SCIENTIFIC COLUMBUS
AN ESTERLINE COMPANY

SCIENTIFIC COLUMBUS, INC. 1900 ARLINGATE LANE, COLUMBUS, OHIO 43228 • TELEPHONE (614) 274-7160

SC® 10V

WATTHOUR

PORTABLE STANDARD

USER'S MANUAL

 March 1988

WARRANTY

Seller warrants its Equipment to meet applicable specifications, if any, and to be free from defects in materials and workmanship for a period of one (1) year from date of shipment to the original Purchaser. Upon receipt of prompt written notice from Purchaser, referencing the order number and detailing the claimed non-conformity or defect, Seller shall, at its option, repair or replace the Equipment (f.o.b. Seller's factory in Columbus, Ohio or other designated facility).

Repair or replacement of the Equipment in the manner above is the exclusive warranty remedy and shall constitute complete fulfillment of all Seller's liabilities for breach of this Warranty. Seller assumes no responsibility hereunder for any Equipment damage or failure caused by (a) improper installation, operation or maintenance of the Equipment; or (b) normal wear and tear on disposable and/or consumable parts. This Warranty shall be void in the event of unauthorized modification or servicing of the Equipment.

THE FOREGOING WARRANTY IS EXCLUSIVE AND IN LIEU OF ANY OTHER WARRANTIES OF QUALITY, WHETHER EXPRESS OR IMPLIED (INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR PURPOSE). In no event shall Seller be liable hereunder for any special, indirect, incidental or consequential damages such as loss of profits or production.

YD-09476-001-N

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1.0 GENERAL INFORMATION

1.1 Introduction

The Scientific Columbus Type SC® 10V Portable Watthour Standard is a solid-state standard designed for field testing of watthour meters. It is physically and electrically interchangeable with electro-mechanical standards and Scientific Columbus Type SC® 10 Solid-State Standards that have been used for many years. New features include lighter weight, potential and auxiliary power auto-ranging, high intensity digital readout and one million/cph and ten million/cph pulse outputs. It may be operated in any position since there are no moving parts.

1.2 Description

The SC® 10V is housed in an aluminum case with a leather carrying strap and removable polycarbonate cover. The top panel contains the high intensity LED digital display and molded-in terminals for voltage and current connections.

Auto-ranging potential voltages (120, 240, and 480 volts) are standard on all models. Four (4) current ranges are provided in popular combinations from 1 ampere to 100 amperes. The auxiliary power voltage is auto-ranging 120/240/480 volts on all the models.

The SC® 10V displays "Equivalent Revolutions" corresponding to the calibration of rotating standards and the SC® 10, so existing test procedures and calibration tables still apply and no additional training is required. The display digits are in two colors. Full "revolutions" are displayed in red and partial "revolutions" are displayed in yellow, eliminating the need for a decimal point and further enhancing readability.

Two pulse outputs (optically isolated open collector) are available from standard BNC connectors on the top panel.

1. Low pulse rate is one million counts per hour for 100% of the potential voltage range displayed and 100% of the current tap in use. It also corresponds to the least-significant digit count rate of the digital readout.

2. High pulse rate is ten million counts per hour for the same given input. The high rate output may be used to obtain increased resolution in short time tests, provided that the associated equiment is capable of receiving this higher pulse rate.

The signal voltage range can also be manually selected by the voltage selection switch.

The third BNC is available as a display gate. The six-digit display can be controlled by the gate (BNC) with a pendant switch. Pressing the switch will stop the display. Pressing the switch again will reset the display and initiate the test sequence. Pulse outputs are not affected.

1.3 Specifications

AVAILABLE MODELS AND OPTIONS:

Auto voltage ranges (all models): (120V, 240V, 480V).

Current Ranges	Model Number
1, 5, 12.5, 50A	6374
1, 5, 15, 45A	6375
1.5, 3, 15, 30A	6376
5A	6377
1, 5, 15, 50A	6384
1, 2.5, 5, 10A	6734
1.5, 5, 15, 45A	6732
1, 5, 25, 50A	6733
1, 5, 12.5, 100A (Special)	6731
Auxiliary Power	120/240/480V Auto-Ranging

INPUT RATINGS

Potential Input:

Range	120 Vac	240 Vac	480 Vac
Operating Range	60V-150 Vac	190-300 Vac	370-600 Vac
Overload, Continuous	720 Vac (rms)	720 Vac (rms)	720 Vac (rms)
Burden @ Rated Input	0.144 VA	0.576 VA	2.307 VA
Impedance in Ohms	100K	100K	100K

Auxiliary Power:

Rated Input	120V	240V	480V
Operating Range	60 - 180V	190 - 360V	384 - 600V
Burden @ Rated Input	11.64 VA	12.48 VA	13.44 VA
Loss in Watts	8.05 W	8.736 W	9.38 W

Current Range	Operating Range (with Specified Accuracy)	Maximum Overload	Burden
1.0A	0.2 - 2A	2A Fused	0.55W
1.5A	0.3 - 3A	3A Fused	1.24W
2.5A	0.5 - 5A	7.5A	0.20W
3.0A	0.6 - 6A	10A	0.53W
5.0A	1 - 10A	15A	1.5W
10A	2 - 20A	25A	0.5W
12.5A	2.5 - 25A	35A	0.8W
15A	3 - 30A	40A	2.31W
25A	5 - 50A	60A	2.4W
30A	6 - 60A	80A	0.62W
45A	9 - 90A	100A	2.5W
50A	10 - 100A	110A	2.45W
100A	20 - 110A	110A	5.0W

NOTE: Burden (loss) in current circuit is almost purely resistive (watts).

OUTPUT RATINGS

Digital Display: K_h (Watthours per Equivalent Revolution).

Range: 0 to 999.999 Equivalent Revolutions.

Ampere Input	Voltage Range		
	120 Vac	240 Vac	480 Vac
1.0A	0.12	0.24	0.48
1.5A	0.18	0.36	0.72
2.5A	0.30	0.60	1.20
3.0A	0.36	0.72	1.44
5.0A	0.60	1.20	2.40
10.0A	1.20	2.40	4.80
12.5A	1.50	3.00	6.00
15.0A	1.80	3.60	7.20
25.0A	3.00	6.00	12.00
30.0A	3.60	7.20	14.40
45.0A	5.40	10.80	21.60
50.0A	6.00	12.00	24.00
100.0A	12.00	24.00	48.00

Low Pulse Output: * K_e (Watthours per pulse; high output divide by 10).

Ampere Input	Voltage Range		
	120 Vac	240 Vac	480 Vac
1.0A	0.00012	0.00024	0.00048
1.5A	0.00018	0.00036	0.00720
2.5A	0.00030	0.00060	0.00120
3.0A	0.00036	0.00072	0.00144
5.0A	0.00060	0.00120	0.00240
10.0A	0.00120	0.00240	0.00480
12.5A	0.00150	0.00300	0.00600
15.0A	0.00180	0.00360	0.00720
25.0A	0.00300	0.00600	0.01200
30.0A	0.00360	0.00720	0.01440
45.0A	0.00540	0.01080	0.02160
50.0A	0.00600	0.01200	0.02400
100.0A	0.01200	0.02400	0.04800

Open Collector Ratings

V_{CE}, maximum	26 Vdc
V_{CE}, saturation	1V at 1.0 mA, 1.3V at 5 mA
I_C, maximum	5 mA

* A pulse is defined as a complete conduction cycle; i.e., an upward transition, a high level, a downward transition, and a low level.

OPEN COLLECTOR OUTPUTS

The open collector watthour outputs are photo-drive transistors that provide complete isolation between the SC® 10V Standard and any external counting device compatible with the transistor ratings. The transistor is equivalent to a switch contact closure. Its collector (+) and its emitter (-) leads are brought out to the BNC connectors on the SC® 10V main panel for use with an external device.

The transistor is dependent upon an external voltage supply to develop an output. Some pulse comparators (counters) provide a voltage source when they are connected to the SC® 10V output connections. If one is not available, an external power source may be added as shown in Figure 1.1.

