FE 20

HI-LO METER

SENCORE

SENCORE SERVICE MANUAL

3200 SENCORE DRIVE, SIOUX FALLS, SOUTH DAKOTA 57107

Safety Precautions

When testing electronic equipment, there is always a danger present. Unexpected high voltages can be present at unusual locations in defective equipment. The technician should become familiar with the device that he is working on and observe the following precautions.

1. An isolation transformer should always be used on equipment having the chassis tied to one side of the AC power line.
2. When making test lead connections to high voltage points, remove the power, if this cannot be done, be sure to avoid contact with other equipment or metal objects. Place one hand in your pocket as a safety precaution and stand on an insulated floor to reduce the possibility of shock.
3. Discharge filter capacitors before connecting test leads to them. Capacitors can store a charge that could be dangerous to the technician.
4. Be sure your equipment is in good order. Broken or frayed test leads can be extremely dangerous and can expose the technician to dangerous potentials.
5. Remove the test leads immediately after the test has been completed to reduce the possibility of shock.
6. Do not work alone when working on hazardous circuits. Always have another person close by in case of accident. Remember, even a minor shock can be the cause of a more serious accident, such as falling against the equipment, or coming in contact with higher voltages.

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INSTRUCTION MANUAL FOR THE SENCORE FE20 HI-LO FIELD EFFECT METER

DESCRIPTION

As the state of the art in electronics progresses, more transistors, FETs, and integrated circuits are being used in radio, television, and industrial markets. Sencore engineers have kept up with todays pace and have developed a new Field Effect meter to meet the more demanding requirements of solid state and integrated circuit servicing.

The FE20 HI-LO meter features new low AC and DC ranges of .1 volts full scale and a low power ohms circuit allowing for the first time accurate resistance measurements in transistor and integrated circuits.

Just compare these features and see why the FE20 is the most advanced meter on the market today:

* High input impedance on all AC and DC ranges (15 megohm DC, 12 megohms AC).
* True peak to peak AC ranges.
* Zero center ranges on DC for solid state servicing.
* Db scale for audio and lab work.
* DC current ranges for general testing.
* Low power (low applied voltage) ohms ranges for solid state servicing.
* Mirrored scale meter for greater accuracy in readings.
* Meter protected from overloads.
* Circuits protected from accidental application of wrong voltages.
* All steel carrying case with cover for greater durability and portability.
* Long life "C" cell power.

SPECIFICATIONS

DC VOLTS

Ranges: 0 to .1, .3, 1, 3, 10, 30, 100, 300, and 1000 full scale
-.05 to .05, -.15 to .15, -.5 to .5, -1.5 to 1.5, -5 to 5, -15 to 15, -50 to 50, -150 to 150, and -500 to 500 Zero Center Scale Ranges.

Input Resistance: 15 megohms shunted by 90 pf in probe "NORM" position; or shunted by 10 pf in probe "120K ISOLATION" position.

Accuracy: $\pm$1.5%

AC Rejection: 30 db Minimum

AC VOLTS

Ranges: (RMS)
0 to .1, .3, 1, 3, 10, 30, 100, 300, and 1000 Full scale

Ranges: (Peak to Peak)
0 to .28, .84, 2.8, 8.4, 28, 84, 280, 840, and 2800 Full scale

Input Resistance: 12 Megohms shunted by 90 pf

Frequency Response:	1 db	10 Hz	-	150 KHz
	3 db	5 Hz	-	500 KHz

OHMMETER

Ranges: HI & LO POWER
0 to 1000 ohms, 10K, 100K, 1 Meg, 10 Meg, 100 Meg, and 1000 Meg with 12 ohms center scale

Accuracy: ± 2 degrees ARC

Applied Voltage: Hi Power 1.5 Volts
Lo Power .08 Volts

DC CURRENT MEASUREMENTS:

Ranges: 0 to 100 microamps, 300 microamps, 1 mA, 3 mA, 10 mA, 30 mA, 100 mA, 300 mA, and 1 amp.

Accuracy: ± 3% full scale

Internal voltage drop: 80 mv on 100 microamp to 10 mA ranges,
100 to 900 mv on 30 mA to 1 amp ranges.

Decibel (db)

Ranges: -20, -10, 0, 10, 20, 30, 40, 50, and 60 db
Reference: 1 mv into 600 ohms

GENERAL SPECIFICATIONS:

Meter: 6 inch, 200 microamp, 2%

Multiplier resistors: 1/2% deposited carbon type

Semiconductor complement:
Transistors: 2 - 2N5457 FETs, 2 - 2N4248, 1 - 2N5172
Diodes: 2 - 1N456, 3 - 1N695, 1 - 16S10

Power supply: 6 each 1.5v "C" cells Eveready #935 or equivalent (not supplied)

Ohms Battery: one 1.5V "C" cell Eveready #1035 or equivalent (not supplied)

Weight: (less batteries) 8 lbs.

Dimensions: 9 1/2" High X 7 3/4" Wide X 3 3/4" Deep.

OPERATION

SHIELDED TEST LEAD AND PROBE ON THE FE20

The FE20 HI-LO Meter is equipped with a shielded test lead to allow accurate measurements on AC in the presence of strong electrostatic and electromagnetic fields. The special probe has a 120K isolation resistor to isolate the cable capacity when making DC voltage measurements in critical circuits such as RF, IF or sweep circuits. For all normal readings including DC voltage, the probe switch is left in the normal position. The only time that the switch is placed in the isolate position is when it is necessary to isolate cable capacity from the circuit being measured. When the switch is in the isolate position, the DC voltage reading on the FE20 will be only 0.6% low. The isolate position should only be used with the DC voltage and AC voltage at 60 Hz functions as much greater error will result on other functions.

