AC/DC Electrostatic Voltmeters

Model ESH

Electrostatic Voltmeter
(high voltage)

Model ESH AC / DC electrostatic voltmeter is available as a single range instrument up to 100 kv fs (150 kv DC only), or with as many as 4 switch-controlled ranges from 3 to 50 kv fs.

Their extremely high impedance (typically 1 x 10^{15th}) prevents loading down circuits. Capacitance varies from approx. 30mmfd on the 5 kv range to 10mmfd on the 50 kv range.

Accuracy is normally +/- 1 % fs but is available to +/- 0.5% fs on selected models up to 50 kv.

6" scale length. Transit lock, carrying handles and brackets for panel mounting available.

Sensitive Research* INSTRUMENTS *A Trademark of EIS

ELECTRICAL INSTRUMENT SERVICE, INC. 25 Dock Street, Mount Vernon, N. Y. 10550 - (914) 699-9717

ELECTROSTATIC VOLTMETERS .5% ACCURACY OPTIONS

SPECIFICATIONS

AC/DC PORTABLE — HORIZONTAL USE

ACCURACY	1% or .5%
SCALE LENGTH	6 inches
SCALE DIVISIONS	Up to 100 as required
PERIOD	3 - 5 seconds
TYPE	Electrostatic
PIVOTS	Diamond Pivoted
JEWELS	Sapphire Spring Mounted
CAPACITY	See below
SHIELDING	Electrostatic
RANGE CHANGING	Multirange, switch controlled
CASE	Cast Aluminum
SIZE	Table on right
INST. WEIGHT	Table on right

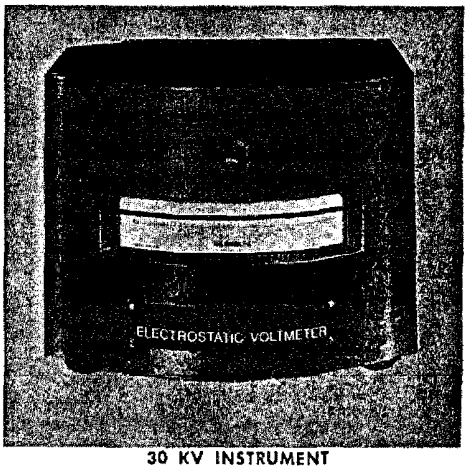
MODEL ESH

Double Pivoted Movement

SINGLE RANGE

Model	Range (KV)	Code Word	Case Style	Lowest Reading
ESH–1	7.5	ESHOLM	A	1.5 KV
ESH–2	10	ESHILT	A	2
ESH–3	15	ESHAIM	A	3
ESH–4	20	ESHUNS	A	4
ESH–5	25	ESHULK	A	5
ESH–6	30	ESHORE	A	6
ESH–7	40	ESHPOT	B	10
ESH–8	50	ESHIGH	B	10
ESH–9	60	ESHPEC	C	10
ESH–10	75	ESHHIY	C	15
†ESH–11	100	ESHOOP	D	20
*†ESH–12	140	ESHCXL	D	30
*†ESH–12M	150	ESHIBM	D	30

*- FOR USE ON DC ONLY
†- ACCURACY DC 2%



30 KV INSTRUMENT

The insulation resistance of these instruments is very high—for instance on the 75 K.V. and 100 K.V. design it is more than 5 x 10^{15} ohms.

HIGH VOLTAGE ELECTROSTATIC DESIGN MULTIRANGE VOLTMETERS FOR A.C. AND D.C.

