ELECTRO-OPTIC DEVICES, INC.

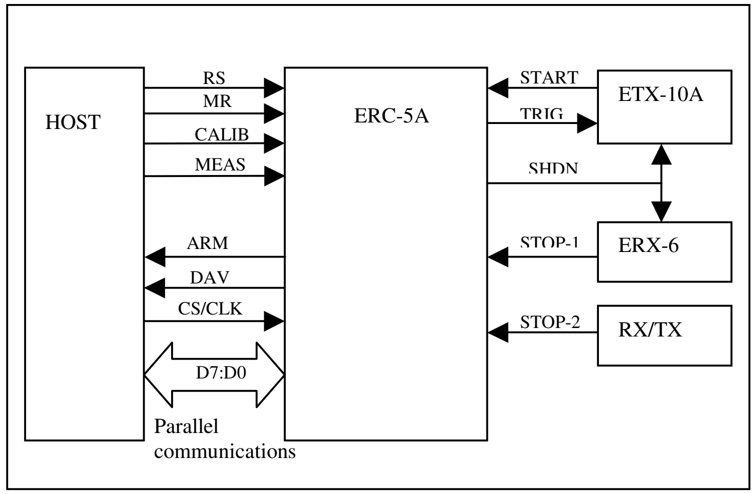
ERC-5A

Asynchronous Single Start Dual Stop Ranging Controller w/ Synchronized Trigger, Adjustable Range Gate and Blanking

(firmware version 1.10)

FEATURES:

- Measurement error < 50ps RMS.
- Range gate adjustable from 1.28 to 261.12 microseconds (selectable in 1.28 µS increments).
- Adjustable blanking.
- Measurement rate in excess of 25kHz (rates will decrease with longer range gates).
- Synchronized laser driver trigger.
- Simultaneously makes two STOP signal edge measurements using the same START signal edge.
- Directly compatible with ETX-10A and ERX-6.
- Can be used as read only or reconfigured through commands.
- Control information and data transfer via synchronous parallel interface.
- Programmable input source and edge selection via configuration command.
- Measurements sent in 3-byte ns results, 18:6 format. (18-bits whole : 6-bits fractional).
- Optional SMA, SMB or SMC coaxial connection for optional receiver STOP-2 analog or digital pulse.
- 1mm FFC connectors for ETX-10A and ERX-6 connection.
- Power management options.
- Single 5-Volt supply requirement.
- Compact 4.2"x3.4" circuit board design.



DESCRIPTION:

The ERC-5A is an asynchronous single START dual STOP laser ranging controller with a synchronized laser trigger. The ERC-5A is designed to interface with the ETX-10A laser driver and the ERX-6 optical receiver. Through a synchronized control signals, the ERC-5A will trigger the ETX-10A laser driver and then monitor the ETX-10A and ERX-6 for START and STOP edges. The ERC-5A will take samples within an adjustable time interval range gate from 1.28µs to 261.12µs at a rate of 25kHz with an accuracy of 50ps RMS. Routine Calibration may be performed periodically using the CALIB signal to keep measurements accurate over the operating temperature range.

Control commands and data transfer are accomplished via synchronous parallel interface. The ERC-5A measures two time intervals for every timing event. Varying combinations of input and edge selection through commands offers more configuration flexibility. Programmable adjustable range gate and blanking values allows the user to configure the ERC-5A for predictable near or far range measurements. The DAV signal informs the host that measurement results are ready for transfer. The two START-to-STOP measurement results are clocked out using the $\overline{CS}$ signal in a three-byte format, 18 whole number bits and 6 fractional bits, in the unit of nanoseconds.

The ERC-5A operates with a single 5Vdc supply typically at 280mA or 370mA while supplying power to both the ERX-6 and ETX-10A through 1mm FFC connection. The ERC-5A has power management command to minimize power demand. Extended power management options are also available. The ERC-5A comes in a compact circuit board design measuring 4.2"x3.4".

INTERFACE:

Connector P1:

Pin	Signal	Dir.	Description
1	VCC	-	+5V power supply requirement
2	GND	-	Ground
3	DB7	I/O	Bit-7 (msb) of the data bus.
4	DB6	I/O	Bit-6 of the data bus.
5	DB5	I/O	Bit-5 of the data bus.
6	DB4	I/O	Bit-4 of the data bus.
7	DB3	I/O	Bit-3 of the data bus.
8	DB2	I/O	Bit-2 of the data bus.
9	DB1	I/O	Bit-1 of the data bus.
10	DB0	I/O	Bit-0 (lsb) of the data bus.
11	VCC	-	+5V power supply requirement
12	GND	-	Ground
13	$\overline{\text{MR}}$	I	Resets the ERC-5A microprocessor.
14	$\overline{\text{RS}}$	I	Resets all counters and timers and puts ERC-5A into ignore mode.
15	MEAS	I	Execute Measurement.
16	ARM	O	ERC-5A is armed and ready to take measurements.
17	$\overline{\text{CLK}}$ /$\overline{\text{CS}}$	I	Clocks data in and out. Chip Select (CS) when sending commands
18	DAV	O	Signals Data Available.
19	CAL	I	Puts ERC-5A into Calibration mode.
20	RSRV	-	Reserved Connection

Connector P5:

Pin	Signal	Dir.	Description
1	DM	I	Discharge Monitor input.
2	GND	-	Ground
3	SHDN	O	ETX-10A Shutdown
4	GND	-	Ground
5	NC	-	No Connection
6	VCC	-	+5V power supply
7	NC	-	No Connection
8	TRIG	O	Used to Pulse Laser Diode.

