COMMUNICATING THROUGH THE AGES

If you are as "ancient" as I am, you will remember when the only two-way communication was by land-line telephone or telegraph, radio telegraph between ships, and a few specialized contacts between people. Two-way voice communication began between "hams" and between commercial offices.

In the early 1920's radio broadcast stations began to operate. People (like me) built crystal radio receivers using coils wound on oatmeal boxes and using "cat's whisker" galena detectors driving high impedance headphones. I remember connecting three or four headphones in series on one crystal set so that several people could listen at the same time.

But nothing is static. All things change. Higher and higher frequencies were used when vacuum tubes replaced the galena detectors and amplifiers were added to drive cumbersome loud-speakers. In time, television was developed from a spinning disk into a system using a cathode ray tube to display the images. FM broadcast stations began, touted as noise-free music stations.

From these meager, and sometimes painful, beginnings you are now able to communicate with people all over the world via telephone and FAX, and by electronic mail on your home computer. Using the Internet or a WEB site you can explore innumerable sources of important and vital information anywhere, any time, for the cost of a local telephone call.

Technology has proceeded at an exponential rate and the end is not in sight.

Some of the items available in this catalog would not have been possible a decade ago. Some call us foolish, but we continue to keep abreast of the changes in test requirements for EMI specifications. For example, we have developed tunable modules (**Type 9554 series**) which, when used with our **Model 9354-1 Universal Transient Generator**, enable test engineers (like you) to apply damped sine wave pulses to a test sample over the full range of 10 KHz to 100 MHz at the levels stipulated in MIL-STD-461C/D/E and other specifications. The injection technique requires an Injection Probe, such as our **Type 9335-2**, to couple the pulse onto the line.

Our day-by-day development of new EMI test equipment and related products **since 1960** is substantial proof that, "There is no substitute for experience". We would like to hear from you because we know we can help with your EMI problems. Communicate with us via telephone, FAX or E-mail.

Cordially,

Al Parker

Al Parker

SOLAR ELECTRONICS COMPANY
Innovative EMI Solutions Since 1960
e-mail: sales@solar-emc.com www.solar-emc.com
A division of A.T. Parker, Inc.
(800) 952-5302
(818) 755-1700
FAX (818) 755-0078

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ESSENTIAL APPARATUS FOR PERFORMING TESTS PER MIL-STD-461D/E

TYPE NO.	DESCRIPTION	CE 101	CE 102	CS 101	CS 109	CS 114	CS 115	CS 116	RE 101	RE 102	RE 103	RS 101	RS 103	RS 105
6220-1A	Audio Isolation Transformer			X[1]										
6220-2	Audio Isolation Transformer			X[1]										
7032-1	Isolation Transformer, 800 W.			X[2]	X[2]									
7032-2	Isolation Transformer, 800 W.			X[2]	X[2]									
7334-1	Loop Antenna								X					
7720-( )	High Pass Filter, 50 ohms										X[3]			
8231-*/*	Band Reject Filter, 50 ohms										X[3]			
8850-1	High Power Sweep Generator, 200 W.			X										
9123-1N	Current Probe, 10 KHz-500 MHz					X	X	X						
9125-1	Calibration Fixture, Injection Probe					X	X	X						
9133-1	'Delta' Capacitor Assembly			X										
9142-1N	Injection Probe, 2MHz-450 MHz					X	X	X						
9144-1N	Injection Probe, 10 KHz-200 MHz					X								
9146-1	'Wye' Capacitor Assembly			X										
9207-1	Current Probe, 20 Hz-150 MHz	X										X		
9224-1.0	Precision Resistor, 1.0 ohms	X												
9225-0.5	Precision Resistor, 0.5 ohms			X										
9226-0.5	Precision Resistor, 0.5 ohms				X									
9229-1	Loop Sensor											X		
9230-1	Radiating Loop											X		
9233-50-TS-50-N	LISN		X	X		X	X		X	X		X	X	X
9335-2	Multi-Port Coupling Device							X						
9357-2	Calibration Fixture							X						
9410-1	H.V. Attenuator						X	X						
9454-1	H.V. Attenuator							X						
9354-1	Universal Transient Generator							X[4]						
9355-1	Pulse Generator						X							
9401-1	10 pF Series Capacitor									X				

NOTE:

x[1] Type 6220-1A is rated at 50 amperes secondary current.

Type 6220-2 is rated at 100 amperes secondary current.

x[2] Type 7032-1 is rated at 120 volts, 50-400 Hz, 800 W.

Type 7032-2 is rated at 240 volts, 50-400 Hz, 800 W.

x[3] High pass filters can be supplied up to 50 MHz, 50 ohms.

Band reject filters can be supplied up to 50 MHz, 50 ohms.

x[4] Test may require variable frequency modules
Type 9554-10K/100K
Type 9554-100K/1M
Type 9554-1M/16M
Type 9554-6M/50M
Type 9754-35M/85M step frequency module

ESSENTIAL APPARATUS FOR PERFORMING TESTS

in accordance with MIL-STD-461A/B/C

TYPE NO.	DESCRIPTION	CE 01	CE 02	CE 03	CE 04	CE 05	CE 06	CE 07	CS 01	CS 02	CS 03	CS 04	CS 05	CS 06	CS 08	CS 09	CS 10	CS 11	CS 12	CS 13	RE 01	RE 02	RE 03	RE 04	RE 05	RE 06	RS 01	RS 02	RS 03	RS 04	RS 05	RS 06
6220-1A	Audio Isolation Transformer	X[1]							X					X														X				
6254-5S	RFI Transient Generator, 10µS													X[5]														X				
6338-5-PJ-50-N	LISN		X[2]		X[2]					X[2]									X[2]	X[2]		X[2]										X
6338-57-PJ-50-N	LISN		X[2]		X[2]					X[2]												X[2]										
6512-106R	Feed-thru Capacitor, 10 µF	X		X										X								X		X								X
6550-1	Power Sweep Generator, 100 W.								X																			X				
6552-1A	Audio Amplifier, 100 W.								X																				X	X		
6623-( )	Low Pass Filter, 50 ohms					X	X				X	X	X		X															X		
6741-1	EMI Current Probe	X	X	X	X	X																										
6920-0.5	Resistive Network	X[1]																														
7021-1	Phase Shift Network								X																							
7032-1 (or -2)	Isolation Transf., 800W.	X	X	X	X	X											X	X			X	X	X	X	X	X						
7054-1	Spike Generator, 10 µS													X[5]														X				
7054-1A	Spike Generator, 50 µS													X[3]														X[3]				
7144-1.0	Precision Resistor, 1.0 ohm																										X					
7144-10.0	Precision Resistor, 10.0 ohms																											X[2]				
7205-( )	High Pass Filter, 50 ohms	X		X																												
7334-1	Loop Sensor																				X			X								
7415-3	R.F. Coupler-High Pass Filter									X																						
7429-1	Loop Antenna																										X					
7835-891	Coupling Network							X																								
7835-892	Coupling Network							X																								
7835-896	Coupling Network							X																								
8022-1	Current Probe															X																
8282-1	Spike Generator, .15/5/10 µS													X[4]														X[4]				
8309-5-TS-100-N	LISN																X	X	X[6]	X[6]											X	X[6]
8415-1	Precision Resistor, .001 ohm																											X				
8850-1	Power Sweep Generator, 200 W.								X																			X				
9354-1	Transient Generator																X	X														

NOTE: x[1]. See Notice 3, MIL-STD-462 for CE01 in lieu of current probe.
x[2]. Required by Notice 3, MIL-STD-462, U.S. Army Contracts and Notices 5, MIL-STD-462, U.S. Navy Contracts.
x[3]. Used on B1 aircraft susceptibility tests.
x[4]. Supplies all 3 waveshapes of MIL-STD-461B/C.
x[5]. Used for Part 2 and 4, U.S. Army (only)
x[6]. For five microhenry applications above 50 amps.

MODEL 9354-1 UNIVERSAL TRANSIENT GENERATOR

for susceptibility tests MIL-STD461C/D/E, DO-160C/D and other specifications

APPLICATION

The **Model 9354-1 Universal Transient Generator** was especially designed for the performance of a variety of pulse susceptibility tests on subsystems and/or equipment, in accordance with MIL-STD-461D and E, method CS116; RTCA DO160D, section 22; MIL-STD-461C, methods CS10 and CS11.

Through the use of many Solar accessories, including various reactive networks and coupling devices, as well as other commercially available items such as loop antennas, parallel plates, and TEM cells, the generated output may be modified and applied to other specifications. (Contact Solar customer service for details.)

DESCRIPTION

Model 9354-1 Universal Transient Generator provides nine selectable waveforms, including six damped sinusoidal pulses (10 KHz, 100 KHz, 1 MHz, 10 MHz, 30 MHz, and 100 MHz) and three double exponential pulses (6.4 µS, 70 µS and 500 µS).

Auto pulsing of the sinusoidal repetition rate is internally adjusted from 0.5 to 1.0 pulse per second. A front panel-mounted push button can be used to manually trigger single pulses. The peak amplitude of the selected output pulse is adjustable as a percentage of the charge voltage.

The six damped sinusoidal waveforms were designed to meet the requirements of MIL-STD-461D and E, method CS116, when applied in accordance with the test method of MIL-STD-462D. Continuous tunable frequencies can be obtained by the use of the optional variable frequency modules.

These same waveforms are applicable to the requirements of MIL-STD-461C, methods CS10 and CS11, when applied in accordance with the test method of MIL-STD-462, Notice 5.

The 1MHz and 10 MHz damped sinusoidal waveforms have been extended to a peak open circuit voltage of 3200 volts and a calculated short circuit current of 128 amperes to meet the requirements of RTCA DO-160D, Section 22, Table 22-2, waveform 3.

The three double exponential pulses were designed to meet the requirements of RTCA DO-160D, Section 22, Tables 22-2 and 22-3. Table 1 lists the test level that can be achieved from the **Model 9354-1**.

FEATURES

- Panel-mounted digital voltmeter. Monitors the adjusted open circuit discharge voltage.
- Pulse rates up to two pulses per second maximum (factory adjusted).
- Single pulse feature enables controlled isolation of transient effects.
- Output voltage adjustable from 0.1% to 100% of selected discharge voltage.

Table 1: DO-160D Test Levels possible from Model 9354-1

Waveform	Pin Injection	Cable Bundle Injection
1 (70 µS)	no requirement	level 1- 4
2 (6.4 µS)	no requirement	level 1 - 4
3 (1MHz & 10 MHz)	level 1 - 5	level 1 - 4
4 (70 µS)	level 1 - 5	level 1 - 4
5B (500 µS)	level 1 - 4	level 1 - 3

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e-mail: sales@solar-emc.com www.solar-emc.com
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AVAILABLE ACCESSORIES

Variable and Step Frequency Modules. Provides tunable frequencies for injection of damped sinusoidal wave forms from 10 KHz to 100 MHz when used with **Model 9354-1**. Five individual modules waveforms cover the entire frequency range required by MIL-STD-461D. Detailed information provided on separate data sheet.

Type 9335-2 Universal Coupling Device. An inductive injection device that provides voltage and current transfer of 1:1, 1:1.5 and 3:1 voltage step-up (current step-down) as well as 2:1 voltage step-down (current step-up). For maximum power transfer, these ratios are selected by connecting to one of the four BNC connectors. This device, through its various connector ports, provides a better impedance match or power transfer, higher open circuit voltages, or higher short circuit currents. Useable for cable current injection from 10KHz to 10 MHz. Detailed information provided on separate data sheet.

Type 9719-1N Injection Probe. Provides the required current leveles of MIL-STD-461D and E, method CS116 throughout the entire frequency range of 10 KHz to 100 MHz.

Type 9357-1 Calibration Fixture. Calibration fixture provides a 50 ohm characteristic impedance based on the dimensions of the **Type 9335-2 Universal Coupling Device** and **Type 9719-1N Injection Probe**. The fixture maintains a low standing wave ratio from 10 KHz to 100 MHz in a 50 ohm circuit.

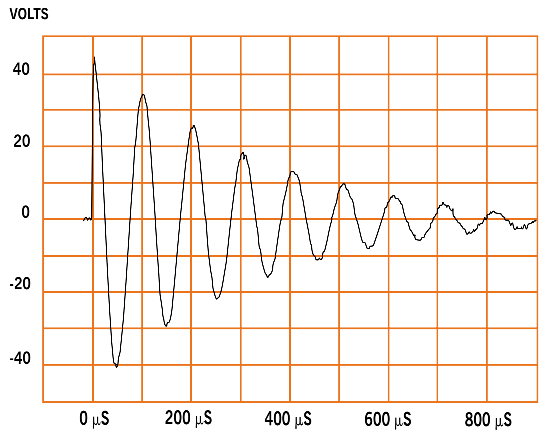
Type 9142-1N Injection Probe. Used to inject current on cables from 1 MHz to 100 MHz.

Type 9125-1 Calibration Fixture. Calibration fixture for use with **Type 9142-1N Injection Probe**.

Type 9123-1N Current Probe. Used to monitor injected pulses. Frequency range from 10 KHz to 500 MHz.

Type 9410-1 50Ω/50Ω and Type 9454-1 600Ω/50Ω High Voltage Attenuators. Provides 40 dB attenuation from 10 KHz to 100 MHz. Protects oscilloscope from high voltage damage when verifying the output pulses of the **Model 9354-1**. **The Type 9454-1** provides a high impedance to the oscilloscope for making measurements of open circuit output pulses.

Type 6220-4 High Voltage Audio Isolation Transformer. When connected in series with the power lead under test, provides twice the open circuit voltage or twice the short circuit current for the 10 KHz and 100 MHz damped sinusoid waves and the 6.4 µS and 70 µS double exponential pulses. Capable of handling up to 4000 volts.



DAMPED SINUSOIDAL PULSE, (10 KHz) INTO AN OPEN CIRCUIT.

Type 9616-1 Injection Clamp. Provides coupling for high voltage pulses produced by the **Model 9354-1**. Meets the inductive indirect injection device requirement of MIL-STD-462, notice 5, method CS10 and CS11. Enables injection of 70 µS double exponential pulses without need for direct connection.

SPECIFICATIONS

DAMPED SINUSOID PULSES

(NOTE: MEASUREMENT OF SHORT CIRCUIT CURRENTS ARE LIMITED BY THE X_L OF THE CIRCUIT. ALL VALUES ARE CALCULATED.)

10 KHz
Open Circuit Voltage . . . . .30 V.
Calculated Short Circuit Current . . . . .120 A.
Source Impedance . . . .<0.25 Ω

100 KHz
Open Circuit Voltage . . . . .300 V.
Calculated Short Circuit Current . . . . .120 A.
Source Impedance . . . .<2.5 Ω

1 MHz
Open Circuit Voltage .3200 V.
Calculated Short Circuit Current . . . . .128 A.
Source Impedance . . . .<25 Ω

10 MHz
Open Circuit Voltage .3200 V.
Calculated Short Circuit Current . . . . .128 A.
Source Impedance . . . .<25 Ω

30 MHz
Open Circuit Voltage .1000 V.
Calculated Short Circuit Current . . . . .20 A.
Source Impedance . . . .<50 Ω

100 MHz
Open Circuit Voltage . . . . .300 V.
Calculated Short Circuit Current . . . . .6 A.
Source Impedance . . . .<50 Ω

DOUBLE EXPONENTIAL PULSES

(NOTE: MEASUREMENT OF SHORT CIRCUIT CURRENTS ARE LIMITED BY THE X_L OF THE CIRCUIT. ALL VALUES ARE CALCULATED.)