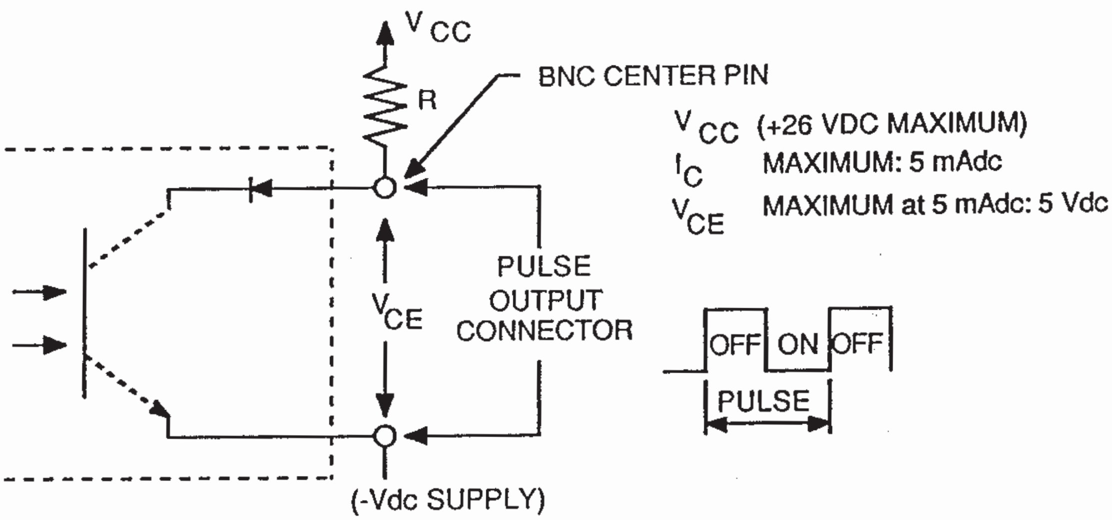

Figure 1.1
Open Collector Parameters for Operation from an External Power Source

The voltage, V_{CC}, must be chosen so that the collector to emitter voltage (V_{CE}) listed in the specifications is not exceeded at any time during operation. The input characteristics of the external device must be considered in choosing R. V_{CC} and R must be selected so that a voltage level compatible with the external device exists when the transistor is not conducting.

!!! CAUTION !!!

Do not connect a voltage exceeding 26 Vdc to the pulse outputs of the SC® 10V. A current-limiting resistor (R) must be used to limit the maximum collector current to 5 mA.

ACCURACY

(Errors expressed in percent of reading for normal operating conditions.)

Accuracy (Watthour)

Maximum Error = ±0.09% R_e ± 0.01 RO

Potential Input	75% to 125% of Range		
Current, % of Range	20 to 50	51 to 150	151 to 200
Unity Power Factor	±0.12%	±0.1%	±0.12%
0.5 Power Factor	±0.25%	±0.2%	±0.25%
Lead or Lag			

NORMAL OPERATING CONDITIONS

Ambient Temperature	23°C ±3°C.
Relative Humidity:	10% to 95%.
Auxiliary Power Voltage:	Rated Input ±20%.
Frequency:	58 to 62 Hz for Watt; 60 Hz only on Var mode.
Orientation:	Any.

INFLUENCES AFFECTING ACCURACY

Potential Input, Extended Range:	±0.1% maximum additional error, 50% to 75% of range.
Temperature:	±0.005%/°C maximum, -20°C to +70°C.
Stability:	±0.05%/year, typical for watts.
Phase Relationship of Auxiliary Power and Potential Input:	±0.02% maximum.

PROTECTION

Isolation:	Complete: Inputs/Outputs/Power/ Case.
Dielectric:	2.5 KV rms, 60 Hz, for one minute, Output/ Inputs/Power/Case. <u>Gate input has 5-volt logic, it does not require dielectric test.</u> **<u>DO NOT HIPOT.</u>**
Surge Withstand:	Meets IEEE SWC Standard 472-1974 (ANSI 37.90a-1974).

PHYSICAL DESCRIPTION

Size:	8.437" high x 5.750" wide x 6.25" deep.
Weight:	8 pounds, 2 ounces.
Panel Layout:	See Figure 1.2.