CONTROLS ON THE FE20

The FE20 HI-LO Meter is as simple to operate as a standard VOM. The front panel controls include the RANGE switch, FUNCTION switch, meter ZERO ADJUST, OHMS ADJUST, ON-OFF switch, and the battery test switches. The following is a brief description of each control and how it is used:

RANGE Switch: The RANGE Switch selects the desired range of voltage, current or resistance to be measured.

FUNCTION Switch: The FUNCTION Switch selects the type of measurement to be made, plus or minus DC volts or current, AC volts, HI or LO power ohms.

ZERO ADJUST: The ZERO ADJUST is used to position the pointer of the meter over the zero at the extreme left of the meter for most measurements, or over the center zero for the zero center ranges.

OHMS ADJUST: The OHMS ADJUST is adjusted with the FE20 leads held open. The OHMS ADJUST control is adjusted so that the pointer of the meter is positioned directly over the infinity mark on the extreme right hand side of the meter. The ohms zero is adjusted with the test leads shorted together and the Range Switch set to any position except RX1 or RX10.

ON-OFF Switch: The ON-OFF Switch controls the power to the meter circuit. In the OFF position, the batteries are disconnected from the meter circuits. In the ON position, battery power is applied to the meter circuitry and the meter is ready to go. When the lid of the FE20 is shut, a special tab automatically shuts off the FE20 to be sure that the batteries do not wear down needlessly.

BATTERY TEST Switches: The FE20 uses two battery test switches. The battery test switch on the left is the test for the main (power) battery, and the switch to the right is the ohms battery test.

OPERATING THE FE20

The Sencore FE20 is simple and easy to operate. The long life "C" cell power supply allows the FE20 to operate anytime, anywhere.

Battery Installation and Testing: To gain access to the battery compartment, remove the two screws in the lead compartment. Lift out the lead compartment, exposing the battery holders.

There are two power supplies used in your FE20. Six "C" cells are connected in series to power the amplifier and bridge circuit, and one "C" cell is used to power the ohms function. To install the six "C" cells for the bridge power supply, place 3 "C" cells in each of the two tubes provided. Install the tubes containing the three batteries each, between the spring battery contacts. Be sure to observe polarity. The ohms battery is installed in the single battery holder that is mounted at an angle. It is recommended that a "premium" cell be used in this application as the current drain can be quite high when using the RX1 HI power ohms range.

The two spring return slide switches on the front panel of the FE20 provide a battery check function. Push the Ohms switch to the right to test the condition of the ohms battery, and push the Main switch to the left to test the condition of the bridge power supply battery.

Operation: To operate the FE20, merely select the desired test with the Function switch, the appropriate range with the Range switch, connect the test leads to the points being measured, and observe the indication on the meter. Here is a brief description of how each test is performed.

Measuring DC Volts: Set the switch on the probe to the NORM position; set the Function switch to either the plus or minus DCV position; set the Range switch for a meter indication as close to full scale as possible. (If the voltage to be measured is unknown, start with the 1000 volt range and work toward the 0.1 volt range).

The DC voltage is read on the two black scales just above the mirror on the meter. The top DC scale is calibrated from 0 to 1.0 volts, with each small scale division representing .02 volts, and is used with the .1, 1, 10, 100, and 1,000 volt ranges. The second DC scale is calibrated from 0 to 3.1 volts with each small scale division representing 0.1 volts, and is used for the .3, 3, 30, and 300 volt ranges. The 0 to 1.0 volt scale is read directly for the 1.0 volt range, and is multiplied by .1, 10, 100, and 1,000 for the .1, 10, 100, and 1,000 volt ranges respectively. The 0 to 3.0 volt scale is read directly for the 3.0 volt range and is multiplied by .1, 10, and 100 for the .3, 30, and 300 volt ranges respectively. For Example: If the scale indication is .42 on the 0-1 volt scale and the Range switch is set to the 10 volt range, you would multiply .42 by 10 resulting in an actual reading or 4.5 volts. If the scale indication is 1.6 on the 0 to 3 volt scale and the Range switch is set to the 0.3 range, the actual reading would be .16 volts.

Measuring DCV with a zero center scale: The zero center scales are used to read plus or minus voltages without the necessity of changing polarity with the leads or the Function switch. To use the zero center scales, set the switch on the probe to the Normal position. Set the Function switch to plus DCV, and adjust the ZERO ADJ until the meter reads at the zero mark in the center of the scale. This gives ranges of plus or minus 0.5 volts (upper scale), or plus or minus 1.5 volts (lower scale). The meter scales are then multiplied by 0.1, 10, 100, or 1,000 depending on the setting of the Range switch. If the Range switch is on the 300 volt position, then the 1.5 volt scale would be multiplied by 100 resulting in a range of plus or minus 150 volts. If the Range switch were on the 0.1 volt range, the plus or minus .5 volt range would be read as plus or minus .05 volts.

If the meter moves up scale to the right, the voltage is positive, and if the pointer moves to the left, the voltage is negative. With a calibrated zero center scale, you can determine not only the polarity of a voltage, but also its magnitude.

Measuring DC Current: To measure DC current, set the probe switch to the Normal position, the Function switch to the +DC mA position, and the Range switch to the desired current range. Remove power from the equipment to be measured, and connect the FE20 in series with the current to be measured. Connect the negative meter lead to the negative source of current and the positive meter lead to the positive source of current. (If the current to be measured is unknown, start with the 1A range and work toward the .1 mA range). Reconnect the power to the equipment being measured, and read the current on the appropriate meter scale. If the meter reads in the negative direction, the current polarity is reversed from that expected and the Function switch of the FE20 should be turned to the -DC mA position.