6.4 µS

Rise Time . . . . .100 nS.
Open Circuit Voltage .1600 V.
Calculated Short Circuit Current . . . . .800 A.
Source Impedance . . . .<2.0 Ω

70.0 µS

Rise Time . . . . .6.4 µS.
Open Circuit Voltage .1600 V.
Calculated Short Circuit Current . . . . .800 A.
Source Impedance . . . .<2.0 Ω

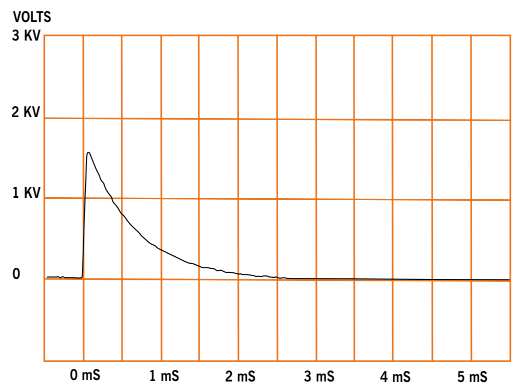
500 µS

Rise Time . . . . .50 µS.
Open Circuit Voltage .1600 V.
Calculated Short Circuit Current . . . . .400 A.
Source Impedance . . . .<4.0 Ω

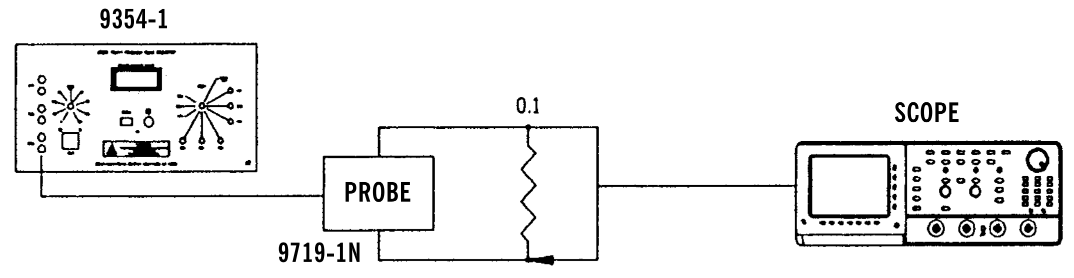
DIMENSIONS

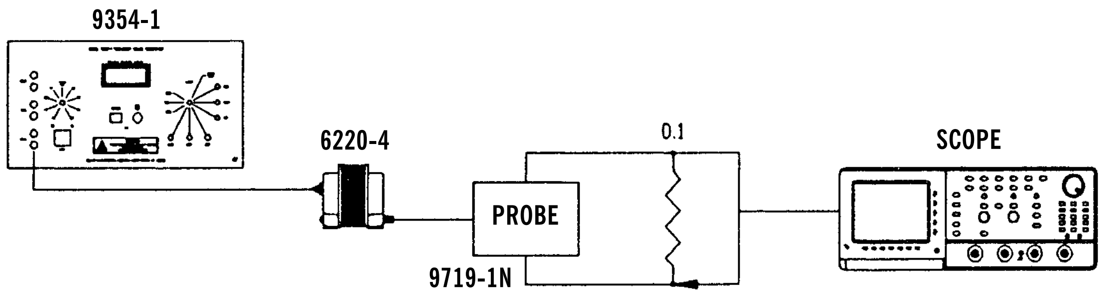
Weight: 55.0 lbs. (25 Kg)

Size: 17.25" (43.5 cm) wide x 8.75" (22.2 cm) high x 13" (33.0 cm) deep.



DOUBLE EXPONENTIAL PULSE INTO AN OPEN CIRCUIT.





MODEL 9554-( ) VARIABLE FREQUENCY MODULES

for use with Model 9354-1 Universal Transient Generator as required by Method CS-116, MIL-STD-461 Rev. D

APPLICATION

Utilizing the high voltage power source in the **Model 9354-1 Universal Transient Generator,** four individual modules can be connected to provide tuning of damped sine waves from 10 KHz to 50 MHz. A fifth module is available which, when used in conjunction with the **Model 9354-1**, provides 20% frequency steps from 30 MHz to 100 MHz.

DESCRIPTION

Individual modules enable tuning of damped sine waves in accordance with the requirement of Method CS-116, MIL-STD-461 Rev. D. The part number of each module indicates the frequency range of the module. For example, P/N **Type 9554-10K/100K** indicates a range of 10 KHz to 100 KHz. The five modules are identified as:

Type 9554-10K/100K variable frequency module

Type 9554-100K/1M variable frequency module

Type 9554-1M/6M variable frequency module

Type 9554-6M/50M variable frequency module

Type 9754-35M/85M step frequency module

Two cables connect the module to the **Model 9354-1**. One cable is a single insulated wire to carry high voltage d.c. to the module. The other cable delivers low voltage d.c. to the module for operation of relays.

OPERATION

The test setup for calibration of test waveform is indicated in Figure CS116-1, page 79 of MIL-STD-462D. To achieve the required injection current, the digital display on the front panel of the **Model 9354-1** can be recorded during the calibration step for reference and repeated when the actual test setup is in accordance with Figure CS116-3, page 81 of MIL-STD-462D. This calibration must be repeated at each test frequency.

The frequency of the damped sine wave is adjusted by a tuning control on the panel of the module. A graph showing frequency versus turns count on the tuning control is supplied.

With the selected module connected, the charge voltage of the module is adjusted by the AMPLITUDE control on the Model **9354-1 Universal Transient Generator**. The AMPLITUDE knob is marked in percentage of the available charge voltage for the module being used.

The amplitude and frequency of the damped sine wave into the load can be determined by an associated oscilloscope with a 50 ohm input.

After the charge voltage is adjusted to the desired value, the damped sine wave is applied to the load by pushing the button on the module.

USEFUL ACCESSORIES

Type 9125-1 Calibration Jig

Type 9142-1N Injection Probe

Type 9357-1 Calibration Jig

Type 9335-2 Multiple Impedance Coupling Device

Type 9410-1 High Voltage Attenuator (The input to the **Type 9410-1** can be used for a 50 ohm coaxial load as required by MIL-STD-462D Figure CS116-1.)

Type 9841-1 1000 Volt Termination, 50 ohm coaxial 1 W average power. Typical input VSWR in a 50 ohm system under 1.5 from DC to 1 GHz.

TYPE 9335-2 MULTIPLE IMPEDANCE COUPLING DEVICE

impedance matching injection probe

APPLICATION

Various EMI specifications require the injection of high level voltage or current pulses and the reception of low level voltage or current emissions using a toroidal transformer or coupling device around the interconnecting conductors of the subsystems/equipment being tested.

The **Type 9335-2 Multiple Impedance Coupling Device** is a split toroid, designed as a versatile impedance matching transformer used in conjuction with a generator as an injection probe for conducted susceptibility tests such as methods CS10 and CS11 of MIL-STD-462, Notice 5; CS116 of MIL-STD-462D; DO-160C, Section 22, Figure 22-12; and other specifications.

INJECTION – High power transient generators with source impedances from 0.25 Ω to 50 Ω can use this probe to deliver high peak voltage or high current pulses into the wires or cables passing through the window of the device.

DESCRIPTION

The unique winding arrangement of this impedance matching probe* provides step-up or step-down ratios with respect to either: 1) the source impedance of the connected generator, when used for injection, or 2) the load impedance of the connected receiver, when used for reception. This results in maximum power transfer into or out of the transformer winding formed by the cable bundle passing through the window.

The **Type 9335-2 Multiple Impedance Coupling Device** provides:

1:1.0 voltage or current transfer
1:1.5 voltage step-up or current step-down
2:1.0 voltage step-down or current step-up
1:3.0 voltage step-up or current step-down

These ratios are selected by connecting to one of the four BNC connectors on the side of the **Type 9335-2**.

Figure 1 shows a family of curves representing the transfer functions for each connector port when the device is used as an **injection probe**.

Through connector port selection, the open circuit voltage or short circuit current can be adjusted for maximum transfer of energy. This is especially useful as an accessory to the **Model 9354-1 Universal Transient Pulse Generator** with its differing source impedances, enabling it to meet various open circuit voltage, and short circuit current requirements.

CALIBRATION

For proper calibration of current probes, a special test fixture must be used to maintain a 50 ohm characteristic impedance for the test signal as it passes through the window of the probe.

The design of the **Type 9357-1 Calibration Fixture** was carefully tailored to provide a 50 ohm characteristic impedance based on the specific dimensions of the **Type 9335-2**. The fixture maintains a low standing wave ratio from 10 KHz to 10 MHz in a 50 ohm circuit.

* We refer to this unique device as the **Knoller Probe**, since it is the brainchild of Hank Knoller, an EMC engineer with more than forty years experience in the design and application of equipment for EMI testing.

TYPE 9335-2 MULTIPLE IMPEDANCE COUPLING DEVICE

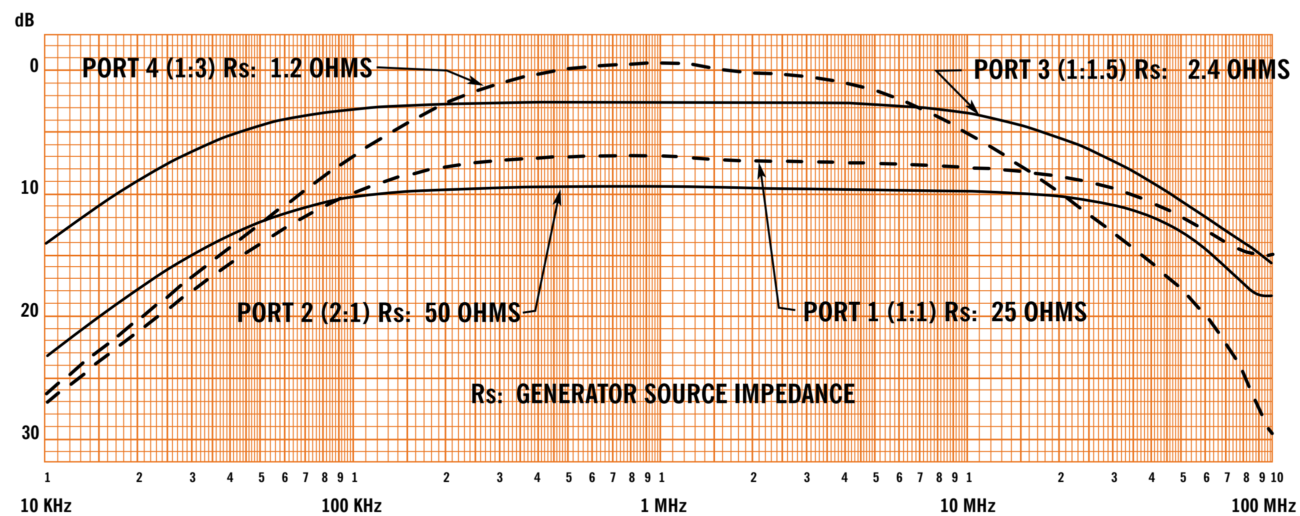
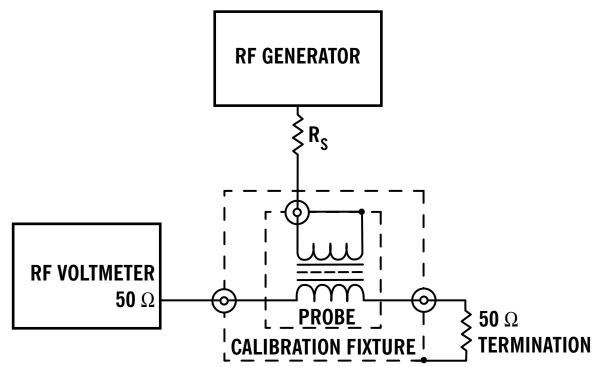


FIG. 1. INJECTION TRANSFER FUNCTION FOR SEVERAL GENERATOR SOURCE IMPEDANCES.



INJECTION PROBE CALIBRATION

MODEL 9355-1 PULSE GENERATOR

for MIL-STD461D/E CS115 susceptibility test

APPLICATION

Solar Model 9355-1 Pulse Generator is designed to provide impulse excitation by means of an injection probe placed around interconnecting cables or power wires. The unit uses a charged transmission line (50 ohms) to generate a pulse with less than 2 nanoseconds rise and fall time, and duration of approximately 30 nS, calibrated in a 50 ohm fixture to deliver up to 5 amperes at a rate of 30 p.p.s. for one minute as required by MIL-STD-461D/E, test method CS115.

DESCRIPTION

The charged line potential of the **Model 9355-1** is adjustable from less than 2 volts to greater than 2000 volts. The repetition rate is variable from less than 0.6 p.p.s. to greater than 150 p.p.s., or single pulses manually triggered by a panel mounted push button. Digital displays monitor the charging voltage and pulse repetition rate.

This unit can also be used as an impulse calibrator to provide an adjustable spectral output up to 150 dB μV/MHz over the frequency range of 1 KHz to 10 MHz constant within ±1 dB.

SPECIFICATIONS

OUTPUT PULSE:

Charging Voltage: Adj. from 0 to 2000 volts
Rise/Fall Time: <2 nanoseconds
Duration Time: 35 nanoseconds
Pulse Repetition Rate: 0.6 p.p.s. to 150 p.p.s.
Polarity: ± selectable
Output Load: 50 ±j 0 ohms

SPECTRAL OUTPUT:

Frequency Range: 1 KHz to 10 MHz
Output Level into 50Ω: Up to 150 dB μV/MHz
Output Flatness: ± 1 dB

FEATURES

- Panel-mounted digital meters monitor the adjustable charged line voltage and pulse repetition rate.
- Adjustable pulse rate from 0.6 p.p.s. to 150 p.p.s., and manual triggering via front panel push button.
- Charged line output voltage adjustable from 1.0 V to >2000 V.
- Pulse generator with spectral output calibrated in terms of dB μV/MHz into a 50 ohm load.

ACCESSORIES RECOMMENDED FOR CS115 TESTING

Type 9233-50-TS-50-N Line Impedance Stabilization Network.

Type 9125-1 Calibration Fixture used to calibrate probes with a window size from 1.25" to 1.50" and a frequency range of 20 Hz to 500 MHz.

Type 9142-1N Current Injection Probe with a frequency range of 2 MHz to 450 MHz, 200 W.

Type 9123-1 Current Monitor Probe with a frequency range of 10 KHz to 500 MHz, 1.25" window.

Type 9410-1 High Voltage 40 dB Attenuator, dc to 1 GHz, 40 dB insertion loss, ±2 dB. Can also be used as a high voltage, 50 ohm coaxial load.

Type 9841-1 1000 Volt Termination, 50 ohm coaxial 1 W average power. Typical input VSWR in a 50 ohm system under 1.5 from DC to 1 GHz.

MODEL 8282-1 TRANSIENT PULSE GENERATOR

for conducted transient susceptibility testing, 0.15 µS - 5.0 µS - 10.0 µS up to 600 volts (peak)

APPLICATION

The **Model 8282-1 Transient Pulse Generator** was designed for screen room use in making conducted spike susceptibility tests. It provides all the waveshapes required by MIL-STD-461B/C and many other military EMI specifications.

DESCRIPTION

Spike generators required for susceptibility testing have been our specialty since 1962, when our first unit, the **Model 6254-1**, was introduced. The **Model 8282-1** incorporates all the flexibility and technical excellence of the previous models and provides features required by specification MIL-STD-461B/C.

Three different spike durations are provided: 0.15 µS, 5.0 µS, and 10.0 µS. The pulse shape approximates the curve of Figure 19 in MIL-STD-462. The amplitude of the spike voltage is fully adjustable and is displayed on an LED meter.

In the series injection mode on 50, 60 or 400 Hz lines, a phase adjustment allows the spike to be positioned anywhere on the sine wave of the power line. This feature makes possible the injection of interfering transients at selected points in time to determine the susceptibility of systems which depend upon frequency or time.

The repetition rate of the spike can be adjusted with a panel control to any rate from 0.5 to 50 p.p.s. A single pulse can be injected with the aid of a panel-mounted pushbutton.

All functions are selected by pushbuttons which are lighted when activated.

The **Model 8282-1 Transient Pulse Generator** provides up to 600 volts peak amplitude for each of the 0.15, 5.0 and 10.0 µS spikes. The output voltage rises steeply to peak amplitude as adjusted by the panel control, then falls exponentially to cross through zero at the duration of 0.15, 5.0, or 10.0 µS as selected by pushbuttons. The voltage falls below zero and "rings" for a period determined by the inductance in the output circuit or the load. **The peak amplitude displayed on the LED meter is the value that would appear across a 5.0 ohm non-inductive load.**

With series injection on 50, 60 or 400 Hz power lines, the spike can be applied to either the positive or negative half cycle of the power frequency sine wave. The spike can be adjusted to fall on the power sine wave from 0° to 360°.

