ELECTRO-OPTIC DEVICES, INC.

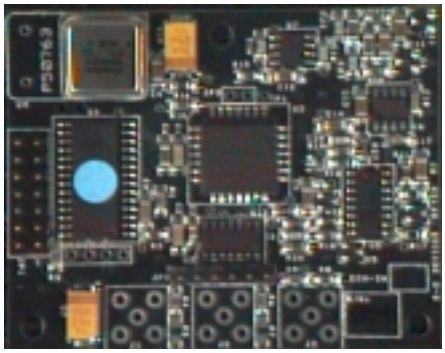
ECH-2

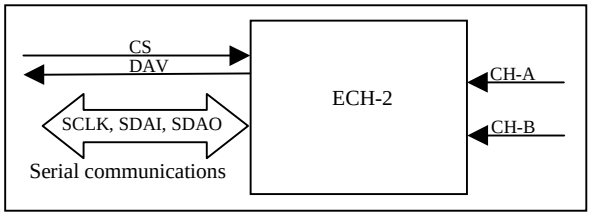
Fully Asynchronous START/STOP Chronometer Module

(firmware version 2.10)

FEATURES:

- Single sample, time interval accuracy to ± 500 ps or 0.01%.
- Measures time interval: A → B, B → A, and pos./neg. pulse width: A → A, B → B.
- Maximum time interval of 20.4 µs (extended range available).
- Control information and data transfer via synchronous serial interface.
- Measurement parameters and execution options programmable via configuration commands.
- Three byte time interval result in unit of nanoseconds (16 bits whole / 8 bits fractional).
- Programmable input source and polarity to fit application.
- ARM signal configurable as input or output.
- Optional SMA or SMB coaxial connections for timing signals.
- Single supply, 5 Volt operation.
- Compact circuit board just 2.00 x 2.50 inches, weight < 2.0 ounces.





APPLICATIONS:

- Devices requiring low power, high accuracy single shot measurements to < 1 ns.
- Pulsed solid-state and gas laser rangefinding requiring asynchronous start/stop.

DESCRIPTION:

The ECH-2A is a fully asynchronous START/STOP chronometer module. The ECH-2A will accept START and STOP signals from either channel A or channel B (A → B, B → A) and is capable of taking positive or negative pulse width measurements (A → A, B → B). The ECH-2A will take single samples with a time interval of up to 20.4µs with an accuracy of 500ps (0.01%).

Control information commands and data transfer is accomplished via synchronous serial interface, which includes the SDAV signal and is polarity configurable through the RESET/CONFIG command. Routine calibration can be made periodically using the CALIBRATE command to keep measurements accurate independent of component and temperature variations during normal use. Channel options and parameters and execution options are programmable via the MEASURE command. Results are received in a three-byte format of 16 whole number bits and 8 fractional bits in the unit of nanoseconds.

The ECH-2A operates with a single 5Vdc supply typically at 200mA. Compact circuit board design with dimensions of 2.00 x 2.50 inches and weighs less than 2.0 ounces. Available with optional SMA or SMB coaxial provides the ECH-2A with more accuracy and less noise for stronger timing signals.

INTERFACE:

Interface Connections:

Connector JP1 (host interface connector)

Pin	Signal	Description
1	VCC	5Vdc @210 mA power supply
2	VCC	
3	GROUND	
4	GROUND	
5	N.C.	no connect
6	N.C.	no connect
7	N.C.	no connect
8	N.C.	no connect
9	SDAV	Serial Data Available (O)
10	SDAO	Serial Data Output (O)
11	SDAI	Serial Data Input (I)
12	SCLK	Serial Data Transfer Clock (I)
13	$\overline{CS}$	Chronometer Select, low active (I)
14	$\overline{MR}$	Master Reset, low active (I)

Connector JP2 (timing signals)

Pin	Signal	Description
1	CHANNEL A	Channel A input (I)
2	GROUND	
3	CHANNEL B	Channel B input (I)
4	GROUND	
5	ARM	Arm Input/Output (selectable as I/O)
6	GROUND	

AIE Option Jumper JP3 (ARM Internal/External):

OPEN = ARM signal generated internally. ARM is an OUTPUT.
CLOSED = ARM signal generated externally. ARM is an INPUT.