The zero center scales may also be used to measure DC current. With the Function switch in the +DC mA position, and the Range switch set correctly, adjust the meter for zero center and apply current to be measured to FE20.

The 100 uA to 300 mA current ranges are protected by the front panel fuse. On the 1 amp range, the shunt resistor is a coil of resistance wire, and will withstand sustained heavy overloads, however, it is possible to damage this shunt resistor if the overload is not removed immediately.

Measuring AC Volts: To read AC Volts, set the Function switch to the AC volts position and the Range switch to the desired voltage range. The switch on the probe should be in the Normal position. To measure RMS voltage, the two black scales marked ACV (rms) are used. To measure peak to peak voltage, the two red scales marked ACV (P-P) are used. The scale readings are multiplied by the same multiplier factors as were used in DCV measurements. On the 0 to 1 volt scale, each small division represents .02 volts, and on the 0 to 3 volt scale, each small scale division represents .1 volts. On the 0 to 2.5 volt peak to peak scale, each small scale division represents .1 volt, and on the 0 to 9 volt peak to peak scale, each small scale division represents .2 volts.

Example: If the scale indication is .6 on the 0 to 1 V AC (RMS) scale, and the Range switch is set to the 0.1 volt range, the actual voltage reading would be 0.6 multiplied by 0.1, or .06 volts AC RMS.

Measuring Resistance (HI POWER OHMS): To measure resistance, set the Function switch to the HI POWER OHMS position, and the Range switch to the range that will put the resistance to be measured as close to the center of the meter scale as possible. When you switch the Function switch to the ohms functions, the meter pointer will move from the left hand edge of the meter (Zero) to the infinity mark on the right hand side of the meter. Use the ohms adjust control to adjust the meter pointer to exactly the infinity mark on the right hand side of the meter.

When the meter leads are shorted together, the meter will indicate zero ohms on the left hand side of the meter. Be sure that the Probe switch is in the Normal position. Any resistance on the Rx1 range is the resistance of the switch contacts and internal wiring in the meter circuit. This small value of resistance (approximately 1.4 ohm) should be subtracted from the measured reading.

When using the HI POWER OHMS function in solid state circuits, the applied voltage from the FE20 will be high enough to cause the diodes or transistors to conduct. This can be used to an advantage because the front to back ratio of the transistor or diode may be measured by reversing the meter leads. The probe lead is + and the black lead - in the ohms functions.

Measuring Resistance (LO POWER OHMS): The LO POWER OHMS function is used to make resistance measurements in solid state circuits when the resistance of the diode or transistor junctions cause an objectionable error. The resistances measured with the FE20 in the LO POWER OHMS function will be the resistance of the circuit components surrounding the transistor or diode, and will not be affected by either. The LO POWER OHMS function applies only .08 volts to the circuit being measured, and even a germanium diode requires a higher voltage to start conducting. The operation of the LO POWER OHMS is the same as that of HI POWER OHMS. Note: To conserve OHMS battery power, DO NOT LEAVE THE FE20 IN THE LO POWER OHMS POSITION WHEN NOT MAKING RESISTANCE MEASUREMENTS. There is a continuous drain of approximately 7 mA from the ohms battery in the LO POWER OHMS position. This 7 mA ohms battery drain can be eliminated by switching to another function.

Measuring Resistance of Thermistors: The LO POWER OHMS function is a must for making accurate measurements of resistances of Thermistors of low resistance value. If this measurement is made in the Hi Power Ohms function, a changing resistance reading will result due to heating caused by the higher current flow through the Thermistor. The Thermistor should not be held in the hand and should be kept away from any other heat to obtain the most accurate measurement.

CAUTION: When making resistance measurements be sure that the power to the equipment under test is disconnected. If voltage is applied to the ohms ranges, the fuse F1 will have to be replaced.

MEASURING HIGH VOLTAGE WITH THE FE20

CAUTION: High voltage is dangerous and caution should be observed when measuring high voltages. Be sure that the ground lead from the FE20 is connected to the appropriate ground in the equipment being measured. If the ground lead is not connected, you are merely extending the high voltage closer to you. If the ground lead is connected to the wrong ground in the equipment being measured, you run the risk of possible damage to the equipment being tested. Stand away from the equipment being measured and keep one hand in your pocket as a safety measure. High voltage in color TV is especially dangerous because it can go as high as 30,000 volts and it is regulated. If you should come into contact with it, it will not load down.

The 39A30 high voltage probe is used to extend the range of the FE20 to 30,000 volts DC. This probe may be used with any DC voltage range on the FE20 to act as a times 100 multiplier and to increase the input impedance of the FE20 to 1500 megohms. In other words, the 0.1 volt range would become a 10 volt range with a high enough input impedance (1500 megohms) which would not affect the most critical circuit.

To use the 39A30 probe, remove the two parts of the probe from the brackets in the cover of the FE20. Insert the end of the probe body with the banana plug of the probe body seat in the banana jack inside the handle. Insert the normal test probe of the FE20 into the small opening of the 39A30 probe, and place the probe switch in the normal position.

To read the actual voltage, multiply the readings on the 3 volt scale by 1000 for the 3KV range, the 1 volt scale by 10,000 for the 10KV range and the 3 volt scale by 10,000 for the 30KV range.

To measure high voltage, set the Function switch to either the plus or minus DCV position and the Range switch to one of the three high voltage positions, 3KV, 10KV or 30KV. Connect the ground lead of the FE20 to the appropriate ground point in the equipment being measured. Be sure to read the preceding paragraphs on the caution to be taken when measuring high voltage, and on the operation of the 39A30 high voltage probe. The 3KV, 10KV and 30KV ranges are to be used only with the 39A30 probe.

