Sonictrac® Series Sonic Measuring Unit

Instruction Manual
Model SMU100-XXX

CAROTRON
Driven by Excellence
D.C. DRIVES, A.C. INVERTERS,
SOLID STATE STARTERS, SYSTEM INTERFACE
CIRCUITS AND ENGINEERED SYSTEMS

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1 General Description

The Carotron Sonictrac® Series is a distance measuring system that uses ultrasonic technology to detect and measure targets up to a distance of 30 feet. An Environmental Grade electrostatic transducer and ranging circuit, developed by Polaroid for use in their auto-focus cameras, combined with Carotron industrial grade interface and processing circuitry provides reliable and accurate operation in a wide range of applications.

Crystal time-based digital counters display distance to 1/10 foot resolution and give 12 - bit resolution to the analog voltage output. The output voltage can be sourced from on-board positive or negative supplies or an external voltage can be multiplied by a percentage of distance.

Distance is divided into four ranges to give maximum output resolution and to establish "valid echo" distances beyond which objects are ignored. The distance to an out-of-range object will be displayed up to 30 feet but the output will not change. Continued operation "out-of-range" for a programmable time period from 1 to 15 seconds will energize a Fault relay whose contacts can be used by the customer to sound an alarm, stop a machine, etc.

2 Specifications

A.C. Input
115 VAC, 50/60 Hz, 1 phase fused at .3 amperes

Signal Inputs
- +10 VDC maximum with 10K ohms input impedance
- External CTL-CLK input, 7 Hz, 50% duty at 5 volts peak maximum for simultaneous "slave" operation as second Sonictrac® Measuring Unit without interference or cross-talk

Signal Outputs
- Positive and negative 10 VDC supplies at 2 mA maximum each (5K to 10K ohm load impedance)
- Inverted CTL-CLK output - 7 Hz, 50% duty at 1 mA maximum - for "slave" operation of a second Sonictrac®
- D.C. Voltage output, variable based on distance, + 10 volts maximum at 10 mA maximum. Resolution to 1/4096 of full scale output possible

Relay Output
- Fault relay - form "C" contact output, 120 VAC at .2 amps inductive or .5 amps resistive load

Display
- 3 digit LED display of distance with .1 foot or 1.2 inches resolution

Range
- The LED display will constantly indicate measured distances up to 30 feet regardless of selected range
- Digital-to-Analog conversion occurs within a distance from 1/2 to 30 feet. This distance is divided into the following four ranges:
  1/2 to 5 feet, 1/2 to 10 feet,
  1/2 to 20 feet, 1/2 to 30 feet

Scan Rate
- Cycles occur at 7 Hz or once every 143 millisec.

3 Theory of Operation

General
Measuring distance with ultrasonics makes use of the fact the sound travels through air at a known speed, 1.775 milliseconds for a 1 foot round trip. The Sonictrac®, like a bat, sends and precisely measures the time for a sound signal to make a round trip to and from the target whose distance must be determined. This round trip time period is calculated with respect to the speed of sound to give an accurate dislay of distance and percentage of output based on distance. Total scan cycle; transmit, receive, process and update display and analog outputs, occurs 7 times per second.

Transducer Components

The electrostatic transducer and interface circuit is designed to act as both a transmitter and receiver of ultrasonic, 49 KHz, pulses. This particular frequency has been determined to experience the least amount of attenuation versus distance over normal conditions of temperature and humidity.

When given a transmit command, CTL CLK, the circuit transmits a burst of high frequency pulses and signals Transmitted. It then blanks operation for 0.88 mSec and switches itself to receiver mode.

NOTE: The 0.88 mSec blanking time accounts for the 1/2 foot minimum in each of the four distance ranges.

When the transmitted signal strikes a target or other object and returns as echos, the first echo received causes a Received signal.

Interface Circuit

Powering the transducer and ranging board and conditioning their signals for transmission over long cable lengths is handled by isolated Interface circuitry. The Interface board receives +5 VDC and the CTL CLK signal from the Control board and sources latched Transmitted and Received signals. All transducer and enclosure wiring is isolated.

Timebase

Precise and stable clock signals are provided by a crystal oscillator. Several counters supply the different clocking signals selected by J1, Range, that allow the 12 bit D-to-A converter to maximize its count for each range. This gives the finest possible output voltage increments; maximum output voltage for each range is divided by 4096.

NOTE: The level of output voltage change or increment is actually determined by the amount of distance change within 1 scan cycle. A distance change of one 4096th of the range in 1/7th of a second will cause a voltage change one 4096th of maximum.

Display Counter

The three digit LED display operates independently of the D-to-A circuit. It continually displays distance to 30 feet regardless of the range selected and has .1 foot or 1.2 inches resolution.

Digital to Analog Converter

The 12 bit D-to-A converter is a four quadrant multiplying type, i.e. it will multiply positive or negative signals by the percentage of measured distance to maximum distance (for each range).

Analog Scaling

The analog output section uses programing jumpers and multi-turn cermet potentiometers to configure the output signal level and logic in any desired format limited to±10VDC maximum.

The programing jumpers determine whether external signals or internal reference supplies are modified by the percentage distance multiplier. They also can determine output signal polarity and whether the level is increasing or decreasing with increasing distance. The pots will set the output level-per-distance and any offset or bias voltage required.

For example, the output can be set at zero volts with the target at mid-range and with an increasing positive voltage as the target rises and an increasing negative voltage as the target falls lower than mid-position.

Out-Of-Range Detection

The Sonictrac® indicates out-of-range targets by flashing LED I1. The out-of-range condition is determined by monitoring the carry outputs on the 12 bit D-to-A counters. Since the Sonictrac® clock signals are scaled to maximize but not exceed the count within each distance range, carry outputs indicate that full count has already been reached and the target is out-of-range.

When an out-of-range condition occurs, the output of the Sonictrac® remains at the level caused by the last valid (in-range) echo. The control does this by comparing the measured round trip time for a cycle to a calibrated pulse whose time period is equal to the round trip time of a maximum range target. Only valid echos with time periods less than or equal to the calibration pulse can update the D-to-A converter.

