ELECTRO-OPTIC DEVICES, INC.

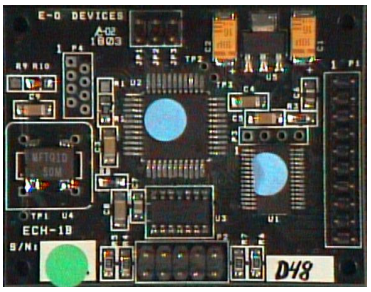
ECH – 1B

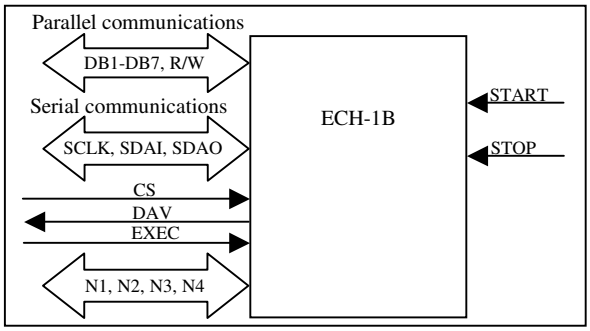
High-PRF Averaging Asynchronous Chronometer Module

(firmware revision 2.10)

FEATURES:

- Averaging chronometer for asynchronous repeating START/STOP events.
- Sample size selectable from 32 to 1,048,576 in 16 binary increments: 2^{n+5} (n = 0...15)
- Time interval accuracy to 20ps (rms).
- Maximum time interval 1.02 µs.
- Maximum repetition rate 250 kHz.
- Asynchronous START and STOP inputs with selectable edge polarity.
- Asynchronous measurement gating.
- Ready output for generating external events.
- Data transfer via 8-bit parallel bus or 4-wire synchronous serial communication interface.
- Capable of accepting programmable commands through communication ports.
- Can operate in read-only environment through hard-wire setup.
- Output format: two bytes, 10 bits whole and 6 bits fractional in unit of nanoseconds.
- Compact, low-cost, 5 Vdc @ 200mA single supply requirement.
- Circuit board size just 1.60 x 2.10 inches, weight < 0.5 ounce.





DESCRIPTION:

The ECH-1B is a high PRF averaging asynchronous chronometer module. The ECH-1B is capable of taking repeated asynchronously gated START/STOP measurement events and averages a programmable amount of samples. Configuration through hardwired or signal generated pins, or by software commands, keeps ECH-1B flexible for many START/STOP designs.

The ECH-1B is capable of taking continual repetitive measurements at a rate of up to 250kHz with a maximum time interval of 1.02µs. The ECH-1B will average a programmable amount of samples (through software command or by a four pin hardware configuration) selectable from 32 to 1,048,576 in 16 binary increments: 2^{n+5} (n = 0...15). The result of the average will be presented in a 16-bit form of 10 whole number bits and 6 fractional bits in the unit of nanoseconds and a time interval accuracy of 20ps (rms).

Pin-out provides sample size configuration and execute control for easy operation. A host may use these signals to configure the sample size before executing the measurement cycle. By hardwiring these signals the ECH-1B may be used as a read only device.

Communication can be accomplished using either the parallel bus or serial communication interface. The ECH-1B will accept configuration and execute commands through both communications ports. Without the need to configure or execute through extra pin-out, a measurement command may be sent to configure the sample size and to execute a measurement cycle. However, when the ECH-1B is used as a read only device, the parallel port (unless Command 3 is carefully sent for serial communication setup) will be used to transmit results to a host as measurements are made.

Keeping design costs low, the ECH-1B is compact with dimensions of 1.60 x 2.10 inches and weighs less than 0.5 ounces. The only power requirement is a single 5Vdc power supply @ 200mA. These features, along with the options to minimize host pin-out, create a powerfully cost effective device.

