Detector Output (J4)
5. Spare Input (J5)
6. Discriminator Out (J6)
7. Busy Output (J7)
8. Data Ready Output (J8)
9. Re-Arm Input (J9)
10. Expansion Interface Connector (J17)

Connectors and Jumpers

The locations of all interface connectors and jumpers are shown below.

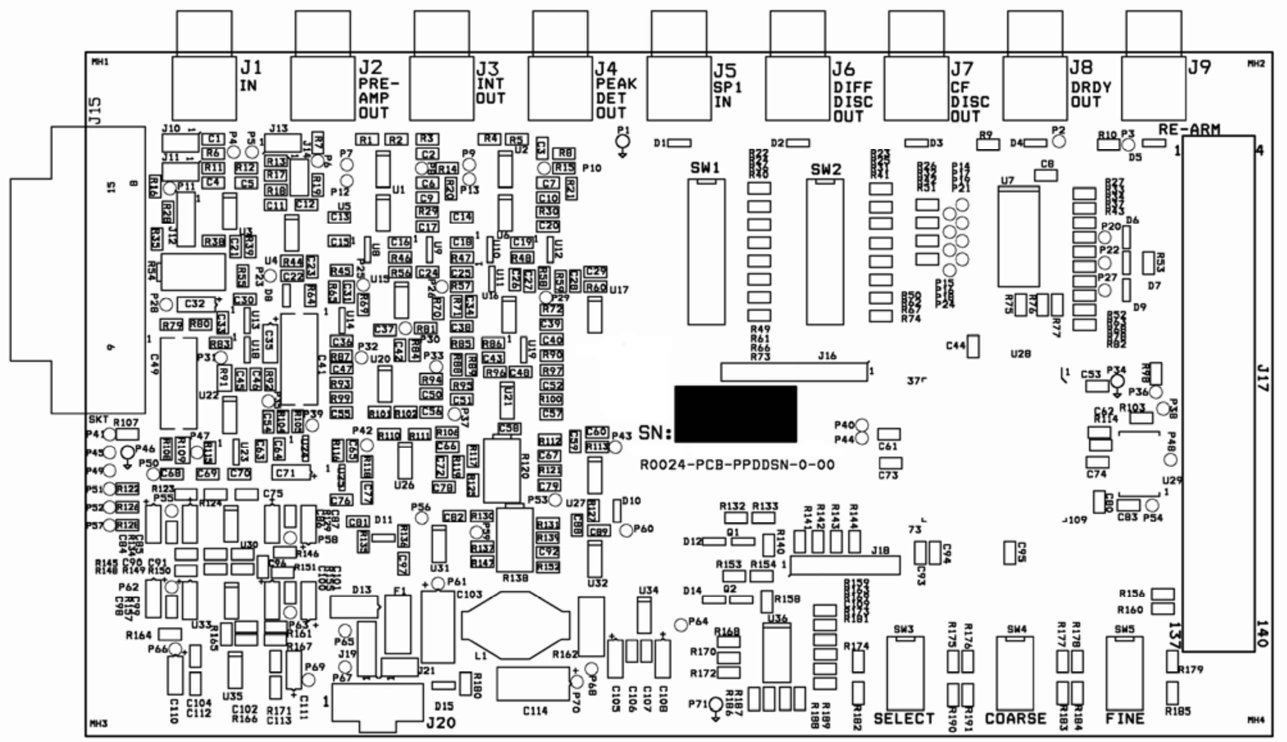

Figure 8: Connector and Jumper Locations

The connector and jumper functions are described in the table below.

Name	Function	Manufacturer	P/N	Mating P/N
J1	Current Input	Johnson	142-0701-321	SMA Plug
J2	Preamp Output	Johnson	142-0701-321	SMA Plug
J3	Integrator Output	Johnson	142-0701-321	SMA Plug
J4	Peak Detector Output	Johnson	142-0701-321	SMA Plug
J5	Spare1 Input	Johnson	142-0701-321	SMA Plug
J6	Discriminator Output	Johnson	142-0701-321	SMA Plug
J7	Busy Output	Johnson	142-0701-321	SMA Plug
J8	Data Ready Output	Johnson	142-0701-321	SMA Plug
J9	External Re-arm Input	Johnson	142-0701-321	SMA Plug
J10	Preamp Gain1 Jumper	-	-	-
J11	Preamp Gain2 Jumper	-	-	-
J12	Baseline Restore Jumper	-	-	-
J13	Post Amp Gain1 Jumper	-	-	-
J14	Post Amp Gain2 Jumper	-	-	-
J15	Reserved Connector (not installed)	AMP	745781-2	D-sub Plug, 9 Pos
J16	Spare Header (unused)	-	-	-
J17	Expansion Interface Connector (EIC)	Samtec	SQT-135-03-L-Q	SQT-135-03-L-Q
J18	Factory Programming Header	-	-	-
J19	Input Power Select Jumper	-	-	-
J20	Auxiliary Power Input (unused)	-	-	-
J21	LED Jumper	-	-	-

Table 5: Connector Functions

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Operation

The TPC100AM is configured by applying a signal to the input and monitoring the analog and digital outputs on the SMA connectors. Adjustments to the operating parameters are made using a combination of dip switches, jumpers, pots, and rotary switches. The dip switches are used to set the modes of the TPC100AM and the jumpers are used to set the current preamp gain. The *threshold point* and the *discrimination point* for the constant fraction discriminator are set using multi-turn pots. The preamp input bias level and TPC100AM timing parameters are adjusted using the three digital rotary switches.