Fault Condition

Switch S1 has four poles and controls the desired time in an out-of-range condition before the Fault relay is energized. It does this by programing a binary counter to count the D-to-A carry outputs and incorporates additional dividers to scale the decimal equivalent of the binary code in seconds. Each bit switch (S1 pole) is labeled with its equivalent decimal "weight" which corresponds to the time in seconds.

For example, the binary number 1111 (all bit switches on) corresponds to the decimal number 15 and a delay before Fault time of 15 seconds. The total time can be easily set by totaling the decimal value (screened on the board adjacent to S1) of each bit switch placed in the "on" position.

The Fault counter will be reset any time a valid echo is received before the programed count is reached. Once the Fault relay is energized, it can only be reset by an external contact or by momentarily removing power from the Sonictrac®.

4 Description of Jumpers, Potentiometers

Jumpers

- J1 sets the operating range in which a detected object will cause a proportional change in analog output voltage. An object outside of the selected range may be detected and have its distance displayed but will not cause a voltage change. J1 has four ranges as follows:
  - 1/2 to 5 feet
  - 1/2 to 10 feet
  - 1/2 to 20 feet
  - 1/2 to 30 feet
- J2 selects the source of the CTL CLK signal. For normal operation it is placed in the INT position. When the Sonictrac® is used in conjunction or close to another Sonictrac® , place J2 in the EXT position to allow use of the "not" or inverted CTL CLK signal from the other unit. This will prevent interference between the two units.
- J3 selects NORMal operation or CALibration mode. This jumper should always be placed in the NORM position. The CAL position is used during factory setup only.
- J4 is used to program the output signal polarity. It's position depends on the logic of the output signal, i.e. whether the output level is increasing or decreasing with increasing distance. Refer to the Adjustment Procedure for more specific information.
- J5 determines whether the output is a ratio of the on-board Fixed ± 10 VDC supplies or an EXTernal MULtiplier signal applied to TB2 terminal 9.
- S1 is a 4 pole switch used to select the time period out-of-range before "FAULT". Refer to section 3.9, "FAULT CONDITION" for a complete description of operation.

Potentiometers

- P1, P2, P3 and P4 are factory adjusted pots that control the maximum sensed distance for each range that will cause a change in the output. These pots should not require adjustment by the customer.

NOTE: A general description of the customer adjustments follows. Specific calibration information will be found in Section 6, Adjustment Procedure.

- P5, Offset, is mainly used to offset or zero any minimum range output signals.
- P6, Bias, is used to set a beginning or "edge of range" signal level.
- P7, Gain, sets the finish or "other edge of range" signal level.

5 Installation Considerations and Procedure

The Sonictrac® Transducer Enclosure and Control Board assembly can be mounted in any position but there are several practical considerations for longest, most accurate and trouble-free operation.

- The ideal application would position the Transducer Assembly above the target with the circular transducer facing down. This would reduce the possibility of moisture, dust or other contaminants from falling on the sensor and causing corrosion or reduced sensitivity.
- Rigid or vibration free mounting is desirable for accuracy and consistant outputs as well as mechanical life of the assemblies.
- Since the Sonictrac® uses reflected echos to determine distance, stronger echos increase the likelihood of detection and accurate measurement. Positioning the flat face of the sensor parallel to flat surfaced targets will maximize the echo strength. The transmitted signal must strike a target and reflect directly back to the transducer sensor.
- The actual shape of the emitted ultrasonic sound signal can be pictured as a cone with the point

behind the transducer. The diameter of the transducer itself is 1.5 inches. At 5 feet the "cone" diameter is between 12 and 18 inches approximately. At 10 feet the diameter is between 24 and 36 inches. Obviously, the size and shape of the target affect how well it is detected at the edge of the signal "cone".

- Rounded objects make good targets because some part of the surface is always parallel to the face of the sensor. This is true of tubular targets as long as the length dimension of the tube is parallel with the face of the sensor.
- Other sources of ultrasonic sound should be accounted for and eliminated if possible. Other Sonictrac® ultrasonic ranging systems can generate interference if not sequenced properly with this system. Please refer to connection diagram D10430 in Section 8. There can also be non-electrical sources of ultrasonic sound such as compressed air leaking or blown in the direction of the transducer.

6 Adjustment Procedure

NOTE: All voltage measurements are made from circuit common at TP1 or TB1 terminals 6 and 11.

It is assumed that the transducer is mounted over and looking down on the target.

Initial Programing

- J1 - Place in the position corresponding to the desired operating range.
- Program the remaining jumpers as follows
  - J2 — INT
  - J3 — NORM
  - J4 — POS
  - J5 — FIXED

Increasing Distance Gives Increasing Positive Output

- Place the target at the minimum desired operating distance (1/2 foot minimum).
- Monitor TP5 and adjust the Offset pot for zero volts.
- Monitor the output at TB1-10 and adjust the BIAS pot for zero volts.
- Place the target at the maximum desired operating distance (must be within the range selected by J1).
- Adjust the GAIN pot for desired output voltage, +10 VDC maximum, at the maximum distance.

Increasing Distance Gives Increasing Negative Output

- Place J4 in the NEG position.
- Place the target at the minimum desired operating distance (1/2 foot minimum).
- Monitor TP5 and adjust Offset for zero volts.
- Monitor the output at TB1-10 and adjust BIAS for zero volts.
- Place the target at the maximum desired operating distance.
- Adjust the GAIN for desired output voltage, -10 VDC maximum, at the maximum distance.

Increasing Distance Gives Decreasing Positive Output

- Place J4 in the NEG position.
- Place the target at the minimum desired operating distance (1/2 foot minimum).
- Monitor TP5 and adjust Offset for zero volts.
- Monitor the ouput at TB1-10 and adjust the BIAS CW for desired level, + 10 VDC maximum.
- Place the target at the desired maximum operating distance.
- Adjust the GAIN for zero volts output.
- Repeat the BIAS and GAIN adjustment procedure as necessary to produce the desired output voltage range.