INTERFACE CONNECTIONS: (signals TTL compatible)

Connector P1 (host interface connector)

Pin	Signal	Description
1	VCC	5Vdc @200 mA power supply
2	VCC	5Vdc @200 mA power supply
3	GROUND	
4	GROUND	
5	DB6	Data Bus bit 6 (I/O)*
6	DB7	Data Bus bit 7 (I/O)*
7	DB4	Data Bus bit 4 (I/O)*
8	DB5	Data Bus bit 5 (I/O)*
9	DB2	Data Bus bit 2 (I/O)*
10	DB3/SDAO	Data Bus bit 3/Sync. Data input (I/O)*
11	DB0/ SDAI	Data Bus bit 0/Sync. Data output (I/O)*
12	DB1/SCLK	Data Bus bit 1/Sync. Clock input (I/O)*
13	R/$\overline{W}$	Read/Write Select (I)*
14	$\overline{CS}$	Chronometer Select (I)*
15	EXEC	Execute Control Signal (I)*
16	DAV	Data Available Flag (O)
17	N1	Sample Size Select bit 1 (I)*
18	N0	Sample Size Select bit 0 (I)*
19	N3	Sample Size Select bit 3 (I)*
20	N2	Sample Size Select bit 2 (I)*

* Weak internal pull-up

Connector P2 (timing signals)

Pin	Signal	Description
1	GROUND	
2	START	START event (I)*
3	GROUND	
4	STOP	STOP event (I)*
5	GROUND	
6	A-GATE	Asynchronous Gate (I)*
7	GROUND	
8	NC	
9	GROUND	
10	READY	READY Signal (O)

* 10k internal pull-down

Jumper Options:

JP1	STP	START edge polarity
		(closed = rising, open = falling)
JP2	SPP	STOP edge polarity
		(closed = rising, open = falling)
JP3	NC	

Operational Interface:

Signal Descriptions
(I = input, O = output, I/O = bidirectional)

$\overline{CS}$ (I) Chronometer select handshake signal used during transfer of data from the chronometer module to the host microprocessor. **$\overline{CS}$** must be low during communications. Timing details may be found in the **Operation** sections. This input has a weak internal pull-up.

R/$\overline{W}$ (I) - Chronometer Read/ **$\overline{W}$rite** handshake signal. Used to transfer data on the parallel port to/from the chronometer module. This input has a weak internal pull-up.

DAV (O) - Data available output flag to the host. This output goes logic high to indicate that measurement result is available to be read by the host system. This output is often used to generate a hardware interrupt at the host. Timing details may be found in **Operation** sections.

EXEC (I) - Execute handshake from the host to the Chronometer. When logic high, the chronometer will begin a measurement sequence. This input is sensed immediately after power-on reset and after the rising edge of **$\overline{CS}$** upon completion of reading the second data byte. If **EXEC** is logic low, the Chronometer remains in a "wait state" until this input goes logic high or a command is sent via communications ports to execute a measurement. This input has a weak internal pull-up.

N_3, N_2, N_1, N_0 (I) - Sample size select inputs. The status of these inputs is read immediately after a logic high state is sensed on **EXEC**. There are 16 sample sizes available (N = 0 – 15) in accordance with the relationship: sample size = 2^{N+5}, where N_0 is the lsb of the 4 bit sample size N. These inputs have weak internal pull-ups. **Note:** The sample size is also programmable through commands received by communication ports. I command method is used, the sample size select inputs are ignored. See **Programmable Commands** section.

DB7 – DB0 (I/O) - The Chronometer parallel data bus. Output is only active after the **DAV** output is asserted and **$\overline{CS}$** input is set logic low. All inputs have a weak pull-up.

SDAO (O) - The Chronometer Synchronous Data Out serial communication pin. This output is only active after serial communication is enabled, **DAV** output is asserted, and **$\overline{CS}$** input is set logic low. More details in the **Serial Communication** section.

SDAI (I) - The Chronometer Synchronous Data Input serial communication pin. This input is only active before measurement(s), after serial communication is enabled, and **$\overline{CS}$** input is set logic low. More details in the **Serial Communication** section. Input has a weak internal pull-up.