For non-synchronous injection, the repetition rate can be adjusted from 0.5 to 50 p.p.s.

A pushbutton enables the "single spike" feature and the spike can be manually triggered by pushing another button. A connector on the rear panel makes provision for remote triggering of the single spike feature.

Two methods of remote triggering are provided. One method requires the application of 24 volts d.c. to trigger the pulse at rates determined by an external switch up to 550 p.p.s. The second method requires the application of a square wave which can be used to trigger the spike up to 50 p.p.s. for the 0.15 µS spike and up to 1000 p.p.s. for the 5.0 and 10.0 µS spikes. This latter feature can be used to trigger the spike in sync with some function within the equipment under test.

FEATURES

- Provides outputs up to 600 volts peak amplitude for the 0.15, 5.0 and 10.0 µS spikes into a five ohm resistive load (low source impedance).
- A wide range of repetition rates allows spike injection in terms of the pulse rates of items being tested.
- The single pulse feature enables controlled isolation of transient effects.

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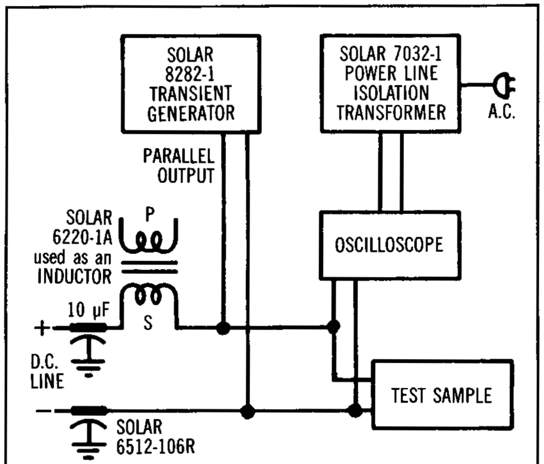
MODEL 8282-1 TRANSIENT PULSE GENERATOR

- Adjustable pulse position on a.c. power lines relates the transient susceptibility to the real time aspects of digital circuitry served by a.c. power.
- Transients can be injected in synchronism with repetitive circuit functions as required by **Method CS06** of MIL-STD-462.
- Remote triggering of single or repetitive pulses in terms of particular system characteristics.
- The upper terminals of the PARALLEL pair and the SERIES pair provide a positive-going spike on the 5 µS and the 10 µS modes. These terminals deliver a negative-going spike in the 0.15 µS mode. When the test plan requires both a positive and a negative spike, it is necessary to reverse the connections to the output terminals of the **Model 8282-1 Spike Generator**.

SPECIFICATIONS

Spike Durations: Pushbutton selectable durations of 0.15 µS, 5.0 µS and 10.0 µS (±20%) to zero crossover, into 5.0 ohm resistive load.



PARALLEL INJECTION ON D.C. LINE

Adjustable Peak Amplitude: Up to 600 volts for 0.15 µS, 5.0 µS and 10.0 µS durations into five ohm non-inductive load.

Internal Impedance: Less than 5.0 ohms for 0.15 µS, less than 2.0 ohms for 5.0 µS, less than 1.0 ohm for 10.0 µS.

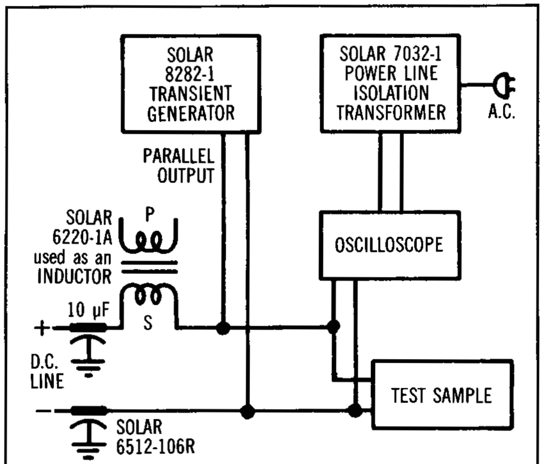
Pulse Repetition Rate: Manually adjustable up to 50 p.p.s. for all pulse durations.

Pulse Shape: Ringing characteristic similar to Figure 19 in MIL-STD-462 when connected to non-inductive load.

Pulse Position: Adjustable from 0° to 360° on 50 Hz, 60 Hz or 400 Hz power lines.

External Sync Operation: Remotely triggerable up to 50 p.p.s. for 0.15 µS, up to 1000 p.p.s. for 5.0 and 10.0 µS.

Amplitude Display: Panel meter is analog LED display of peak amplitude as it would be into a five ohm resistive load.



SERIES INJECTION ON A.C. LINE

Power Current in Series Injection Mode: Handles up to 50 amperes of current at power frequencies.

Power Requirements: 115 volts 60 Hz, 3.0 amperes. (230 volts 50 Hz, 1.5 ampere available.)

Size: 12.25" wide , 8.7" high 13" deep. (311 mm x 211 mm x 330 mm.)

Weight: 30 pounds.

USEFUL ACCESSORIES

Type 7115-2 High Voltage Pulse Transformer. Plugs into SERIES output terminals to provide transient levels up to 15 KV, peak, into **Type 7510-1** Spark Gap assembly for static discharge tests.

Type 7512-1 Spike Injection Probe*

Type 7519-1 Pulse Shaping Network*

Type 7541-1 Spike Receptor Probe*

Type 8282-150 Transient Pulse Transformer. Plugs into SERIES output terminals. Handles up to 150 amperes through the secondary for high current test samples.

Type 8525-1 Non-Inductive Five Ohm Load

Type 8527-2 Transient Pulse Transformer. Plugs into SERIES output terminals to provide spike levels up to 2 KV, peak, into 50 ohms when using the ten microsecond function.

Type 8908-1 Transient Pulse Transformer. Plugs into series output to provide up to 600 V spike into 50 ohms when using 5 µS or 10 µS function.

Type 9007-1 Transient Pulse Transformer. Plugs into SERIES output terminals to provide spike levels up to 1200 V into 50 ohms when using the 0.15 microsecond function.

* See Application Note on Cable Induced Transients

MODEL 7399-2 SPIKE GENERATOR 2500 VOLTS

for conducted transient susceptibility testing

APPLICATION

The Model 7399-2 Spike Generator is a "Big Bang" unit capable of providing high energy spikes with amplitudes adjustable up to 2500 volts, peak, into low impedance loads, as required by paragraph 4.8.5.4 of **MIL-E-16400G** and described in **MIL-STD-1399** Appendices A, B, C, and D. The shape of the spike approximates Figure 1 of **MIL-STD-1399**, Section 103, as shown.

DESCRIPTION

Modes of operation:

- Repetitive spikes up to 2500 volts peak at two pulses per minute.
- Single non-synchronous spike actuated by a pushbutton on the panel.
- Sync functions provide for placing the spike on the power frequency waveform of 50, 60 or 400 Hz power lines. The spike can be moved to any point o the sine wave from 0° to 360°.

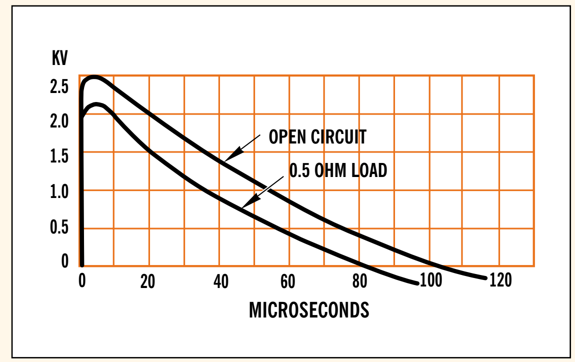
A SYNC TEST function is provided for adjusting the trigger circuit of the associated oscilloscope for response to a single pulse. After this adjustment of the scope, it is ready for viewing the spike. When the READY lamp indicates the storage circuit has been charged to the selected peak voltage, the pushbutton is depressed which triggers the sync circuit of the oscilloscope.

All connections to the **Model 7399-2** are isolated from the chassis. The chassis is grounded through the third wire in the power cord in accordance with safety regulations.

The **Model 7399-2** is provided with two plug-in assemblies which enable it to be configured for series or parallel injection as described in the appendices of MIL-STD-1399:

1) Using the P/N **739945** Plug-in Unit, the equipment is ready for series injection as described in Appendix B of the MIL spec. In this mode, the operation of the **Model 7399-2** is identical to **Model 7399-1**. When using the P/N **739945** Plug-in Unit, heavy duty output jacks provide connections in series with loads up to 100 amperes r.m.s. The mating plugs are well insulated and will handle power line voltages in excess of 500 volts, r.m.s.

2) Using the P/N **739950** Plug-in Unit, the equipment can be used for parallel injection of the spike on single or three phase power circuits as described in proposed Appendices A, C, and D of the MIL spec. This method requires the use of external components determined by the characteristics of the item being tested.



SPECIFICATIONS

	NO LOAD	0.5 OHM LOAD
Peak Amplitude:	100-2500 V	100-2000 V
Rise Time:	≈1 µS	≈2 µS
Duration to 50% of Peak:	≈50 µS	≈31 µS
Duration to Zero Crossover:	≈100 µS	≈77 µS

Repetition Rate: 2 pulses per minute.

Phase Adjustment: Spike position adjustable from 0° to 360° on 50, 60 or 400 Hz sine wave.

Internal Impedance: Less than 0.1 ohm.

Peak Output Power: 8 Megawatts into 0.5 ohm load.

Power Current in Series Injection Mode: Handles up to 100 amperes of current at power frequencies.

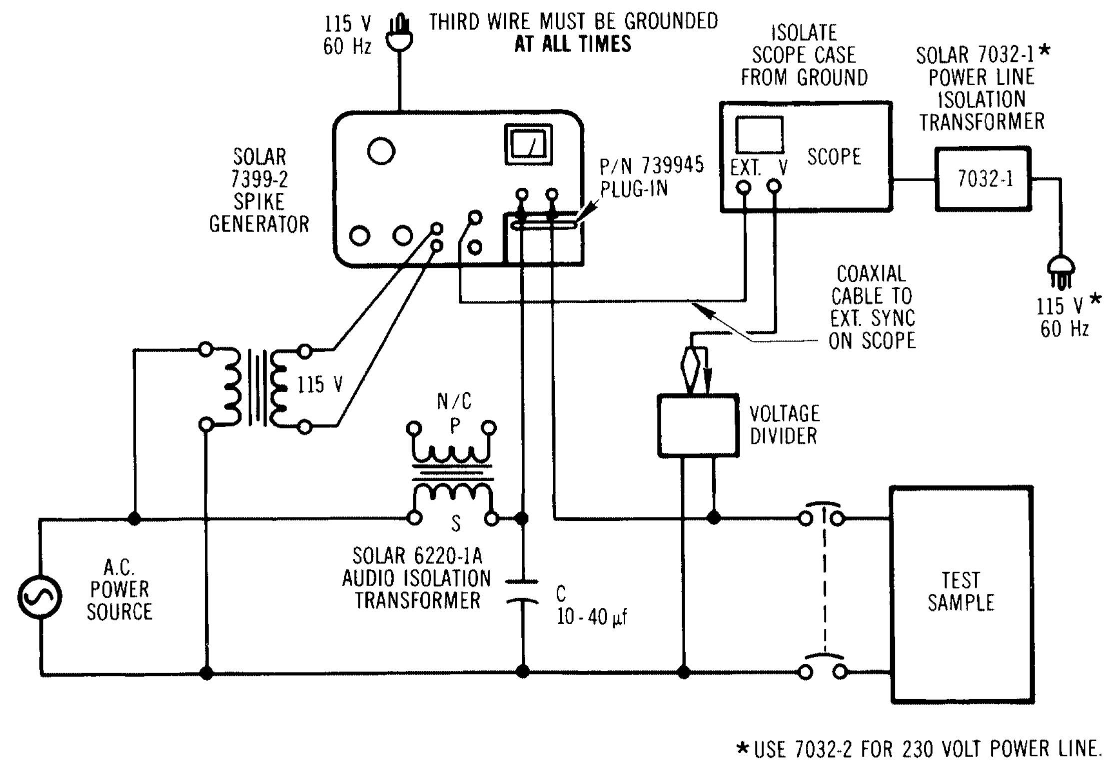
Power Requirements: 115 volts 60 Hz, 2.0 amperes (230 volts 50 Hz, 1.0 ampere available).

Size: 21.06" wide, 12.56" high, 15.50" deep (53.5 cm x 31.9 cm x 39.4 cm).

Weight: 70 pounds plus 5 pounds for accessories.

Total Shipping Weight: 75 pounds.

* Spike duration can be changed from ≈20 µS to ≈100 µS using internal jumpers.



TEST CIRCUIT FOR APPLICATION OF LINE-TO-LINE HIGH VOLTAGE SPIKES TO NAVY EQUIPMENT SUPPLIED BY SINGLE PHASE A.C. POWER. REF.: MIL-STD-1300, APPENDIX B.

ACCESSORIES (Supplied)

P/N **739945 Plug-in Unit** for series injection of spike into power lines.

P/N **739950 Plug-in Unit** for parallel injection (using external components).

Mating connectors: Two 100 ampere styles, for power connections; two 50 ampere styles, for external resistor.

USEFUL ACCESSORIES (Not Included)

Type 6220-1A Transformer. Can be used as a high current series inductor.

Type 7032-1 Isolation Transformer. For removing power ground from the case of the scope (see diagram above).

MODEL 7054-1 SPIKE GENERATOR 600 volts

for conducted transient susceptibility testing up to 600 volts peak

For those who have graduated from the 50 volt and 100 volt spike susceptibility category, we offer this high-power 600 volt transient generator. The **Model 7054-1** delivers over 300 kw into low resistance loads. It has the flexibility and capability of the previous models, including the ability to shift the transient in phase to any position on the sine wave of the a.c. line feeding the test sample. The amplitude and the repetition rate are adjustable.

APPLICATION

The **Model 7054-1 Spike Generator** was especially designed for screen room use in applying high voltage transients at power line inputs to electronic equipment. The adjustable amplitude makes it possible to determine the threshold of susceptibility to spikes appearing on the power line. The **Model 7054-1** may be used for performing tests per Method CS06 of MIL-STD-462, Method 5006.1 of MIL-STD-826A, RTCA D0160D (with impedance matching transformer) various missile specifications and others.

DESCRIPTION

The peak amplitude of the **Model 7054-1 Spike Generator** is adjustable from 10 volts to over 600 volts into 5 ohms. The source impedance is less than 0.5 ohm. The transient shape approximates the curve given in Figure 19 of MIL-STD-462. Less than one microsecond rise time and approximately 10 microseconds fall time.

On 50, 60 or 400 Hz power lines the transient can be applied in a periodic manner to the negative or the positive half-cycle of the power frequency. The transient's relation to the sine wave may be adjusted in phase from 0° to 360°. For non-synchronous injection on either a.c. or d.c. lines, the repetition rate can be adjusted from 0.8 p.p.s. to 10 p.p.s. Single transients can be applied with the pushbutton on the panel.

Two sets of output terminals allow either parallel or series injection into the power line. Series injection may be used on d.c. and a.c. lines. Parallel injection is used on d.c. lines **only**. The output winding used for series injection can carry 25 amperes of power current. The output terminals are isolated from the chassis and the power cord.

SPECIAL MODELS

Model 7054-1A.
Waveshape falls to zero in approximately 50 microseconds. Provides 400 volts peak into 5 ohm load. Handles 15 amperes power current.

Model 7054-1B.
Waveshape falls to zero in approximately 120 microseconds. Provides 400 volts peak into 5 ohm load. Handles 10 amperes power current.

FEATURES

- Provides output levels from 10 volts to more than 600 volts into 5 ohms or less. Delivers more than 300 kw peak into 0.5 ohm load.
- Adjustable pulse position on a.c. lines relates the transient susceptibility to real time aspects of digital systems.
- Single pulse feature for controlled isolation of transient effects.
- Output terminals for series or parallel injection.
- Standard rack panel construction: 7" high, 19" wide, 12.75" deep. (17.78 cm wide, 48.26 cm high, 32.38 cm deep.)

