ELECTRO-OPTIC DEVICES, INC.

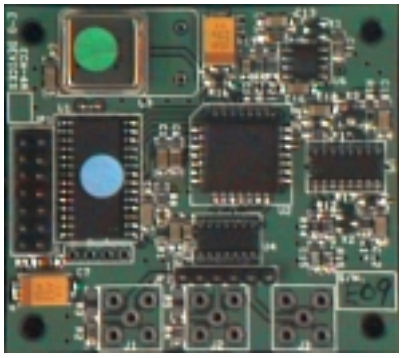
ECH-4

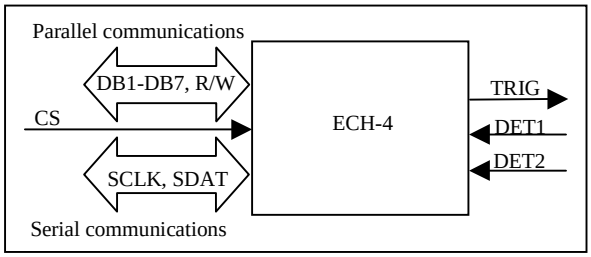
Dual Channel, Single Conversion, Enhanced Time-of-Flight Chronometer Module

Firmware version 3.00

FEATURES:

- Single sample, time interval accuracy to ± 300 ps or 0.01%.
- Maximum time interval (range gate) of 20.4 μs (extended range available).
- Programmable blanking from 0 to 5 μs in 20 ns steps.
- Control information and data transfer via parallel or synchronous serial interface.
- Measurement parameters and execution programmable via configuration commands.
- Three byte time interval result in nanoseconds (16 bits whole/8 bits fractional).
- Programmable input source (1 of 2 channels) and polarity to fit application.
- Trigger output to start an external event - fires laser in LRF applications.
- Optional SMA or SMB coaxial connections for timing signals.
- Single 5 Volt supply operation.
- Compact circuit board just 2.03 x 2.25 inches, weight < 1.5 ounces.





APPLICATIONS:

- Devices requiring high accuracy measurements of < 1 ns.
- Laser/RF pulsed ranging with t_0 and t_{target} successive measurements.
- Laser/RF pulsed ranging with dual receivers for successive measurements.

DESCRIPTION:

The ECH-4 is a dual channel, single conversion, enhanced time-of-flight chronometer module. The Trigger output of the ECH-4 may be used to start an external event such as triggering a single time-of-flight event to obtain a time interval measurement of up to 20.4 μs. Triggered events may be detected by either channel Detect1 or Detect2. Time interval measurements are very accurate to ± 300 ps or 0.01%.

The ECH-4 comes with a programmable parallel or synchronous serial communication interface. From these communication interfaces, measurement parameters and execution may be programmed via configuration commands. Configuration commands may also be used to set blanking control values from 0 to 5 μs in 20 ns steps to prevent false return signals. Detect inputs and edges selections may be configured using measurement commands. Execution commands may be used to reset or initiate a trigger to begin a measurement as well as executing a calibration routine for better measurement accuracy. Measurement results are returned in a three-byte format (16 whole bits and 8 fractional bits) in the unit of nanosecond and may be preceded by a preamble byte by use of the PD trigger command bit.

ECH-4 requires only a single 5-Volt DC power supply and typically draws around 200mA. It is compact in design with dimensions of 2.03 x 2.25 inches and weighs less than 1.5 ounces. The ECH-4 may also be ordered with optional SMA or SMB coaxial connectors for the trigger output and the detect inputs.