Measuring Decibels (db): The FE20 has a convenient db scale for easy db measurements. The nine AC voltage ranges are in perfect 10 db steps, so that starting from "O" db on the 1.0 volt range, you add 10 db for each range above 1.0 volts and subtract 10 db for each range below 1.0 volts. Db measurements are actually a measure of the ratio between the power in the circuit under test, and some reference power level. The reference level used for the FE20 is a 1 milliwatt into 600 ohms. If the impedance being measured across is other than 600 ohms, you will have to use the chart in Figure 1 to determine the actual power level or db. Example: The scale reading

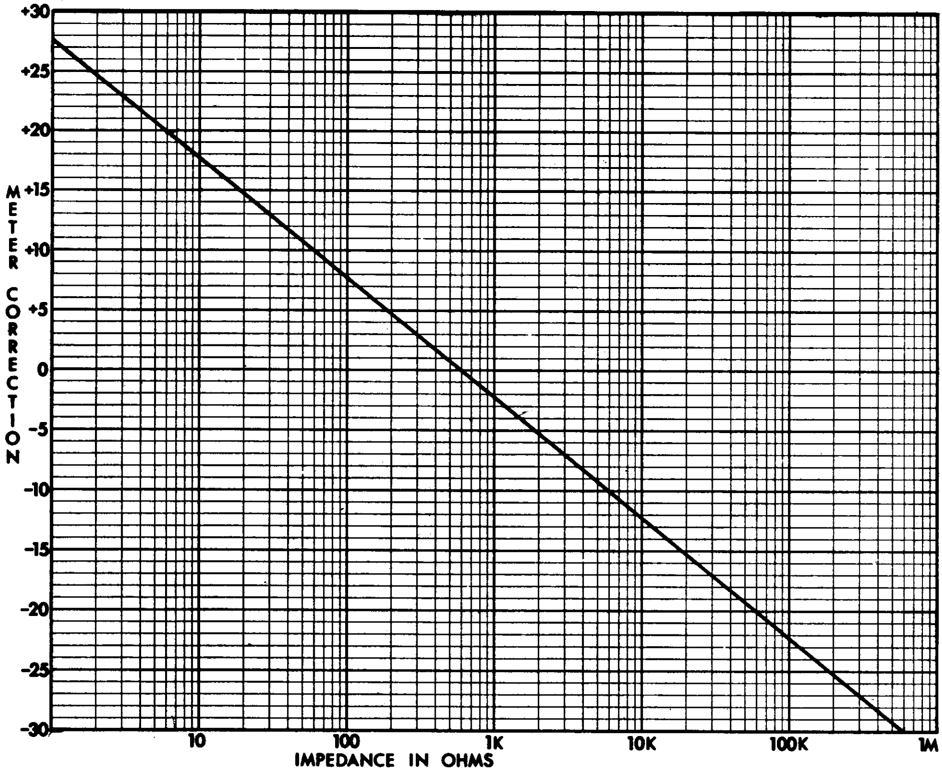


Fig. 1 db Correction Chart

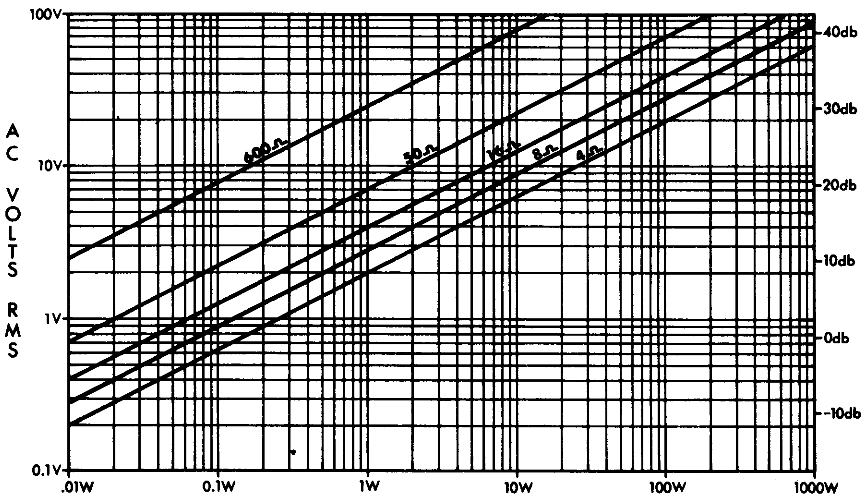


Fig. 2 Voltage vs. Power Chart (sine wave conditions only)

is -4db, the Range switch is on the 100 volt scale, and the impedance is 6 ohms. The 100 volt range is 4 ranges higher than the 1.0 volt range, so adding 40 db to the meter reading results in 36 db. Using the chart in Figure 1, the correction factor is plus ~~30~~ 20 ? db, or an actual db measurement of 56 db.

The chart in Figure 2 can be used to determine the actual power being dissipated in a circuit if the circuit impedance along with either the applied voltage, or the db as measured on the FE20 meter is known. The chart in Figure 2 also shows the relationship of AC volts to db. If the AC voltage is increased 10 times, the db reading goes up by 20 db.

Note: The db scales of the FE20 and the charts in Figure 1 and Figure 2 only apply when the voltage being measured is a pure sine wave as from an audio generator. The FE20 is a true reading peak to peak meter and the complex waveform of music material will not give a true RMS reading for the db system to work on.

Measuring AC Current with the FE20: The FE20 can be used to measure AC current with the circuit shown below. The resistor or resistors are placed in series with the AC source going to the device under test. The FE20 is set to the AC Volts function and the AC voltage drop across the resistors is measured and can be converted directly into AC amps. It would be most convenient to build this adaptor into a box with a switch to change ranges. The resistors used are all 1 ohm of at least one watt. The Ohmite 995 series of 1 1/2 watt wirewound resistors is ideal for this. A standard one watt carbon resistor will also work, but if the unit is to be left on for an extended period of time, a two watt should be used.