ETX-10A LASER Driver interface connector for a START input signal. This is an analog AC coupled input to a comparator. The threshold of the comparator is adjustable by VR1 potentiometer. See operational description.

Connector P6:

Pin	Signal	Dir.	Description
1	NC	-	No Connection
2	ASO	I	Analog Signal Input
3	GND	-	Analog Ground
4	SHDN	O	APD Bias Shutdown
5	NC	-	No Connection
6	VCC	-	APD +5V bias supply
7	VCC	-	+5V power supply
8	GND	-	Ground

ERX-6 Optical Receiver interface connector for a STOP input signal. This is an analog AC coupled input to a comparator. The threshold of the comparator is adjustable by VR2 potentiometer. See operational description.

Coaxial Connector J1:

PC-mount SMA, SMB or SMC connector jack for optional START or STOP input. This input is AC terminated into 50Ω (1/10W) and DC terminated into 2.7KΩ (1/10W) (other termination configurations are optional). This input can be configured as a digital (TTL) or analog input (resistor placement option).

CFD Connector J2:

0.100” SIP plug-in header for the external Constant Fraction Discriminator (CFD) add-on board. This add-on board may be used for more accurate stop edge detection.

Interface Description:
(I = input, O = output, I/O = bidirectional)

DB7:DBO (I/O) – Parallel data bus to send commands to and receive result data from the chronometer. Timing details can be found in the **communication** section.

$\overline{\text{MR}}$ (I) - Master Reset input (hardware reset). Logic LOW applied to this input performs a hardware reset on the ERC-5A’s main microprocessor.

$\overline{\text{RS}}$ (I) – Reset input (counter reset). Logic LOW applied to this input resets all counters and timers and puts the ERC-5A into an ignore mode, which ignores any inputs from the host and ignores any measurement signals.

ARM (O) – ERC-5A ARM output. When HIGH, informs the host that the ERC-5A is armed, ready and waiting for a measurement.

$\overline{\text{CLK}}$/$\overline{\text{CS}}$ (I) - Chronometer Chip Select/CLocK handshake signal. Used during transfer of commands and data between the chronometer module and the host microprocessor. More information and timing details can be found in the **communication** section.

DAV (O) – Data AVailable output flag to the host. This output goes logic HIGH to indicate that measurement information is available and ready to be read by the host system. This output is often used to generate a hardware interrupt at the host. **Note:** While DAV is HIGH and **$\overline{\text{CLK}}$/$\overline{\text{CS}}$** is brought LOW is the only time the data bus is ever set as an output. Therefore, DAV can be used to prevent the host and ERC-5A from configuring their data-bus to an output at the same time. Timing details can be found in the **communication** section.

CAL (I) – CALIBration input. Active high signal that puts the ERC-5A into calibration mode. For greater measurement accuracy in extreme conditions, a calibration should be performed frequently. **Note:** Calibration must be performed at least once after $\overline{MR}$ reset or power-up.

MEAS (I) – Execute MEASurement input. Active high signal used to execute a measurement cycle.

OPERATIONAL DESCRIPTION:

Commands:

ID = 0, INPUT SELECT AND POLARITY

byte 1

b7	b6	b5	b4	b3	b2	b1	b0
0	0	E2	C2	E1	C1	SE	SC

byte 2
8-bit range-gate increments of 1.28µS.

BYTE 1

SC: START source channel *(default = 0)*

0 = START input (ETX-10A)
1 = J1 input (optional START digital input)

C1, C2: STOP1 and STOP2 source *(default = 0)*

0 = P6 or J1 input (Digital signal from Analog input).
1 = J1 input (Direct to Digital input).
Note: If CFD add-on board is used, this configuration is ignored and the inputs default to use the CFD.

SE, E1, E2: START, STOP1 and STOP2 edge *(default = 1,1,0)*

0 = Falling edge
1 = Rising edge

BYTE 2

Range gate value in 1.28µS increments from 1.28µS to 261.12µS. Used to increase range gate for far distant measurements. Default = hex value 0x01 (1.28µS).

ID = 1, BLANKING COMMAND

byte 1

b7	b6	b5	b4	b3	b2	b1	b0
0	1	b5	b4	b3	b2	b1	b0

BYTE 1

b5-b0: Blanking amount *(default = 0x00)*
Blanking amount = value of b5-b0 * 40ns + 15ns (±5ns).

Example:
0x48 – blanking value = 8 * 40 + 15 = 335ns ±5ns.

ID = 2, POWER MANAGEMENT COMMAND

byte 1

b7	b6	b5	b4	b3	b2	b1	b0
1	0	X	X	X	X	X	SHDN

BYTE 1

SHDN: Shutdown enable/disable *(default = 0)*

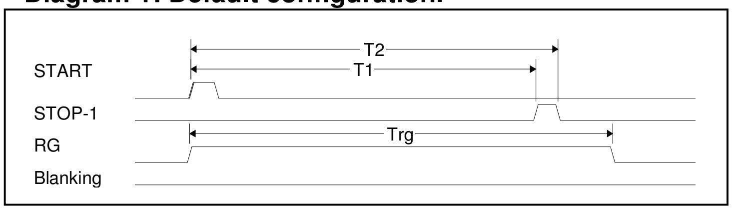
0 = Disable shutdown for ETX-10A and ERX-6
1 = Enable shutdown for ETX-10A and ERX-6

Examples:

Default configuration is to simultaneously measure the time interval from the leading-edge of a positive going START pulse to the leading-edge of a positive going STOP-1 pulse for the first (T1) measurement and the trailing-edge of the same STOP-1 pulse for a second (T2) measurement. The time between the start and each stop edges must occur within the default configured range gate of 1.28µs. The configuration bits are set as follows:

SC = 0, SE = 1, C1 = 0, E1 = 1, C2 = 0, E2 = 0
RG = 0x01 (1.28µs)
Blanking = 0x00 (0ns)
SHDN = 0

Diagram 1: Default configuration.