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MODEL 7054-1 SPIKE GENERATOR 600 volts

SPECIFICATIONS

Spike Amplitude: Continuously adjustable from 10 volts to over 600 volts peak.

Repetition Rate: Continuously adjustable from 0.8 to 10 p.p.s.

Rise Time: Less than 1.0 microsecond, into 5 ohm resistive load.

Spike Duration: Output falls to zero in approximately 10 microseconds.

Spike Shape: See curve. Similar to Figure 19 of MIL-STD-462.

Phase Adjustment: Spike position adjustable from 0° to 360° periodically on 50, 60 or 400 Hz sine wave.

Internal Impedance: Less than 0.5 ohm.

Output Power: More than 300 kw peak into 0.5 ohm load.

Power Current in Series Injection Mode: Handles up to 25 amperes of current at power frequencies.

Power Requirements: 115 volts 60 Hz, 1.6 amperes. (230 volts 50 Hz, 0.8 ampere available.)

Size: Standard rack panel: 7" high, 19" wide, 12.75" deep. (17.78 cm x 48.26 cm x 32.38 cm.)

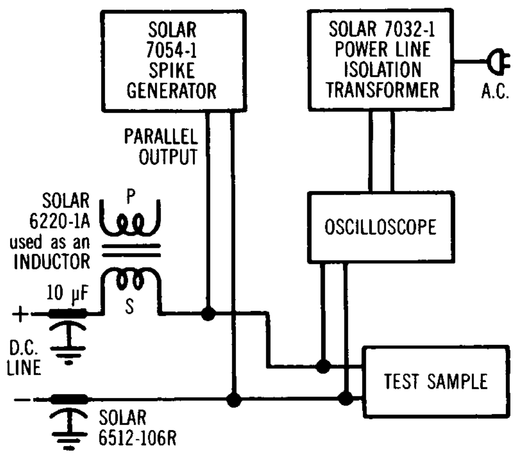
AVAILABLE ACCESSORIES

Type 7332-1 Transient Pulse Transformer. Plugs into SERIES output terminals of **7054-1A** to provide spike levels up to 600 volts, peak, into 6 ohm load.

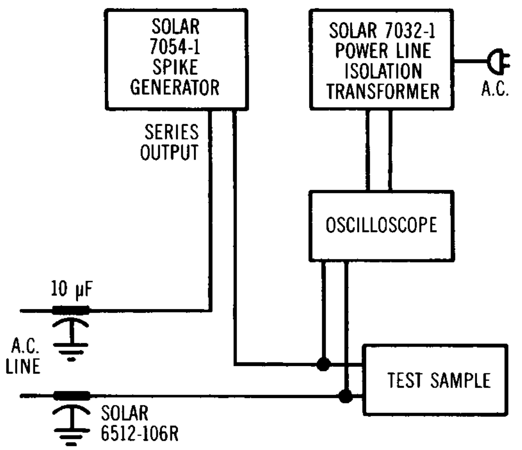
Type 7406-1 Transient Pulse Transformer. Plugs into SERIES output terminals of **7054-1** to provide spike levels up to 1200 volts, peak, into 50 ohm load.

Type 8525-1 Noninductive Five Ohm Load.

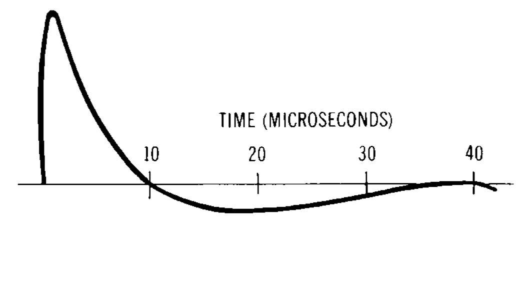
Type 8527-1 Transient Pulse Transformer. Plugs into SERIES output terminals of **7054-1** to provide spike levels up to 2 KV, peak, into 50 ohm load.



PARALLEL INJECTION ON D.C. LINE



SERIES INJECTION ON A.C. LINE



TRANSIENT SHAPE INTO FIVE OHM LOAD
REQUIRED BY MIL-STD-461A/462

MODEL 6254-5S RFI TRANSIENT GENERATOR

for conducted transient susceptibility testing up to 250 volts, peak

This generation of our well known RFI Transient Generator incorporates all of the flexibility and technical improvements of the previous models including the ability to shift the transient to any position on the sine wave of a power line. This phase adjustment makes possible the application of interfering transients at selected points in time to determine the susceptibility of systems which depend upon frequency or time for correct operation.

This transient generated can be synchronized with external digital signals over a wide range of repetition rates. Also, it can be remotely triggered by the application of switch controlled 24 volts d.c. at rates up to 20 p.p.s.

APPLICATION

The **Model 6254-5S RFI Transient Generator** was especially designed for screen room use in making conducted transient susceptibility tests as required by military specifications. These specifications include: parts of MIL-STD-461A/462, MSFC-STD-279, Lockheed 422966 (L1011), TRW TOR-1001, Douglas WZZ-7000 (DC-10), and others.

DESCRIPTION

The **Model 6254-5S RFI Transient Generator** provides up to 250 volts peak amplitude. The output transient shape follows the curve given in Figure 19 of MIL-STD-462. Less than 1.0 microsecond rise time, falling to zero in 8 to 14 microseconds, crossing through zero to "ring" in the manner of an inductive transient and returning to zero again as it "rings." The amplitude of the transient is adjustable from less than 10 volts to over 250 volts peak.

Using series injection on 50, 60 or 400 Hz lines, the transient can be applied to the positive or the negative half-cycle. The transient's relation to the sine wave may be adjusted in phase from 0° to 360°. For non-synchronous injection, the repetitive rate of the transient can be adjusted from 0.5 to 500 p.p.s.

For synchronous injection, a square wave input from an external source enables the transient to be triggered in terms of the digital or pulse characteristics of the test sample through the range 0.1 p.p.s. to 800 p.p.s.

A panel mounted push-button allows manual injection of single transients. A rear connector provides for remote triggering of single transients in terms of your system requirements.

Output terminals provide for either series injection on AC. lines or parallel injection on d.c. lines as required by specifications. Output terminals are isolated from chassis and the a.c. line.

FEATURES

- Provides outputs from less than 10 volts to over 250 volts peak amplitude into high impedance loads and more than 35 kw into 0.5 ohm load.
- Wider range of repetition rates allows greater utilization in empirical setups.
- Output terminals for series or parallel injection.
- Single pulse feature enables controlled isolation of transient effects.
- Adjustable pulse position on a.c. lines relates the transient susceptibility to the real time aspects of digital systems.
- Transient may be injected in synchronism with repetitive circuit functions as required by Method CS06 of MIL-STD-462.
- Remote triggering of individual or repetitive pulses in terms of particular system characteristics.

MODEL 6254-5S RFI TRANSIENT GENERATOR

SPECIFICATIONS

Spike Amplitude: Continuously adjustable from less than 10 volts to more than 250 volts peak.

Repetition Rate: Continuously adjustable from 0.5 to 500 p.p.s.

Rise Time: Less than 1.0 microsecond.

Spike Duration: Output falls to zero in approximately 8 to 14 microseconds.

Spike Shape: Ringing characteristic as shown in Figure 19 of MIL-STD-462.

Phase Adjustment: Spike position adjustable from 0° to 360° on 50, 60 or 400 Hz lines.

Sync Operation: Triggers at any rate from once every ten seconds to over 800 transients per second.

Internal Impedance: 0.5 ohm.

Output Power: More than 35 kw peak into 0.5 ohm load.

Power Current in Series Injection Mode: Handles up to 50 amperes at power frequencies.

Power Requirements: 115 volts 60 Hz, 1.8 amperes. (230 volts 50 Hz, 0.9 ampere available.)

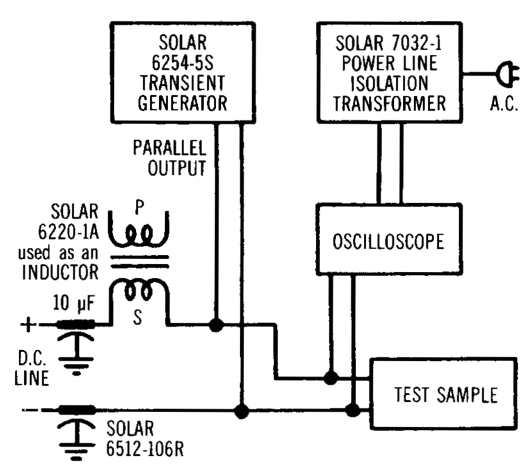
Size: 8.125" wide, 9" high, 14.625" deep. (20.64 cm x 22.86 cm x 37.15 cm.)

AVAILABLE ACCESSORIES

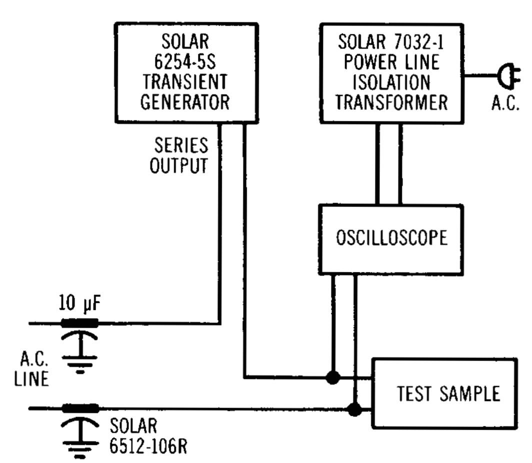
Type 6254-150 Transient Pulse Transformer. Plugs into SERIES output terminals. Handles up to 150 amperes through the secondary for high current test samples.

Type 7115-1 High Voltage Transient Transformer. Plugs into SERIES output terminals to provide transient levels up to 15 KV peak, into spark gap for static discharge tests.

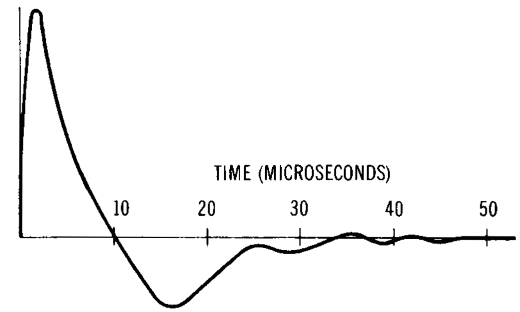
Type 7802-1 Transient Pulse Transformer. Plugs into SERIES output terminals to provide up to 450 volts peak, into 12 ohms.



PARALLEL INJECTION ON D.C. LINE



SERIES INJECTION ON A.C. LINE



TRANSIENT SHAPE INTO FIVE OHM LOAD REQUIRED BY MIL-STD-461A/462

MODEL 8850-1 HIGH POWER SWEEP GENERATOR

for conducted audio frequency susceptibility testing

APPLICATION

The **Model 8850-1 Power Sweep Generator** was developed in response to the demand for increased audio voltage from a low impedance source when performing CS01 Conducted Audio Susceptibility tests per MIL-STD-461B/C and CS101 conducted susceptibility test per MIL-STD-461D and E. This high power unit is especially suited for rapidly making tests in the shielded room.

When used with the **Type 6220-1A (or 6220-2) Audio Isolation Transformer,** the combination enables the injection of sine wave audio voltages into active power lines supplying power to an Equipment Under Test (EUT).

DESCRIPTION

The **Model 8850-1 Power Sweep Generator** provides audio power in a manually tuned or sweeping mode for four frequency bands covering 30 Hz to 100 KHz. Each band can be swept for one minute, or all bands can be swept in sequence for one minute. In the manual mode, a tuning knob controls the output frequency.

Both the frequency in KHz and the output level in volts r.m.s. are continuously displayed on two digital meters on the panel.

When used in conjunction with the **Type 7021-1 Phase Shift Network** and the **Type 6220-1A Transformer,** provision is made for sensing the audio voltage being injected into the EUT and displaying it on the digital panel meter. In this arrangement, the unit maintains a constant injection level (up to a maximum of 7.5 volts r.m.s.) as frequency is scanned or swept.

Maximum power output of the unit into a 1.5 ohm resistive load is over 300 watts and 200 watts into 2.5 ohms. The output voltage into a 0.5 ohm load connected to the secondary of the associated **Type 6220-1A Transformer** can be adjusted to a level in excess of ten volts at 1.0 KHz.

FEATURES

- Manual or automatic frequency sweep from 30 Hz to 100KHz.
- Digital display of frequency and output voltage level or injection voltage level.
- Remote sensing of voltage being injected into the Equipment Under Test.
- Automatic leveling of output voltage as frequency is scanned or swept.
- Protective circuits prevent damage to output stages caused by power frequency feedback in typical a.c. test setups.
- Low output impedance for greater transfer of audio power.
- Up to 300 watts output into 1.5 ohm resistive load and 200 watts into 2.5 ohms.

AVAILABLE ACCESSORIES

Type 6220-1A Audio Isolation Transformer. Use for injecting output of 8850-1 in series with power to test sample as required by test method CS01.

Type 7021-1 Phase Shift Network. Use for removing the power frequency from the voltmeter in CS01 tests.

Type 8810-1 Impedance Matching Transformer. Plugs into output terminals to step up the output to 50 ohms Impedance. Use when a 50 ohm signal source is needed.

Type 8811-1 Wide Range Transformer. Plugs into output terminals to provide up to 115 volts r.m.s. at 200 watts. Use as a power source for frequencies from 30 Hz to over 2 KHz.

Type 9138-1 Step-up Transformer. Plugs into output terminals to provide up to 2 KV into 20,000 ohm load, 3 KHz to 30 KHz.

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MODEL 8850-1 HIGH POWER SWEEP GENERATOR

SPECIFICATIONS

Frequency Range: 30 Hz to 100 KHz in four bands, manually tunable or by automatic sweep and continuous display on digital panel meter.

Output Power: 300 watts into 1.5 ohms 200 watts into 2.5 ohms.

Output Voltage: 22 volts r.m.s. maximum at 1 KHz.

Output Current: 15 amperes maximum at 1 KHz.

Output Level: Manually controlled by panel knob. Continuously displayed on digital panel meter.

Sweep Duration: One minute for one band or one minute for all four bands selected by push-buttons.

Remote Sense: Automatically maintains output voltage at the level set by the operator, up to 7.5 volts r.m.s., as frequency is scanned or swept.

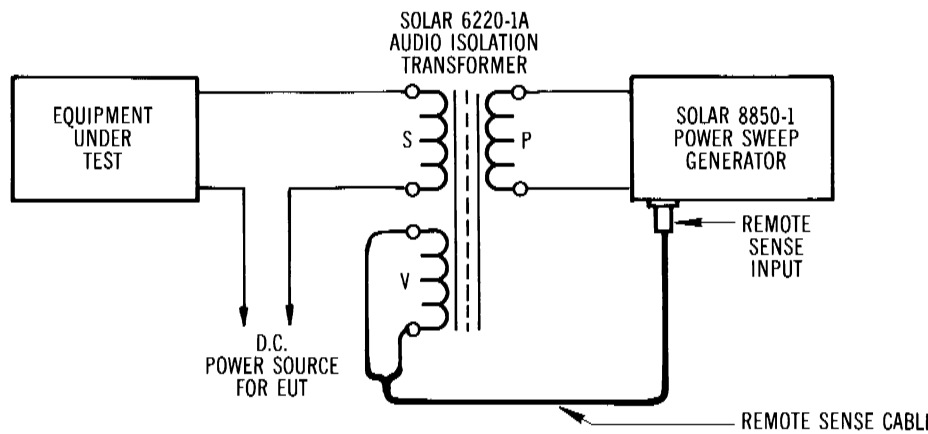
Frequency Stability: 250 ppm/C.

Output Level Drift: Less than 0.5%.