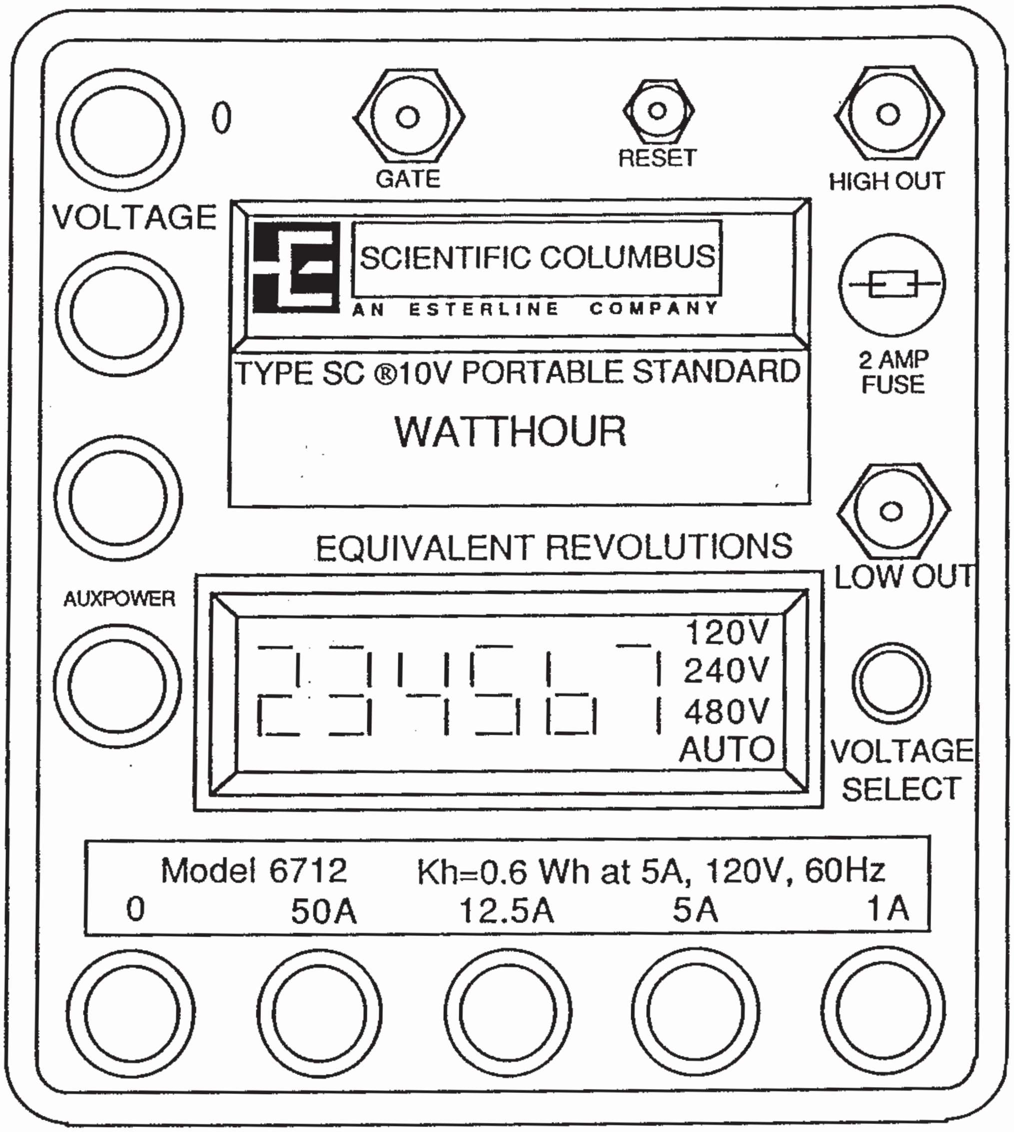

Figure 1.2
Top Panel Layout

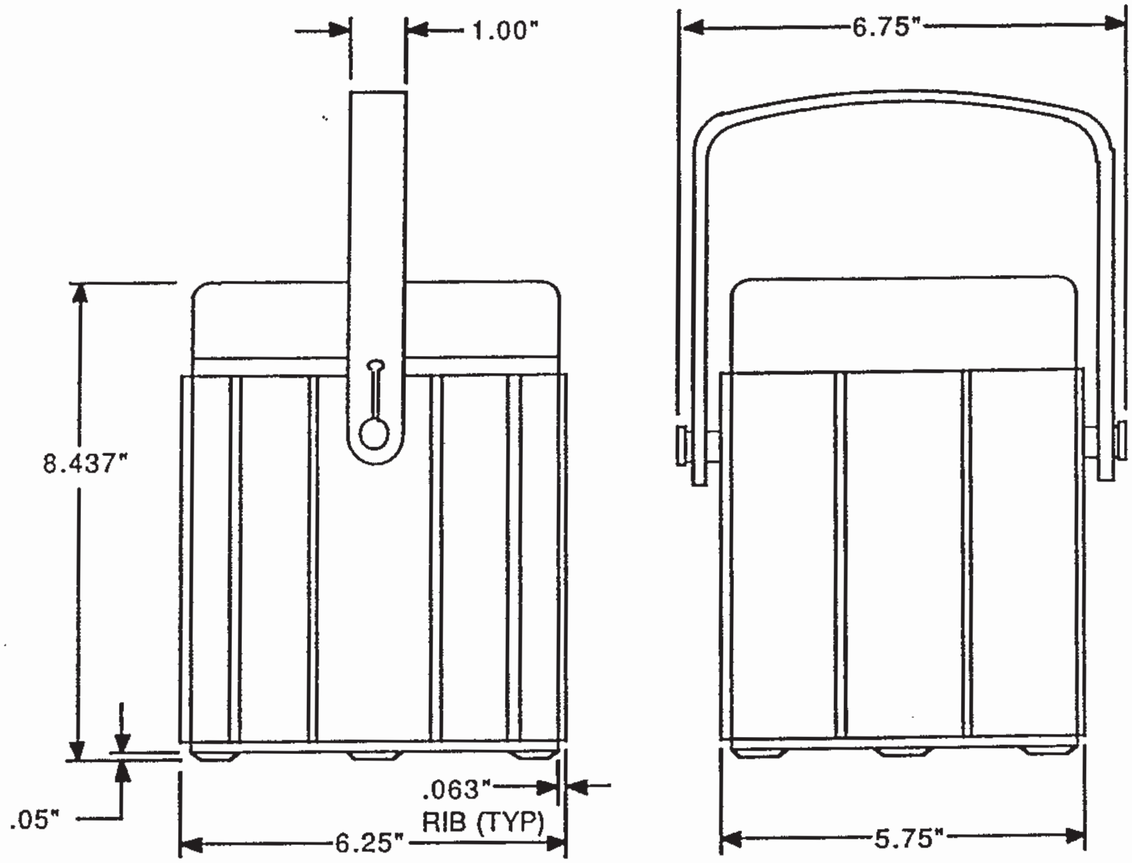

Figure 1.3
SC® 10V Outline and Dimensions

2.0 OPERATING INSTRUCTIONS

2.1 General

This section describes the connection and operation of the SC® 10V Portable Watthour Standard. Measurements made with the standard on watthour meters as well as measurements made with other standards on the SC® 10V standard are on a comparison basis. That is, a standard and a unit under test are both connected to simultaneously measure power dissipated in a single load (equal to power supplied by a single source) for an identical length of time. The energy thus measured is therefore equivalent, and the percentage difference in readings obtained is the percent error.

In contrast to the electro-mechanical watthour standards, the SC® 10V will not run backwards if its connections are improperly phased. Instead, its zero reading will be retained to indicate the improper phasing.