Auxiliary Coaxial Connectors:

Optional PC-mount SMA or SMB connector jacks for ARM input/output, CHANNEL A and CHANNEL B inputs. The channel 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. The ARM input/output is terminated into 10 KΩ.

J1: CHANNEL A
J2: CHANNEL B
J3: ARM

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

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

SDAV (O) - Serial data available output flag to the host. This output goes logic LO or logic HI (programmable) to indicate that measurement information 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 the section on **communication**.

SDAO (O) - Serial data output from the chronometer to the host for synchronous data transfer. Timing details may be found in the section on **communication**.

SDAI (I) - Serial data input to the chronometer from the host for synchronous command transfer. Timing details may be found in the section on **communication**.

SCLK (I) - Serial clock input from the host for synchronous data/command transfer. Timing details may be found in the section on **communication**.

$\overline{MR}$ (I) - Master reset input. Logic LOW applied to this input performs a hardware reset of the ECH-2.

CHANNEL A, CHANNEL B (I) - These inputs carry the signal(s) from which time interval information is to be measured. Each input has a programmable polarity to provide sensitivity to either a high-going or low-going edge for timing purposes. In this manner, time intervals A $\rightarrow$ B, B $\rightarrow$ A and positive/negative pulse widths A $\rightarrow$ A, B $\rightarrow$ B can be determined.

ARM (I/O) - Programmable (via jumper JP3) as an internal ARM output from the chronometer or as an external ARM input to the chronometer. As an output, ARM is normally logic LO until the chronometer is "ARMED" via software command, after which it will remain logic HI until disarmed. In this configuration, the ARM output can be used to signal external devices that the ECH-2 is ready to measure time intervals. When configured as an input, ARM assumes a "gating" function. This configuration allows external devices to determine when the ECH-2 will monitor the inputs to measure time intervals. The ECH-2 must first be armed via software before the gating signal will take effect. Thereafter, a logic HI must be present during both the START and STOP signals for the ECH-2 to determine a time interval.

Command and Data Formats:

ID = 0, RESET/CONFIG

b7	b6	b5	b4	b3	b2	b1	b0
0	0	0	rsrv	rsrv	rsrv	DAVP	AUTO

Where:

AUTO: Auto rearm enable *(default = 0)*

0: MEASURE command required to ARM the chronometer for each measurement.
1: Chronometer REARMS itself automatically after data is read.

DAVP: Serial data available output polarity *(default = 0)*

0: SDAV logic LO indicates data available
1: SDAV logic HI indicates data available

rsrv: reserved

ID = 1, CALIBRATE

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

Where:

rsrv: reserved

ID = 2, MEASURE

b7	b6	b5	b4	b3	b2	b1	b0
0	1	0	M1	M0	PA	PB	ARM

Where:

M1, M0: Measurement type selection *(default = 0)*

0 (0,0) = CH-A → CH-B
1 (0,1) = CH-B → CH-A
2 (1,0) = CH-A → CH-A (width)
3 (1,1) = CH-B → CH-B (width)

PA: POLARITY, CHANNEL A *(default = 0)*

for MEASUREMENT TYPE 0, 1:
PA = 0: falling edge, CH-A
PA = 1: rising edge, CH-A
for MEASUREMENT TYPE 2, 3:
PA = 0: negative width, CH-A
PA = 1: positive width, CH-A

PB: POLARITY, CHANNEL B *(default = 0)*

for MEASUREMENT TYPE 0, 1:
PB = 0: falling edge, CH-B
PB = 1: rising edge, CH-B
for MEASUREMENT TYPE 2, 3:
PB = 0: negative width, CH-B
PB = 1: positive width, CH-B

ARM: Arming/arming enable *(default = 0)*

for AIE = 0 (internal arming):
ARM = 0: disarmed
ARM = 1: armed
for AIE = 1 (external arming):
ARM = 0: arming disabled
ARM = 1: arming enabled

Command Details:

RESET/CONFIG (ID = 0)

Resets the ECH-2 to default parameters (measure CH-A falling edge to CH-B falling edge). This command also configures the SDAV output polarity and auto-rearm enable. The AUTO feature is often used when the ECH-2 is programmed to perform only a single type of measurement. In this way, the chronometer is given one measure command after which it will continually measure asynchronous events as they occur. When SDAV signals data is available, the host MUST read data from the ECH-2 before it will auto-rearm for the next event. If an external event occurs during communication or rearming, ambiguous results may occur. Often, events coincident with command control of the ECH-2 will result in a failed measurement result: $FF, $00, $FF.