Interface Connections:

Connector JP1 (host interface connector)

Pin	Signal	Description
1	VCC	5Vdc @210 mA power supply
2	VCC	
3	GROUND	
4	GROUND	
5	DB7	Data bus bit 7 (I/O)
6	DB6	Data bus bit 6 (I/O)
7	DB5	Data bus bit 5 (I/O)
8	DB4	Data bus bit 4 (I/O)
9	DB3	Data bus bit 3 (I/O)
10	DB2	Data bus bit 2 (I/O)
11	DB1/SCLK	Data bus bit 1 (I/O) / Serial clock (I)
12	DB0/SDAT	Data bus bit 0 (I/O) / Serial data (I/O)
13	$\overline{CS}$	Chronometer Select, low active (I)
14	R/$\overline{W}$	Read / Write control for parallel bus (I)

Connector JP2 (timing signals)

Pin	Signal	Description
1	DETECT1	Channel 1 detection input
2	GROUND	
3	DETECT2	Channel 2 detection input
4	GROUND	
5	TRIGGER	Trigger Output
6	GROUND	

Auxiliary Coaxial Connectors:

Optional PC-mount SMA or SMB connector jacks for TRIGGER output, DETECT 1 and DETECT 2 inputs. The inputs are DC terminated into 50Ω (1/4 W) and should be used only with short, positive TTL pulses to prevent overheating of the termination resistors.

J1: DETECT 1
J2: DETECT 2
J3: TRIGGER

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

$\overline{CS}$ (I) - Chronometer Select handshake signal. Used during communication between the chronometer module and the host microprocessor to transfer commands and data. **$\overline{CS}$** must be low during communications. Timing details may be found in the section on communication.

R/$\overline{W}$ **(I)** - Read/*$\overline{Write}$* control for parallel data communication. Timing details may be found in the section on communication.

DB0/SDAT **(I/O)** - Parallel data bus bit 0 -or- bidirectional serial data line between chronometer and host for synchronous data/command transfer. This data line also provides a "data ready" function. After a trigger command is given, this line becomes a normally high output that goes low to indicate conversion is complete and data is available. Timing details may be found in the section on communication.

DB1/SCLK **(I/O)** - Parallel data bus bit 1 -or- serial clock input from the host for synchronous data/command transfer. Timing details may be found in the section on communication.

DB2 – DB7 **(I/O)** - Parallel data bus data bits 2 – 7 for parallel data transfer.

DETECT 1 **and** ***DETECT 2*** **(I)** - These detect inputs sense the end of a time interval initiated by the TRIGGER output. Only one input is active during any measurement (dual input, single conversion). The active input has programmable polarity to provide sensitivity to either a high-going or low-going edge for timing purposes.

TRIGGER **(O)** - A normally low output. Momentarily asserts an 80 ns positive pulse shortly after the chronometer module is given a Trigger execution command. This output generally starts an external event. In a laser rangefinder, this signal triggers a laser transmitter.

Command and Data Formats:

Command Types:

Chronometer Configuration Commands set the operating configuration of the ECH-4.

Interface Configuration establishes the communication interface method. (Default is serial communication on power-up)

Blanking Configuration sets the range blanking time interval. (Default is 0 on power-up)

Measurement Selection Commands set the measurement parameters of the ECH-4.

Trigger→ Detect 1 time interval from Trigger out to Detect 1 input. (Detect 1 may be programmed for rising or falling edge)

Trigger→ Detect 2 time interval from Trigger out to Detect 2 input. (Detect 2 may be programmed for rising or falling edge)

Execution Commands cause the ECH-4 to perform a function.

Reset executes a soft-reset returning all parameters to default status.

Trigger executes a measurement according to set parameters.

Command Formats:

Configuration Commands:

Interface Config.

b7	b6	b5	b4	b3	b2	b1	b0
1	1	1	1	S/P	X	X	X

Blanking Config.

b7	b6	b5	b4	b3	b2	b1	b0
1	1	0	1	B3	B2	B1	B0

Where:

S/P = serial/parallel interface
0 = parallel communication interface
1 = serial communication interface [DEFAULT]

B0 – B3 = blanking interval selection (20 ns steps)
0 – E = short interval selection (0 – 280 ns).
F = extended blanking interval selected, 8 bit interval byte MUST follow.