For improved readability, the SC® 10V uses a two-color, high brightness LED display. The three, left-most, red digits indicate integral equivalent revolutions and the three, right-most, yellow digits indicate partial (thousandths) equivalent revolutions.

Two consequences result from the use of this type of indicator:

1. Auxiliary power is necessary for the display. (In most cases, this auxiliary power can be derived from the potential being measured.)

2. When first energized, the indicator may display any combination of lighted and unlighted segments, the most frequent being a series of Es. The display can be set to zero by pushing the reset button on the face plate.

2.2 Connections

Many different configurations can be made to test a meter. These depend on meter configuration and on power available. A basic comparison test will be discussed here, but for a thorough discussion of meter testing techniques we recommend the "Handbook for Electricity Metering, Eighth Edition, Edison Electric Institute, Washington, D.C."

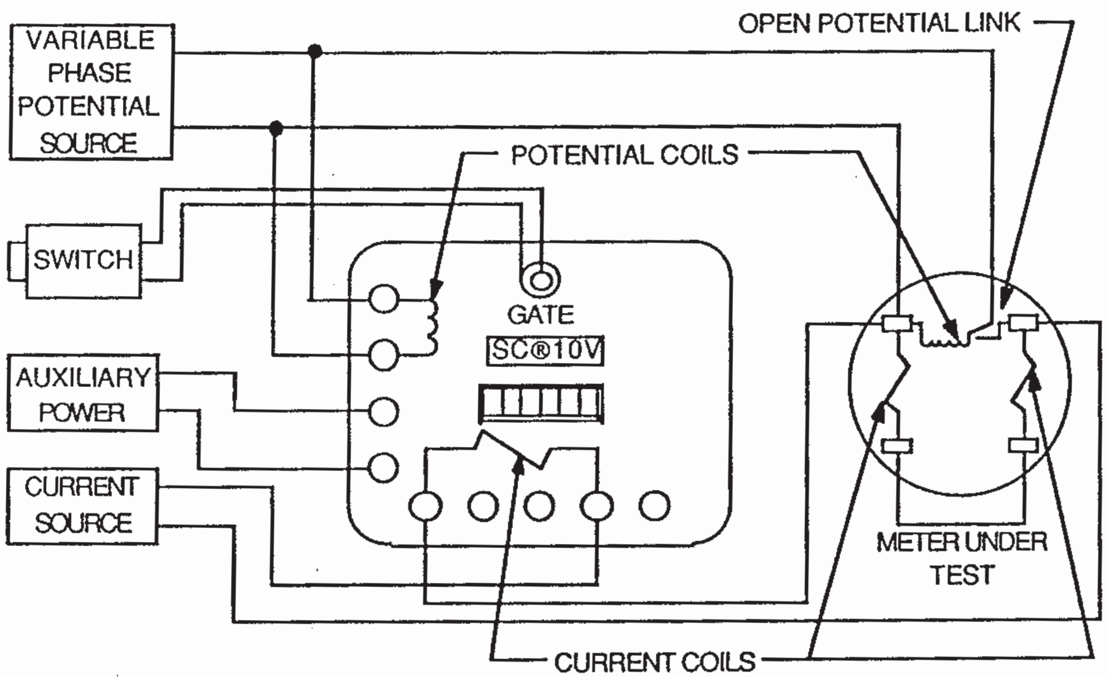

Figure 2.1
Fundamental Meter Test Circuit

!!! W A R N I N G !!!