SCLK (I) - The Chronometer Synchronous Clock pin. Used to synchronize serial communications and must be provided by host. More details in the **Serial**

Communication section. Input has a weak internal pull-up.

START, STOP (I) - The START and STOP event inputs carry the signals from which a time interval is to be measured. Each input has programmable polarity to provide sensitivity to either a high-going or low-going edge for timing purposes. In this manner, time intervals START → STOP can be determined. These inputs are internally pulled-down by 10kΩ.

A-GATE (I) - The Asynchronous Gate input provides external hardware gating of the time interval measurement. This input must be logic high during the START and STOP edges for a measurement to occur. Bringing this input logic low will cause the ECH-1B to ignore START and STOP inputs. Care must be taken to not assert A-GATE after START or before STOP as this would cause a false measurement. This input is internally pulled-down by 10kΩ.

READY (O) - The rising-edge of this output indicates the Chronometer has begun a measurement and can be used to trigger external events. One rising-edge of **READY** will occur per sample measurement. **READY** remains logic high during each sampled measurement.

Programmable Commands:

Command - 0: RESET

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

Description: Resets the ECH-1B

Command - 1: Measure

b7	b6	b5	b4	b3	b2	b1	b0
0	1	E	N	N3	N2	N1	N0

Description: Programs ECH-1B for measurement where:

Where:

E = EXEC control (0 = H/W, 1 = S/W)
N = N factor (0 = H/W, 1 = S/W)
N3,N2,N1,N0 = Sample Size (used only when N = 1)

Command - 2: Reserved

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

Description: Reserved for future use.

Command - 3: Serial Communication

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

Description: Sets ECH-1B to communicate through serial port. Serial communication remains enabled until reset is issued. See communication section.

Parallel Communication:

The ECH-1B starts (by power up or reset) in parallel communications mode by default. The 8-bit parallel bus is bi-directional and can be read from or written to by asserting or de-asserting **R/*W***. All pins have a weak internal pull-up.

Note: No commands (besides to set up serial communications) may be sent to the ECH-1B chronometer if **EXEC** is hard-wired high.

To send commands using parallel port:
1) Set **R/*W*** to low.
2) Put command data onto the data bus.
3) Set **C̄S** to low.
4) Pause.
5) Set **C̄S** to high.

To receive measurement result data using parallel port:
1) Wait for **DAV** to be asserted.
2) Set **R/*W*** to high.
3) Set **C̄S** to low.
4) Read 1st byte of data from data bus.
5) Set **C̄S** to high.
6) Set **C̄S** to low.
7) Read 2nd byte of data from data bus.
8) Set **C̄S** to high.

Serial Communication:

The ECH-1B can be set to serial communications mode by sending Command-3 (See **Programmable Commands** section) to the parallel data bus. This is possible by performing the following steps upon startup:

1) Hard-wire **R/*W*** to ground.
2) All pins on data bus have weak internal pull-up. Leave **DB2** and **DB4-DB7** unconnected to keep high by internal pull-ups. **DB3/SDAO** will be high from pull-up and should not be driven by an external signal since this signal becomes and output after command is received. **SCLK** bit is ignored.
3) Make sure **SDAI** is set low.
4) Set **C̄S** to low.
5) Pause.
6) Set **C̄S** to high.
7) Communications is now set to serial mode.

Note: If **EXEC** is hard-wired high (or left unconnected), execution of the measurement begins right away. If the preceding procedure is not performed and ready before chronometer startup, serial communication is not possible. After this command is received, no other commands may be sent to the chronometer. Commands can only be sent when **EXEC** is logic low.

When the ECH-1B uses the TTL level, 4-wire synchronous serial communication interface, commands are sent to the ECH-1B on the **SDAI** line and clocked (shifted in) in on the **SCLK** line. When measurement data is available, the ECH-1B will bring the **DAV** signal output to logic high. The Chronometer then sends data output results on the **SDAO** signal line.