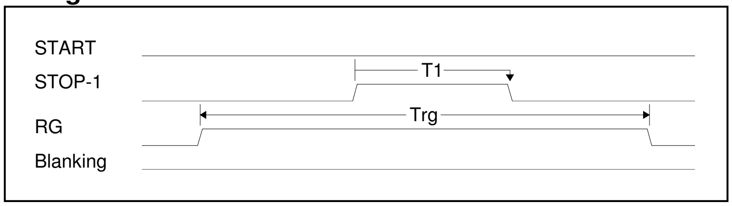


T1 = t_{START} (rising-edge) to t_{STOP-1} (rising-edge)
T2 = t_{START} (rising-edge) to t_{STOP-1} (falling-edge)
Trg = t_{START} (rising-edge) to range gate amount.

Pulse width measurements can be made from a single digital signal with the ERC-5A. In this example we use a range gate of 2.56µs. We use the STOP-2 digital input from the J1 connector and the configuration bits are set as follows:

SC = 1, SE = 1, C1 = 1, E1 = 0, C2 = 1, E2 = 0
RG = 0x02 = 2.56µs*Repetition rate changes with RG.
Blanking = 0x00 (0ns)
SHDN = 0

Diagram 2: Pulse Width Measurement.



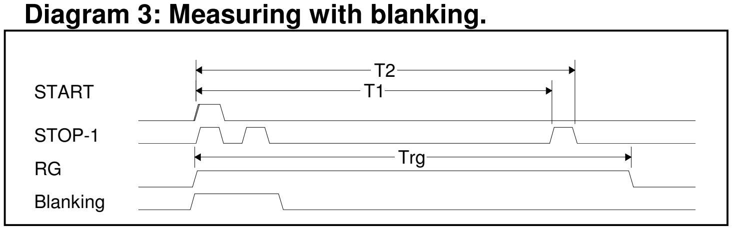
T1 = T2 = $t_{STOP\text{-}2}$ (rising-edge) to $t_{STOP\text{-}2}$ (falling-edge)

The two results should be identical with a small amount of offset due to propagation delay differences. This difference should stay consistently constant with each measurement.

Measuring with blanking can be accomplished by sending the blanking command. In this example we set blanking to a value long enough to ignore false alarms that can be common while emitting the laser diode (noise or stray light reflected back to the optical receiver within the system) or to ignore close up objects that may be mildly obstructing the view of the intended target. Much like the default configuration, we want to simultaneously measure the time interval from the leading-edge of a positive going START pulse (from the analog input of the ETX-10A laser driver) to the leading-edge of a positive going STOP-1 pulse (from the analog input or the ERX-6 optical receiver) for the first (T1) measurement and the trailing-edge of the same STOP-1 pulse for a second (T2) measurement. The time between the start and each stop edges must occur within the default configured range gate of 6.4µs. The configuration bits are set as follows:

SC = 0, SE = 1, C1 = 0, E1 = 1, C2 = 0, E2 = 0
RG = 0x05 (6.4µs) *Repetition rate changes with RG.
Blanking = 0x08 (75ns ±5ns)
SHDN = 0

Diagram 3: Measuring with blanking.



T1 = t_{START} (rising-edge) to $t_{STOP\text{-}1}$ (rising-edge)
T2 = t_{START} (rising-edge) to $t_{STOP\text{-}1}$ (falling-edge)
Trg = t_{START} (rising-edge) to range gate amount.

As can be seen from diagram 3, the first two pulses on the STOP-1 signal were ignored so that the intended return pulse could be detected. If blanking were not used, the first pulse on the STOP-1 signal would be detected as the return pulse resulting in an erroneous measurement.

Operation:

The following timing diagrams show timing information needed for taking measurements from, resetting, sending commands to, and calibrating the ERC-5A.

At power-up or after a hard-reset. the first thing a host user must look for is the ARM signal to go HIGH. None of the following modes can be entered and no measurements may be taken without ARM becoming high. If ARM does not go high after power up, something is wrong with the system or connections.

Holding the $\overline{MR}$ signal low keeps the ERC-5A in a hard-reset mode. This mode keeps the microprocessor of the ERC-5A in hard reset and consequently prevents the ERC-5A from responding to any signals. When the ERC-5A is not in use, this mode may be used to conserve power.

Holding the $\overline{RS}$ signal low keeps the ERC-5A in a soft-reset mode. This mode resets counters and holds the ERC-5A in an ignore mode. This mode ignores all measurement (ARM LOW), commands, and calibration attempts as well as keeping all counters reset. ERC-5A resets counter automatically after each measurement cycle and does not require the soft-rest mode to be initiated by the user. The $\overline{RS}$ signal may also be used to discard any amount of the measurement results from the last measurement taken.