Note and practice the safety recommendations listed under the heading of "Safety" and "Good Practices for the Meterman" in the Handbook for Electric Metering.

2.2.1 Referring to Figure 2.1 "Fundamental Meter Test Circuit," and with the current source turned off, connect the current coils of the SC® 10V and the current coils of the meter under test in series with the source.

!!! W A R N I N G !!!

If connections are made, changed, or broken with the current source turned on, dangerously high voltages can be developed, with attendant shock hazards. For personnel protection, no source should be turned on while connections are being made, changed, or broken.

2.2.2 Connect the SC® 10V potential terminals to a source of potential. Connect the potential coil of the meter under test directly to the same source of potential, making certain that its test link, if any, is open before this connection is made. Connect the snap switch to the gate output as it is shown in Figure 2.1.

2.2.3 Connect the SC® 10V to a proper auxiliary power source. When auxiliary power is connected, the display should energize and may be reset to zero. A minimum warm-up period of 30 seconds is recommended.

When the current is turned on, the meter under test should respond and, if the gate snap switch is pressed, the SC® 10V display will count. Since the SC® 10V Watthour Standard is intended for unidirectional energy measurement, it will not register if proper phasing of the power sources is not observed. If, therefore, the display does not count when power is applied, check the polarity of the connections and, after turning the source off, reverse either the potential or the current leads at the SC® 10V as necessary.

2.3 Testing

Testing of a watthour meter using the SC® 10V Watthour Standard is of a comparison nature. That is, the meter and the standard measure the same power for the same length of time. The energy measured by each is equal and differences obtained indicate error in the meter.

2.3.1 Testing a Rotating Disk Meter with the SC® 10V

Set the SC® 10V function switch to the watthour position, as it is appropriate.

Stop the standard by pressing the gate snap switch. When the gate snap switch is pressed again, it will reset the SC® 10V for counting to start.

While watching the disk of the watthour meter under test, start the standard (by opening the gate switch shown on Diagram 2.1) at the precise moment that the mark on the disk passes a particular point on the meter frame.

At some number of disk revolutions, perhaps 10, stop the standard again at the precise moment that the mark passes the point. A sufficient number of revolutions should be taken to make negligible any errors of observation and to minimize errors due to not starting or stopping the standard simultaneously with the mark passing the point on the frame.

Record the number of revolutions counted for the disk of the meter under test, the watthour constant of the meter under test, the number of equivalent revolutions registered by the standard*, and the watthour constant of the standard, for the ranges used. The standard's watthour constant is shown on Pages 6 and 7 of this manual and on the calibration card inside the lid of the SC® 10V.

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* Note that red digits display integral equivalent revolutions, while yellow digits display fractional (thousandths) equivalent revolutions.

2.3.2 Testing a Solid-State Meter with the SC® 10V

To test a meter using a pulse initiator (KYZ) output, connections and setup are made as shown in Figure 2.2. This type of test requires use of a test counter which can be preset to start and stop the test. The preset counter is connected to control the SC®10V by using the SC®10V gate input.

- Set preset counter to the number of desired test counts; e.g., 10.
- Reset SC®10V (or it will reset automatically at start of test).
- Enable start of test at preset counter. Counter will close relay starting test on first count (pulse) received from test meter.
- Test will be complete when the number of counts preset (N_t) are received and the counter stops the test.
- Read standard counts (equivalent revolutions from the SC®20); e.g., 11.107.
- Compute accuracy of result.

$$\%R = \frac{N_t \times Kh_t}{N_s \times Kh_s} \times 100$$

For Example, if:
$N_t = 10$ (Preset Count)
and $N_s = 11.107$ (Standard Count)
or equivalent revolutions

KH_t is the effective test meter constant. If using a KYZ output, use K_e x 2; e.g., K_e=1.0, Kh_t=2.0. Kh_s is the standard constant <u>adjusted for other external</u> factors such as the number of elements of the meter; e.g., for a 3-element meter, use 0.6 x 3 = 1.8.

$$\text{Then, } \%R = \frac{10 \times 2.0}{11.107 \times 1.8} \times 100 = 100.04\%$$

This is interpreted as meaning the device tested is 0.04% fast, assuming a perfect standard.

