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Instruction Sheet
for the PASCO
Model CI-6742

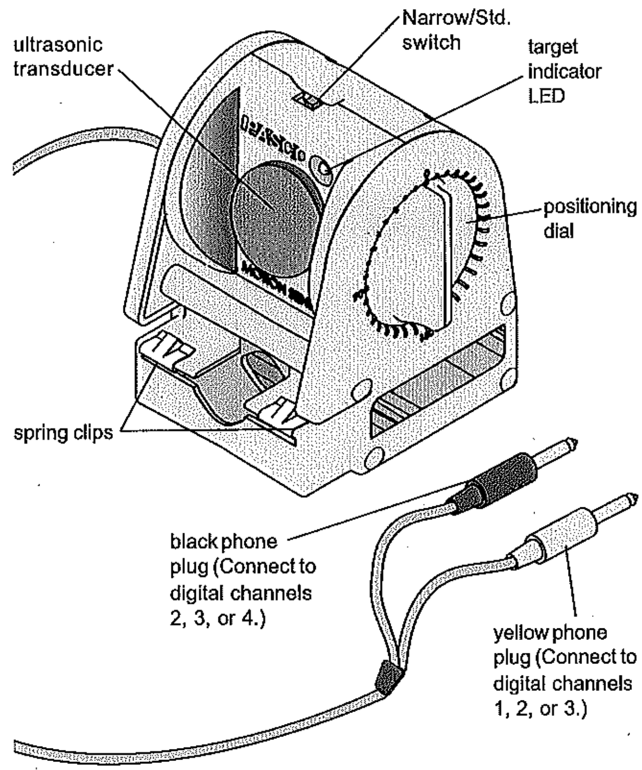
Motion Sensor II

Introduction

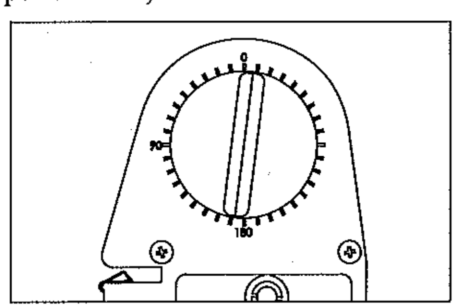
The PASCO CI-6742 Motion Sensor II is a sonar ranging device with a sensing range of 0.15 to about 8 meters. When used with an interface, the Motion Sensor II emits ultrasonic pulses and detects pulses returned as echoes from the target. The *ScienceWorkshop* program calculates the distance to the object from the speed of sound and half the sonic pulse round trip time. The program can also calculate velocity and acceleration from the distance and time measurements. The trigger rate for the Motion Sensor can be set in the *ScienceWorkshop* program to trigger as few as 5 times per second (for recording relatively slow events over large distances) or for as many as 120 times per second (for quick events such as a free-fall experiment).

The CI-6742 Motion Sensor II has several improved features, compared to the CI-6529 Motion Sensor:

- reduced minimum distance of operation
- reduced sensitivity to false targets
- front panel LED that lights when the Motion Sensor acquires the target
- additional mounting and positioning options
- compatibility with Texas Instruments® and Casio® scientific calculator-sensor interfaces
- compatibility with ULI interfaces



Important Operating Note: When operating in the Std. mode, it may be necessary to tilt the transducer up 5-10 degrees for best performance, as shown.



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Operation with CBL and EA-100 systems

An accessory cable (available separately, PASCO part no. 514-06862) is required for operation of the Motion Sensor II with a Texas Instruments CBL System™ or a Casio EA-100 Data Analyzer™.

An accessory cable (available separately, PASCO part no. 514-06933) is required for operation of the Motion Sensor II with a ULI interface.

Theory of Operation

When triggered, the module produces a burst of 16 pulses at a frequency of about 49 KHz. This produces an audible click from the electrostatic transducer which functions as both a speaker and a microphone. The time between the *trigger* rising edge and the *echo* rising edge is proportional to the distance. The trip time for sound in air is about 0.3 ms/m, so an object at a distance of 0.6 m produces a round-trip time delay of 3.6 ms. The sound intensity decreases with distance, and for a round trip the attenuation can be large enough for the receiver to miss the echo. Therefore the gain of the receiver's amplifier is increased in discrete amounts in 11 steps where the maximum gain is reached in 38 ms. This increases the usable distance to about 8 meters with a highly reflective target. Operating the receiver at reduced gain at the beginning of the cycle reduces the circuit's sensitivity to false echoes.