Sending commands allows the default configuration setting to be changed (*see commands section*). There are 1-byte and 2-byte commands. Care must be taken to insure the ERC-5A receives the correct amount of clocks for a given command. *Warning:* Do not try to send commands while DAV is high.

Follow these required guidelines for sending commands:

1. CLEAR $\overline{CS}$ and insert the command data onto the data bus.
2. Wait Tcs-clk before setting $\overline{CS}$ HIGH to clock in the data.
3. If sending 1-byte command, skip to step 5. If sending 2-byte command, wait Tclk before clearing $\overline{CS}$ again and place the second byte of data onto the data bus.
4. Wait Tclk before setting $\overline{CS}$ HIGH to clock in the second byte of data.
5. Once $\overline{CS}$ is returned to its inactive state and the correct amount of clocks have been sent, ARM will return HIGH to indicate that the ERC-5A has received command and is ready to make a measurement.

Calibration is performed to keep measurements accurate across large temperature ranges. Since change in temperature can change the timing characteristics of components on the ERC-5A, the calibration mode is used to test for these changes in timing. **Note:** Calibration must be executed at least once after power up or a $\overline{MR}$ before any measurements can be made.

Follow these required guidelines for calibrating:

1. Set CALIB signal high to enter calibration mode.
2. Wait Tcalib before clearing the CALIB signal.
3. Once the CALIB is returned to its inactive state, ARM will return HIGH to indicate that the ERC-5A is ready to receive a new measurement.

After $\overline{CS}$ and/or CALIB are detected by the ERC-5A, all measurements are ignored and ARM is reset into its inactive state. The ERC-5A will not exit the receive command and/or Calibration mode and rearm itself until $\overline{CS}$ and/or CALIB respectively are returned to their inactive states. The ERC-5A uses new command and calibration data until power has been cycled, an $\overline{MR}$ reset has occurred or another command or calibration has been executed to replace it. **Note:** Calibration must be executed at least once after power up or an $\overline{MR}$ before any measurements can be made

To make a measurement, the MEAS signal is used to execute a measurement event by setting it HIGH. This will cause the TRIG signal to the ETX-10A to go high for time Ttrig (Diagram 4) to fire the LASER. At this time ARM can also be monitor to confirm that the measurement cycle has begun. Then DAV will indicate that a measurement has been completed and data is available.

The Tarm-dav (Diagram 5) shows the maximum time it will take for a measurement to complete from the time ARM goes LOW, to inform the host that a measurement is in progress, to the time DAV goes high, to inform the host of measurement results being available. Before ARM becomes LOW, the ERC-5A will except any of the three $\overline{RS}$, $\overline{CS}$, or CALIB signals and execute there functions as required. Once ARM becomes LOW due to a measurement cycle being executed, the ERC-5A will ignore all of these signals until DAV goes HIGH. The result data can then be clocked out of the ERC-5A or the RS signal can be used to discard all result data and enter a reset mode.

Operational Adjustments:

The inputs of the ERC-5A are received by the ETX-10A and ERX-6 by comparators. In order to detect these signals effectively, adjustments need to be made. These comparators and the variable resistors that require adjustments are located on the bottom-right of the ERC-5A (see picture on last page of this document).

Start Signal Threshold Sensitivity (VR1) – The VR1 trim potentiometer effects the voltage level at which the START signal's falling-edge from the ETX-10A will initiate range counting. Start is an analog signal generated by the laser transmitter and is temporally coincident with the laser emission. VR1 may require adjustment if the laser power is set very low on the ETX-10A laser driver.

Stop Signal Threshold Sensitivity (VR2) – The VR2 trim potentiometer effects the voltage level at which the STOP signal's rising-edge from the ERX-6 will terminate range counting. STOP is an analog signal that comes from the optical receiver's post-amplifier. Adjustment of VR2 will affect the detection sensitivity of the rangefinder system.

Test Points 1 & 2 – (**Note:** TP1 and TP2 are connected to pin 7 of U20 and U22 respectively) TP1 or TP2 is monitored with an oscilloscope while setting the Start or Stop threshold (respectively). The pulsed signals at TP1 and TP2 should be normally logic LO and pulsing HI only briefly (5 – 50ns). TP1 should have a pulse rate identical to the laser PRF. TP2 will have a pulse rate equal to or greater than the laser pulse rate if a target is detected. If the Stop threshold (VR2) is set unusually high, only strong (or close) targets can be detected by the rangefinder. Under these circumstances, the pulse rate at TP2 will be approximately the same as the laser PRF. Normal operation will have the Stop threshold set low enough to detect distant targets plus some tolerable level of false alarms (response to random fluctuations of the Stop signal).