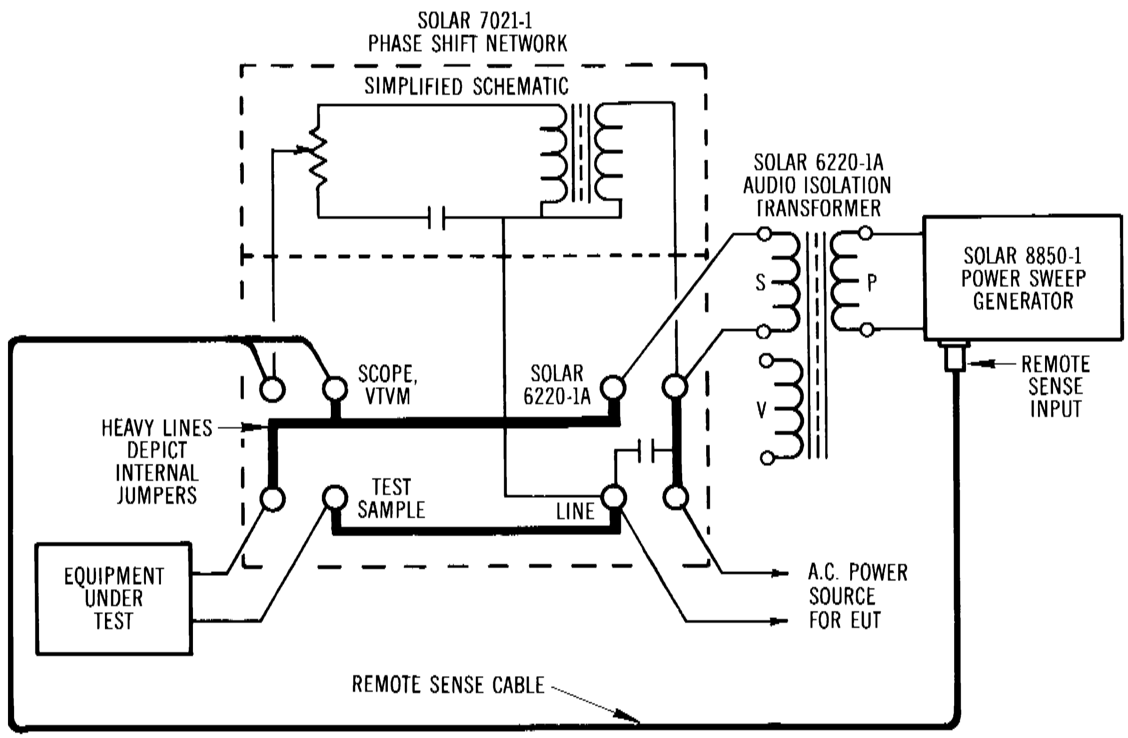
Overload Protection: Automatic shut down for excess temperature, over-voltage, or over-current conditions in output circuit.

Power Requirements: 115 volts 60 Hz, 6 amperes (230 volts 50 Hz, 3 amperes available.)

Size: 8.75" wide, 17.25" high, 13" deep. (22.22 cm x 43.82 cm x 33.02 cm.)



AUDIO SUSCEPTIBILITY TEST SETUP FOR D.C. LINES



MODEL 6552-1A 100 watt Solid State AUDIO AMPLIFIER

for conducted audio frequency susceptibility testing

APPLICATION

The **Model 6552-1A 100 watt Solid State Audio Amplifier** was specifically designed for use with the **Type 6220-1A Audio Isolation Transformer** in making conducted audio frequency susceptibility tests as required by MIL-STD-461A/462 and other EMI specifications.

DESCRIPTION

The **Model 6552-1A Audio Amplifier** has a wide frequency response and is capable of providing up to 100 watts at 1000 Hz into 2.4 ohms at low distortion levels. Requires approximately 0.6 volt signal input for maximum power output at 1000 Hz. Incorporates feedback circuit for flat response within one dB from 30 Hz to 100 KHz at reduced power levels.

The -3 dB points are 25 Hz and 120 KHz when using the **6220-1A Transformer** loaded with 0.6 ohm. Cleverly designed protective circuit prevents damage due to transients, back EMF, overload or overdrive. Designed for laboratory use with portable case and conventional binding posts spaced .75" for standard shielded lead and double plug connections.

FEATURES

- Solid state.
- Up to 100 watts output.
- Wide frequency range.
- Low input impedance.
- No output transformer.
- Input and output protective circuits.
- Lightweight and portable.

AVAILABLE ACCESSORIES

Type 6220-1A Audio Isolation Transformer. Use for injecting output of 6552-1A in series with power to test sample as required by test method CS01.

Type 7032-1 Isolation Transformer. Use for removing power ground from the case of scope or voltmeter.

Type 7033-1 Impedance Matching Transformer. Plugs into output terminals to step up the normal 2.4 ohms to 50 ohms impedance. Use when a 50 ohm source impedance is needed.

Type 8415-1 Precision Resistor, .001 ohm ± .25%, 100 amperes. Use for accurate measurement of injected audio currents to 10 KHz.

SPECIFICATIONS

Input Voltage: 0.6 volt for maximum power output at 1000 Hz.

Input Impedance: 500-600 ohms.

Output Power: 100 watts at 1 KHz into 2.4 ohms.

Output Impedance: 2.4 ohms.

Output Voltage: 16 volts r.m.s. at 1000 Hz into 2.4 ohms (non-inductive).

Output Voltage at Secondary of 6220-1A: 7.7 volts r.m.s. into 0.6 ohm (non-inductive).

Gain Control: Panel mounted input level control.

Terminals: Three-way binding posts spaced at .75" for input and output.

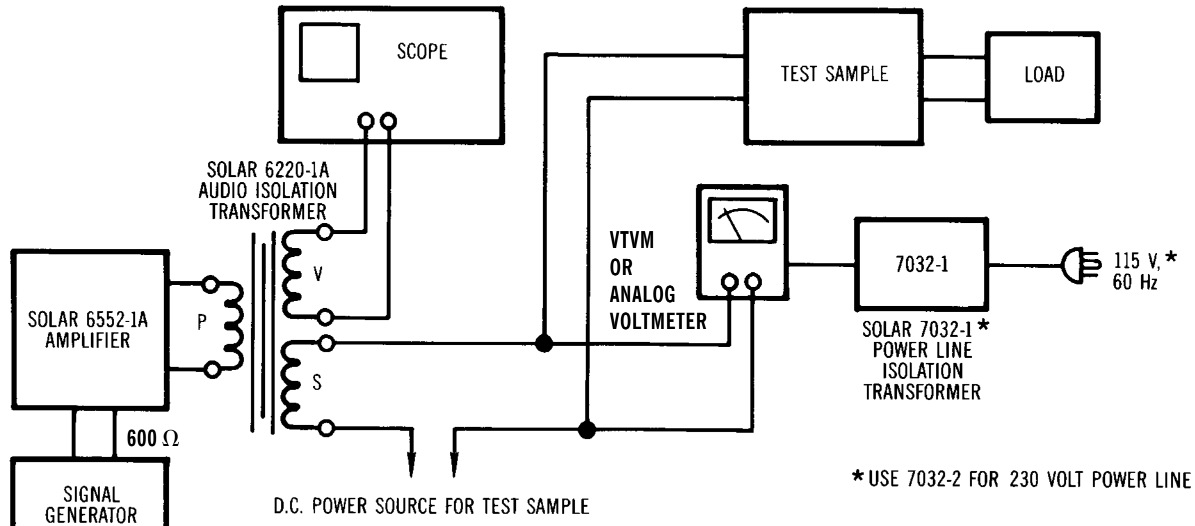
Fuses: Two a.c. line fuses (5 amps), one d.c. power supply fuse (5 amps), one output overload fuse (6 amps).

Power Requirements: 115 volts 60 Hz, 4.0 amperes. (230 volts 50 Hz, 2.0 amperes available.)

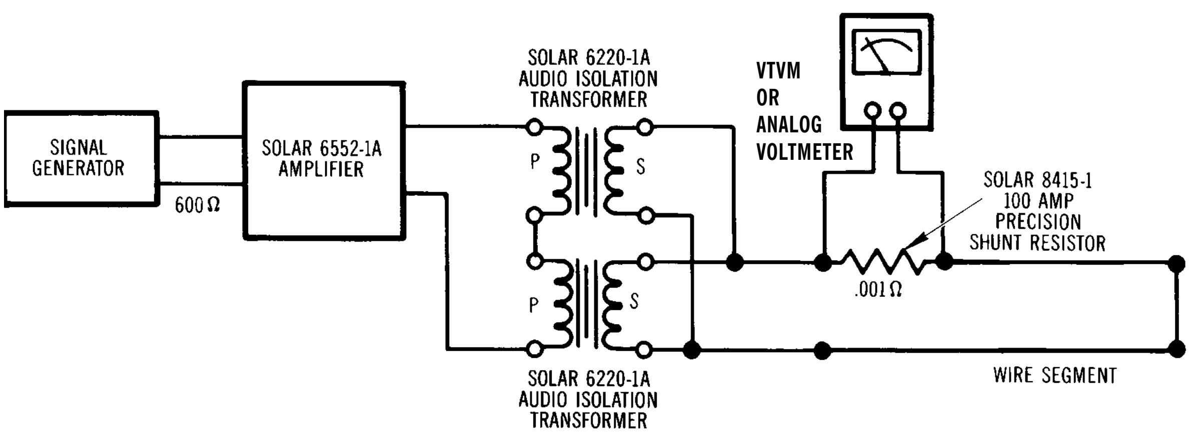
Size: 8.12" wide, 9" high, 14.62" deep. (20.64 cm x 22.86 cm x 37.15 cm.)

Model 7824-1. Rack version of Model 6552-1A. All connections out the rear.
Dimensions: 8.75" high x 19" wide x 12.75" deep. (22.22 cm x 48.24 cm x 32.38 cm.)

SOLAR ELECTRONICS COMPANY
Innovative EMI Solutions Since 1960
e-mail: sales@solar-emc.com www.solar-emc.com
A division of A.T. Parker, Inc.
(800) 952-5302
(818) 755-1700
FAX (818) 755-0078



AUDIO SUSCEPTIBILITY TEST SETUP FOR D.C. LINES
See back of Data Sheet No. 6550-1 for a.c. power lines



SUGGESTED METHOD OF GENERATING UP TO
30 AMPERES IN WIRE SEGMENT FOR SHORT PERIODS, 20 Hz to 5 KHz

MODEL 6550-1 POWER SWEEP GENERATOR

100 watt source for conducted audio frequency susceptibility testing

APPLICATION

The **Model 6550-1 Power Sweep Generator** is an unusually versatile instrument which produces triangular, square and sine waves at 100 watt levels with selectable sweep rates or manual control. This generator is especially suited for rapidly making conducted susceptibility tests on power line inputs to test samples as required by MIL-STD-461A/462 and other EMI specifications.

DESCRIPTION

A switch allows selection of triangular, square wave and sine wave shapes. The frequency range switch provides ten-to-one ranges from 15 Hz to 150 KHz in four steps. The calibrated tuning dial covers the range for manual tuning. In addition, an automatic sweep selector switch provides two rates of sweep. An output level control adjusts the output to any desired level up to 100 watts. Protective circuits prevent damage due to line transients or overload.

Designed for laboratory use with portable case and conventional binding posts spaced .75" for standard shielded lead and double plug connections.

FEATURES

- Solid state.
- Up to 100 watts output.
- Protective circuit at output.
- Wide frequency range, 15Hz to 150 KHz.
- Manual or automatic frequency sweep.
- Three basic wave shapes: triangular, square, sine.
- Low output impedance.

AVAILABLE ACCESSORIES

Type 6220-1A Audio Isolation Transformer. Use for injecting output of 6550-1 in series with power to test sample as required by test method CS01.

Type 7021-1 Phase Shift Network. Use for removing the power frequency from the scope and voltmeter in CS01 tests.

Type 7032-1 Isolation Transformer. Use for removing power ground from the case of scope or voltmeter.

Type 7033-1 Impedance Matching Transformer. Plugs into output terminals to step up the normal 2.4 ohms to 50 ohms impedance. Use when a 50 ohm signal source is needed.

Type 7035-1 Wide Range Transformer. Plugs into output terminals to provide up to 115 volts r.m.s. at 80 watts. Use as a power source for frequencies from 20 Hz to 10 KHz.

SPECIFICATIONS

Frequency Range: 15 Hz to 150 KHz.

Wave Shapes: Triangular wave, square wave and sine wave.

Output Power: 100 watts sine waves at 1000 Hz into 2.4 ohms (non-inductive).

Output Impedance: Approximately 2 ohms.

Output Voltage: 16 volts r.m.s. at 1KHz into 2.4 ohms (non-inductive).

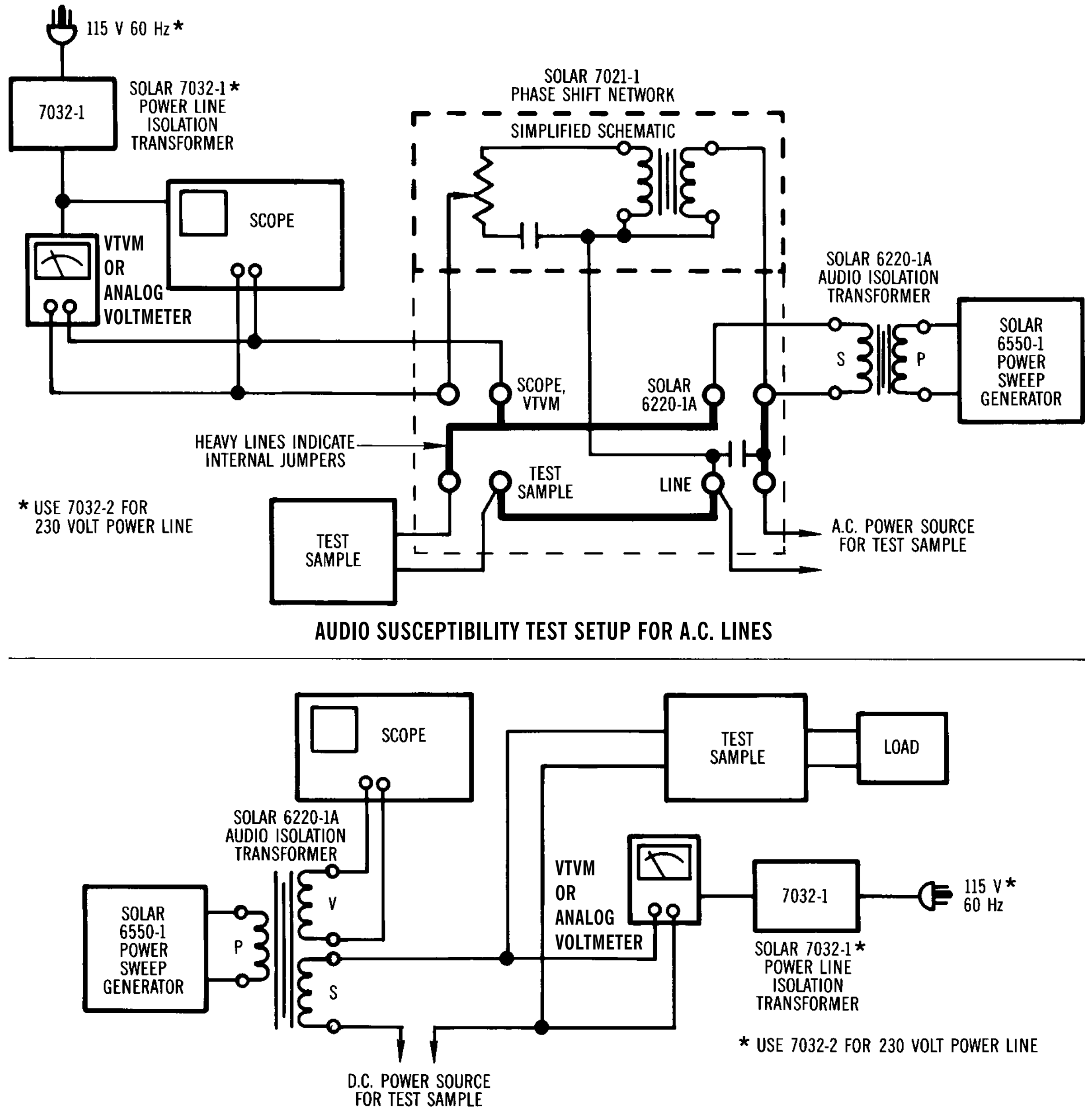
Level Control: Panel mounted output level control.

Sweep Rates: 1 per minute, 10 per per minute, or manual dial.

Terminals: Binding posts with .75" spacing for 3-way connection.