Measurement Commands:

Trigger→ Detect 1

b7	b6	b5	b4	b3	b2	b1	b0
0	0	0	0	0	0	D1p	X

Trigger→ Detect 2

b7	b6	b5	b4	b3	b2	b1	b0
0	0	0	0	1	0	X	D2p

Where:

D1p = Detect 1 input polarity0
0 = rising edge triggered [DEFAULT]
1 = falling edge triggered

D2p = Detect 2 input polarity
0 = rising edge triggered [DEFAULT]
1 = falling edge triggered

Execution Commands:

Reset

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

Trigger

1	0	0	1	CD	PD	X	X

Where:

CD = calibration disable
0 = cal enabled [DEFAULT]
1 = cal disabled, measurement calculated using previous calibration data obtained when executing this instruction with CD=0. Disabling calibration on subsequent Trigger Commands consumes minimum execution time by ECH-4 for higher sampling rates.

PD = preamble disable
0 = preamble enabled [DEFAULT]
1 = preamble disabled, reduces result transfer to three bytes from four for increased sampling rates.

Data Format:

Following the **Trigger** command, the chronometer will return either three or four bytes of information depending upon the PD bit (preamble disable) in the command.

If PD is cleared, the first byte is the result preamble byte containing measurement setup information and a status bit indicating a successful/failed conversion. If the conversion was successful, the following three bytes contain a valid time interval measurement result,

otherwise the three bytes will contain the value $FF, $00, $FF.

If the PD bit is set, the preamble byte is skipped and only the three-byte result is returned. This feature can be used to speed data transfer. Since the maximum range gate of the ECH-4 is less than the $FF, $00, $FF reading returned from failed conversions, this can be interpreted in the same manner as the conversion status bit.

Result Preamble Byte:

b7	b6	b5	b4	b3	b2	b1	b0
S	M3	M2	M1	M0	X	D1p	D2p

Where:

S = Conversion status flag
S = 0, conversion failed
S = 1, conversion successful

M3, M2,M1,M0 = measurement type (0..F)
0 = T→ Detect 1 [DEFAULT]
1 = T→ Detect 2
2 - F = Reserved
X = Reserved

D1p = Detect 1 input polarity
0 = rising edge triggered [DEFAULT]
1 = falling edge triggered

D2p = Detect 2 input polarity
0 = rising edge triggered [DEFAULT]
1 = falling edge triggered

Result Data Bytes (3 byte format)

[whole MSB] [whole LSB] . [fraction byte FRB]

unit: nanoseconds

Programming Examples:

Time interval measurement from trigger to rising-edge on Detect 1, no blanking.

a) Send **Reset** (optional) ***10000000***
b) Send **Measurement Type** ***00000000***
(Trigger -> Detect1, +edge)
c) Send **Trigger** command ***10010000***
d) Monitor **DB0/SDAT**, wait for low signal
e) Receive preamble + three byte result

Time interval measurement from trigger to falling-edge on Detect 2, 100 ns blanking.

a) Send **Reset** (optional)
1000000
0
b) Send **Blanking Configuration** (short)
1101010
1
c) Send **Measurement Type**
0000100
1
(Trigger -> Detect2, -edge)
d) Send **Trigger** command
1001000
0
e) Monitor **DB0/SDAT**, wait for low signal
f) Receive preamble + three byte result

Time interval measurement from trigger to rising-edge on Detect 1, 2 μs blanking, no calibration, no preamble.

a) Previous ranging with calibration enabled, then...
b) Send **Blanking Configuration**
1101111
1
c) Send extended blanking interval
0110010
0
d) Send **Measurement Type**
0000000
0
(Trigger -> Detect1, +edge)
e) Send **Trigger** command
1001110
0
f) Monitor **DB0/SDAT**, wait for low signal
g) Receive three byte result without preamble

Communication:

The ECH – 4 is capable of serial or parallel data communication. By default on power-up, the ECH – 4 assumes serial communication. Systems requiring parallel communication would immediately configure the chronometer for parallel mode by bit toggling the proper sequence to serially transmit the appropriate interface configuration command: $F0.

Care must be taken to insure that **$\overline{CS}$** remains low throughout the 8 bit serial data transmission or parallel read/$\overline{Write}$ and that data is held for the minimum hold time of 640ns.

Parallel communication between the host microprocessor and the ECH – 4 module is accomplished with the **$\overline{CS}$**, **R/*W*** signals and data bus **DB0 – DB7**. The parallel interface is not intended for a general-purpose data bus application. The **DB0** signal is used to indicate “data ready” and is an active output from the ECH – 4 after executing a Trigger command, regardless of the state of the **$\overline{CS}$** input.