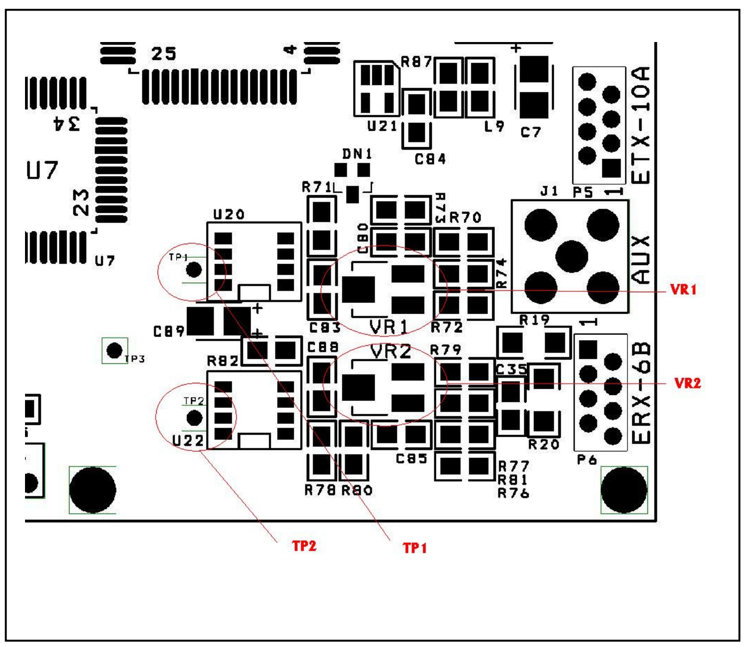


Diagram 4: Measurement Timing.

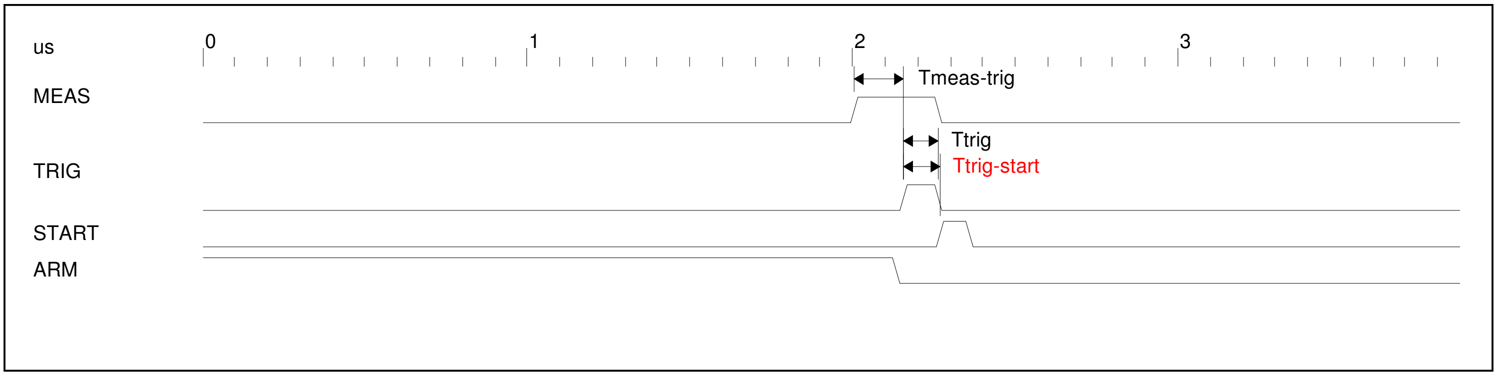


Table 1: Timing under normal operating temperature (25 degrees C).

Event	Description	Time	Unit
Tmeas-trig	Time it takes TRIG to become LOW after receiving MEAS	150	ns
Ttrig	The approximate time TRIG will stay low.	100	ns
Ttrig-start	Time it takes a START signal from ETX-10A to signal pulsed laser after TRIG	*100	ns

Note: Timing is subject to change in future revisions.
*START signal must be received with ~2µS after TRIG is sent. Please contact E-O Devices for any adjustment options.

Diagram 5: Measurement Timing.

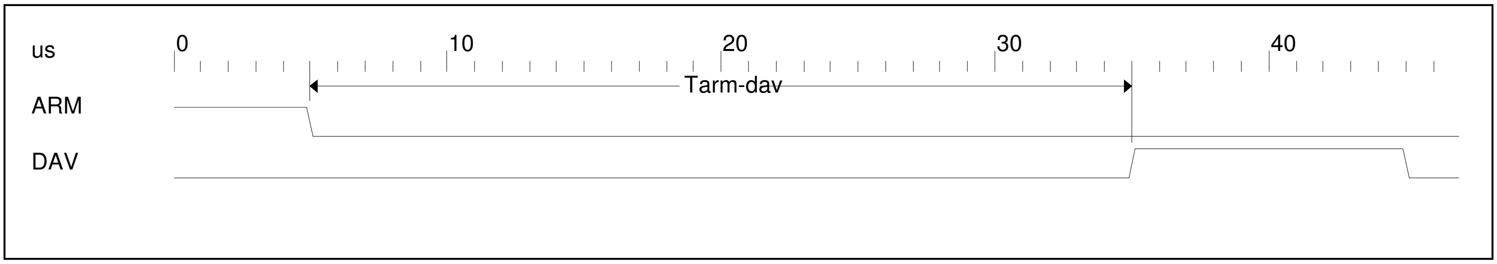


Table 2: Timing under normal operating temperature (25 degrees C).

Event	Description	Time	Unit
Tarm-dav	Maximum time to take a measurement. **Note 1**	30+RG	µs

Note: Timing is subject to change in future revisions.
RG = Range Gate or START-to-STOP time. For every extra µs the measured signal is, it takes an extra µs to capture timing data. It takes less than 30µs to calculate the result after timing data is captured.

Diagram 6: Resetting when ARM is HIGH.