Increasing Distance Gives Decreasing Negative Output

- Place J4 in the POS position.
- Place the target at the minimum desired operating distance (1/2 foot minimum).
- Monitor TP5 and adjust OFFSET for zero volts.
- Monitor the output at TB1-10 and adjust the BIAS CCW for desired level, - 10 VDC maximum.
- Place the target at the desired maximum operating distance.
- Adjust the GAIN for zero volts output.
- Repeat the BIAS and GAIN adjustment procedure as necessary to produce the desired output voltage range.

Zero Volts at Mid-Range, Positive Above and Negative Below Mid-Range

- Place J4 in the NEG position.
- Place the target at the center of the operating range.

NOTE: The range center is half-way between the 1/2 foot minimum and maximum of the range selected.

- Monitor TP5 and adjust the OFFSET CW for zero or minimum voltage.
- With the target still at center range, adjust the BIAS for zero volts output at TB1-10.
- Place the target at 1/2 foot or the desired minimum distance from the sensor. The output will increase positive.
- Adjust the Gain for the desired output level, +10 VDC maximum.
- As the target is moved through center range to the maximum distance, the output voltage will swing negative but will be equal in amplitude to the positive level set in the previous step.
- Repeat the BIAS and GAIN adjustment procedure as necessary to produce the desired output voltage range.

Zero Volts at Mid-Range, Negative Above and Positive Below Mid-Range

- Place J4 in the POS position.
- Place the target at the center of the operating range.
- Monitor TP5 and adjust the OFFSET CCW for zero or minimum voltage.
- With the target still at zero, adjust the BIAS for zero volts output at TB1-10.
- Place the target at 1/2 foot or the desired minimum distance. The output will increase negative.
- Adjust the GAIN for the desired output level, -10 VDC maximum.
- Repeat the BIAS and GAIN adjustment procedure as necessary to produce the desired output voltage range.