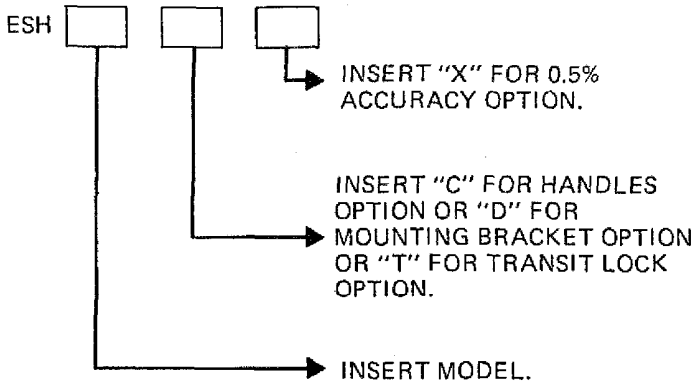
By using a uniquely designed internal high voltage switch, multiranges of voltages from 3000 full scale volts up to 50,000 volts are obtained. This system has a distinct advantage because the capacity of the instrument decreases as the ranges increase. Briefly explained, the switch operating in successive "click" positions, moves the stator electrode away from the rotor in predetermined positions. The voltmeter is not limited to AC but can be used over all its ranges on DC. The capacity of its lowest range (3000 volts) is approximately 11 mmfd, and is about 10 mmfd at 50 to 100 kilovolts.

SWITCH CONTROLLED MULTIRANGE VOLTMETERS

Model	Code	Range	Case Type	Lowest Reading
ESH–13	ESHAKE	5/10 KV	A	1000 V
ESH–14	ESHEEP	5/15	A	1000
ESH–15	ESHICK	10/15	A	2000
ESH–16	ESHOTS	10/20	A	2000
ESH–17	ESHAMP	10/30	A	2000
ESH–18	ESHULE	15/30	A	3000
ESH–19	ESHUL	5/7.5/10	A	1000
ESH–20	ESHMIP	5/10/15	A	1000
ESH–21	ESHMOT	5/15/30	A	1000
ESH–22	ESHMUS	10/20/30	A	2000
ESH–23	ESHMIX	10/25/50	B	2000
ESH–24	ESHUTE	5/7.5/15/30	A	1000
ESH–25	ESHMOO	5/10/15/20	A	1000
ESH–26	ESHMEE	5/10/20/30	A	1000
ESH–27	ESHMAY	10/20/30/40	B	2000
ESH–28	ESHMAX	5/10/25/50	B	1000
ESH–29	ESHDCH	3/7.5/15/30	A	600
ESH–30	ESHMIL	3/10/30	A	600
ESH–31	ESHALL	3/7.5/15	A	600
ESH–32	ESHALE	20/40	B	4000
ESH–33	ESHAME	25/50	B	5000

NOTE: All Models except ESH - 9, 10, 11, 12, 12M, available at 0.5% Accuracy

HOW TO ORDER A MODEL ESH



EXAMPLE: ESH 7 DX = A 40 KILOVOLT INSTRUMENT WITH MOUNTING BRACKET AND 0.5% ACCURACY.

NON–CATALOG INSTRUMENTS

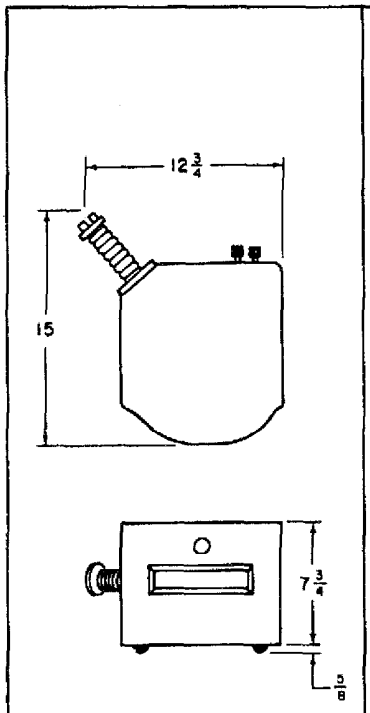
ANY COMBINATION OF UP TO 4 RANGES CAN BE SUPPLIED PROVIDING:

(A) RANGES ARE BETWEEN 3 AND 50 KV.
(B) RANGES ARE SPACED AT LEAST 5 KV APART.
(C) RATIO BETWEEN HIGHEST AND LOWEST RANGE IS NOT GREATER THAN 10:1.