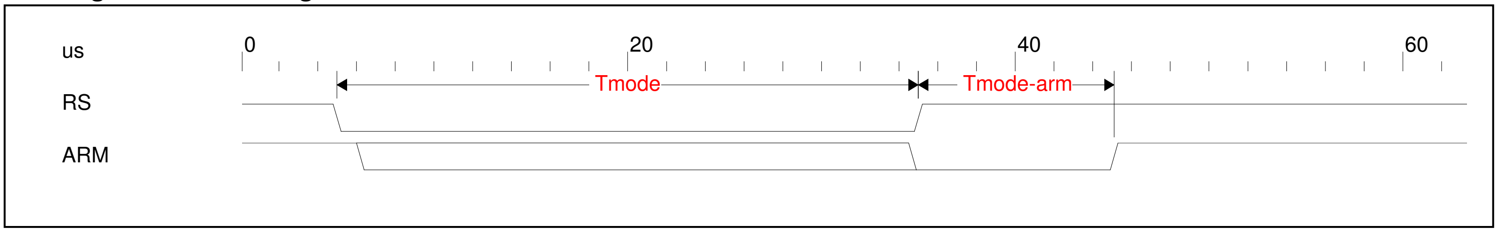


Diagram 7: Sending 1-Byte Commands when ARM is HIGH.

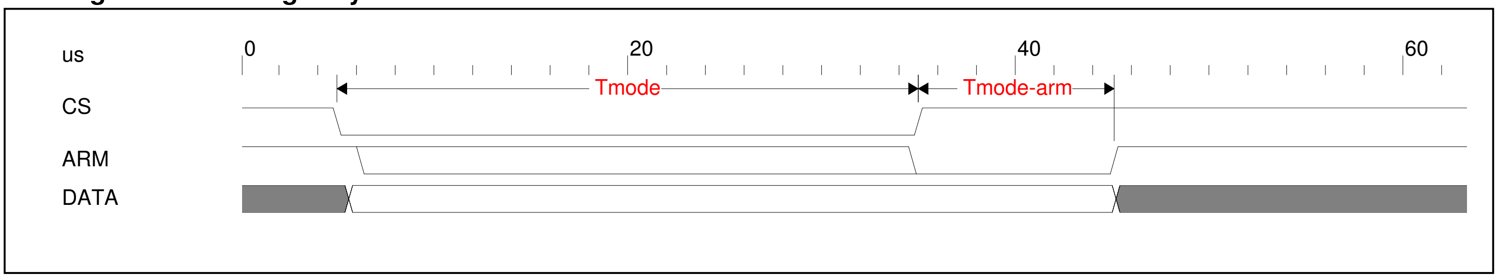


Diagram 8: Sending 2-Byte Commands when ARM is HIGH.

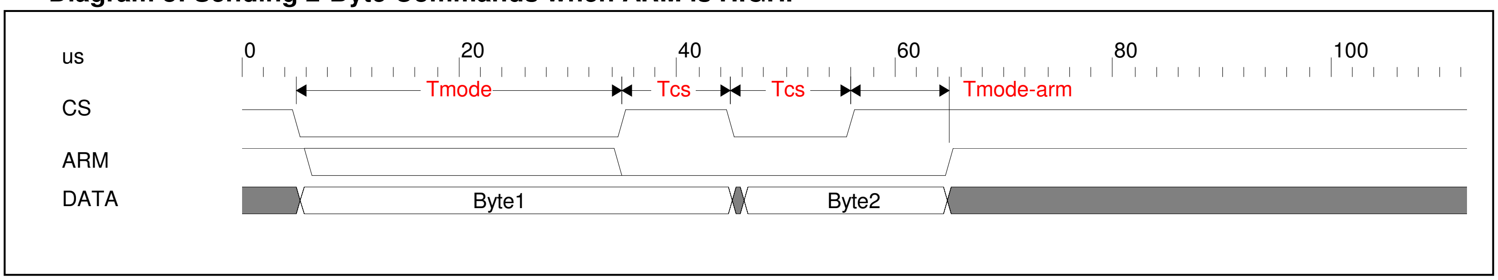


Diagram 9: Calibrating when ARM is HIGH.