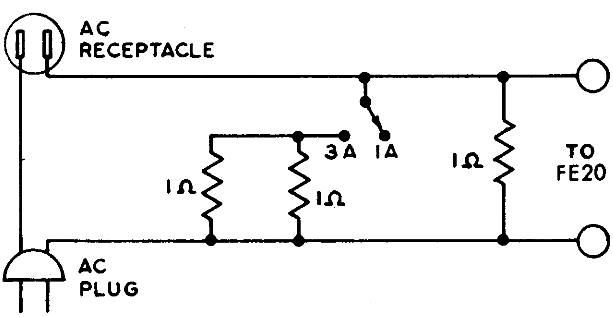


Fig. 3 AC Current Adapter

When measuring from zero to one amp, the one ohm resistor is used, and the FE20 Range switch is in the one volt position. To measure three amps of AC current, the switch is closed so that there are now three one ohm resistors in parallel. A current of three amps will now produce a one volt drop across the three resistors, so leave the FE20 on the one volt range, and read the 0 to 3.0 scale for three amps of AC current.

Measuring Small Leakage Current: The FE20 can be used to measure the leakage current of any low leakage device. All that is necessary is a power supply rated at the test voltage of the device being measured, 2-15 meg ohm resistors and your FE20. Connect the 2-15 meg ohm resistors in series across the input of the FE20, and then connect the power supply, the device under test, and the FE20 in series. (See Fig. 4).

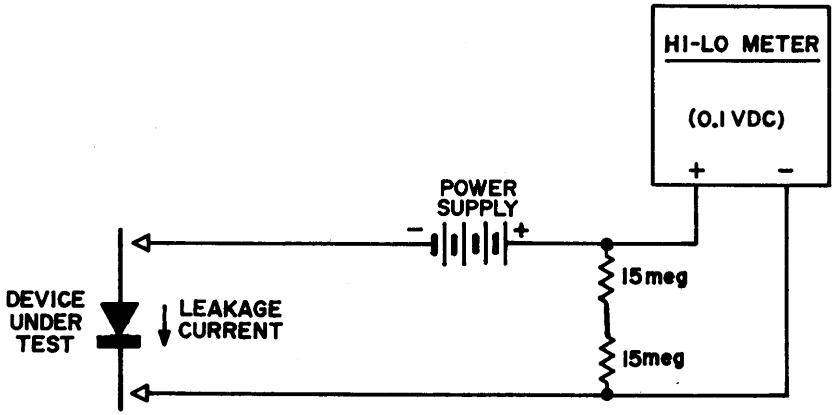


Fig. 4 Measuring Small Leakage Currents

Set the Range switch to .1 V, and the Function switch to + DCV position, the Probe switch to the normal position. The FE20 will now read leakage from 0 to .01 ua (10na) on the 0-1 scale.

Overload Protection: Your FE20 is protected against accidental overloads on all ranges and functions. The voltage ranges are protected because the high input impedance of the FE20 limits the amount of current that can flow into the meter to damage it. On the resistance and current functions, the fuse F1 on the front panel of the FE20 protects both the meter movement and the circuitry of the FE20. This fuse should be replaced with one of the same type so that the protection feature or accuracy of the FE20 are not affected. Input switching and components are protected against accidental overload by a spark gap. Meter protection is provided by a germanium diode across its terminals.

FUSE TYPE: 3AG .6AMP. DO NOT use a slow blow type fuse. Inaccuracy and possible damage to the HI-LO meter may result.

CIRCUIT DESCRIPTION

General

The Sencore FE20 Field Effect meter uses a balanced bridge impedance converter consisting of two Field Effect and two bi-polar transistors. This circuitry provides high input impedance and excellent stability. When measuring AC volts an additional amplifier stage which is compensated against changes in voltage, temperature and frequency is used to drive the peak to peak detector.

DC Voltage: The DC voltage at the input passes through the AC rejection filter consisting of R1 and C1 to the voltage divider (R2 through R10). The Range switch S3B selects the required input voltage to be applied to the gate of TR1. The FET TR1 provides the necessary high input impedance, and drives the base of TR2. The source output of TR1 and the collector output of TR2 are in parallel, with both output currents flowing through the common load resistor R29. TR2 provides the necessary current gain required to drive the meter. The TR3 and TR4 section of the balanced impedance converter is held constant, because the gate of TR4 is tied to ground through the AC cal control R36. The meter, in series with the DC cal control, is connected between the collector of TR2 and the collector of TR3, with the positive meter lead connected to the collector of TR2.

This balanced impedance converter is temperature stable because any change in temperature will affect both sides of the balanced circuit equally, keeping the circuit balanced. The circuit is compensated against changes in supply voltage, because the voltage at the source of TR4 remains nearly constant and is used as a bias voltage for TR1 gate. It is applied to the gate of TR1 through resistor R40, the DC balance control R39 and the zero adjust R50.

DC Current: When measuring DC current, one of the standard resistors, R17 through R25, is selected by the Range switch to be put in series with the circuit to be measured. The circuit described in the preceding paragraph (DC voltage) is then used to measure the voltage across the standard resistor. The fuse F1 protects R17 through R24, or up to the 300 mA range. The meter movement itself is protected on all ranges because it is isolated thru the impedance converter and shunted with a diode.