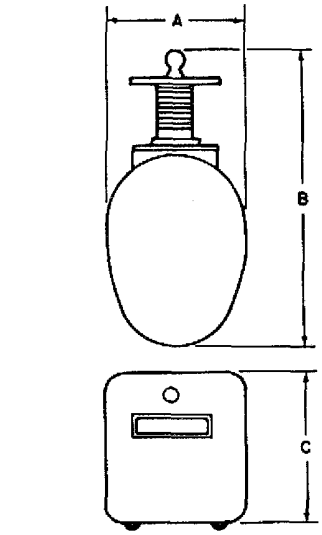
COST WILL BE THE SAME PRICE AS AN INSTRUMENT HAVING THE SAME NUMBER OF RANGES AND THE SAME HIGHEST FULL SCALE RANGE. IF THE SAME HIGHEST RANGE IS NOT LISTED, USE PRICE FOR THE NEXT HIGHER RANGE.

Case Style	Size	Weight	Shipping Weight
A	16" x 13" x 9	21 lbs.	29 lbs.
B	23-1/2" x 13" x 14-1/2"	29 lbs.	39 lbs.
C	42-1/2" x 21-1/4" x 22"	101 lbs.	217 lbs.
D	52" x 27" x 26"	145 lbs.	358 lbs.

Outline Dimensions

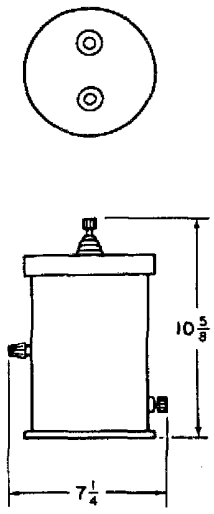


Case Style A

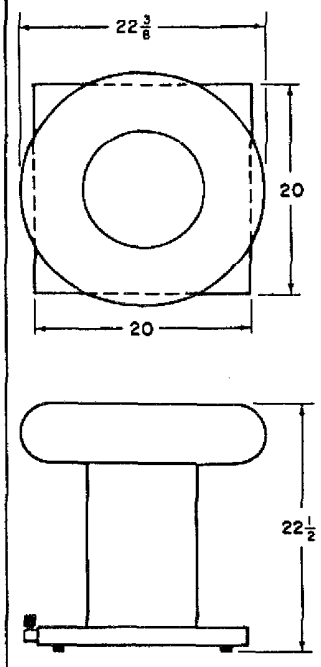


STYLE	DIMENSION		
	A	B	C
B	13 in	23 1/2 in	14 1/2 in
C	21 1/4 in	42 1/2 in	22 in
D	27 in	54 in	26 in

Case Style B, C, D



Model VPA



Model Park

CHARACTERISTICS OF THE ELECTROSTATIC VOLTMETER

Measures True Voltage Directly

The outstanding feature of electrostatic voltmeters is that they represent the only true method of measuring voltage directly. Conventional voltmeters universally measure voltage as a function of current. The electrostatic voltmeter operates directly from the impressed voltage and draws virtually no current. Any current that does flow is incidental to the measurement and is not the cause of the deflection. The deflection is directly proportional only to the rms value of the voltage appearing between the plates.

On DC the instrument draws a momentary charging current which instantly drops to a negligible value determined by the insulation resistance of the instrument. The insulation resistance is always several terohms and varies with the type of instrument, temperature, humidity and other factors. However, under the worst conditions, charging current from this cause is several hundred times smaller than the current drawn by any other type of voltmeter. In the great majority of steady DC circuits, the electrostatic voltmeter can be considered a "zero current" device.

Operates Over Wide Frequency Range

The frequency range of the electrostatic voltmeter is almost unlimited. There are three factors which place the upper frequency limit on the use of the instrument.

The first is the effect of loading on the circuit being measured. The voltmeter as a circuit element is a very low loss capacitor. Its capacitance lies between the limits of 225 pf for the 120 volt instruments to about 10 pf for the 100 kilovolt type. In the radio frequency range, the reactance of the instrument is a quantity to be considered.