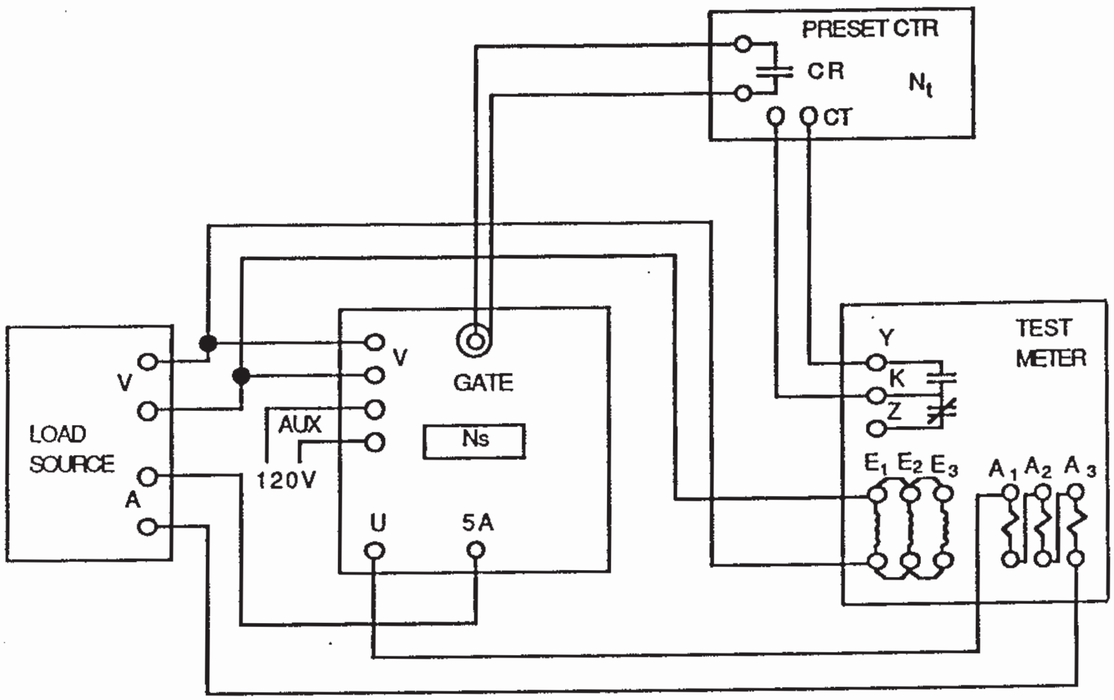

Figure 2.2
Connections and Setup for Testing a Meter
Using a Pulse Initiator (KYZ) Output

2.4 Calculations

Percent registration of the meter under test is that ratio expressed as a percentage.

$$\text{Percent Registration (Meter Under Test)} = \frac{100 \times r \times K_h \text{ (Test)}}{R \times K_h \text{ (standard)}} = \frac{100 \times \text{watthours of meter U.T.}}{\text{Watthours of Standard}}$$

r	=	revolutions of meter under test
K_h (test)	=	watthour constant of meter under test
R	=	equivalent revolutions of standard
K_h (standard)	=	watthour constant of the standard

For maximum test accuracy, inherent calibration offset of the standard at each test point must be factored into the final calculation of percent registration of the meter under test. These standard correction factors designated CF are derived from the percent error (%E) column for the appropriate test point from the calibration card supplied with each SC® 10V Standard, using the following formula:

$$\text{Standard Correction Factor CF} = \frac{100}{100 + \%E}$$

CF	=	standard correction factor
%E	=	percent error of the applicable test point from the standard calibration card.

* Note that red digits display integral equivalent revolutions, while yellow digits display fractional (thousandths) equivalent revolutions.

Corrected percent registration of the meter under test then is calculated by the formula:

$$\text{Corrected Percent Registration (Meter Under Test)} = \frac{100 \times r \times K_h \text{ (test)}}{R \times K_h \text{ (standard) (standard} \times \text{CF)}}$$

3.0 THEORY OF OPERATION

The SC® 10V uses the time division multiplier principle which depends on combined pulse width and pulse amplitude modulation of a rectangular pulse train. Accuracy and stability of the SC® 10V are primarily dependent on a stabilized, temperature compensated zener reference diode and a quartz crystal oscillator. The power supply is well regulated.