The **R/*W*** control input must be established prior to **$\overline{CS}$** going LOW and during the **$\overline{CS}$** low period. **R/*W*** is HIGH for reads and LOW for writes.

Serial communication between the host microprocessor and the ECH – 4 module is accomplished with the **$\overline{CS}$**, **SDAT** and **SCLK** signals.

Using serial communication, when the host wants to transfer a command to the ECH – 4, it brings the **$\overline{CS}$** input logic LOW. This tells the module to be ready to receive command information from the host. The host then serially shifts out 8 bits, MSB first, using the **SCLK** signal's rising edge to cause the chronometer to sample each data bit. At the end of each byte, the **$\overline{CS}$** line must be taken back to logic HI before the host can send another byte in an identical manner. During transfer, the **$\overline{CS}$** signal remains LOW.

When the host must receive result information, it again brings **$\overline{CS}$** input LOW. The host then serially shifts in 8 bits, MSB first, using the **SCLK** signal's rising edge to read the bit and falling edge to cause the chronometer to shift out the next bit. When 8 bits have been received, the host returns **$\overline{CS}$** to HIGH. This is repeated for each byte of information to be received.

Trigger Command:

The trigger command is unique. Immediately after sending a **Trigger** command, the host must reverse direction on the **DB0/SDAT** signal. This signal acts as a "data ready" flag to indicate the conversion is complete. When the ECH – 4 has completed the measurement, it will output a logic LOW on the **DB0/SDAT** signal to the host. When the host sees the LOW level, it then proceeds to receive the conversion result information.

Range Blanking:

The programmable blanking feature of the ECH – 4 is very important. Upon power-up, the blanking is defaulted to zero (none). Range blanking allows the chronometer to ignore transitions on the DETECT inputs during the programmed blanking period.

For example, if the ECH – 4 is programmed for rising-edge measurement on DETECT 1 input with 100 ns blanking, it will make a time interval measurement to the first rising-edge on the DETECT 1 input after 100 ns from the leading edge of the trigger output. All transitions during the blanking interval are ignored. In fact, if the DETECT 1 input is in the middle of a pulse (HIGH) at the instant blanking is complete, the signal will be ignored until it returns LOW and then transitions high again.

Range blanking is very useful to avoid unwanted near range targets, smoke, or haze which may be located in the path of the beam in laser rangefinders. Blanking is also useful to overcome EMI generated during the laser-firing events when inadequate shielding or grounding is present. In this case, a short blanking value of 40 – 120 nanoseconds is usually sufficient.

Functional Test Setup:

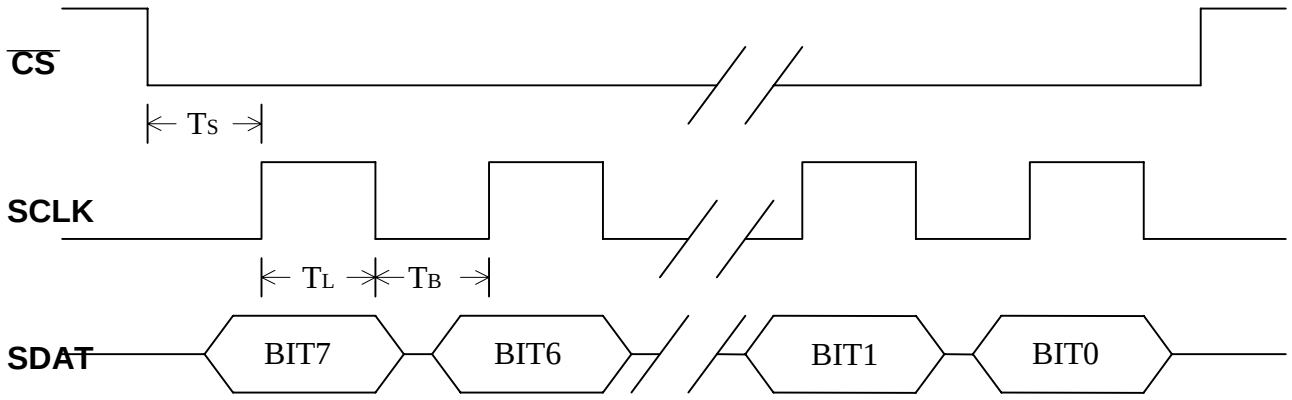
A functional test of the ECH – 4 can be performed by looping back the TRIGGER output to the DETECT 1 input. This is best accomplished with properly terminated 50Ω transmission line.