To write a command to the ECH-1B, the host first brings **$\overline{CS}$** low. This instructs the ECH-1B to receive a command from the host. The host then shifts out 8 bits, MSB first, on the **SDAI** input of the ECH-1B. The host must generate the shift clock (**SCLK**) using the rising-edge to cause the controller to sample (shift in) each data bit. At the end of each byte, the **$\overline{CS}$** input must be returned to logic high.

To read data from the ECH-1B, the host must wait for the **DAV** output to become active, indicating that data is available. To read the first data byte from the ECH-1B, the host first brings **$\overline{CS}$** low. This informs the Chronometer that the host is ready to receive information and the first data bit (MSB first) is placed on **SDAO**. The host reads the bit by generating a rising **SCLK** signal. A falling-edge signal on SCLK then shifts out the next bit. This is repeated for all eight bits, then the **$\overline{CS}$** input is returned to logic high. This procedure is repeated for both data result bytes.

Data Result Format:

Upon completion of a measurement cycle (2^{N+5} samples), a two-byte result must be read on the data bus. In binary format, the two byte result takes the form:

2^9 2^8 2^7 2^6 2^5 2^4 2^3 2^2 2^1 2^0 . 2^{-1} 2^{-2} 2^{-3} 2^{-4} 2^{-5} 2^{-6}
|---------- byte #1 ----------| |---------- byte #2 ----------|

Operation:

Set option jumpers accordingly:
a) JP1 and JP2, START and STOP event edge polarity.
b) The A-GATE input can be hard-wired high or set high accordingly for each measurement.
c) Send Command-3 if using serial communications (see Programmable Commands section).
d) If required, send Command-1 to the chronometer for software control.

If the Command-1 N bit is set, configure the sample size using Command-1. If Command-1 is not used, set the sample size (N) inputs according to desired accuracy and time interval readout rate (sampling rate divided by sample size):

N	Sample Size	Basic RMS Accuracy (±)
0	32	3.530 ns
1	64	2.500 ns
2	128	1.768 ns
3	256	1.250 ns
4	512	0.884 ns
5	1024	0.625 ns
6	2048	0.442 ns
7	4096	0.313 ns
8	8192	0.221 ns
9	16384	0.156 ns
10	32768	0.110 ns
11	65536	0.078 ns
12	131072	0.055 ns
13	262144	0.039 ns
14	524288	0.027 ns
15	1048576	0.020 ns

1. If the Command-1 E bit is set, execution of measurement will start right after command is sent. If not used, assert the **EXEC** input with logic high to begin the measurement cycle.

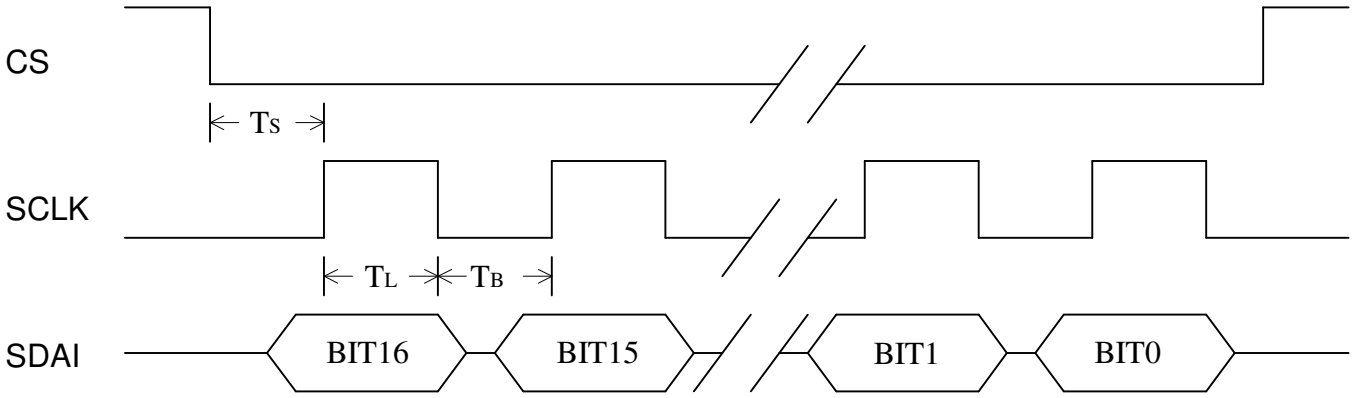
2. The **READY** output will go logic high shortly thereafter to signal external hardware of the beginning of each sample measurement. The **READY** output goes logic low upon completion of each sampled measurement and returns logic high at the beginning of the next. This occurs once for each sample of the selected sample size.