The second limitation is that the instrument and its leads behave as a resonant or partially resonant transmission line. The leads and the capacitive termination formed by the voltmeter movement may result in a voltage distribution along the line which is not constant. Thus the instrument may indicate a voltage which is not the same as that to which the leads are connected.

The third limitation is the current-carrying capacity of the instrument. For any given combination of voltage and frequency, such capacity will allow a current to flow. This current must not exceed 200 mA (for all models) or a permanent change in calibration may occur. This poses an upper frequency limit which is dependent on the voltage level used with the instrument.

For example: a 30 kilovolt instrument (capacity about 10 pf) at 20 kilovolt, could be used up to approximately 160 kHz.

Measures RMS Voltage of all Waveforms

The electrostatic voltmeter measures rms voltage whether the voltage is DC, sinusoidal AC, or pulsed. The pulse or high-peaked type of voltage wave usually has an rms value which is small compared to the peak value. This sometimes misleads the user into thinking that the instrument is not functioning properly.

The instantaneous torque developed by the electrostatic voltmeter is equal to a constant (for a given deflection) multiplied by the square of the instantaneous terminal voltage. If the instantaneous terminal voltage is steady DC, then the average torque which produces the deflection is the same as the instantaneous torque and the instrument reads DC voltage. When alternating voltages are applied, the instantaneous torque of the electrostatic voltmeter is proportional to the square of the instantaneous terminal voltage. This results in the alternating voltage producing surges of torque which are mechanically averaged by the instrument movement.

The instrument movement can do an accurate averaging job because it has a mechanical time constant which is very long, compared to the period of the alternating voltage being measured. Consequently, the instrument responds to the theoretical concept of root mean square voltage, regardless of wave shape.

Since the electrostatic voltmeter as a circuit element is a high quality capacitor, the power taken by the instrument is negligible.

Multirange Instruments

Sensitivity of an electrostatic voltmeter depends upon the spacing of the electrodes and can therefore be altered by varying the electrode spacing. The SENSITIVE RESEARCH Model ESH High Voltage Electrostatic Voltmeter uses this principle in a very refined mechanism for positioning the stationary electrode in as many as four positions to obtain an equivalent number of voltage measurements with one instrument. The ranges available are shown on page 6. The Model ESH also has the advantage of the voltmeter capacity decreasing as the voltage range increases.

The Model ESD electrostatic voltmeters obtain their multiranges by different means. It is not convenient to vary the spacing of the electrodes in the more sensitive instruments and so capacity type voltage multipliers are used. From the circuit shown in Figure 1, the condensers form a voltage divider for AC components which provide fixed accurate multiplying factors. The dotted resistances shown represent leakage resistances of the individual condensers used in the divider when DC is applied. Due to normal