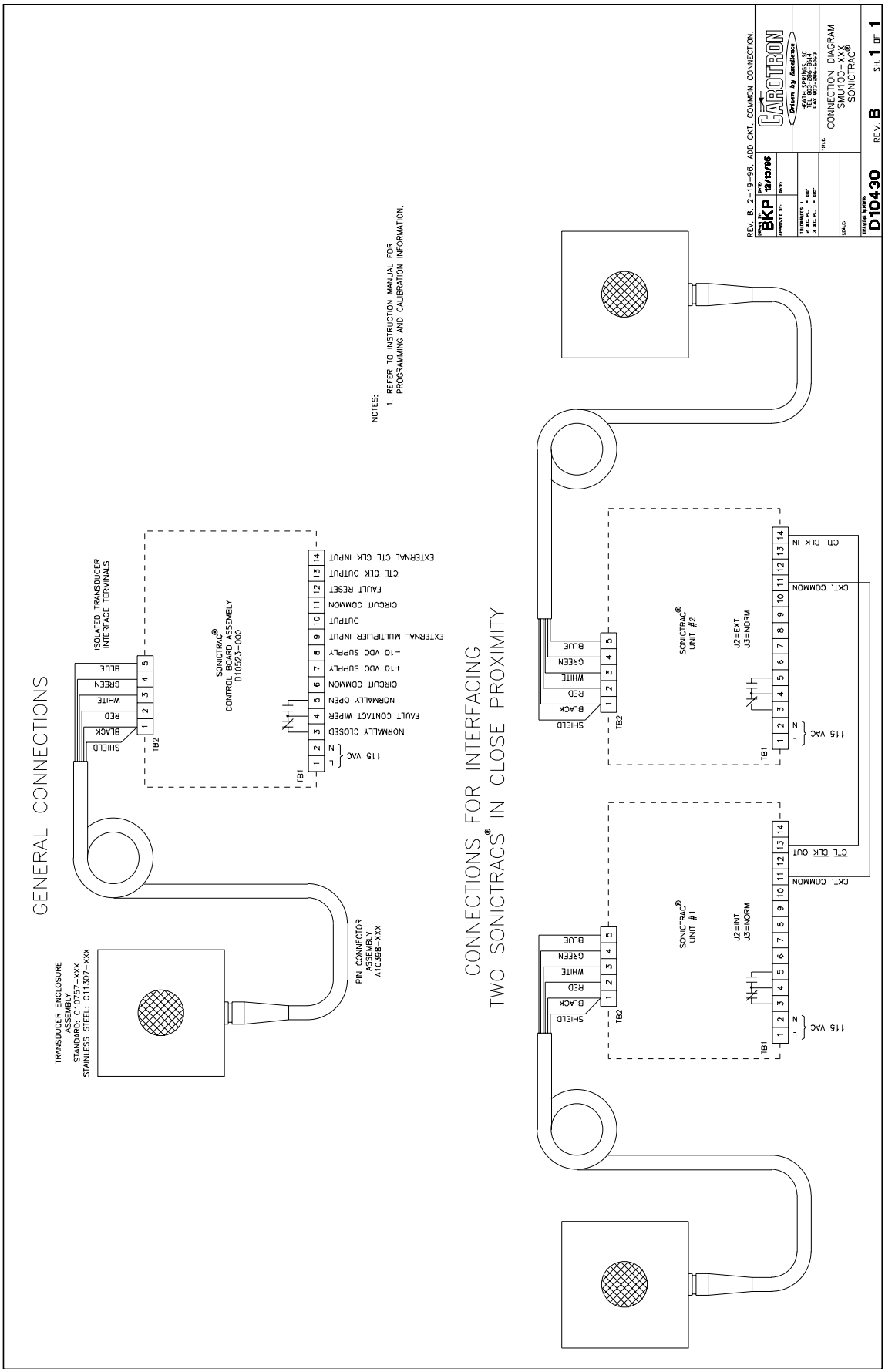
External Input Signals

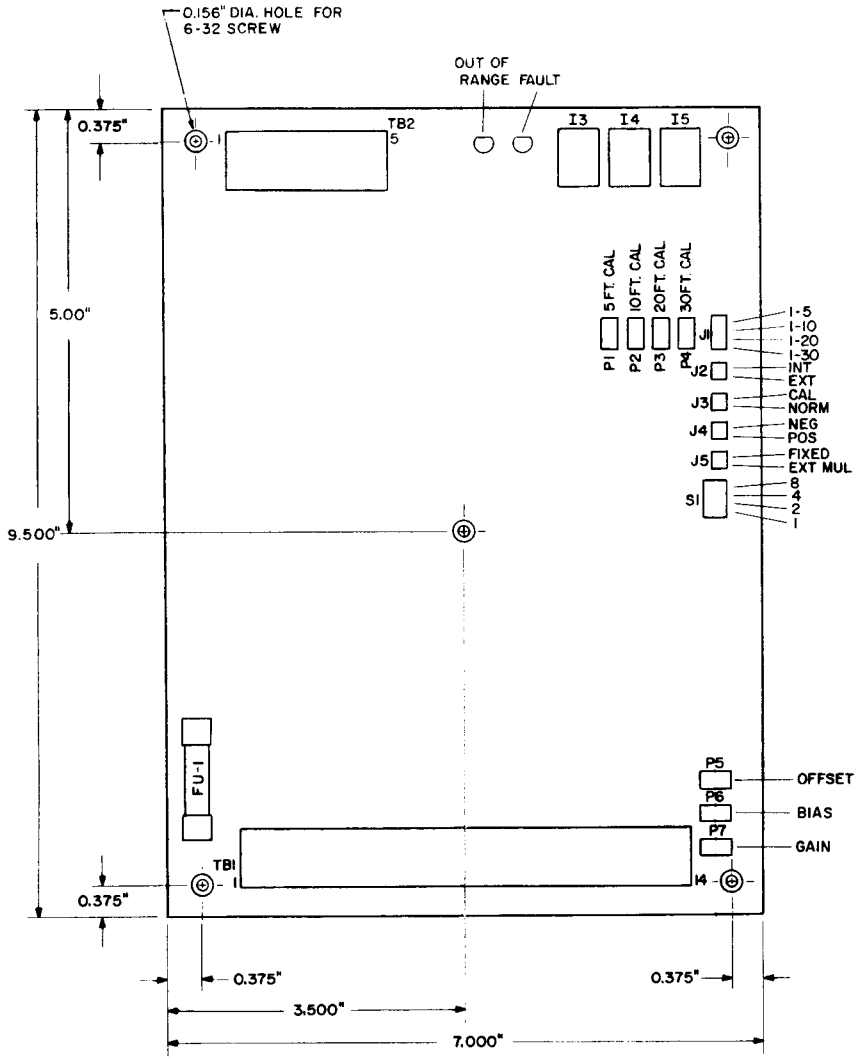
- External signals are connected between common and input terminal TB1-9. Their levels should not exceed ± 10VDC. A signal applied here will be inverted in polarity at the output and is multiplied by a percentage of measured distance to maximum distance (for each range).
- These signals, like the fixed ± 10VDC supplies can be offset and amplified by the OFFSET, BIAS and GAIN adjustments
- Adjustments for an operation using an external multiplier is most straightfoward for an application where the output increases as distance increases. Consult factory for assistance when using external input signals.

7 Spare Parts

Standard Transducer/Enclosure Assembly	C10757-000
Stainless Steel Transducer/Enclosure Assembly	C11307-000
SMU100 Series Control Board	D10253-000
Standard Transducer Only	CON1008-01
Environmentally Hardened Transducer Only	CON1011-00
20 ft. Cable Assembly	A10398-000
40 ft. Cable Assembly	A10398-001
60 ft. Cable Assembly	A10398-002
80 ft. Cable Assembly	A10398-003
100 ft. Cable Assembly	A10398-004

8 Prints


GENERAL CONNECTIONS
TRANSDUCER ENCLOSURE ASSEMBLY
STANDARD: C10757-XXX
STAINLESS STEEL: C11307-XXX
PIN CONNECTOR ASSEMBLY A10398-XXX
ISOLATED TRANSDUCER INTERFACE TERMINALS
SHIELD
BLACK
RED
WHITE
GREEN
BLUE
TB2
SONICTRAC® CONTROL BOARD ASSEMBLY D10523-000
TB1
115 VAC
NORMALLY CLOSED
FAULT CONTACT WIPER
NORMALLY OPEN
CIRCUIT COMMON
+10 VDC SUPPLY
-10 VDC SUPPLY
EXTERNAL MULTIPLIER INPUT
OUTPUT
CIRCUIT COMMON
FAULT RESET
CTL CLK OUTPUT
EXTERNAL CTL CLK INPUT
NOTES:
1. REFER TO INSTRUCTION MANUAL FOR PROGRAMMING AND CALIBRATION INFORMATION.
CONNECTIONS FOR INTERFACING TWO SONICTRACS® IN CLOSE PROXIMITY
SONICTRAC® UNIT #1
J2=INT J3=NORM
SONICTRAC® UNIT #2
J2=EXT J3=NORM
CTL CLK OUT
EXT. COMMON
CTL CLK IN
REV. B, 2-19-96, ADD CKT. COMMON CONNECTION.
BKP 12/13/95
CAROTRON
Drives by Excellence
CONNECTION DIAGRAM SMU100-XXX SONICTRAC®
D10430
REV. B
SH. 1 OF 1