Input voltage is divided by the potential transformer and converted into variable width pulses by the triangle generator and comparator. Input current is reduced by the current transformers and provides a secondary current through the modulator switch. A signal results which has a width proportional to voltage and amplitude proportional to current.

The resulting signal is proportional to the average value of the product of instantaneous voltage and amps which is watts.

This signal, whose average value is a dc current proportional to watts, is fed into an integrator which converts the signal into a ramp. When this ramp reaches a threshold, it triggers a monostable multivibrator controlled by a 400 kHz tuned crystal oscillator circuit, which swamps the dc current with a large negative current. The rate of occurrence of this trigger pulse is proportional to the dc current, which is also proportional to watts.

Pulses are divided into two paths. In one path, pulses are counted and displayed, and the other path leads to an opto-isolated output. See Figure 3.1 for oscilloscope waveforms on a block diagram.

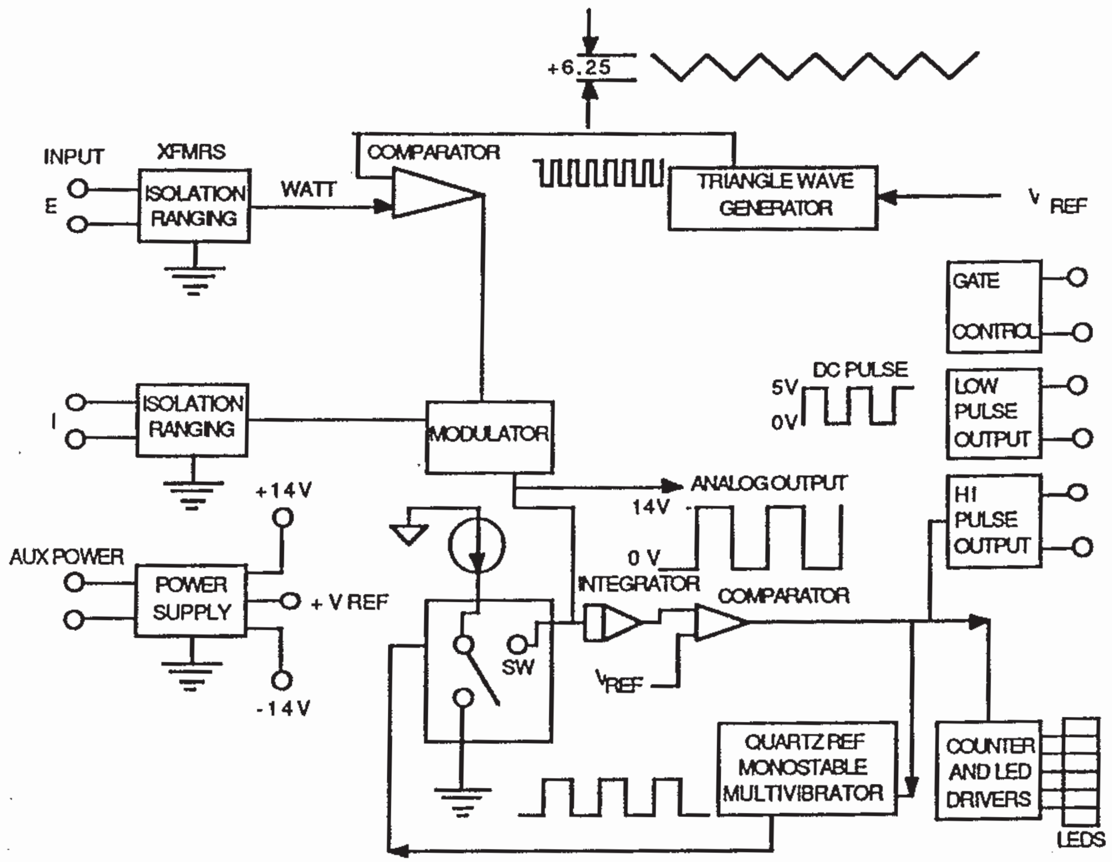

Figure 3.1
Simplified Block Diagram - SC® 10V Operation

4.0 SERVICE

This manual is intended for user instructions only. Additional technical/service manuals will be provided as required.

The only user serviceable parts are the low current range fuses replaceable from the front-panel fuseholders.

1 AMP Range	2 AMP Fuse
1.5 AMP Range	3 AMP Fuse

For further service information or return authorization, contact the local Scientific Columbus representative.

!!! W A R N I N G !!!

UNAUTHORIZED SERVICE OR OPENING OF UNIT MAY VOID THE FACTORY WARRANTY.