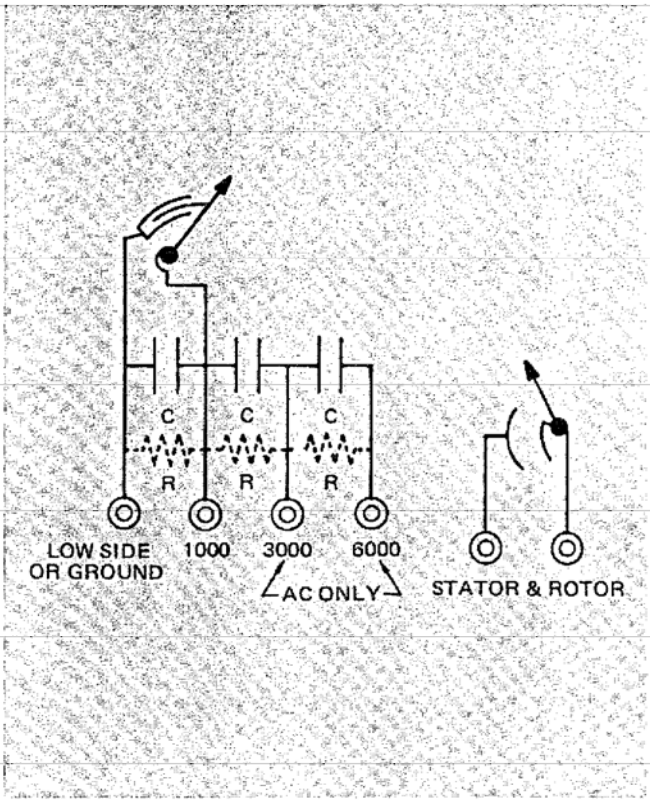


Figure 1

manufacturing tolerances, this leakage resistance can only be held within a range above some given high value, but not to a definite value of resistance. The DC path is through the leakage resistances, with the voltage appearing across the movement being proportional. Since the leakage resistances are of undetermined values, the voltages appearing across them are unreliable. For this reason, multirange Model ESD instruments should be used for DC readings only on the lowest range.

Special Uses for the Electrostatic Voltmeter:

As a High Impedance AC Voltmeter:

At commercial power frequencies, the electrostatic voltmeter provides a very high impedance instrument for many types of measurement. For instance, the Model ESH 30 kilovolt instrument at 60 hertz has an input impedance of about 266 megohms, due to its capacitance, and draws a current of only 120 microamperes. It compares favorably with any type of electronic instrument in impedance, and is much superior in long term stability.

At lower voltages such as 1000 volts, 60 hertz, the Model ESD instrument with a capacitance of about 55 pf draws a current of 20.6 microamperes. This represents an equivalent input impedance of 48.5 megohms.

High voltage measurements on high reactance transformers, such as those used for cathode ray tube supplies and low current, high voltage supplies for breakdown testing, are examples requiring high voltage measurements at low current drain.

It should also be noted that this is a completely reactive current and there is no power consumption even at low levels. This is usually a theoretical advantage, however, rather than of practical importance.

The inclusion of an electrostatic voltmeter for AC measurements at power frequencies may in many cases eliminate the necessity of electronic circuitry with the attendant difficulties of tube replacements, recalibrations, etc.

As an Extremely High Resistance DC Meter:

When used as a DC voltmeter, the electrostatic voltmeter has no equal in having high input resistance at high voltage. The electrometer tube voltmeter for measuring a few volts has a comparable input resistance, but when the range of 100 volts and up is reached, the electrostatic instrument is in a class by itself.

An electrostatic voltmeter on DC draws only a momentary charging current due to its capacitance and draws a very low current thereafter. The value of this current is very small. For instance, a 10,000 volt instrument has a leakage resistance of at least 3×10^{15} ohms. After the initial charging current, such an instrument draws a current of only 3×10^{-11} amperes, a completely negligible value.

This low current is extremely useful for many applications such as Geiger counters, condenser microphones, ionization chambers, etc. These devices employ a polarizing voltage from a very limited current source. It is difficult to measure these voltages with ordinary instruments because of the current drain error. With the electrostatic voltmeter, true readings are easily obtained. In fact, the current drain is so low that it can be neglected entirely and the meter left connected for monitoring during any operation.

"Atomic" batteries using a radioactive source for providing power in place of chemical action can be readily checked with an electrostatic voltmeter. Any other type instrument will give incorrect low readings because of the limited current capabilities of this type of battery.

Any requirement for measuring voltage in the DC ranges, from 30 to 40 volts up to 100 kilovolts, in which very limited power is available for operation of an instrument, becomes the natural field of measurement using the electrostatic voltmeter.

CHARACTERISTICS OF THE ELECTROSTATIC VOLTMETER (Continued)

Other Uses

At all times an electrostatic instrument reads the rms value of the impressed voltage. This fact makes the instrument very useful as an AC-DC transfer standard, particularly in the high voltage ranges where its low power consumption makes it an attractive transfer device. The practically infinite impedance of the instrument makes it a very successful tool for the investigation of electrostatic fields. Its use in the printing, textile and paper industries is widespread. In a place where quantities of any insulating material are moved, troublesome static charges build up. This is particularly true where long continuous sheets are handled. Static fields cause sticking, misfeeding, sparking and other difficulties.