> ***Note:*** This instruction sheet was written assuming that the user is familiar with *ScienceWorkshop*. Users can gain familiarity by working through the tutorials provided with *ScienceWorkshop*.

Motion Sensor II CI-6742

FC Tested To Comply With FCC Standards

FOR HOME OR OFFICE USE

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/ TV technician for help.

Limited Warranty

PASCO scientific warrants the product to be free from defects in materials and workmanship for a period of one year from the date of shipment to the customer. PASCO will repair or replace, at its option, any part of the product which is deemed to be defective in material or workmanship. The warranty does not cover damage to the product caused by abuse or improper use. Determination of whether a product failure is the result of a manufacturing defect or improper use by the customer shall be made solely by PASCO scientific. Responsibility for the return of equipment for warranty repair belongs to the customer. Equipment must be properly packed to prevent damage and shipped postage or freight prepaid. (Damage caused by improper packing of the equipment for return shipment will not be covered by the warranty.) Shipping costs for returning the equipment after repair will be paid by PASCO scientific.

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TechNote 64 Details

Affected Products:

CI-6742 Motion Sensor II

Problem/Symptom:

What are the technical specifications of the CI-6742 Motion Sensor?

PASCO Solution:

- **Precision:** 1.72 $\times 10^{-4}$ m
- **Accuracy :** +/- 0.2 % (1 Point Calibrated)* / +/- 0.8 % (Typical Uncalibrated)
- **Range:** 15 -200 or 24-1000 cm (depending on "range" setting.)
- **Temporal Resolution:** +/- 5 $\times 10^{-7}$ s
- **Sample Rate:** 5 Hz - 120 Hz (lower is better for avoiding jitter resulting from echoes)
- **Timing Accuracy for Spatial Determination:** 1 ms (16 bit counter)
- **Transducer Rotation:** 360°
- **Mount Clearance:** 12.5 mm rod
- **Ultrasound Frequency:** 50 kHz
- **Dead Time:** 0.85 ms

* Please note that you must calibrate the sensor from the position of the piezoelectric emitter, which is set back from the track by 2.0 cm, meaning that 98.0 cm on the track marker equals 1.000 m for the purposes of calibration.

Creation Date: 01/1/2000
Last Modified: 02/11/2003
Mod Summary:

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PH317 Lab 9 - Interfacing with the STAMP

(one week)

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Objectives:

1. Starting with a data sheet and basic information, interface a serial ADC with the STAMP.
2. Use the output of the ADC to make a digital "voltmeter" that can read between 0 and 5 volts.
3. Use the EEPROM on the STAMP to store 1000 Bytes of data using a Pasco Sonic Ranger and an LM335 temperature sensor.

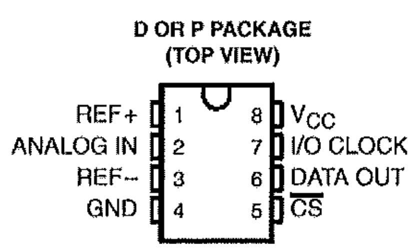
Parts Needed:

1. Stamp II - BS2-IC
2. RS-232 cable (9-pin D-sub to pin connections)
3. Sonic Ranger
4. SC-2075 extension board
5. TLC549 serial ADC
6. LM335 temperature sensor
7. LM358 op-amp

References:

1. ..\Documentation\Basic_Stamps\BASIC_Stamp_Manual_v1_9.pdf
2. ..\Documentation\Basic_Stamps\BASIC_Stamp_Windows_Interface_Manual_v1_2.pdf
3. ..\Documentation\Educational_Curriculum\What's_A_Microcontroller_v1_5.pdf
4. ..\Documentation\Educational_Curriculum\Basic_Analog_and_Digital_v1_0.pdf
5. Example program for interfacing the ADC0831 on the Stamp CD

Procedure:

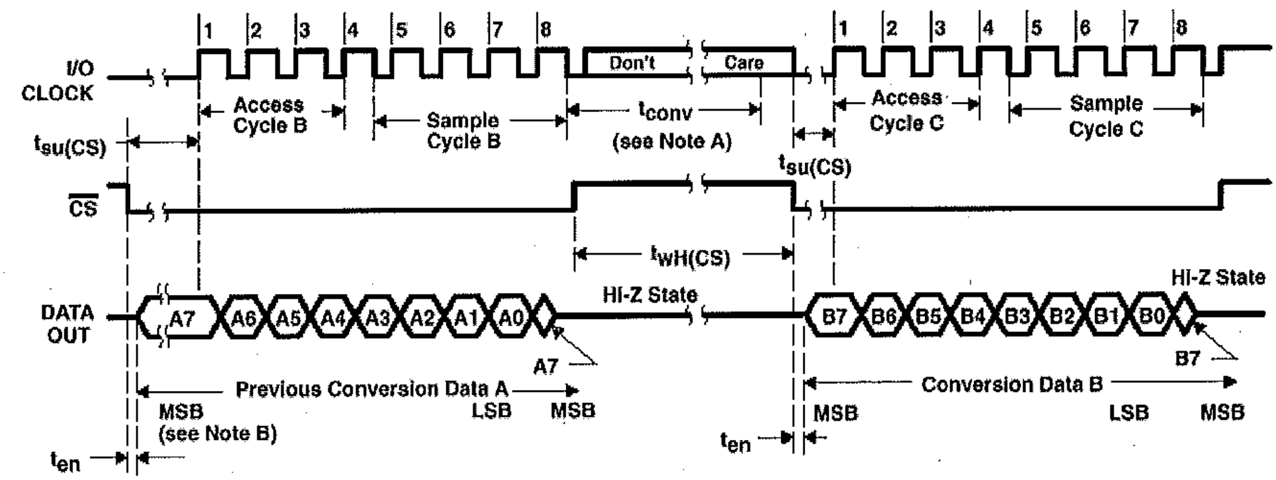


Serial ADC:

The use of a serial ADC allows many devices to be connected to a microcontroller with a small number of pins. The Texas Instrument Serial ADC TLC549 is one such device. The data sheets for this common ADC are in the attached appendix. The pinout of this IC is

For testing this device REF+ will by +5 v = V_{CC} and REF- = GND. There are three pins that will be connected to the STAMP, I/O CLOCK, DATA OUT and CS'. This compares with 12 that would have been required for the ADC0809 used in Lab 7.

operating sequence



NOTES: A. The conversion cycle, which requires 36 internal system clock periods (17 μs maximum), is initiated with the eighth I/O clock pulse trailing edge after $\overline{CS}$ goes low for the channel whose address exists in memory at the time.

B. The most significant bit (A7) is automatically placed on the DATA OUT bus after $\overline{CS}$ is brought low. The remaining seven bits (A6–A0) are clocked out on the first seven I/O clock falling edges. B7–B0 follows in the same manner.

The serial ADC simultaneously outputs the last conversion, which takes only ~17 μ s, and begins a new conversion. There are two clocks, one external which is used to set the rate of data transfer, and an internal 1.1 MHz clock that takes over during the conversion process.

The setup time t_{SU}(CS) has a value of 1.4 m s and the conversion time t_{CONV}(CS) is at least 17 m s. The other oddity of this conversion process is that all the bits are not shifted out the same. The MSB is available almost directly after the CS' line goes low. All other bits are read on the next 7 falling edges. A final clock pulse must be sent to end the sample cycle, and start the conversion. What is the state of the DATA OUT line after a falling clock edge, but just before the next rising edge? Design a program to connect this to the STAMP and read result of outputs. A good starting point is the example program for the ADC0831, a similar ADC from National. Note that it cannot be exactly used because of the way the TCL549 outputs the MSB. For reference this is the way that the SHIFTIN command works for the STAMP.

SHIFTIN dpin,cpin,mode,[result{\bits}{,result{\bits}...}]

Shift data in from a synchronous-serial device.

• **Dpin** is a variable/constant (0–15) that specifies the I/O pin that will be connected to the synchronous-serial device's data output. This pin's I/O direction will be changed to input and will remain in that state after the instruction is completed.

- **Cpin** is a variable/constant (0–15) that specifies the I/O pin that will be connected to the synchronous-serial device's clock input.

- **Mode** is a value (0—3) or 4 predefined symbols that tells Shiftin the order in which data bits are to be arranged and the relationship of clock pulses to valid data. Here are the symbols, values, and their meanings:

Symbol Value Meaning

MSBPRE 0 Data msb-first; sample bits before clock pulse

LSBPRE 1 Data lsb-first; sample bits before clock pulse

MSBPOST 2 Data msb-first; sample bits after clock pulse

LSBPOST 3 Data lsb-first; sample bits after clock pulse

(Msb is most-significant bit; the highest or leftmost bit of a nibble, byte, or word. Lsb is the least-significant bit; the lowest or rightmost bit of a nibble, byte, or word.)