3. Upon completion of the measurement cycle the **DAV** output goes logic high indicating that all samples have been collected, a time interval has been calculated and the result is ready to be read on the parallel/serial bus. See Parallel / Serial communication sections for retrieving measurement data result.

4. Once the two-byte data result is received, upon returning **$\overline{CS}$** to its inactive state of logic high, the Command-1 bits E and N are reset. The Chronometer then samples the **EXEC** input to start a new measurement and checks the communication ports for new commands.

5. Command-1 must once again be sent to the ECH-1B in order to begin a new measurement. **Note:** Command-3 does not have to be sent again unless a hardware reset or command-0 reset occurs. Chronometer stays in serial communications mode until reset occurs.

ECH-1B Synchronous Receive Time Diagram



Note: Most significant bit received first. SCLK should be low before CS is brought low.

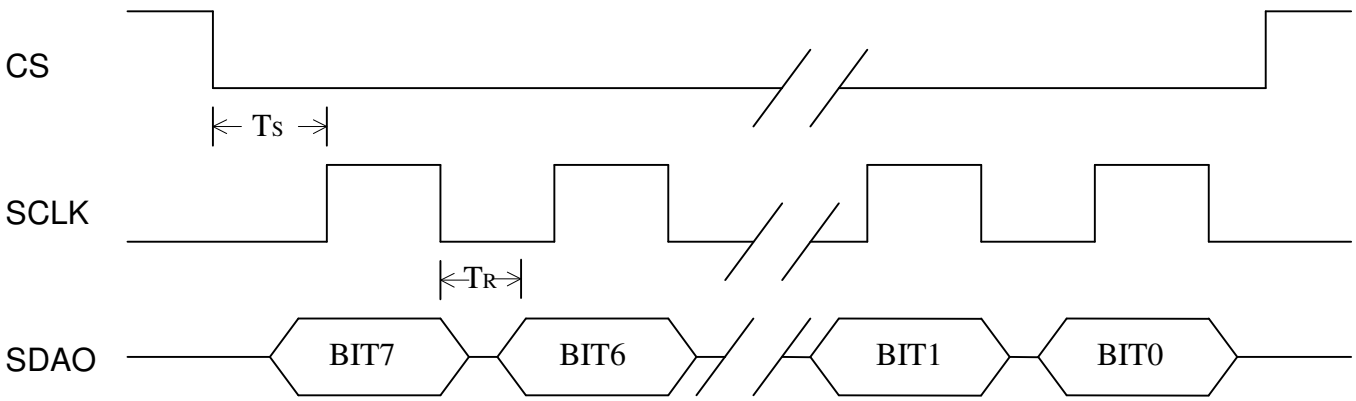
T_S – Setup Time – Minimum time CS needs to be low before sending data to the ECH-1B is 3.5µs.

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-1B Synchronous Transmit Time Diagram



Note: Most significant bit transmitted first. SCLK should be low before CS is brought low.

T_S – Setup Time – Minimum time CS needs to be low before receiving data from ECH-1B is 2µs.