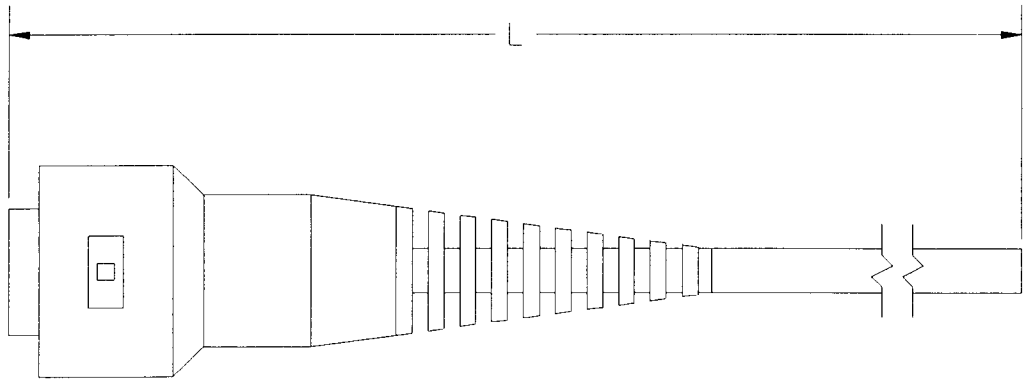


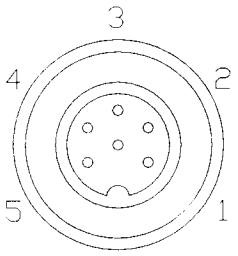
DATE	BY/M	REVISION RECORD	AUTH	DR	CK

TOLERANCES (EXCEPT AS NOTED)	CAROTRON, inc		
DECIMAL .		SCALE	DRAWN BY HJH
FRACTIONAL .	TITLE DIMENSIONS AND ADJUSTMENTS SMU100-XXX		APPROVED BY
ANGULAR ±	DATE 7-5-89	DRAWING NUMBER C10431	

MADE IN U.S.A.

DASH NO.	L	
-00	20'	
-01	40'	
-02	60'	
-03	80'	
-04	100'	



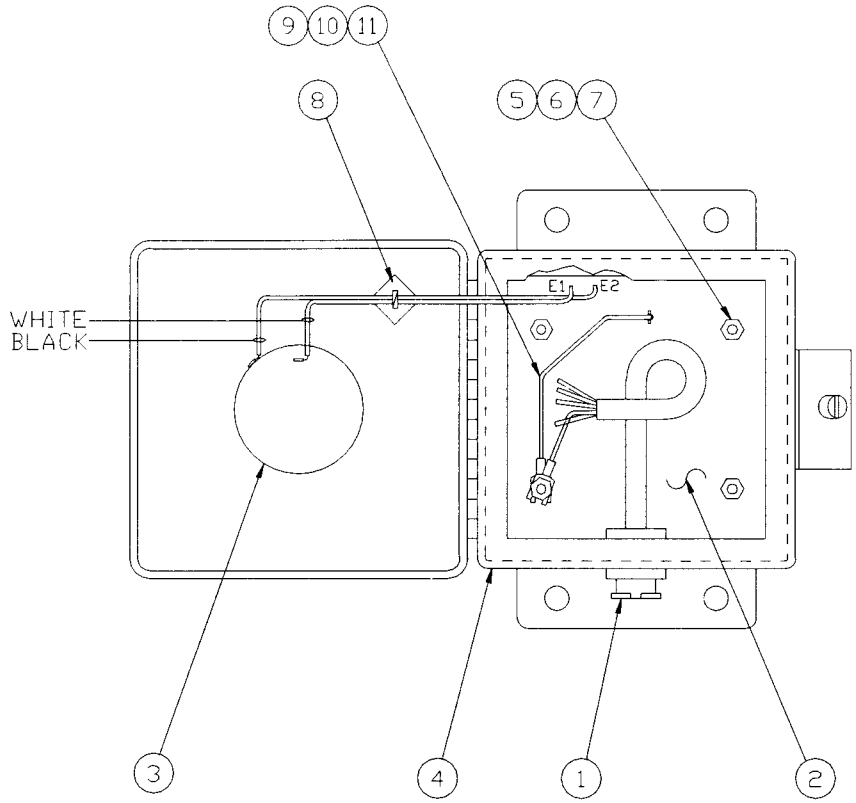


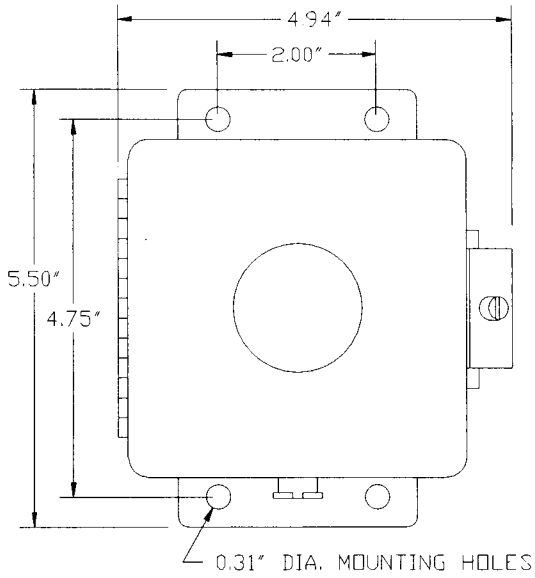
PIN 1 = BLK
PIN 2 = WHT
PIN 3 = GRN
PIN 4 = BLU
PIN 5 = RED
PIN 6 = SHIELD (CENTER)

NOTES:
1. REF. B.O.M. A10398-XXX.
2. BROWN WIRE NOT USED.