With an appropriate probe or collector, the electrostatic instrument will provide measurement of wide fields with an accuracy limited primarily by the sensing device rather than the instrument. The measurement and plotting of such fields is the first step in being able to eliminate them to the extent required for satisfactory performance of the equipment.

The general principle to be observed in setting up such a measurement system is to provide a well insulated conductor from the field to a "field-free" position where it is connected to the high side of the electrostatic voltmeter. Under these conditions, the voltmeter reading will then be directly proportional to the field intercepted by the conductor. If such measurements have to be made at a distance, shielded cable can be used to eliminate pickup on the leads. However, the cable must be of exceptionally high insulation value or it will provide an attenuation of reading too great to tolerate.

Scale Ranges

The ESD instruments up to 1,000 volts have a nearly square law scale giving very satisfactory readings down to about 1/3 of the full scale voltage with lowest calibrated point at 1/5 of full scale. Instruments above 1,000 volts have scales which tend to close down at the upper end.

The Model ESH has neither a true square law or linear scale. Its actual configuration is based on the full scale range of the instrument, and the combination of ranges with which it is included. Its lowest calibrated point is about 1/5 full scale.

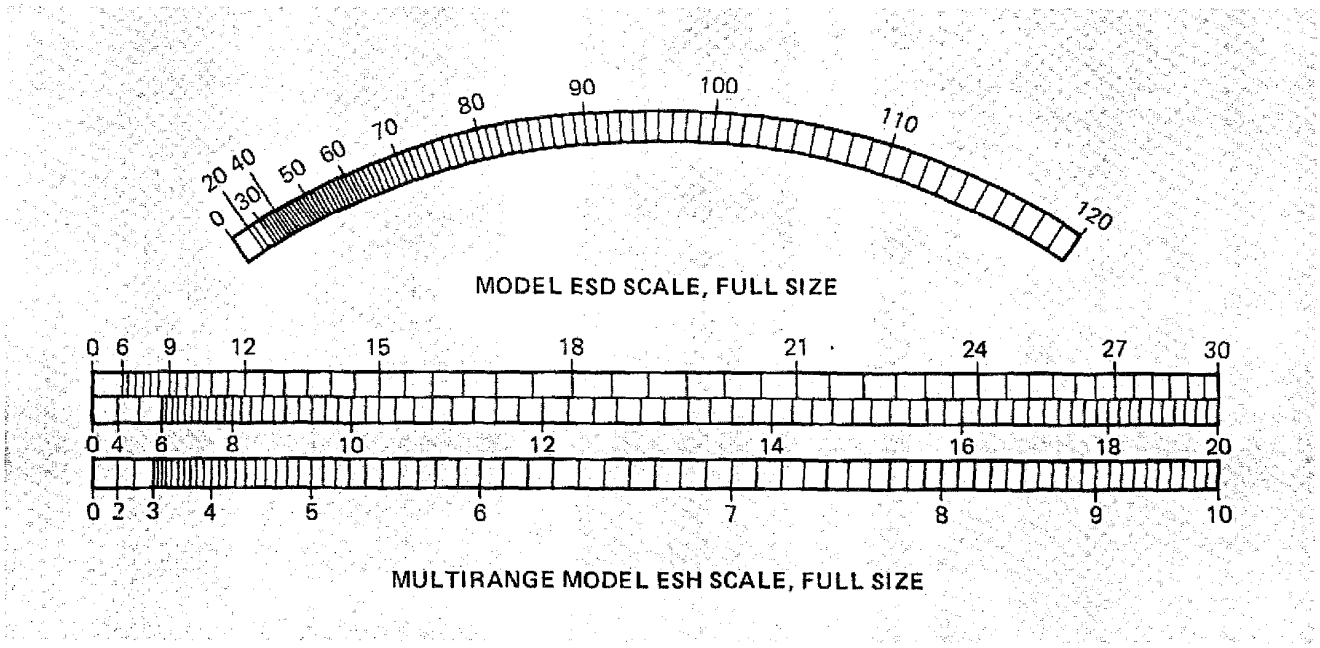


Figure 2