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 – 1B	Standard chronometer (100ppm timebase)
ECH – 1B – 25	Enhanced chronometer (25ppm timebase)

OPERATING SPECIFICATIONS:

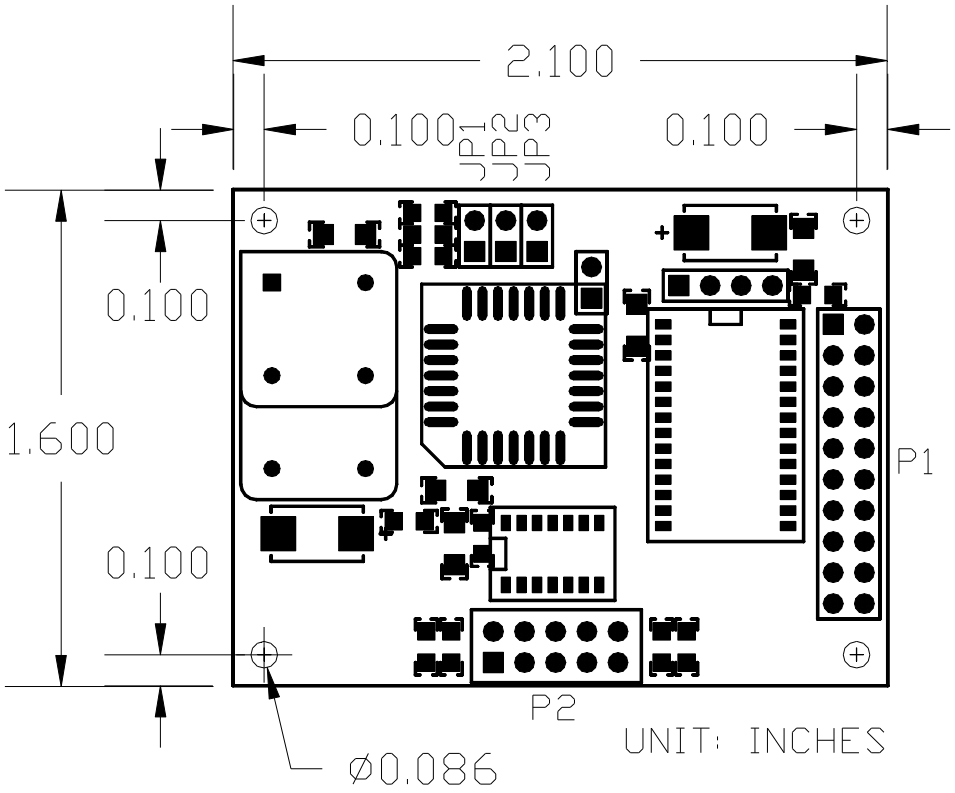
PARAMETER	MIN.	TYP.	MAX.	UNIT
Supply Voltage[1]	4.85	5.0	5.15	Vdc
Supply Current		200		mA
$t_{interval}$, time interval range of measurement[2]	5		1.02	µs
$t_{resolution}$, time interval measurement resolution		15.6		ps
$t_{accuracy}$, time interval measurement accuracy[3,4]		20		ps (rms)
f_{sample}, sampling rate			250	kHz

NOTES:
1. The external 5V supply must be regulated and filtered to 5V +/- 0.15V
2. Measurement error may occur for intervals less than 5ns. For intervals longer than 1µs, call tech support.
3. 25ppm timebase and 1,048,576 samples.
4. Time interval accuracy to (25ppm * interval) $\pm$ 20ns/$\sqrt{(2^{N+5})}$ [rms].

PARALLEL COMMUNICATION SPECIFICATIONS:

PARAMETER	MIN.	TYP.	MAX.	UNIT
Transmit				
$t_{dav\text{-}csl}$, DAV high – to – CS low setup time[5]		1.8		µs
$t_{csl\text{-}data}$, CS low – to – data output on bus[5]		0		ns
$t_{csh\text{-}csl}$, CS high – to – CS low 2nd byte read setup time[5]		1.2		µs
$t_{csl\text{-}csh,}$ CS low – to – CS high read time[5]		0		ns
Receive				
$t_{csl\text{-}data}$, CS low – to – data latched on bus[5]		4.2		µs

NOTES:
Parallel data transfers only. Please see communication section of this data sheet for more information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