CAROTRON

TITLE: SONICTRAC PIN CONNECTOR ASSEMBLY			DWG. NO. A10398		
DRAWN BY: BKP	APPROVED BY:	DATE: 12/15/95	SCALE: 1=1	REV. -	SHEET 2 OF 2



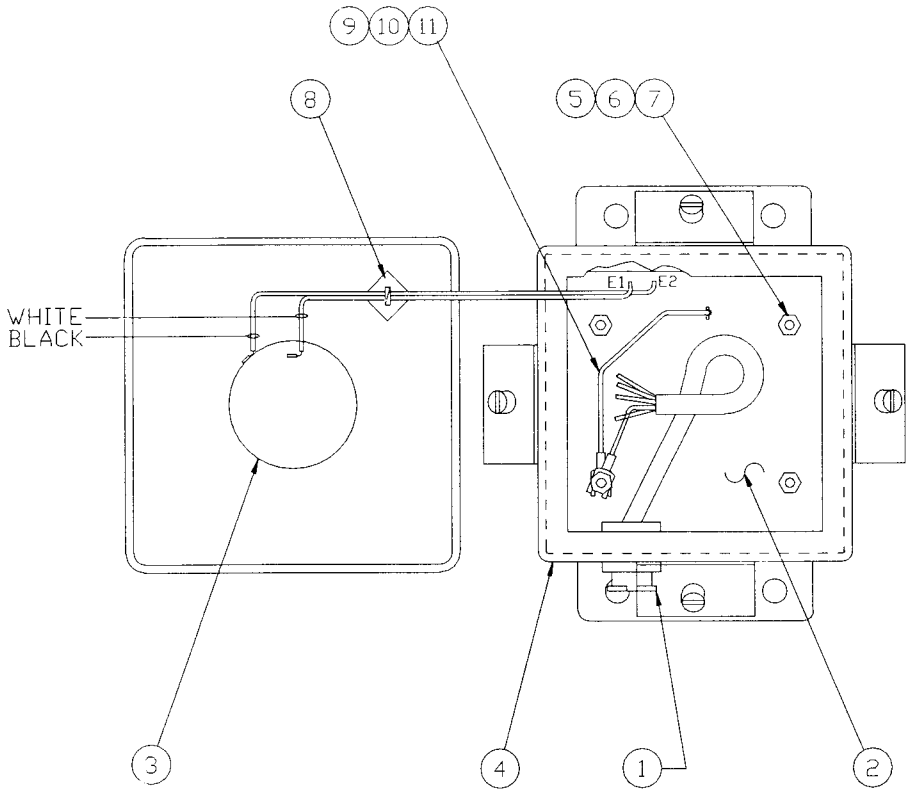


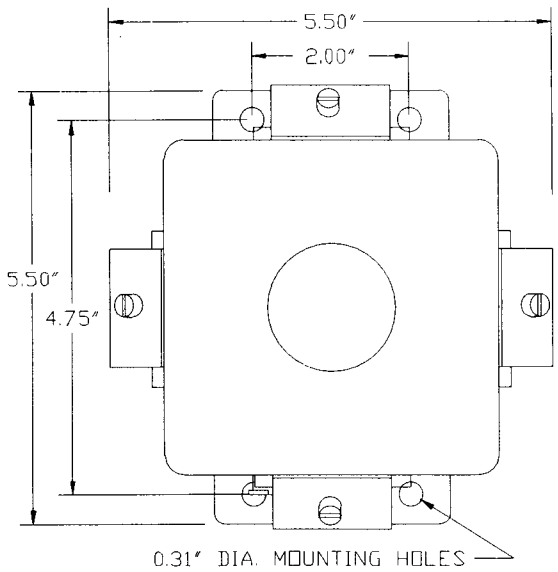
MAX. HEIGHT = 3.50"

NOTES;
1. SECURE TRANSDUCER TO ENCLOSURE WITH A 1/4" WIDE BEAD OF RTV. KEEP CONNECTION TERMINALS FREE OF RTV.
2. RECEPTACLE & CABLE MUST BE INSTALLED IN ENCLOSURE BEFORE SOLDERING CABLE TO INTERFACE BD.
3. REFER TO SCHEMATIC C10750.

REV.B, 12-14-95
REV.A,ECO 227, 8-6-93

DRAWN BY: HJH	DATE: 5/19/92
APPROVED BY:	DATE:
TOLERANCES: ± 2 DEC. PL. = .010" 3 DEC. PL. = .005"	CAROTRON Driven by Excellence HEATH SPRINGS, SC TEL 803-286-8614 FAX 803-286-6063
SCALE:	TITLE: TRANSDUCER ENCLOSURE ASSEMBLY,VER. 2
DRAWING NUMBER: C10757	REV. B SH. 1 OF 1



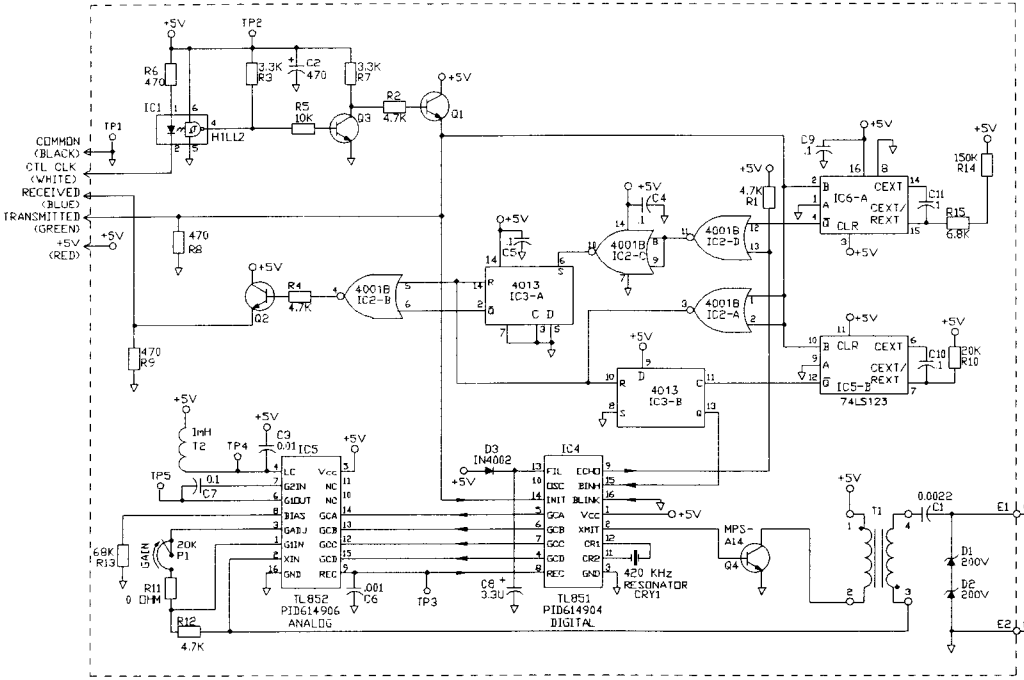


MAX. HEIGHT = 3.50″

NOTES;
1. SECURE TRANSDUCER TO ENCLOSURE WITH A 1/4″ WIDE BEAD OF RTV. KEEP CONNECTION TERMINALS FREE OF RTV.
2. RECEPTACLE & CABLE MUST BE INSTALLED IN ENCLOSURE BEFORE SOLDERING CABLE TO INTERFACE BD.
3. REFER TO SCHEMATIC C10750.