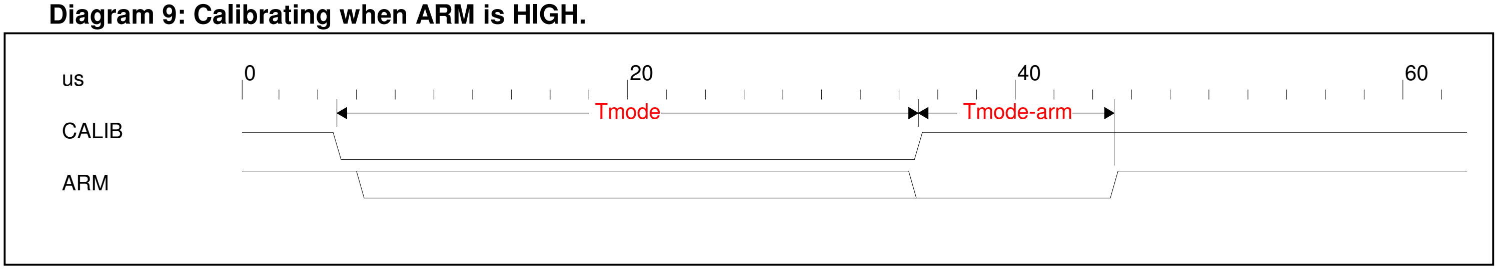


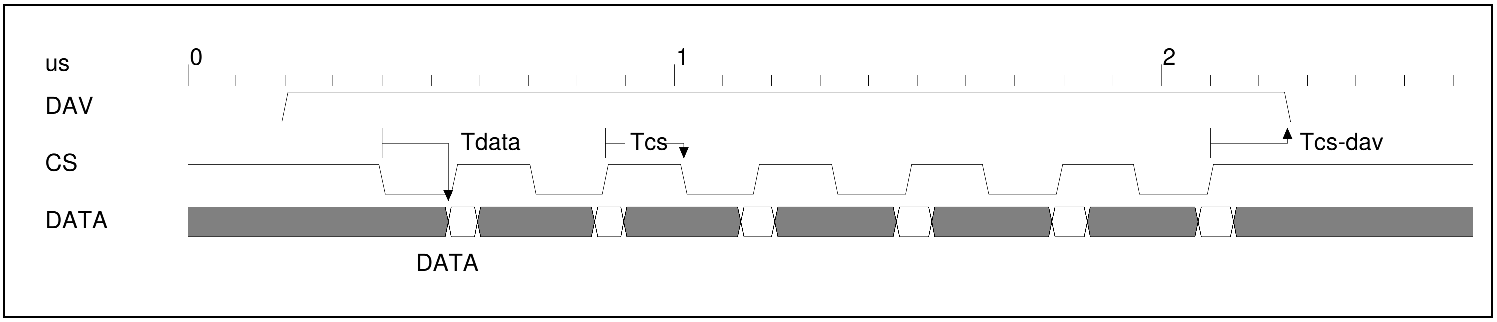
Table 3: Timing under normal operating temperature (25 degrees C).

Event	Description	Time	Unit
Tmode	Maximum time any mode pin ($\overline{RS}$, $\overline{CS}$, CALIB) needs to remain active.	30	µs
Trmode-arm	Maximum time it will take ARM to go HIGH after mode pin becomes inactive.	10	µs
Tcs	Time $\overline{CS}$ needs to stay HIGH or LOW while clocking in multi-byte commands	10	us

Receiving Results:

The following timing diagram shows the timing requirements for receiving data results from the ERC-5A parallel communications bus (Serial communications is currently unavailable). The DAV signal indicates to the host that a measurement has been made and results are ready to be transmitted to the host. The host brings $\overline{CS}$ LOW and waits for Tdata time to expire before reading the data byte from the bus. After reading the Byte of data from the bus, the host can then bring $\overline{CS}$ HIGH for the Tcs required time. All data is clocked in the same way until all four result-bytes are received. After the last data byte is received and $\overline{CS}$ returns HIGH, DAV will return LOW after Tcs-dav time. *Note*: The only time the data bus is ever set as an output is while DAV is HIGH and $\overline{CS}$ is LOW. As soon as $\overline{CS}$ returns HIGH, even while DAV is HIGH, the data bus returns as an input.

Diagram 10: Clocking in data on the synchronous parallel port.



Event	Description	Time	Unit
Tdata	Maximum time before data is available after $\overline{CS}$ goes LOW.	150	ns
Tcs	Minimum $\overline{CS}$ HIGH time.	160	ns
Tcs-dav	Maximum time before DAV to return LOW after final data byte is clocked.	160	ns

Note: Timing is subject to change in future revisions.

Result Data Format:

Following a ranging event, the two 3-byte (six bytes altogether) results must be read from the ERC-5A (unless $\overline{RS}$ is LOW to discard data). If the measurement was successful, each three-byte data will contain the time interval measurement result, otherwise it will be 0xFFFFFF hex, indicating no START was detected within a 2.5µS time frame after trigger is sent or 0x000000 hex, indicating no STOP edge was detected within the required measurement range gate.

Byte transfer order: (6 bytes total)

These bytes represent the result format from the START edge of the selected START input to the STOP edge of the selected STOP input:

T1 = START to STOP1
T2 = START to STOP2

1st byte = Most Significant Byte of T1.
2nd byte = Center Significant Byte of T1.
3rd byte = Least Significant Byte of T1.
4th byte = Most Significant Byte of T2.
5th byte = Center Significant Byte of T2.
6th byte = Least Significant Byte of T2.

A successful result contains the following data format:

Result Data Bytes (3-byte format)

[18-bit whole number] . [6-bit fractional number]

unit: nanoseconds

The first byte, second byte and the two most significant bits in the third byte contain the whole nanoseconds. The 6 least significant bits in the third byte contains the fractional nanoseconds. In binary format, each three-byte result takes the form:

Byte 1: 2^{17} 2^{16} 2^{15} 2^{14} 2^{13} 2^{12} 2^{11} 2^{10}
Byte 2: 2^{9} 2^{8} 2^{7} 2^{6} 2^{5} 2^{4} 2^{3} 2^{2}
Byte 3: 2^{1} 2^{0} **.** 2^{-1} 2^{-2} 2^{-3} 2^{-4} 2^{-5} 2^{-6}

A failed measurement is generally caused by:

a) No START signal received within ~2µS after trigger.
b) Time intervals exceeding range gate.
c) A START signal edge without a STOP signal edge is considered a no-return or out-of-range return pulse.
d) A STOP signal edge received before START edge.

A data result of 0xFFFFFF hex will be returned by the ERC-5A for failures a) above. A data result of 0x000000 hex will be returned by the ERC-5A for failures b) – d) above.