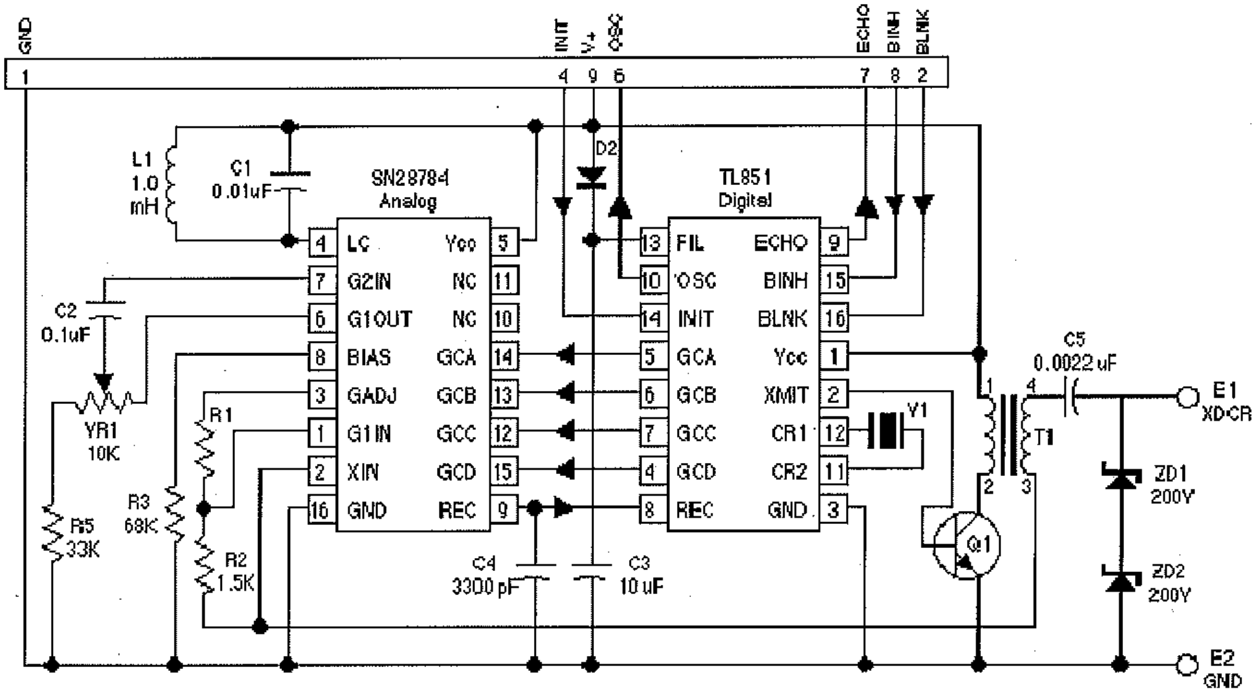
- **Result** is a bit, nibble, byte, or word variable in which incoming data bits will be stored.

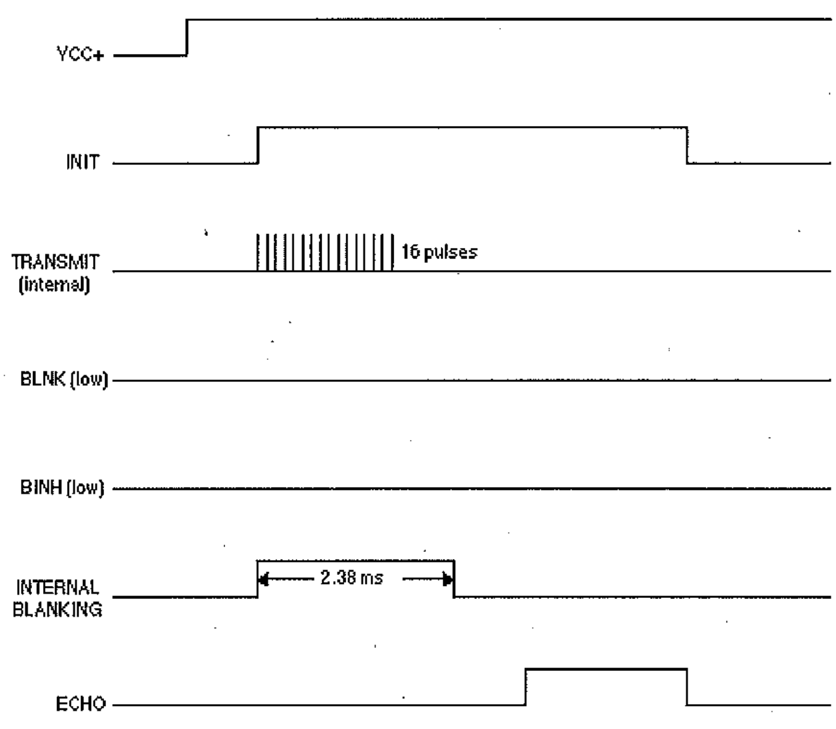
- **Bits** is an optional entry specifying how many bits (1—16) are to be input by Shiftin. If no bits entry is given, Shiftin defaults to 8 bits.