Power Requirements: 115 volts 60 Hz, 4.0 amperes. (230 volts 50 Hz, 2.0 amperes available.)

Size: 8.12" wide, 9" high, 14.62" deep. (20.64 cm x 22.86 cm x 37.15 cm.)



AUDIO SUSCEPTIBILITY TEST SETUP FOR A.C. LINES

AUDIO SUSCEPTIBILITY TEST SETUP FOR D.C. LINES

RFI/EMI CURRENT PROBES AND INJECTION PROBES

CURRENT PROBES

Current probes required by various EMI specifications (such as MIL-STD-461/2) are toroidal transformers designed to measure r.f. currents on active power lines or other conductors.

APPLICATION

A current probe is used as a "pick-up" device for measuring r.f. current in single conductors or cable bundles when connected to the 50 ohm input of a radio frequency interference measuring receiver or spectrum analyzer.

DESCRIPTION

Direct connection to the conductor carrying EMI current is not necessary, since the probe may be opened for insertion of the conductor into the window of the toroid and then closed again to form a toroidal transformer with the conductor acting as a one-turn primary.

A correction factor graph is provided to convert measured microvolts to EMI microamperes. When the EMI current is measured in dB above one microvolt as indicated on a conventional EMI meter, the correction factor will convert the measurement to dB above one microampere. The correction factor is the inverse of the transfer impedance, Zt. Each probe is shipped with a graph of the correction factor versus frequency, keyed to the serial number on the probe.

Under certain conditions, a current probe can be used to inject *low level* r.f. signals into individual wires or cable bundles. Ask our engineers for advice in the use of current probes for this purpose. Some current probes can be easily damaged or are otherwise unsuitable for this application.

INJECTION PROBES

Specifications require the injection of large high frequency currents into cable bundles and individual wires, using inserted secondary toroidal transformers placed around the conductors being tested.

APPLICATION

High power r.f. amplifiers with 50 ohm output impedance are used to deliver voltage to the injection probe. The wire or cable through the window of the probe acts as a secondary of the toroidal transformers. This test method is intended to be used instead of earlier methods, such as CS-01, CS-02, and RS-02 of MIL-STD-461.

DESCRIPTION

Bulk Current Injection Probes are available in two styles:

1. Fixed window style where the wire(s) under test must be passed through the window.
2. A split toroidal design where the probe can be opened up and clamped over the wire(s) under test.

Each probe is calibrated for insertion loss and transfer impedance in a test fixture designed for the particular window size. This fixture provides a signal path with a low Voltage Standing Wave Ratio. A typical fixture is **Solar Type 9125-1**, used for probes with 32 to 44 mm diameter windows. Ask for details on this and other test fixtures.

Injection probes available at the time of this printing are described later in this section. Development of new styles is ongoing. If a probe meeting your requirements is not found on the list, send us details and we will satisfy your need.

TECHNICAL INFORMATION

Current probes used as receptors are known as "inserted primary toroidal transformers" for connection to EMI receivers. **Injection probes** which deliver high r.f. currents into wires through the window are called "inserted secondary toroidal transformers".

The maximum voltage carried on wires through the window is limited only by the insulation of the wires. Maximum primary current in the wires through the window of **current probes** is listed on the table below (symbol Ip).

The signal input to **injection probes** is rated in watts from the signal source as indicated in the table on the following page.

Development is continuing on new and useful probes, both current measuring "sensor" probes and high wattage injection probes. The following is a partial list. As time goes on, the list will grow. If you do not see what you need, just ask.

CLAMP-ON CURRENT PROBES				MAXIMUM PRI. (Ip) CURRENT, AMPS			
SOLAR TYPE NO.	WINDOW DIAMETER	NOMINAL Z_T OHMS	DC to 60 Hz	400 Hz	RF (CW)	PULSE	FREQUENCY RANGE
9124-1N	1.25" (32.0 mm)	0.001	200	70	50	5000	1 KHz -200 MHz
9204-1	1.25" (32.0 mm)	0.33	350	350	50	100	1 KHz - 8 MHz
9205-1	1.25" (32.0 mm)	0.33	800	800	50	100	20 Hz - 8 MHz
9118-1	1.25" (32.0 mm)	0.10	350	150	22	500	500 Hz -200 MHz
9134-1	1.25" (32.0 mm)	0.70	500	400	5	100	20 Hz -100 MHz
6741-1	1.25" (32.0 mm)	0.70	350	225	5	100	10 KHz -100 Mhz
9206-1	1.25" (32.0 mm)	1.0	350	350	4.2	100	10 KHz -150 MHz
9207-1	1.25" (32.0 mm)	1.0	800	450	4.2	100	20 Hz -150 MHz
9208-1	1.25" (32.0 mm)	1.0	350	350	100	200	10 KHz - 30 MHz
9209-1	1.25" (32.0 mm)	1.0	800	800	100	200	20 Hz - 30 MHz
9145-1	1.25" (32.0 mm)	5	350	350	42	100	10 KHz -150 MHz
9119-1N	1.25" (32.0 mm)	1-7	200	200	40	70	1 MHz- 1.2 GHz
9123-1N	1.25" (32.0 mm)	1-5	200	200	40	60	10 KHz -500 MHz
9115-1N	1.25" (32.0 mm)	10	250	250	50	100	3 MHz-200 MHz
9214-1	1.25" (32.0 mm)	5	600	600	21	200	20 Hz -150 MHz
9215-1N	1.25" (32.0 mm)	1-5	400	350	40	100	20 Hz -500 MHz
9231-1	1.25" (32.0 mm)	.010	300	200	7	3000	1 KHz -200 MHz
9219-1N	1.25" (32.0 mm)	.025	400	300	150	200	20 Hz - 20 Mhz
9242-1	1.25" (32.0 mm)	.025	400	80	35	100	20 Hz - 20 MHz
9250-1N	1.25" (32.0 mm)	.10	200	200	10	200	10 KHz -450 MHz
9136-1N	2.62" (67.0 mm)	5	350	350	100	200	10 KHz -100 MHz
9249-1N	2.62" (67.0 mm)	8	350	350	60	200	10 KHz -300 MHz
9256-1N	2.62" (67.0 mm)	2	350	350	200	200	10 KHz - 30 MHz
9257-1N	2.62" (67.0 mm)	2	500	500	200	200	20 Hz - 30 MHz
9258-1N	2.62" (67.0 mm)	5	500	500	100	200	20 Hz -100 MHz
9260-1N	2.62" (67.0 mm)	2	350	75	2.6	100	10 KHz -200 MHz

(continued on next page)

CLAMP-ON CURRENT PROBES (continued)				MAXIMUM PRI. (Ip) CURRENT, AMPS			
SOLAR TYPE NO.	WINDOW DIAMETER	NOMINAL Z_T OHMS	DC to 60 Hz	400 Hz	RF (CW)	PULSE	FREQUENCY RANGE
9261-1N	2.62" (67.0 mm)	2	500	500	2.6	100	20 Hz -200 MHz
9262-1N	2.62" (67.0 mm)	.03	350	150	80	200	100 KHz - 100MHz
9263-1N	2.62" (67.0 mm)	.3	500	500	80	200	20 Hz -100 MHz
9301-1N	2.62" (67.0 mm)	8	500	500	60	200	20 Hz -500 MHz
9302-1N	2.62" (67.0 mm)	.001	400	70	100	500	20 Hz -100 MHz
9303-1N	2.62" (67.0 mm)	.001	500	200	100	5000	20 Hz -100 MHz
9304-1N	2.62" (67.0 mm)	1	350	350	2.3	200	10 KHz -200 MHz
9305-1N	2.62" (67.0 mm)	1	500	500	2.3	200	20 Hz -200 MHz
9306-1N	2.62" (67.0 mm)	.005	200	65	60	5000	10 KHz -100 MHz
9307-1N	2.62" (67.0 mm)	.005	300	300	60	5000	20 Hz -100 MHz
9308-1N	2.62" (67.0 mm)	.01	300	75	17	2000	10 KHz -200 MHz
9309-1N	2.62" (67.0 mm)	.01	450	450	17	2000	20 Hz -200 MHz

FIXED WINDOW PROBES				MAXIMUM PRI. (Ip) CURRENT, AMPS			
SOLAR TYPE NO.	WINDOW DIAMETER	NOMINAL Z_T OHMS	DC to 60 Hz	400 Hz	RF (CW)	PULSE	FREQUENCY RANGE
9218-1	.50" (12.7 mm)	.1	10	10	8	100	10 KHz -250 MHz
9248-1	.50" (12.7 mm)	1	10	10	10	100	10 KHz - 50 MHz
9203-1	.50" (12.7 mm)	1	10	10	2.2	100	10 KHz -250 MHz
9211-1	.50" (12.7 mm)	.5-3	10	10	5	100	1 MHz- 1 GHz
9202-1	.50" (12.7 mm)	5	10	10	10	100	10 KHz -250 MHz
9246-1	.50" (12.7 mm)	.1	150	150	8	100	10 KHz -250 MHz
9253-1	.50" (12.7 mm)	1	150	150	65	100	20 Hz - 50 MHz
9245-1	.50" (12.7 mm)	1	150	150	3	100	10 KHz -300 MHz
9210-1	.50" (12.7 mm)	.3-5	150	150	16	100	300 KHz -500 MHz
9212-1	.50" (12.7 mm)	.3-4	150	150	30	100	1 MHz- 1 GHz
9244-1	.50" (12.7 mm)	5	150	150	13	100	10 KHz -600 MHz
9346-1	.50" (12.7 mm)	5	150	150	13	100	20 Hz -600 MHz

We provide equivalents for most Stoddart and Eaton probes.

We provide equivalents for most Stoddart and Eaton probes.

CLAMP-ON INJECTION PROBES

SOLAR TYPE NO.	WINDOW DIAMETER	WINDING CURRENT	RATED WATTS	INSERTION LOSS UNDER 6 dB	INSERTION LOSS UNDER 10 dB	INSERTION LOSS UNDER 15 dB	INSERTION LOSS UNDER 20 dB	FREQUENCY RANGE
9108-1N	1.25" (32 mm)	10	50	—	—	120 KHz - 70 MHz	60 KHz - 150 MHz	10 KHz - 200 MHz
9120-1N	1.25" (32 mm)	30	50	—	12 MHz - 600 MHz	7 MHz - 900 MHz	4 MHz - 1GHz	4 MHz - 1 GHz
9121-1N	1.25" (32 mm)	30	50	—	100 MHz - 550 MHz	50 MHz - 800 MHz	30 MHz - 1GHz	10 MHz - 1 GHz
9142-1N	1.50" (38 mm)	50	200	10 MHz - 350 MHz	5 MHz - 430 MHz	2.5 MHz - 500 MHz	1.5 MHz -500 MHz	2 MHz -500 MHz
9144-1N	1.50" (38 mm)	26	100	—	200 KHz - 8 MHz	70 KHz - 90 MHz	40 KHz -100 MHz	10 KHz -100 MHz
9217-1N	1.50" (38 mm)	26	100	800 KHz - 1.5 MHz	500 KHz - 40 MHz	250 KHz - 100 MHz	150 KHz -100 MHz	10 KHz -100 MHz
9310-1N	2.62" (67 mm)	26	100	—	15 MHz - 450 MHz	800 MHz - 650 MHz	4 MHz -800 MHz	5 MHz -800 MHz
9607-1N	1.25" (32 mm)	10	50	—	500 KHz - 1 MHz	200 KHz - 30 MHz	120 KHz -300 MHz	10 KHz -300 MHz

Injection probes can also be used as current probes. A correction factor graph and instructions for its use are supplied.

CALIBRATION FIXTURES

Note: Except for p/n 9125-1 and 9357-1, the probes are supported and centered in the fixture.

SOLAR PART NO.	DESCRIPTION
9125-1	For Injection Probes, 1.5" (32 mm - 44 mm) diameter window. 20 Hz to 500 MHz. Type BNC connectors.
9125-2	For Solar 9119-1N Probe and similar, 1.25" (32 mm) diameter window. 400 MHz to 3 GHz. Type N connectors.
9251-1	For Eaton, Stoddart and Solar Probes, 1.25" (32 mm) diameter window. 20 Hz to 500 MHz. Type BNC connectors.
9254-1	For Eaton, Stoddart and Solar Probes, 2.62" (66 mm) diameter window. 20 Hz to 500 MHz. Type N connectors.
9321-1	For Eaton, Stoddart and Solar Probes, 0.75" (19 mm) diameter window, totally enclosed. 20 Hz to 1.5 GHz. Type BNC connectors.
9330-1N	For Eaton, Stoddart and Solar Probes, 1.25" (32 mm) diameter window, totally enclosed. 20 Hz ≈ 1.0 GHz. Type N connectors.
9357-1	Clam Shell Fixture for Solar 9335-2 Probe. 20 Hz to 100 MHz. Type BNC connectors.

LINE IMPEDANCE STABILIZATION NETWORKS

APPLICATION

When measuring conducted radio interference voltages from active power lines to ground, it is essential to know the line impedance so that repeatable tests can be made by more than one laboratory. Artificial line impedances are specified in MIL-STD-462, V.D.E., C.I.S.P.R., C22.4, NACSEM 5100, ANSI C63.2 and other EMI specifications.

The characteristic impedance of the five microhenry and 50 microhenry LISNs brackets the mean value of power line impedance which has been measured by independent researchers. These two inductance values in parallel with the 50 ohms of the EMI meter fall between the minimum and maximum line impedance values which have been measured. The mean value would be represented by a twenty microhenry inductor in parallel with100 ohms.

DESCRIPTION

The Solar Electronics LISNs use a series inductor between the test sample and the power source to provide the impedance-versus-frequency characteristic. A coaxial connector with d.c. isolation is provided for connection to the associated frequency selective EMI meter. The power source end of the inductor is bypassed to ground.

Due to the large current-carrying capability of some LISNs, it is not always practical to use a switch for changing inductance values. Instead, some models are equipped with a high current pin plug-and-jack combination for quickly connecting and disconnecting a network and substituting another. This nylon insulated pin plug and jack arrangement is a safety feature, well isolated from inadvertent short circuits, providing protection to operating personnel.

Current ratings up to 200 amperes are available in 50 µH styles and 500 amperes in 5 µH styles. See the chart on the following page.

When measurements are made in a shielded room, the LISNs intended for F.C.C. applications will also serve for V.D.E. tests. When operating on an unfiltered power line, the V.D.E. specifications require a filter consisting of 250 microhenry inductor and a capacitor. This filter is included in the 24 ampere LISN, **Type 9348-50-R-24-BNC**, and the 50 ampere LISN, **Type 8602-50-TS-50-N**.

EMI specifications require one LISN in each ungrounded power lead. Even though the neutral is considered "ground," if it is not connected to chassis **inside** the unit under test, the lead must be tested with an LISN. Therefore, use two LISNs in d.c. or single phase a.c. applications, three LISNs for delta-connected three phase circuits, and four LISNs for 'Y' connected three phase circuits.