Resistance (HI POWER): To measure the resistance of an unknown resistor, the FE20 connects the unknown resistance, a 1.5 volt battery, and a standard resistor in series. The FE20 then measures the voltage across the unknown resistance. The ohms adjust control has the same effect as the DC cal control, in that it is connected in series with the meter and is used to adjust the sensitivity of the meter. When there is an infinite unknown resistance (open circuit) the FE20 will measure the full battery voltage. The ohms adjust control is adjusted with the test leads open, so that the full voltage will read infinity on the meter. When the FE20 leads are shorted together, the voltage will be zero, and the meter will read zero. If an unknown resistance is exactly equal to the standard resistance in the FE20, the voltage across the unknown resistance will be one half of the total, or the meter will read one half scale. With a standard resistor of 1200 ohms, and the unknown resistance of 1200 ohms, one half of the voltage would be across the unknown resistor, and the FE20 would read one half scale. A reading of 1/2 scale would be equal to 1200 ohms. The S3A section of the Range switch is used to select different standard resistors for the different resistance ranges. All resistance standard resistors, except the RX10 and RX100 ranges, are protected from overloads by the fuse F1.

Resistance (LO POWER): The LO POWER ohms function on the FE20 is to be used when working on solid state equipment in cases where the resistance of the resistors alone, and not the diode junction resistance of the transistors is important. The LO POWER ohms function applies only .08 volts (80 mv) to the circuit being measured, so that the diode junctions of any transistor will not conduct.

The LO POWER ohms function operates the same as the HI POWER ohms function, with the exception that a voltage divider comprised of R14 and R15 is used to set the test voltage to .08 volts. The DC voltage measuring circuit of the FE20 is still connected across the unknown resistance, but the sensitivity of the voltage measuring circuit is increased so that .08 volts will read full scale. The S3A section of the Range switch is used to select different standard resistors for the ohms ranges.

AC Voltage: The AC voltage at the input is coupled through C1 to the top of the voltage divider comprised of R2 through R10. The S3B section of the Range switch selects the voltage to be applied to the input of TR1. TR1 acts as a source follower. The output of TR1 and TR2 is coupled through C12 and R38 to the input of TR5. TR5 acts as a common emitter amplifier to provide a voltage gain of approximately 10 times. TR5 drives the peak to peak detector comprised of C13, C16, CR3, and CR4. A negative output from the peak to peak detector is applied through R33 and the AC cal control (R36) to the gate of TR4. The DC voltage applied to the gate of TR4 caused the bridge to be unbalanced and the meter to read the AC voltage.

MAINTENANCE

Introduction: The only normal maintenance required by the FE20 is replacement of the batteries. The calibration and balance adjustments have been made carefully and accurately at the factory, and should not need readjusting, unless a component should change value.

If you wish to service the FE20 yourself, refer to the following procedures for instructions on how to disassemble, calibrate and troubleshoot.

Disassembly Instructions: There are six screws that must be removed to remove the FE20 from its case. First, remove the four screws from the back of the FE20. This loosens the main assembly from the case. Second, remove the two screws inside the lead compartment. This loosens the sub panel from the case. Third, lift the main assembly and the sub panel out of the case at the same time. Take care to do this gently, as the battery holder will remain inside the case. Fourth, lift the battery holder off the two posts that locate it in the bottom of the case.

For the location of the following adjustments, refer to the PC board layout diagram. Figure 5.

Calibration of the HI-LO Meter

DC Balance: The DC balance control is adjusted, so that with the front panel zero adjust control fully clockwise and the Function switch in the DC volts or current position, the meter will indicate between .6 and .7 on the 0 to 1 volt scale. To adjust the DC balance control, set the Range switch to the 1KV range, set the Function switch to either DC volts position, and turn the front panel zero adjust control fully clockwise. Adjust the DC balance control until the meter indicates .7 on the 0 to 1 volt scale.

Zero Range adjustment: Set the zero adjust control to exactly 1/2 rotation. Adjust zero range adjustment so that meter reads zero. Recheck DC balance range and readjust if necessary.

DC Volts Calibration: First check the setting of the mechanical and electrical zero adjustments. Set the Range switch to the .1 volt range, and the Function switch to the plus DC volts position. Check to see if probe switch is in normal position. Apply exactly .1 volts DC to the input terminals, and adjust R41 for exactly a 1.0 indication on the meter.

AC Volts Calibration: First check the setting of the mechanical and electrical zero adjustments. Set the Range switch to the .1 volt position, and the Function switch to the AC volts position. Short test leads together and zero meter. Apply exactly .1 volts AC sine wave (60 Hz to 1KHz) to the input terminals, and adjust R36 for exactly a 1.0 indication on the meter.

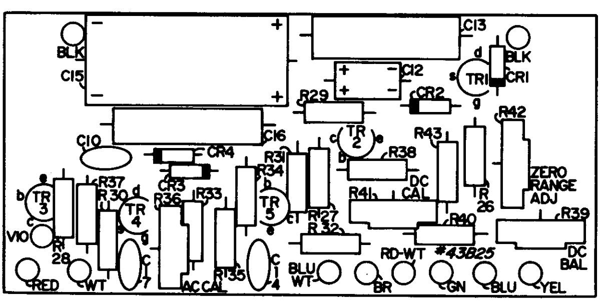


Fig. 5 P.C. Board Layout

Building a Meter Calibrator

If an accurate source of .1 volt AC and DC is not available, you may wish to build an inexpensive meter calibrator such as the one shown below: You may order all the electronic components from Sencore, with the exception of the battery, for $5.00. Or, you may purchase parts locally. The accuracy of the calibration with this fixture will be the accuracy of the battery, which on a new cell is on the order of 1.5%. The 2.8 V battery is two 1.4 volt mercury batteries connected in series.