The ADC once connected can be used as a continuous reading voltmeter with two adjustments. One a loop must be added to continue execution. Second, the output must be changed from the binary form to a decimal form for sending back in the DEBUG command. Construct the necessary software and hardware. There is an example for this in the fourth reference listed above. Document with timing diagrams how fast the conversion takes. How does this compare to the DMMs that we use in lab? Why is there a difference?

Polaroid based Sonar Range finder:

The PASCO system is based on the same electronics as all others. In addition to providing power (the tip of the BLACK connector is +5 v, and both sleeves are GND), there is a signal in on the ring of the YELLOW connector (INIT) and a signal out on the ring of the BLACK connector (ECHO). The functions of these are shown below in a schematic and a timing diagram.





The signal that indicates that an object was found some distance away is from the return of the 16 pulses of TRANSMIT, which is indicated by ECHO. These are all TTL signals naturally. This element draws only 50 mA, so is suitable as a remote sensor.

Temperature sensor

The output of the National Semiconductor sensor (LM335) is a voltage that is proportional to the absolute temperature. They behave as zener diodes with zener voltages that are temperature-dependent. As with all zener circuits it is necessary to have sufficient current (more than ~0.5 mA) of reverse current in order for these to operate. A good circuit that provides the necessary bias current is a voltage divider with the lower element the 335. Then at room temperature there is a voltage of 2.93 v already. In order to use this as a sensor with only an 8 bit ADC it will be necessary to correct for the offset. The easiest circuit to construct is with a LM358 single supply op amp.

APPENDIX

Conversion process from the TLC549 data sheet SLAS067C - SEPTEMBER 1996

The control sequence has been designed to minimize the time and effort required to initiate conversion and obtain the conversion result. A normal control sequence is:

1. CS is brought low. To minimize errors caused by noise at CS, the internal circuitry waits for two rising edges and then a falling edge of the internal system clock after a CS¯ before the transition is recognized. However, upon a CS rising edge, DATA OUT goes to a high-impedance state within the specified t_{dis} even though the rest of the integrated circuitry does not recognize the transition until the specified t_{su} (CS) has elapsed. This technique protects the device against noise when used in a noisy environment. The most significant bit (MSB) of the previous conversion result initially appears on DATA OUT when CS goes low.
2. The falling edges of the first four I/O CLOCK cycles shift out the second, third, fourth, and fifth most significant bits of the previous conversion result. The on-chip sample-and-hold function begins sampling the analog input after the fourth high-to-low transition of I/O CLOCK. The sampling operation basically involves the charging of internal capacitors to the level of the analog input voltage.
3. Three more I/O CLOCK cycles are then applied to the I/O CLOCK terminal and the sixth, seventh, and eighth conversion bits are shifted out on the falling edges of these clock cycles.
4. The final (the eighth) clock cycle is applied to I/O CLOCK. The on-chip sample-and-hold function begins the hold operation upon the high-to-low transition of this clock cycle. The hold function continues for the next four internal system clock cycles, after which the holding function terminates and the conversion is performed during the next 32 system clock cycles, giving a total of 36 cycles. After the eighth I/O CLOCK cycle, CS must go high or the I/O clock must remain low for at least 36 internal system clock cycles to allow for the completion of the hold and conversion functions. CS can be kept low during periods of multiple conversion. When keeping CS low during periods of multiple conversion, special care must be exercised to prevent noise glitches on the I/O CLOCK line. If glitches occur on I/O CLOCK, the I/O sequence between the microprocessor/controller and the device loses synchronization. When CS is taken high, it must remain high until the end of conversion. Otherwise, a valid high-to-low transition of CS causes a reset condition, which aborts the conversion in progress.

A new conversion may be started and the ongoing conversion simultaneously aborted by performing steps 1 through 4 before the 36 internal system clock cycles occur. Such action yields the conversion result of the previous conversion and not the ongoing conversion.