Mode Switches

The operating modes of the TPC100AM are set using DIP switch SW1 and are summarized in Table 6 below. The default configuration is all switches on. Switch SW2 is for factory functions and should be configured with all switches off.

SW #	Function	Switch On	Switch Off
1	System	Operate	Reset
2	Baseline Restorer	Active	Disabled
3	Discriminator Type	Differential	Constant Fraction
4	Peak Detector Type	Sampling	Tracking

Table 6: Mode Switches (SW1)

Current Preamp Gain

Adjustment of the current preamp gain is made using jumpers according to Table 7. Under normal conditions the gain should not have to be changed. However, if the discriminator output is unreliable over the range of input pulse sizes, the gain may have to be adjusted to better match the input conditions. The gain should be set so that the maximum input pulse results in approximately 1.5 volts of signal swing (0.75 volts into 50 ohms) at the preamp output (J2).

Gain	J10	J11
+2.5 dB	Out	In
0.0 dB	In	Out
-5.0 dB	In	In

Table 7: Current Preamp Gain Adjustment

Post Amp Gain

The post amplifier that follows the preamplifier is factory configured with jumper J14 loaded. Under normal conditions it should not be necessary to change its gain. However an additional 10 dB of gain can be added by removing jumper J14 and loading jumper J13.

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Background Current Cancellation Range

Jumper J12 sets the range of the background current cancellation circuit. The factory default setting is pins 1, 2, and 3 connected together. This jumper should not be removed.

Threshold

The *threshold point* is adjusted with potentiometer R138 by applying an input to the TPC100AM while monitoring the BUSY output (J7). Potentiometer R138 should be set just beyond the point where the system no longer triggers on noise.

Constant Fraction Discriminator Threshold

Potentiometer R120 sets the *discrimination point* and hence the *trigger point* for the constant fraction discriminator. This adjustment should be made while monitoring the discriminator output (J6). It is only applicable when the constant fraction discriminator is selected.

Rotary Switches

The rotary switch functions are listed in Table 8. To use the switches, select the desired *function* using the eight position SELECT rotary switch. The *program* LED (D14) will illuminate indicating that the *value* switches, labeled as COARSE and FINE, are active and that the selected *function* can be updated. The *value* switches correspond to the most significant and least significant decimal digits of a two digit parameter. Enter the desired value for the selected *function*. Any time the *value* switches are changed (rotated), the selected *function* will automatically be updated with the new *value* and stored in non-volatile memory. To prevent accidental changes to stored values, the SELECT switch should be set to the "Safe" position (position 0). When in this position the *program* LED is off. It is recommended that the SELECT switch be set to position 0 when not updating functions.

Pos	Function
0	Safe
1	Trigger to Sample Time (t_3)
2	Data Ready Period (t_{rdy})
3	Constant Fraction Lockout Period (t_{lo})

Table 8: Rotary Switch Functions

Trigger to Sample Time (t_3)

This timing parameter is adjusted with the SELECT rotary switch in position 1. The trigger to sample time (in microseconds) is equal to the two digit decimal value of the *value* rotary switches.

Data Ready Period (t_{rdy})

Position 2 on the SELECT rotary switch is used to set the data ready period. This parameter (in microseconds) is equal to the two digit decimal value of the *value* rotary switches times two.

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Constant Fraction Lockout Period (t_{lo})

The lockout period for the constant fraction discriminator is set using Position 3 on the SELECT rotary switch. This parameter (in microseconds) is equal to the two digit decimal value of the *value* rotary switches.

Reserved Connector (RSVD)

The TPC100AM has provisions for installation of a 15-position D-sub connector. The signals on this connector are defined as shown in Table 9 below.