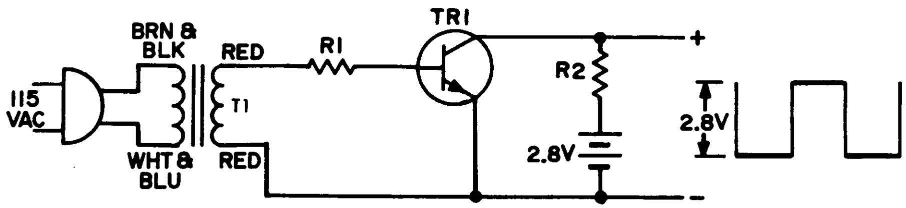


Fig. 6 Calibrator for HI-LO Meter

T1	-	28A35 Transformer - Any low current transformer with secondary voltage between 6 volts and 12 volts.
TR1	-	19G29 Transistor 2N5172
R1	-	Resistor 5.6K 1/2W 10%
R2	-	Resistor 10K 1/2W 10%

With the AC signal from the transformer connected to the base of the transistor, the fixture will produce a square wave of the same peak to peak value as the battery voltage, (2.8V). Due to the slight error of reading peak to peak voltages of a square wave with any true reading peak to peak meter, the 2.8V peak to peak signal will indicate exactly 3.0V peak to peak on the FE20. Use the 2.8 volt peak to peak scale, and adjust R36 the AC cal control for 3.0 volts peak to peak on the meter. With the signal removed from the base of the transistor, the output will be the battery voltage or 2.8 volts DC. This 2.8 volts DC may be used to calibrate the 3 volt DC range. Set the FE20 to the 3 volt range, and adjust R41 the DC cal control for 2.8 volts on the meter.

FE20 TROUBLE CHART:

Symptom	Probable cause	Corrective Measure
Unit dead, meter does not read;	Defective batteries; Poor battery contact; Broken wire from battery bracket;	Check and replace; Check battery contacts; Check battery wiring;
1 amp range inoperative;	Burned out R25	Replace resistor (coil of resistance wire)
Ohms functions will not operate;	Blown fuse Defective ohms battery; Poor contact on ohms battery; Broken wire from battery bracket;	Replace fuse check and replace; Check contact tension; Check wires from ohms battery;
AC volts readings Inaccurate;	Probe switch in wrong position; Weak main batteries; Defect in P/P detector; CR4, C16 R26 changed value;	Set switch on probe to "NORM"; Operate main battery; check switch; replace batteries if necessary; Check components and replace when necessary; Check resistance of R26;
Meter reads up scale in .1VDC position only and on RX1M range only;	Defective TR1, or CR2;	Check components for leakage and replace when necessary;
Meter reads up scale in .1VAC position;	AC Pickup (Normal condition in strong electrical field);	Short test leads together to remove AC pickup;

Symptom	Probable cause	Corrective Measure
Meter pins in ohms function;	Range switch incorrectly set;	Set Range switch to active range;
Meter reads slightly up scale in RX1 and RX10 ohms positions with test leads shorted;	Indication is that of test leads, switch contacts and fuse resistance. This is a normal condition;	Zero Adj ohms in RX100 or above ranges;

SERVICE AND WARRANTY

You have just purchased one of the finest field effect voltmeters on the market today. The Sencore HI-LO Meter has been inspected and tested twice at the factory to insure the best quality instrument to you. If something should happen, the HI-LO Meter is covered by a standard 90 day warranty as explained on the warranty policy enclosed with your instrument.

For the best service on out of warranty work, send the HI-LO Field Effect Meter directly to the factory service department. Be sure to state the nature of your problem to insure faster service.

If you wish to repair your own HI-LO Field Effect Meter, we have included a schematic, parts list, and trouble chart. Any of these parts may be ordered directly from the factory service department.

We reserve the right to examine defective components before an in warranty replacement part is issued.