CALIBRATE (ID = 1)

Calibrates the ECH-2 internal timing mechanism. Calibration should be performed periodically to insure that measurement error due to temperature changes and aging are removed. The ECH-2 must be calibrated at least once prior to making time interval measurements. Calibration takes place in less than 2 milliseconds after the issue of this command. Future firmware revisions may have option switches included in the command.

MEASURE (ID = 2)

Places the ECH-2 into measurement mode. The signal characteristics to be measured are set according to the following switch designations. The actual measurement does not take place until the asynchronous timed event occurs. The ECH-2 will remain in MEASURE mode until issued any other command, or another MEASURE command is issued with the ARM switch set to disable.

The ARM switch arms or enables arming of the ECH-2 when given the MEASURE command. When AIE jumper (JP3) is open, arming is generated internally by the ECH-2 and the ARM signal is an output. If the ARM bit is set, the ARM output goes logic HI to indicate to external logic that a measurement event has been armed and is ready for the timing signals. To disable a measurement event prior to receiving timing signals, the ARM bit must be cleared.

When the AIE jumper (JP3) is closed, the ARM signal is an input. The ECH-2 uses this ARM switch to place the chronometer into measurement mode, but the final gating signal is generated externally and must be supplied to the ARM signal input.

Result Data Format:

Following a ranging event, a three-byte result must be read from the ECH-2. If the measurement was successful, the following three bytes will contain the time interval measurement result, otherwise the three bytes will contain the value $FF, $00, $FF indicating a failed measurement.

A successful result contains the following data format:

Result Data Bytes (3 byte format)

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

unit: nanoseconds

The first byte read is the Most Significant Byte (MSB) in whole number nanoseconds. The second byte contains the Least Significant Byte (LSB) in whole number nanoseconds. The third byte contains the FRactional Byte (FRB) in fractional nanoseconds. In binary format, the three byte result takes the form:

2^{15} …… 2^{3} 2^{2} 2^{1} 2^{0} **.** 2^{-1} 2^{-2} 2^{-3} 2^{-4} 2^{-5} 2^{-6} 2^{-7} 2^{-8}

A failed measurement is generally caused by:

a) Time intervals exceeding 20.4 microseconds.
b) A START signal edge without a STOP signal edge.
c) A STOP signal edge received before START edge.
d) Host communication or auto-rearming coincide with a timing event.

Communication:

The ECH-2 uses a 4-wire, TTL level, synchronous serial communication interface. Commands are sent to the ECH-2 on the **SDAI** line and clocked on the **SCLK** line. The Chronometer responds to the MEASURE command with data output on the **SDAO** signal line. When measurement data is available, the ECH-2 will bring the **SDAV** signal output to logic LO or HI depending upon it's programmed setting (see RESET/CONFIG command).

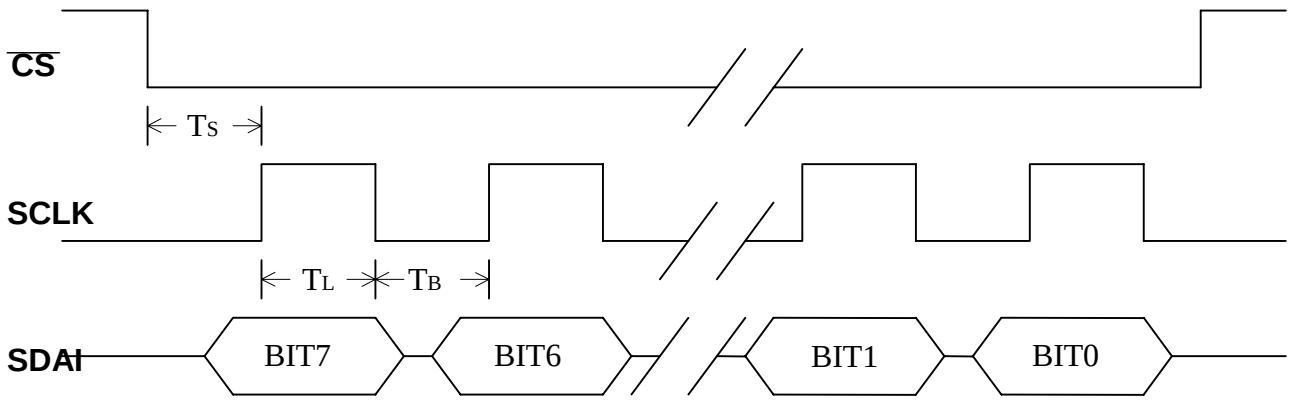
Communication with the four-wire interface option is straightforward. Four signals are used to accomplish information transfer: $\overline{\textbf{CS}}$, **SCLK**, **SDAI**, and **SDAO**.