ERC-5A ORDERING OPTIONS:

ORDERING CODES:

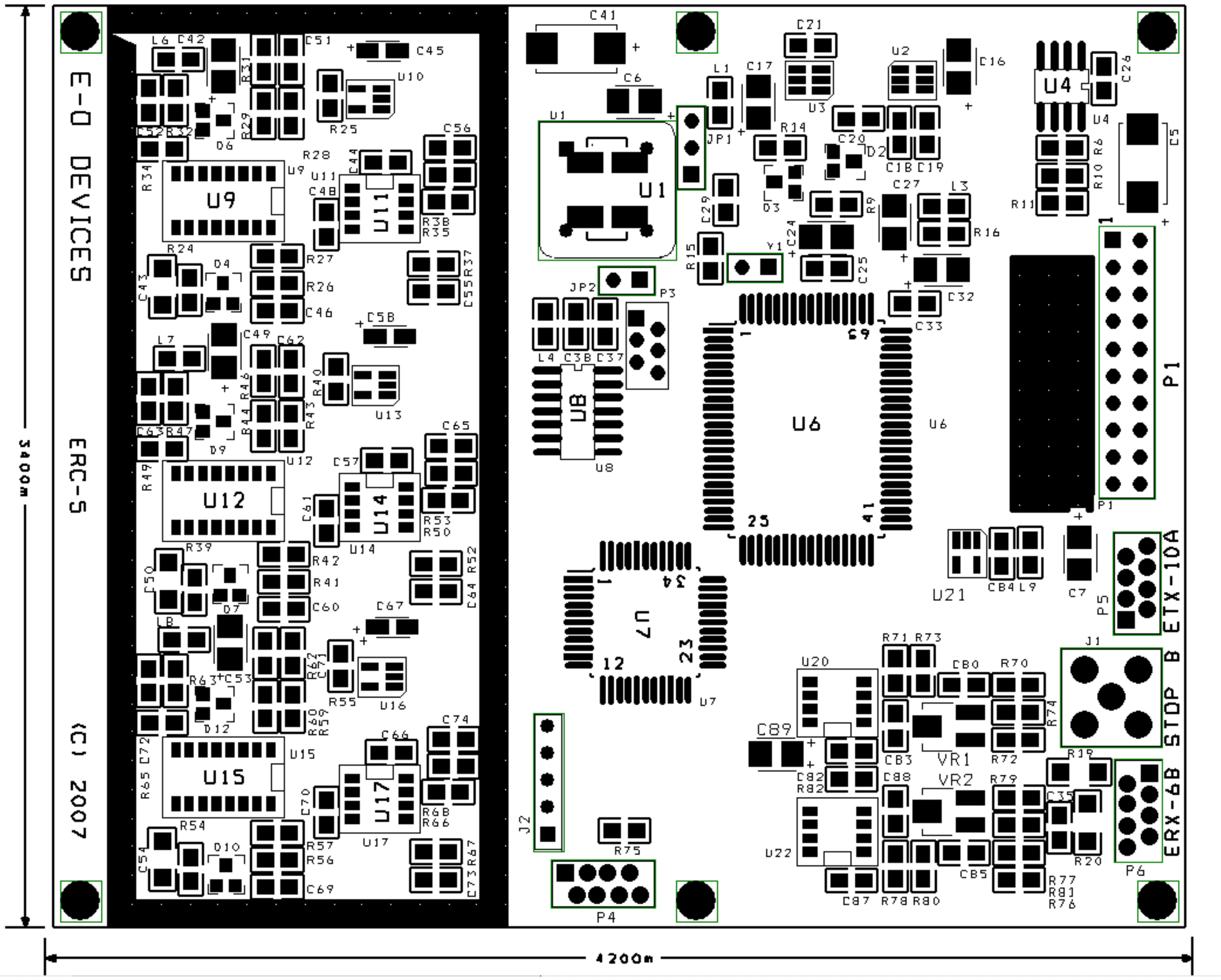
ERC – 5A	Standard chronometer with 1mm FFC receiver connector.
ERC – 5 A– SMA	Standard chronometer with SMA receiver connector
ERC – 5 A– SMB	Standard chronometer with SMB receiver connector
ERC – 5 A– SMC	Standard chronometer with SMC receiver connector

*All orders come standard with 1mm FFC transmitter connector.

OPERATING SPECIFICATIONS: **(-20C < Ta < +85C)**

PARAMETER	MIN.	TYP.	MAX.	UNIT
Supply Voltage[1]	4.85	5.0	5.15	Vdc
Supply Current[2, 6]		290		mA
VIN(TX) (negative pulse)			1	Vp-p
VIN(RX) (positive pulse)			4	Vp-p
$t_{interval}$(IN), time interval range of measurement[3]	0.002		261.12	µs
$t_{resolution}$(IN), resolution of time interval measurement		15		ps
$t_{accuracy}$(IN), accuracy of time base		50		ppm
t_{error}, error of measurement (not including timebase accuracy) [4]		25	50	ps **(RMS)**
$t_{response}$, response time to data available after triggering[5]		30	40	µs

NOTES:
1. The external power supply must be regulated and filtered to +/- 0.15V.
2. During active measuring.
3. Adjustable by command from 1.28µs to 261.12µs in 1.28µs increments.
4. Standard time base accuracy is 50ppm.
5. Value at 1µs measurement. Time will increase proportionally with longer START-to-STOP times or range gates. Add 1µs for every 1µs longer START-to-STOP time or range gate (in case of a No-Return result).
6. Supply current requirements increase when connected to ETX-10A and ERX-6. See device datasheets for more information.



E-O DEVICES
ERC-5
(C) 2007
ETX-10A
STOP B
ERX-6B
3400m
4200m