First, send the **Reset** command to the module. The chronometer is now in its default state: trigger -> detect 1, +edge, no blanking. Send the execution **Trigger** command ***10010100*** to cause a measurement to occur without a preamble in the result.

The three-byte result information returned represents the propagational delay of the transmission line and the propagation/setup delays of the chronometer. Typically, a reading of 60 ns (+/- 10ns) is obtained if the loop back is shorter than 2 meters. By increasing the length of the transmission line, appropriate propagation delays should be apparent in the measurement results.

A measurement result of $FF, $00, $FF indicates an open loop back or improper connection of the TRIGGER output to the DETECT 1 input.

ECH-4 Synchronous Receive Time Diagram



Note: Most significant bit received first. **SCLK** should be low before **$\overline{CS}$** is brought low.

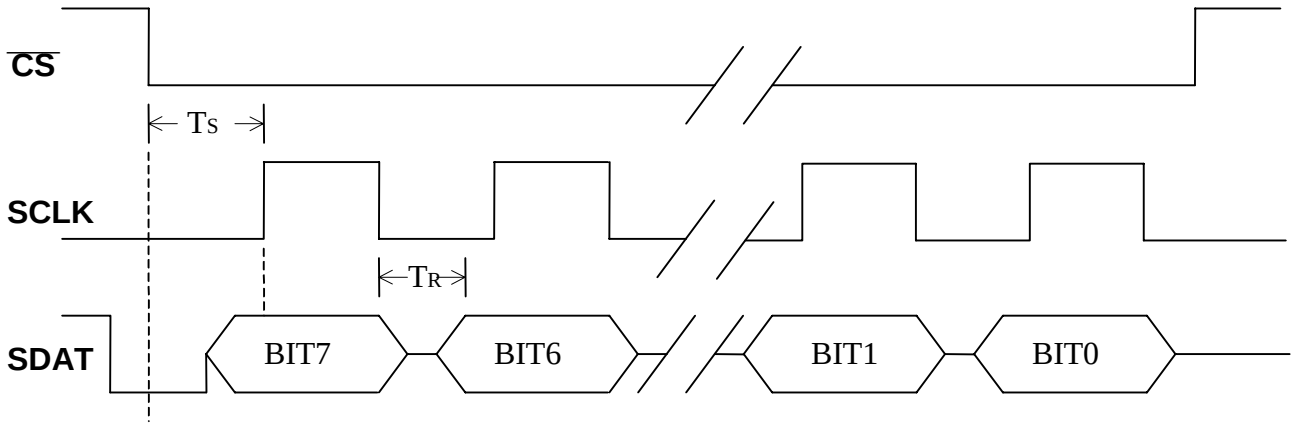
T_S – Setup Time – Minimum time **$\overline{CS}$** needs to be low before sending data to the ECH-4 is 2µs.

T_L – Latch Time – Minimum time data should be available after **SCLK** rising edge is 640ns.

T_B – Bit Time – Minimum time before controller is capable of receiving another bit after bit has been latched is 800ns.

*Communicating with an **SCLK** of no more than 500KHz with a 50% duty cycle should be used to assure proper communication.

ECH-4 Synchronous Transmit Time Diagram



Note: Most significant bit transmitted first. SCLK should be low before **$\overline{CS}$** is brought low.

T_S – Setup Time – Minimum time **$\overline{CS}$** needs to be low before receiving data from ECH-4 is 1.6µs.

T_{TR} – Transition Time – Time from falling edge of **SCLK** before next bit is available is 800ns.

*Communicating with an **SCLK** of no more than 500KHz with a 50% duty cycle should be used to assure proper communication.