DRAWN BY: HJH	DATE: 10-28-93	CAROTRON Driven by Excellence
APPROVED BY:	DATE:	HEATH SPRINGS, SC TEL 803-286-8614 FAX 803-286-5083
TOLERANCES: ± 2 DEC. PL. 3 DEC. PL.		TITLE: STAINLESS STEEL TRANSDUCER ENCLOSURE ASSEMBLY
SCALE: ----		
DRAWING NUMBER: C11307	REV. A	SH. 1 OF 1

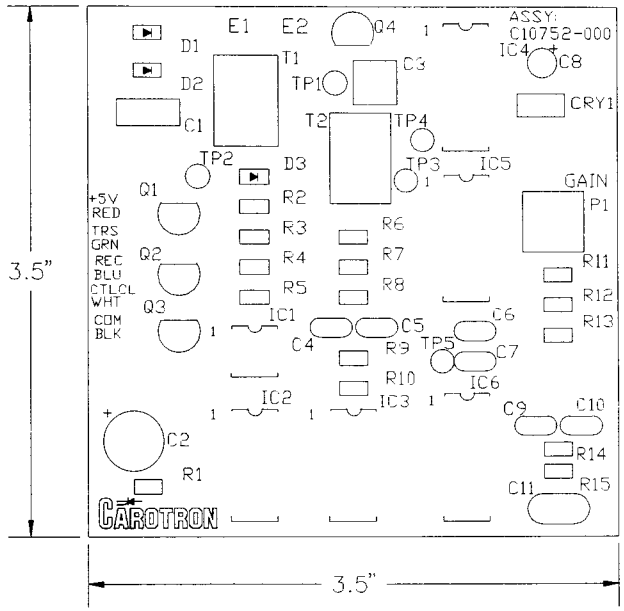
SCHEMATIC



C10750
REV.B, ECO 238, 9-24-93

NOTES:
1. REFER TO INTERFACE BOARD ASSEMBLY, C10752 AND FINAL ASSEMBLY, C10757.