Name	Pin Number	Description
DISC1+	1	Spare Differential Output #1 (+)
DISC1-	2	Spare Differential Output #1 (-)
DISC2+	3	Spare Differential Output #2 (+)
DISC2-	4	Spare Differential Output #2 (-)
PD+	5	Peak Detector Differential Output (+)
PD-	6	Peak Detector Differential Output (-)
INT+	7	Integrator Differential Output (+)
INT-	8	Integrator Differential Output (-)
+15V	9	Unused input
-15V	10	Unused input
+5V	11	+5V Power Input
DRDY	12	Data Ready Output
SPRO1	13	Spare Output
RE-ARM	14	Re-arm Input
GND	15	System Ground (Power Supply Return)

Table 9: Reserved Connector (J15)

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Factory Parameters

The factory calibration and timing parameters are set before shipment and should not need to be changed under normal circumstances. If necessary they can be modified but only if the TPC100AM is unlocked with a key code programmed into DIP switch SW2. The descriptions below describe the factory configured parameters.

Rotary Switch Factory Functions

The factory functions for the rotary switches are listed in Table 10. These functions can only be accessed when the unlock key code is programmed into DIP switch SW2.

Pos	Function
4	Preamp Input Bias
5	Constant Fraction Offset
6	Preamp Output Offset
7	Peak Detector Offset

Table 10: Rotary Switch Factory Functions

Preamp Input Bias

The bias voltage at the input to the current preamp can be varied from +0.094V to +1.970V using the *value* rotary switches in the range from 03 to 63. The applied bias voltage is approximately equal to +31.25mV times the two digit decimal value. The default value is 40 (+1.250V).

Constant Fraction Offset

This value can be adjusted from -50mV to +50mV using the *value* rotary switches in the range from 0 to 63. The programmed offset is equal to +1.563mV times the *value* rotary switches minus 50mV.

Preamp Output Offset

This value can be adjusted from -1.00mV to +1.00mV using the *value* rotary switches in the range from 0 to 63. The programmed offset is equal to +31.25uV times the *value* rotary switches minus 1.00mV.

Peak Detector Offset

This value can be adjusted from -20mV to +20mV using the *value* rotary switches in the range from 0 to 63. The programmed offset is equal to +625uV times the *value* rotary switches minus 20mV.

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Mechanical Information

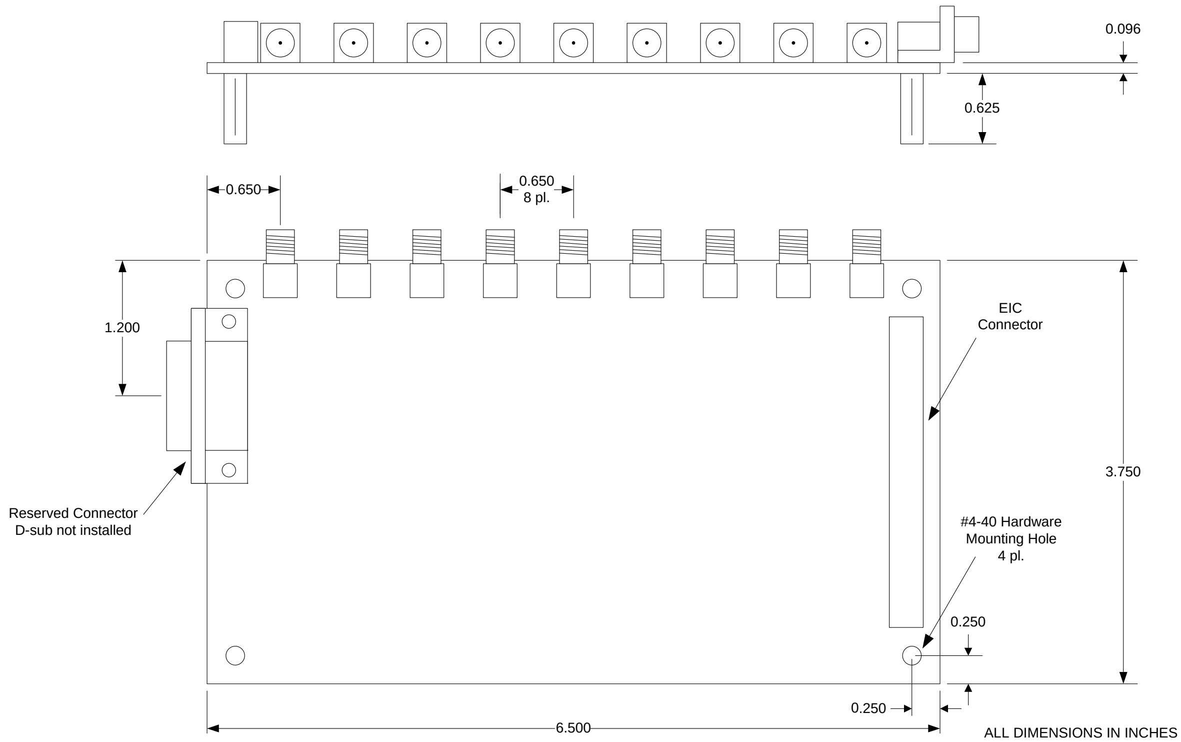

Figure 9: Printed Circuit Board Mechanical Assembly

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