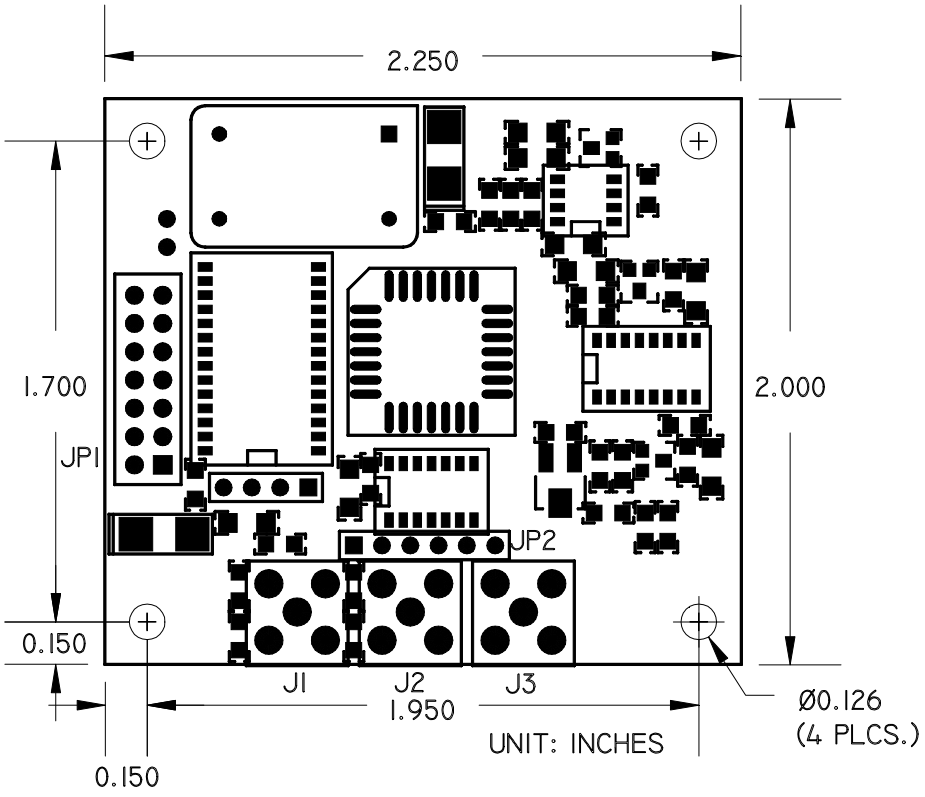
ORDERING CODES:

ECH – 4	Standard chronometer (0.01% timebase)
ECH – 4 – 1	Extended accuracy chronometer (0.0001% timebase)
ECH – 4 – SMA	Standard chronometer with SMA timing connections
ECH – 4 – SMA – 1	Ext. Acc. chronometer with SMA timing connections
ECH – 4 – SMB	Standard chronometer with SMB timing connections
ECH – 4 – SMB – 1	Ext. Acc. chronometer with SMB timing connections

OPERATING SPECIFICATIONS:

PARAMETER	MIN.	TYP.	MAX.	UNIT
Supply Voltage[1]	4.85	5.0	5.15	Vdc
Supply Current[2]		200		mA
$t_{interval}$(IN), time interval range of measurement[3]	0		20.4	µs
$t_{resolution}$(IN), resolution of time interval measurement		20		ps
$t_{accuracy}$(IN), accuracy of time base (ECH-4)		0.01		%
$t_{accuracy}$(IN), accuracy of time base (ECH-4-1)		0.0001		%
t_{error}, error of measurement (not including timebase accuracy)	-300		+300	ps
t_{jitter}, jitter of time interval measurement		50		Ps **(RMS)**
t_{pw}(OUT), trigger output pulse width		80		ns
$t_{response}$, response time to data available after triggering		1		ms
$t_{blanking}$, blanking time range	0		5.1	µs
$t_{interface}$, parallel communication data hold time	800			ns

NOTES:
1. The external 5V supply must be regulated and filtered to 5V +/- 0.15V
2. Standard version ECH – 4.
3. After correcting for offset (propagational delays). For longer intervals, call technical support.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