To write a command to the ECH-2, the host first brings $\overline{\textbf{CS}}$ low. This instructs the ECH-2 to receive a command from the host. The host then shifts out 8 bits, MSB first, onto the **SDAI** input pin of the ECH-2. The host must generate the shift clock (**SCLK**) using the rising-edge to cause the controller to sample each data bit. At the end of each byte, the $\overline{\textbf{CS}}$ input must be returned to logic **high**.

Information can be read from the ECH-2 only after a MEASURE command is issued **and** the **SDAV** output goes active indicating that data is available. **NOTE**: Bringing the $\overline{\textbf{CS}}$ input logic LO before the SDAV output goes active can interfere with the measurement process - potentially causing incorrect results or failed measurements.

To read a data byte from the ECH-2, the host first brings $\overline{\textbf{CS}}$ 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 and then the $\overline{\textbf{CS}}$ input is returned to logic high. This procedure is repeated for all three data result bytes.

ECH-2 Synchronous Receive Time Diagram



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

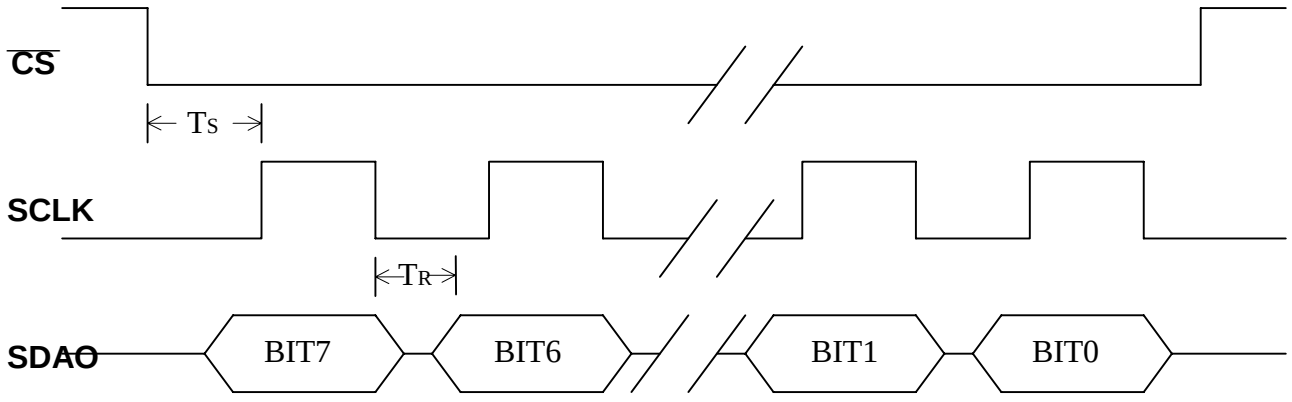
T_S – Setup Time – Minimum time **$\overline{CS}$** needs to be low before sending data to the ECH-2 is 2µs.

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-2 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-2 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 – 2	Standard chronometer (0.01% timebase)
ECH – 2 – SMA	Standard chronometer with SMA timing connections
ECH – 2 – SMB	Standard 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-2)		0.01		%
t_{error}, error of measurement (not including timebase accuracy)	-500		+500	ps
t_{jitter}, jitter of time interval measurement		200		ps **(RMS)**
$t_{response}$, response time to data available after triggering		1		ms

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