Explanation of Type Numbers

8602-50-TS-50-N

- N: R.F. connector style
- 50: Current rating, amperes
- TS: Terminals: TS = Terminal Screw; PJ = Plug and Jack
- 50: Series inductance, microhenries
- 8602: Basic model number

Type Number	Current Amps	Inductance µH	Line/Ground Voltage 50-60 Hz	400 Hz	Case Size*	Circuit	Frequency Range
6330-100-PJ-50-N	50	100	270	130	#3	Single	10 KHz- 4 MHz
6330-100-TS-50-N	50	100	270	130	#3	Single	10 KHz- 4 MHz
6330-250-PJ-50-N	50	250	270	130	#3	Single	8 KHz- 4 MHz
6330-250-TS-50-N	50	250	270	130	#3	Single	8 KHz- 4 MHz
6330-600-PJ-50-N	50	600	270	130	#3	Single	7.5 KHz- 5 MHz
6330-600-TS-50-N	50	600	270	130	#3	Single	7.5 KHz- 5 MHz
6338-5-PJ-50-N	50	5	270	130	#1	Single	150 KHz- 65 MHz
6338-5-TS-50-N	50	5	270	130	#1	Single	150 KHz- 65 MHz
6338-57-PJ-50-N	50	57	270	130	#2	Single	14 KHz- 4 MHz
6338-57-TS-50-N	50	57	270	130	#2	Single	14 KHz- 4 MHz
6516-5-TS-10-BNC	10	5	270	130	#5	Single	150 KHz- 65 MHz
6516-57-TS-10-BNC	10	57	270	130	#6	Single	14 KHz- 4 MHz
7225-1	10	650	270	130	#1	Single	10 KHz-400 MHz (useable up to 1 GHz)
7333-5-PJ-50-N	50	5	500	240	#1	Single	150 KHz- 65 MHz
7333-5-TS-50-N	50	5	500	240	#1	Single	150 KHz- 65 MHz
7333-57-PJ-50-N	50	57	500	240	#2	Single	14 KHz- 4 MHz
7333-57-TS-50-N	50	57	500	240	#2	Single	14 KHz- 4 MHz
8012-50-R-24-BNC	24	50	135	N/A	#1	Dual	10 KHz- 50 MHz
8028-50-TS-24-BNC	24	50	270	130	#1	Single	10 KHz- 50 MHz
8116-50-PJ-100-N	100	50	270	130	#3‡	Single	10 KHz- 30 MHz
8116-50-TS-100-N	100	50	270	130	#3‡	Single	10 KHz- 50 MHz
8116-100-PJ-100-N	100	100	270	130	#3‡	Single	10 KHz- 4 MHz
8116-100-TS-100-N	100	100	270	130	#3‡	Single	10 KHz- 4 MHz
8116-250-PJ-100-N	100	250	270	130	#3‡	Single	8 KHz- 4 MHz
8116-250-TS-100-N	100	250	270	130	#3‡	Single	8 KHz- 4 MHz
8309-5-PJ-100-N	100	5	500	240	#3	Single	150 KHz- 65 MHz
8309-5-TS-100-N	100	5	500	240	#3	Single	150 KHz- 65 MHz
8328-50-PJ-50-N	50	50	270	130	#3	Single	10 KHz- 50 MHz, 0.1µf coupling capacitor
8328-50-TS-50-N	50	50	270	130	#3	Single	10 KHz- 50 MHz, 0.1µf coupling capacitor

***Case Sizes (w x h x l)**

Add 3" (7.62 cm) for Base Plate

‡ With 50 or 60 Hz Ventilating Fan; add 7.09" (18.00 cm)

#1: 4.5" x 4.5" x 9.25" (11.43 cm x 11.43 cm x 23.5 cm)

#2: 7.0" x 7.0" x 8.25" (17.78 cm x 11.78 cm x 24.13 cm)

#3: 10.06" x 9.0" x 13.12" (25.72 cm x 22.86 cm x 33.34 cm)

#4: 7.53" x 7.63" x 18.97" (19 cm x 19.43 cm x 48.26 cm)

#5: 3.12" x 1.75" x 3.87" (7.94 cm x 4.44 cm x 9.84 cm)

#6: 2.75" x 2.45" x 5.7" (6.98 cm x 6.22 cm x 14.48 cm)

#7: 13.06" x 7.0" x 10.06" (33.20 cm x 17.78 cm x 25.55 cm)

Type Number	Current Amps	Inductance µH	Line/Ground Voltage 50-60 Hz	400 Hz	Case Size*	Circuit	Frequency Range
8410-250-R-24	24	250	270	130	**#1**	Dual	250µH choke network with AC receptacle for use with 8012-( ) and 9252-( ) for VDE applications
8602-50-PJ-50-N	50	50	270	130	**#4**	Single	10 KHz- 50 MHz w/ 250µH choke
8602-50-TS-50-N	50	50	270	130	**#4**	Single	10 KHz- 50 MHz w/ 250µH choke
8610-50-PJ-100-N	100	50	500	240	**#3‡**	Single	10 KHz- 30 MHz
8610-50-TS-100-N	100	50	500	240	**#3‡**	Single	10 KHz- 30 MHz
8611-50-TS-10-N	10	50	270	130	**#2**	Single	10 KHz- 30 MHz w/ 250µH choke
8615-2-TS-100-N	100	2	270	130	**#1**	Single	1 MHz- 1 GHz
8616-5-PJ-200-N	200	5	270	130	**#3‡**	Single	150 KHz- 65 MHz
8616-5-TS-200-N	200	5	270	130	**#3‡**	Single	150 KHz- 65 MHz
8616-50-PJ-200-N	200	50	270	130	**#3‡**	Single	10 KHz- 50 MHz
8616-50-TS-200-N	200	50	270	130	**#3‡**	Single	10 KHz- 50 MHz
8902-5-TS-500-N	500	5	500	240	**#4**	Single	150 KHz- 1 GHz
8905-50-TS-50-N	50	50	270	130	**#3**	Single	10 KHz-200 MHz
8907-250-TS-24	24	250	270	130	**#1**	Dual	250µH choke network with binding posts. For use with two 8028-( ) for VDE applications
9106-1300-N-10-N	10	1300	270	130	**#1**	Single	10 KHz- 1 GHz
9117-5-PJ-50-N	50	5	500	240	**#1**	Single	150 KHz- 1 GHz
9117-5-TS-50-N	50	5	500	240	**#1**	Single	150 KHz- 1 GHz
9233-50-PJ-50-N	50	50	270	130	**#3**	Single	10 KHz- 50 MHz, 0.25µF coupling capacitor
9233-50-TS-50-N	50	50	270	130	**#3**	Single	10 KHz- 50 MHz, 0.25µF coupling capacitor
9247-50-TS-50-N	50	50	500	240	**#3**	Single	10 KHz- 50 MHz, 0.1µF coupling capacitor
9252-50-R-24-BNC	24	50	270	130	**#7**	Dual	10 KHz- 50 MHz, 0.25µF coupling capacitor
9322-50-R-10-BNC	10	50	270	130	**#7**	Dual	10 KHz- 50 MHz
9331-50-PJ-200-N	200	50	500	240	**#3‡**	Single	10 KHz- 50 MHz
9331-50-TS-200-N	200	50	500	240	**#3‡**	Single	10 KHz- 50 MHz
9345-5-R-10-BNC	10	5	135	N/A	**#1**	Dual	150 KHz- 65 MHz
9348-50-R-24-BNC	24	50	270	130	**#7**	Dual	10 KHz- 50 MHz with 250µH choke

***Case Sizes (w x h x l)**
Add 3" (7.62 cm) for Base Plate
‡ With 50 or 60 Hz Ventilating Fan; add 7.09" (18.00 cm)
#1: 4.5" x 4.5" x 9.25" (11.43 cm x 11.43 cm x 23.5 cm)
#2: 7.0" x 7.0" x 8.25" (17.78 cm x 11.78 cm x 24.13 cm)
#3: 10.06" x 9.0" x 13.12" (25.72 cm x 22.86 cm x 33.34 cm)
#4: 7.53" x 7.63" x 18.97" (19 cm x 19.43 cm x 48.26 cm)
#5: 3.12" x 1.75" x 3.87" (7.94 cm x 4.44 cm x 9.84 cm)
#6: 2.75" x 2.45" x 5.7" (6.98 cm x 6.22 cm x 14.48 cm)
#7: 13.06" x 7.0" x 10.06" (33.20 cm x 17.78 cm x 25.55 cm)

Type Number	Current Amps	Inductance µH	Line/Ground Voltage 50-60 Hz	400 Hz	Case Size*	Circuit	Frequency Range
9351-5-TS-200-N	200	5	500	240	**#3‡**	Single	100 KHz- 1 GHz, 150 Ω impedance
9403-5-TS-10-BNC	10	5	270	130	**#5**	Single	150 KHz- 65 MHz
9408-50-R-24-BNC	24	50	500	240	**#7**	Dual	10 KHz- 50 MHz
9409-50-R-24	24	50	135	N/A	**#2**	Dual	6 Output Auxiliary, no RF connector
9509-50-R-24-BNC	24	50	500	240	**#7**	Dual	10 KHz- 50 MHz w/ 250µH choke
9517-50-R-10-BNC	10	50	270	130	**#7**	Dual	10 KHz- 50 MHz w/ 250µH choke
9608-50-BP-10-BNC	10	50	500	240	**#7**	Dual	10 KHz- 50 MHz, binding posts, no switch
9615-50-R-25-BNC	25	50	270	130	**#7**	Dual	10 KHz- 30 MHz, air coil
9622-50-BP-10-BNC	10	50	500	240	**#1**	Single	10 KHz- 50 MHz
9623-50-TS-25-BNC	25	50	270	130	**#1**	Single	10 KHz- 30 MHz, air coil
9629-50-TS-25-BNC	25	50	500	240	**#1**	Single	10 KHz- 30 MHz
9632-50-TS-50-N	50	50	270	130	**#3**	Single	10 KHz- 50 MHz, high wattage for GM spec
9702-50-TS-100-N	100	50	270	130	call	Single	10 KHz- 50 MHz w/ 250µH choke
9706-5-TS-250-N	250	5	270	130	**#3**	Single	150 KHz- 65 MHz
9845-50-BP-10-BNC	10	50	135	N/A	**#1**	Dual	10 KHz- 30 MHz, binding posts, no switch
9847-50-TS-50-N	50	50	270	130	**#3**	Single	with 20µF capacitor
9857-50-BP-24-BNC	24	50	135	120	**#1**	Dual	10 KHz- 50 MHz, binding posts, no switch
9861-50-BP-24-BNC	24	50	270	130	**#7**	Dual	10 KHz- 50 MHz, binding posts, no switch
9867-5-TS-50-N	50	5	270	130	**#2**	Single	10 KHz- 400 MHz w/ 10µF capacitor
9911-50-R-10-BNC	10	50	135	N/A	**#1**	Dual	10 KHz- 50 MHz
9913-50-TS-10-BNC	10	50	270	130	**#7**	Dual	10 KHz- 50 MHz, 6-32 threaded terminals
9924-5-TS-100	100	5	270	130	**#3**	Isolated	100 KHz- 100 MHz (ISO 7637-2)

***Case Sizes (w x h x l)**
Add 3" (7.62 cm) for Base Plate
‡ With 50 or 60 Hz Ventilating Fan; add 7.09" (18.00 cm)
#1: 4.5" x 4.5" x 9.25" (11.43 cm x 11.43 cm x 23.5 cm)
#2: 7.0" x 7.0" x 8.25" (17.78 cm x 11.78 cm x 24.13 cm)
#3: 10.06" x 9.0" x 13.12" (25.72 cm x 22.86 cm x 33.34 cm)
#4: 7.53" x 7.63" x 18.97" (19 cm x 19.43 cm x 48.26 cm)
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#7: 13.06" x 7.0" x 10.06" (33.20 cm x 17.78 cm x 25.55 cm)

F.C.C. LINE IMPEDANCE STABILIZATION NETWORKS

The F.C.C. in **Part 15 Subpart J** has adopted the 50 microhenry **Line Impedance Stabilization Network (LISN)** described in Figure 15 of the German Document VDE 0876/1/9.78 for use in performing conducted emission tests on power lines (10 KHz-30 MHz). (Five microhenry units are required for F.C.C. Part 18. See listing on back side of "LINE IMPEDANCE STABILIZATION NETWORKS" data sheet.) In selecting the appropriate LISN, the impedance-versus-frequency characteristic is the most important parameter to be considered. The impedance curve of the units closely matches the F.C.C. requirements.

DESCRIPTION

The **Type 8012-50-R-24-BNC** is a dual network for use on 120 volt d.c. or 50-60 Hz single phase power lines. It will handle up to **24** amperes of power current to the equipment under test (EUT). It is fitted with a power cord on one end and a power receptacle on the other end. The receptacle is the style used in the USA with parallel blades and a U shaped grounding pin. A rotary switch selects which of the two power leads is connected to the BNC r.f. jack for test. The unused line is terminated in a 50 ohm resistor.

The **Type 8028-50-TS-24-BNC** is a single line LISN* rated at 270 volts for 50-400 Hz single phase or three phase test setups. It will handle up to **24** amperes of power current to the EUT. This unit is equipped with terminal studs on each end for making connections to the line and the load.

The **Type 8328-50-TS-24-BNC** is a single line LISN* with impedance characteristics similar to the **Type 8028-50-TS-24-BNC** except rated at **50** amperes.

The **Type 8610-50-TS-100-N** is a single line LISN* with impedance characteristics similar to the **Type 8028-50-TS-50-BNC** except rated at **100** amperes and uses a Type "N" r.f. connector. The unit includes a cooling fan with a power cord for connection to an a.c. power line. Line voltage 115 V. 60 Hz or 230 V. 50 Hz must be specified.

The **Type 8616-50-TS-200-N** is a single line LISN* with impedance characteristics similar to the **Type 8028-50-TS-50-BNC** except rated at **200** amperes and uses a Type "N" r.f. connector. The unit includes a cooling fan with a power cord for connection to an a.c. power line. Line voltage 115 V. 60 Hz or 230 V. 50 Hz must be specified.

NOTE: **Part 15 Subpart J, Appendix A** describes a line probe which may be used under some conditions in lieu of an LISN. Our **Type 8614-1 Line Probe** satisfies the requirements of paragraphs 5.2, 5.6 and Figure 4 of the appendix. Our **Type 9533-1 Voltage Probe** satisfies a similar C.I.S.P.R. 16-1 specification requirement, Sub-clause 12.2, Figure 10.

APPLICATION

When the associated measuring equipment is either a spectrum analyzer or EMI meter which uses electronically controlled solid state attenuators, **precautions must be taken**. Attenuators of this nature use FET semi-conductors which are readily damaged by transients. Transients in the setup can be caused by switching the power to the load or by switching the measuring instrument from one power lead to another. It is recommended that a high pass filter be used between the LISN and the EMI meter. If the lowest frequency to be measured is 10 KHz, the **Type 7801-8.0 High Pass Filter** (8.0 KHz, 50 ohms) is suitable. If the lowest frequency is 150 KHz or more, the **Type 7801-100 High Pass Filter** (100 KHz, 50 ohms) is recommended. In addition, it is advisable to disconnect the EMI meter from the LISN before applying or disconnecting the power to the test sample.

For portable equipment, the EUT is isolated from the ground plane. For free-standing or equipment which will be permanently installed, the EUT is placed on the ground plane and electrically bonded to it in a manner which simulates the actual installation. For most consistent test results, the tests should be performed in a shielded room. Two approaches to the test setup are shown on the next page. Either method complies with the requirements of the F.C.C. docket. The EUT must be at least 80 cm (31.5") away from any metallic surface except for the ground plane. The EMI meter and high pass filter are grounded with the shield of the 50 ohm coaxial cable.