SENCORE

NO. 1 MANUFACTURER OF ELECTRONIC MAINTENANCE EQUIPMENT

3200 SENCORE DRIVE, SIOUX FALLS, SOUTH DAKOTA 57107

Form 545

SENCORE

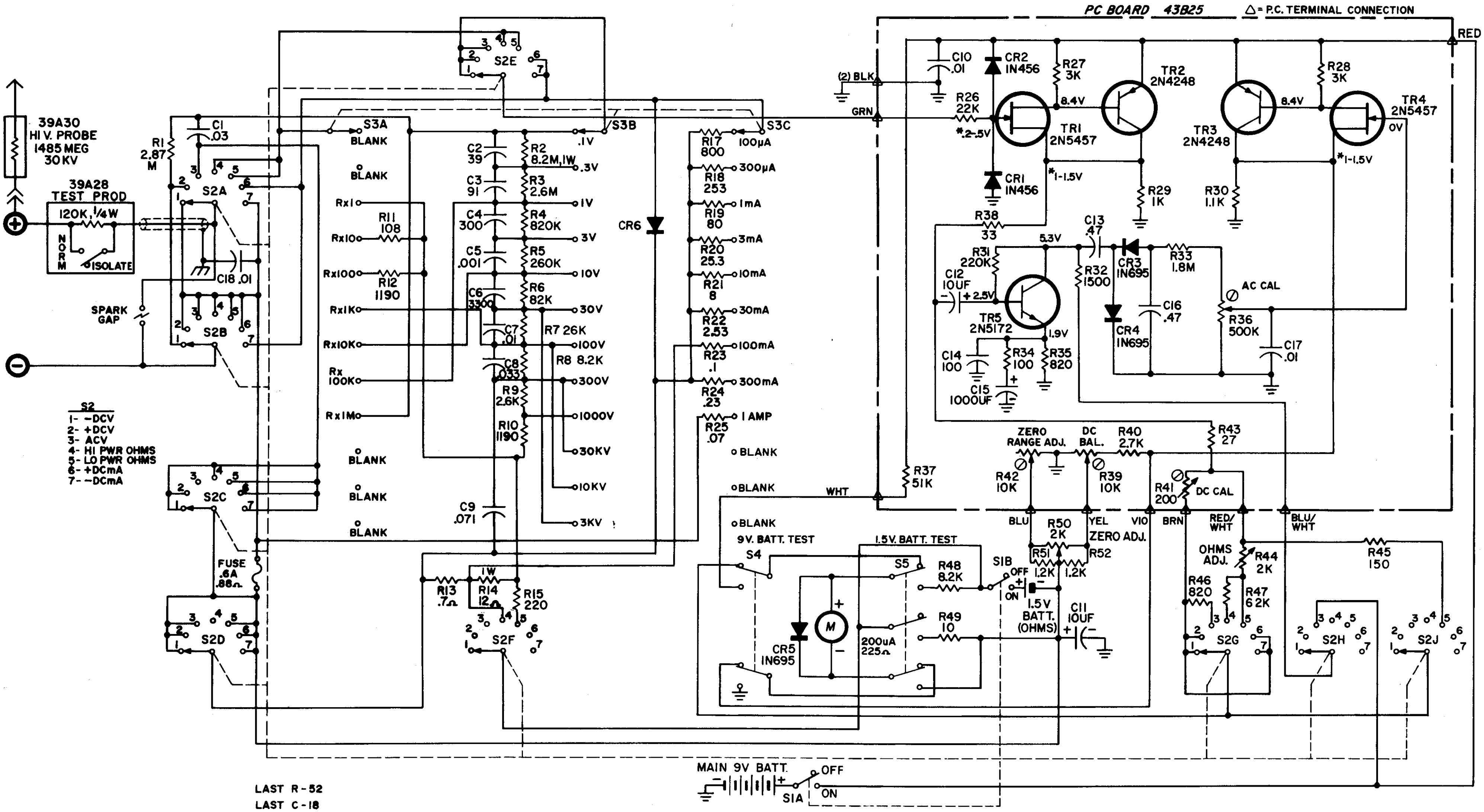
NO. 1 MANUFACTURER OF ELECTRONIC MAINTENANCE EQUIPMENT

3200 SENCORE DRIVE, SIOUX FALLS, SOUTH DAKOTA 57107

SCHEMATIC AND PARTS LIST
FOR
FE20 HI-LO METER

CAPACITORS SCHEMATIC REFERENCE	PART NO.	DESCRIPTION	PRICE
C2	24G220	39PF@700V Disc	.25
C3	24G187	91PF @630V 2.5% Poly	.25
C4	24G217	300PF @63V 5% Poly	.25
C6	24G182	3300PF@33V 5% Poly	.25
C7	24G183	.01 MF@33V 5% Poly	.25
C8	24G184	.033MF@63V 5% MYLAR	.25
C9	24G185	.071MF@33V 5% Poly	.25
RESISTORS			
R1	14C29=2876	2.87MEG 1/2w 1%	.75
R2	14C31-8206	8.2MEG 1w 1%	.75
R3	14C28-2606	2.6MEG 1/2w 1/2%	1.25
R4	14C28-8205	820K 1/2w 1/2%	1.25
R5	14C28-2605	260K 1/2w 1/2%	1.25

RESISTORS			
R6	14C28=8204	82K 1/2w 1/2%	1.25
R7	14C28-2604	26K 1/2w 1/2%	1.25
R8	14C28-8203	8.2K 1/2w 1/2%	1.25
R9	14C28-2603	2.6K 1/2w 1/2%	1.25
R10 & 12	14A41-1193	1.19K 1/2w 1%	.75
R11	14C29-1082	108 ohms 1/2w 1%	.75
R13	14B65-7	.7 ohm wire	.75
R14	14C32-1201	12 ohm 1w 1%	.75
R16			
R17	14A41-8002	800 ohm 1/2w 1%	.75
R18	14A41-2532	253 ohm 1/2w 1%	.75
R19	14A41-8001	80 ohm 1/2w 1%	.75
R20	14A41-2531	25.3 ohm 1/2w 1%	.75
R21	14A41-8000	8 ohm 1/2w 1%	.75
R22	14A4-2530	2.53 ohm 1/2w 1%	.75
R23	14B65-5	.1 ohm wire	.75
R24	14B65-8	.25 ohm wire	.75
R25	14B65-6	.067 ohm wire	.75
Hi V Probe	14A63-3 1485 MEG, 30KV		
SEMICONDUCTORS			
TR 1, 4	19C11-1	2N5457 FET (specify color)	1.25
TR 2, 3	19C14-1	2N4248 PNP Silicon	.50
TR 5	19C4-1	2N5172 NPN Silicon	.50
CR 1, 2	50C5-1	1N456 DIODE	.50
CR 3, 4, 5	50C3-2	1N695 DIODE	.50
CR 6	16S10	1N4004 RECTIFIER	1.00
CONTROLS			
R36	15C7-6	500K VERT P.C.MT.	.75
R39, 42	15C7-2	10K VERT P.C. MT.	.75
R41	15C7-15	200 OHM VERT P.C. MT.	.75
R44, 50	15B8-1	2K PANEL MT	.75
MISCELLANEOUS			
	23C35	6" 200 uA METER	25.00
S1	25A135	RANGE SWITCH	9.95
S2	25A134	FUNCTION SWITCH	8.95
	25A132	MINI SLIDE SWITCH FOR TEST PROBE	.50
	39A28-2	TEST PROBE COMPLETE WITH CABLE FOR FE20	
	39A30	HIGH VOLTAGE PROBE	12.00



LAST R-52
LAST C-18

*-VOLTAGE DEPENDS ON FET SELECTION.

FE20 SCHEMATIC

ISSUE DATE: 6-17-70

SENCORE INC. - FE20