ASSEMBLY



C10752
REV.A, ECO 129, 9-25-91

NOTES:
1. REF. B.O.M.: A10752-000
2. REF. SCHEM.: C10750

DRAWN BY: BKP	DATE: 12/14/95	CAROTRON Driven by Excellence
APPROVED BY:	DATE:	HEATH SPRINGS, SC TEL 803-286-8614 FAX 803-566-6053
TOLERANCES: X DEC. PL. ± .010" X DEC. PL. ± .005"		TITLE: SCHEMATIC & ASSEMBLY, SONICTRAC TRANSDUCER INTERFACE BOARD VER. 2
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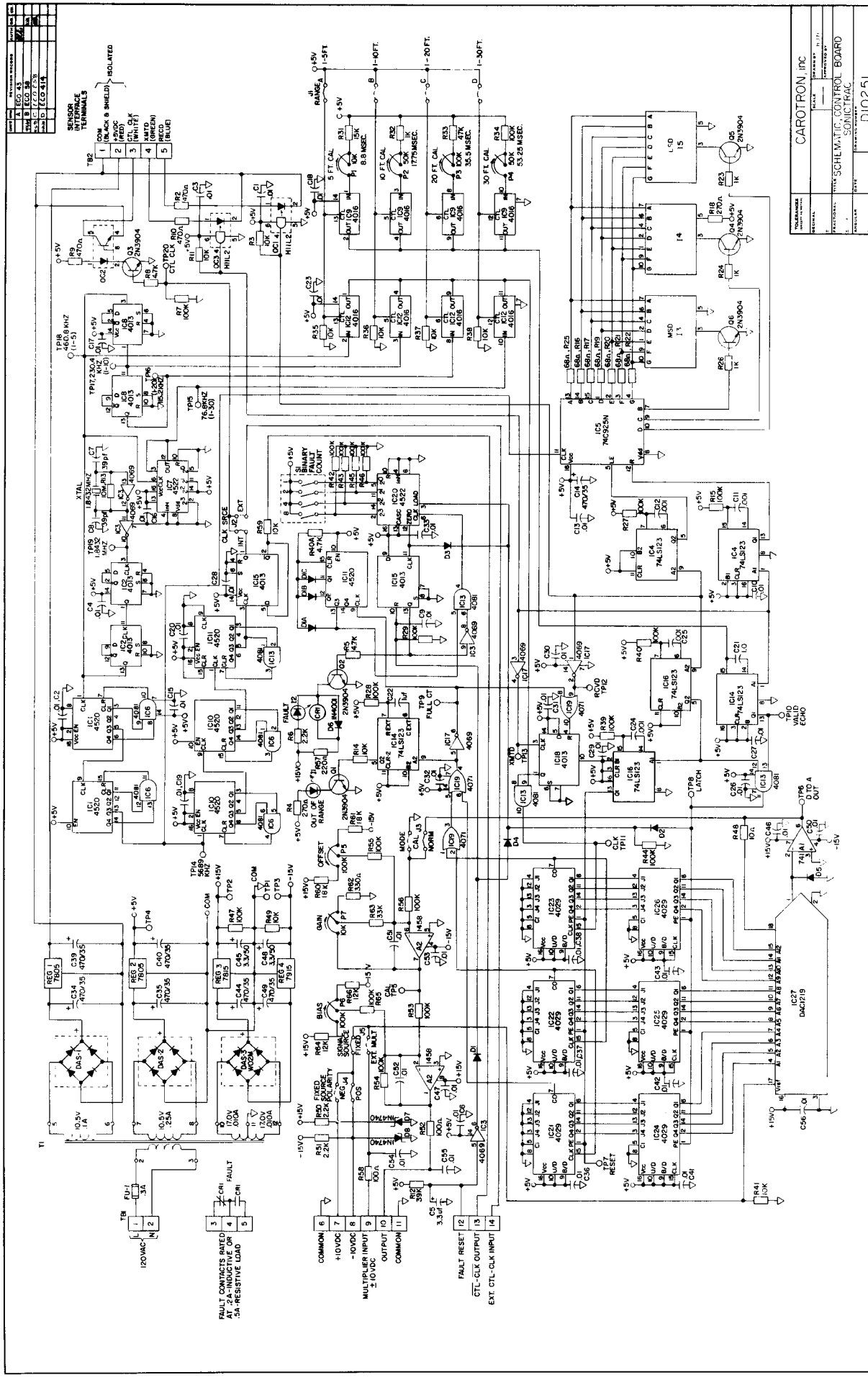
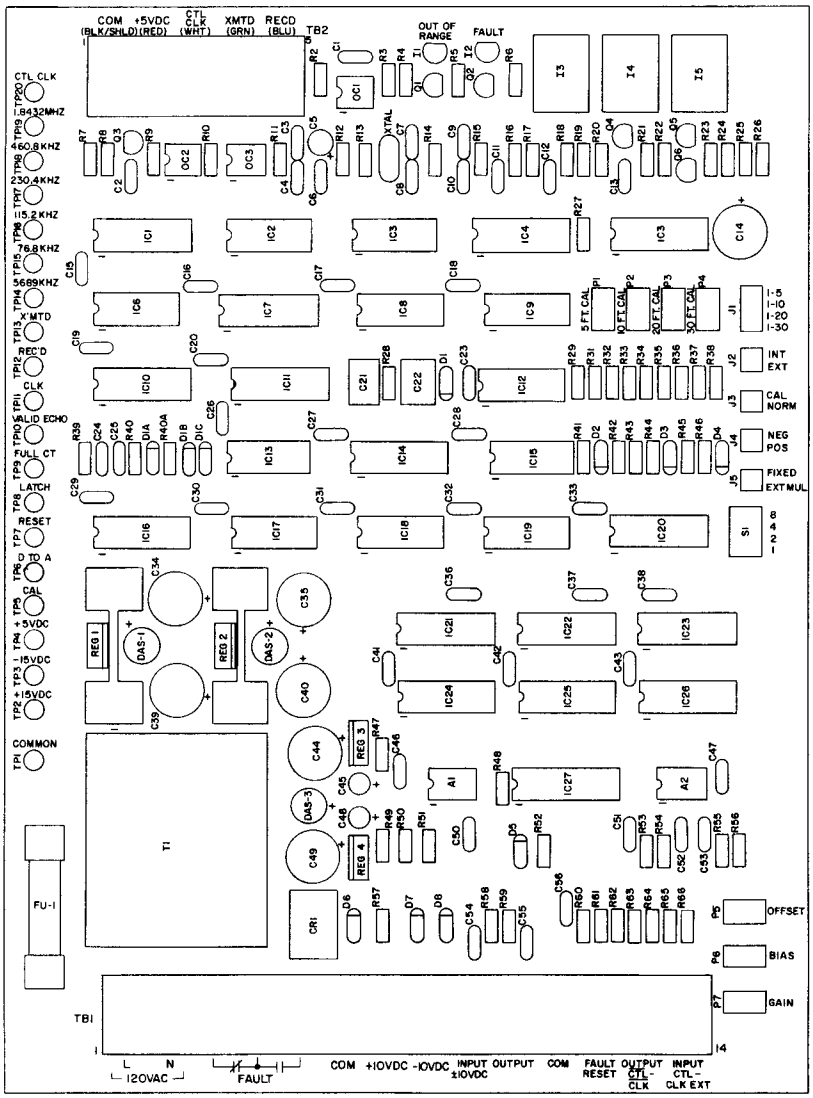

CAROTRON, inc
SCHEMATIC, CONTROL BOARD
SONICTRAC
D10251
SENSOR INTERFACE TERMINALS
ISOLATED
TB2
COM (BLACK & SHIELD)
+5VDC (RED)
CTL CLK (WHITE)
XMTD (GREEN)
RECD (BLUE)
J1 RANGE
5 FT. CAL
10 FT. CAL
20 FT. CAL
30 FT. CAL
1775 MSEC.
35.5 MSEC.
53.25 MSEC.
8.8 MSEC.
XTAL
4.9152 MHZ
CLK SRCE
BINARY FAULT COUNT
FAULT
OUT OF RANGE
VALID ECHO
LATCH
D TO A OUT
RESET
TB1
120VAC
FU1 .3A
FAULT CONTACTS RATED AT .2A INDUCTIVE OR .5A RESISTIVE LOAD
COMMON
+10VDC
-10VDC
MULTIPLIER INPUT ±10VDC
OUTPUT
COMMON
FAULT RESET
CTL-CLK OUTPUT
EXT. CTL-CLK INPUT



CAROTRON, inc.

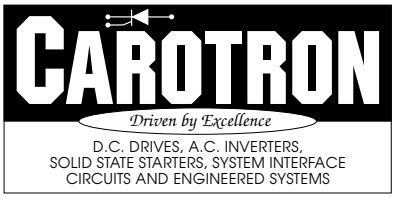
TOLERANCES — DECIMAL — FRACTIONAL — ANGULAR

SCALE — DRAWN BY HJH — APPROVED BY

TITLE ASSEMBLY, CONTROL BOARD SONICTRAC

DRAWING NUMBER D10253

DATE 7-3 89



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MAN 1019-0E
Issued 11-17-11