***Single line units are needed in each power lead. Use two for single phase or d.c. systems; three for delta connected three-phase lines; four for Wye connected three-phase lines.**

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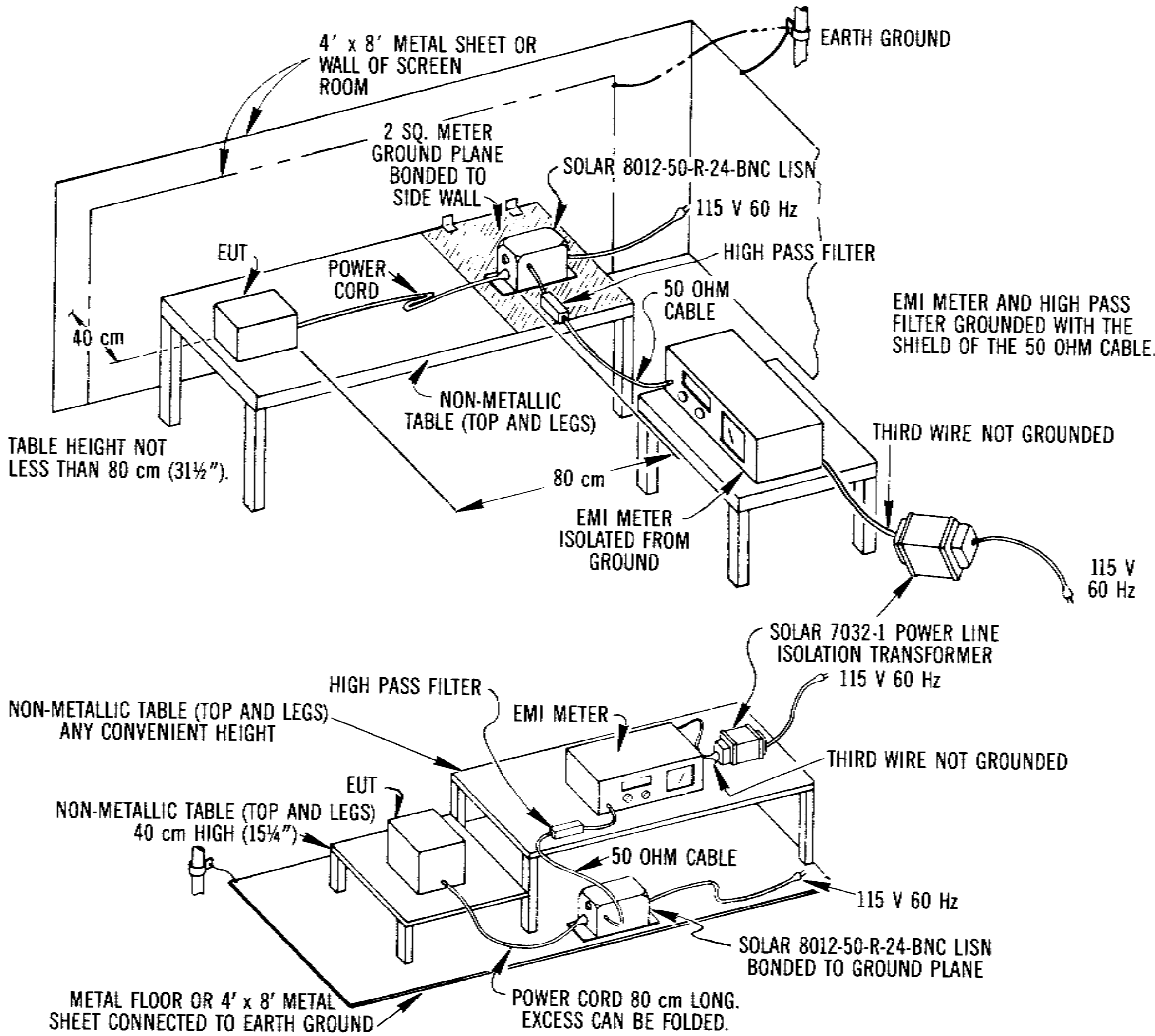

TYPICAL TEST SETUPS FOR CONDUCTED EMISSIONS

SPACECRAFT LINE IMPEDANCE SIMULATION NETWORKS

The distinction between Line Impedance **Stabilization** Networks and Line Impedance **Simulation** Networks is twofold:

a. Simulation networks do not contain an r.f. factor.

b. Simulation networks are normally used on d.c. lines only (See the back side of this page for a.c.-d.c. units).

The acronym LISN is often used for either type of unit and it is important to provide modifiers to distinguish which unit is being described.

Line Impedance **Stabilization** Networks are used in many cases to measure the r.f. voltages (from line-to-ground) conducted on a.c. or d.c. power leads. They establish a known impedance-versus-frequency condition over the frequency range of interest. These units include an r.f. connector for cabling to an EMI meter or spectrum analyzer to perform the measurement. See catalog page LINE IMPEDANCE STABILIZATION NETWORKS for details on these units.

Line Impedance **Simulation** Networks are used for testing items which will be installed in spacecraft. They establish an impedance-versus-frequency condition which simulates the d.c. power sources used on satellites and other vehicles operating in a space environment. These are dual units with both positive and negative leads going through. Both lines are isolated from the case.

Spacecraft designers do not always agree on the characteristics of the d.c. power source aboard the vehicle. The inductance in series with the load, the resistance across the inductor, and the series resistance in each leg of the unit are variables specified by different spacecraft engineers.

In the styles we have provided to date, inductors are used in both sides of the line, except for the two styles marked with * in the following table.

Type Number**	Inductance, microhenries	Current Rating	Resistor across coil	Resistance in series
7505-4-TS-15-BP	4	15 A.	25 ohms	250.0 milliohms
8212-4-TS-100-BP	4	100 A.	25 ohms	0.36 milliohms
8312-4-TS-15-BP	4	15 A.	25 ohms	50.0 milliohms
† 8509-1-TS-15-BP	1	15 A.	50 ohms	82.0 milliohms
* 8708-26-PJ-50-X	26	50 A.	None	9.3 milliohms
* 8709-3.5-PJ-50-X	3.5	50 A.	None	2.8 milliohms
† 8712-2-TS-10-BP	2	10 A.	50 ohms	50.0 milliohms
† 8718-2-TS-50-BP	2	50 A.	50 ohms	50.0 milliohms
8809-1.3-TS-50-BP	1.35	50 A.	25 ohms	1.5 milliohms
† 8812-2-TS-120-BP	2	120 A.	50 ohms	2.2 milliohms
8901-4-TS-15-BP	4	15 A.	25 ohms	250.0 milliohms
8903-4-TS-100-BP	4	100 A.	25 ohms	0.36 milliohms
8904-4-TS-15-BP	4	15 A.	25 ohms	50.0 milliohms
8910-4-TS-15-BP	4	15 A.	25 ohms	0.25 milliohms
9002-1	0.9	6 A.	None	113.0 milliohms
9102-5-TS-10-X	5	10 A.	25 ohms	125.0 milliohms
9213-5-TS-50-BP	5	50 A.	25 ohms	50.0 milliohms
9238-10-TS-50	10	50 A.	25 ohms	0.50 milliohms
9336-100-TS-100-BP	100	100 A.		
9344-3/12-TS-50-BNC/PJ	0.25	50 A.		
9350-4-TS-50-N	4	50 A.		

*The return lead (negative) does not contain an inductor.

The letters PJ indicate **Plug and **J**ack power connections. The letters TS indicate **T**erminal **S**crew power connections. The letters BP at the end of the type number indicate **B**inding **P**osts connected across the coil. This enables the user to connect an oscilloscope across the coil for measuring line transients and ripple as required by NASA document SL-E-0002, paragraph 6.20.

† **In addition to the internal capacitance from line-to-line, these four units require another 45,000 µF, supplied by an external unit.**

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HIGH VOLTAGE, HIGH CURRENT, HIGH FREQUENCY LINE IMPEDANCE STABILIZATION NETWORKS

Five microhenry unit

To answer the need to cover the frequency range up to 1.0 GHz and to accommodate higher line voltages and currents, we offer the **Type 8902-5-TS-500-N** Line Impedance Stabilization Network. At the low frequency end of the spectrum, this network provides the impedance characteristic of all other 5 microhenry units and maintains the required 50 ohm (±20%) impedance up to 1.0 GHz. It is rated at 500 v.a.c. and 500 amperes., a.c. It is a single line unit in an aluminum case measuring 7.625" x 7.625" x 19". The line and load terminals are.5-20 threaded brass studs. The r.f. connector is a conventional Type N.

Fifty microhenry unit

For operation up to 100 MHz with a 50 microhenry coil, the **Type 8905-50-TS-50-N** is a Line Impedance Stabilization Network rated at 270 v.a.c., 50 amperes. The impedance characteristic meets the requirements at 10 KHz, sloping upward toward 50 ohms as frequency increases and maintains the required 50 ohm (±20%) impedance up to 200 MHz.

LINE IMPEDANCE SIMULATION NETWORKS FOR A.C. AND D.C. APPLICATIONS

In the application of Line Impedance Simulation Networks, some specifications require that NASA units (4 µH) be used on both a.c. and d.c. power circuits. To do this, the large electrolytic capacitor stipulated for d.c. applications must be disconnected when the network is used on a.c. lines. Our engineers believed that the end-user might not be aware of this detail or would not know whether the capacitor was in place at the time the test was being set up. **A SPECIAL SERIES OF UNITS IS OFFERED WHICH AUTOMATICALLY CONNECT OR DISCONNECT THE CAPACITOR WHEN THE NETWORK IS CONNECTED TO A POWER LINE.**

When the power line is 24 to 30 volts d.c., the capacitor is automatically connected into the circuit. However, when the power line is 110 to 115 volts a.c., the capacitor is automatically switched out of the circuit. Since the switching function is automatic, there is no need to operate a switch or disconnect a wire to accomplish this. The end-user does not need to think about it.

These innovative combination networks are available in current ratings up to 100 amperes and with specified resistance values across the coil and differing series resistance in the circuit.

Type Number**	Inductance, microhenries	Current Rating	Resistor across coil	Resistance in series
8901-4-TS-15-BP	4	15 A.	25 ohms	250.00 milliohms
8903-4-TS-100-BP	4	100 A.	25 ohms	0.36 milliohms
8904-4-TS-15-BP	4	15 A.	25 ohms	50.00 milliohms

TYPE 9230-1 RADIATING LOOP; TYPE 9229-1 LOOP SENSOR

for MIL-STD-461D/RS101 magnetic field tests

DESCRIPTION

Test Method RS101 of MIL-STD-461D requires radiated magnetic fields over the frequency range 30 Hz to 100 KHz to determine the susceptibility or immunity of the equipment under test (EUT). Two loop antennas are required for compliance with the requirements. The radiating loop is 12 cm in diameter and the sensing loop (used for calibration) is 4 cm in diameter. The **Type 9230-1 Radiating Loop** has been designed so that the **Type 9229-1 Loop Sensor** can be attached at the required 5 cm distance.

APPLICATION

The test method requires calibration of the radiated energy at 1.0 KHz prior to the test. Calibration of the **Type 9230-1 Radiating Loop** is accomplished by coupling the **Type 9229-1 Loop Sensor** to it at a distance of 5 cm. The arrangement is indicated in Fig. 1 on the next page. With a known current flowing in the radiating loop, the magnetic field can be measured.

Two graphs are supplied with the loops to make life easier for the test engineer. Fig. 2 shows a typical correction factor curve for the **Type 9229-1 Loop Sensor**. Fig. 3 indicates the amount of current flowing through the **Type 9230-1 Radiating Loop** to generate the required magnetic field, in dB/pT.

The current level to produce 110 dB/pT at 1.0 KHz is 3.0 mA. An accurately calibrated EMI meter or spectrum analyzer will measure this as 42 dB/μV. Adding the correction factor of 68 dB/pT/μV from Fig. 2 equals 110 dB/pT as required by the specification.

In those instances where the spectrum analyzer does not have sufficient sensitivity, the calibration can be accomplished just as well at a higher current level. For example, using 300 mA, the measurement would be 82 dB. Subtracting 40 dB from this answer and adding the 68 dB factor will equal 110 dB/pT/μV.

Another approach to the calibration and the measurement depends on the accuracy of the EMI receiver. Simply subtract the sensor correction factor in dB/pT/μV (Fig. 2) from the desired magnetic field level in dB/pT (Fig. 3). Then adjust the current until the EMI meter reads this value in dB above one microvolt.

Example: For a field of 110 dB/pT at 1.0 KHz, subtract 68 dB (Fig. 2) from this to obtain 42 dB. This value in dB above one microvolt on the EMI meter is equal to 126 μV as indicated in RS101.

A typical calibration test setup is shown in Fig. 4a. For current levels below 25 mA, it is feasible to use a standard laboratory signal generator. For higher current levels, the signal must be amplified (Fig. 4b). Both methods show a 0.1 ohm precision resistor (**Type 9817-0.1**) and a digital voltmeter for measuring the current.

USEFUL ANCILLARY DEVICE

Type Type 9817-0.1 Precision Resistor, 0.1 ohm, ±1%. For measuring current flowing in the radiating loop.

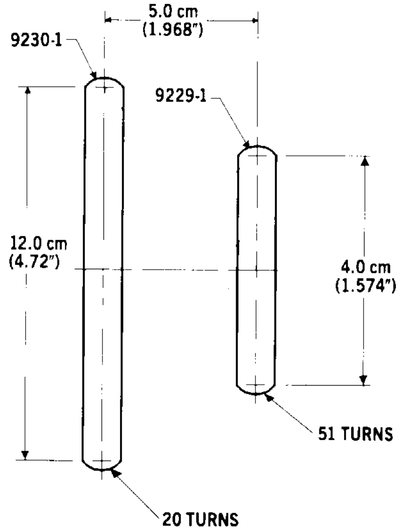

FIG. 1 PHYSICAL RELATIONSHIP

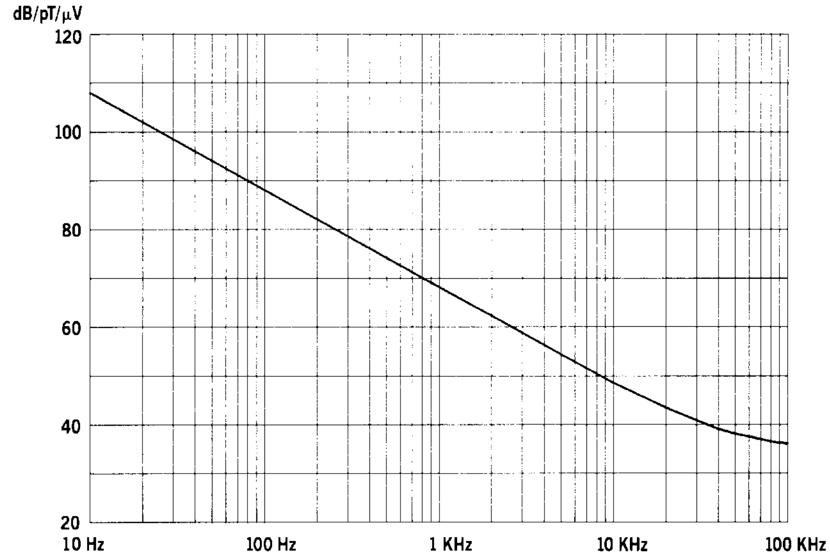

FIG. 2 CORRECTION FACTOR, TYPE 9229-1 LOOP SENSOR

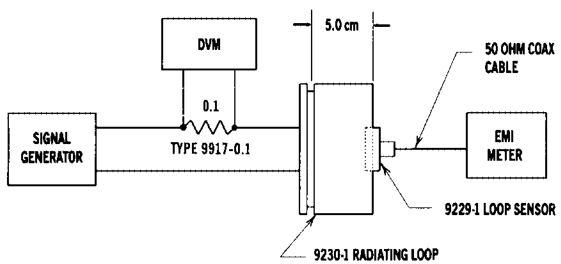

FIG. 4a TEST SETUP FOR CURRENTS UP TO 25 mA

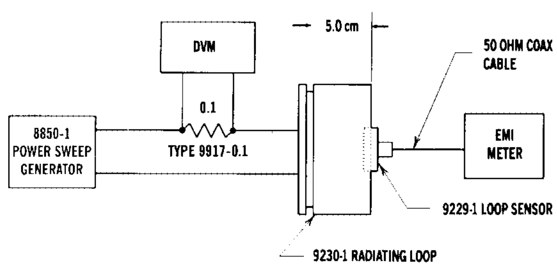

FIG. 4b TEST SETUP FOR CURRENTS GREATER THAN 25 mA

REV 07-07-93

TYPE 7334-1 LOOP ANTENNA

for RE01 and RE101 magnetic emission tests

HISTORICAL NOTE

The AT-205/URM-6 Loop Sensor described in Test Method RE01 of MIL-STD-462 is one of the antennas designed for use with the Navy AN/URM-6B and Stoddart NM-10A receivers. These were the low frequency EMI meters that, in 1948, initiated the emphasis on EMI by the military departments and created the technical discipline we now know as Electromagnetic Compatibility.

DESCRIPTION

The Solar **Type 7334-1 Loop Antenna** has been designed as a substitute for the AT-205/URM-6 antenna and is a replacement for Eaton Model 94607-1. It uses 36 turns of wire on a 5.25" (13.3 cm) diameter form enclosed in an electrostatic shield as described in paragraph 5.2.1 of MIL-STD-461A.

The **Type 7334-1** is equipped with an epoxy-glass base plate which serves as a spacer to enable the user to place the loop at exactly 7 cm from the face of the item under test as required by test procedure RE01 of MIL-STD-462.

APPLICATION

Connection to the loop is through a BNC connector which enables coaxial cabling to the EMI receiver. The loop is supplied with a correction factor graph showing the values in dB which must be added to the reading of a 50 ohm EMI meter to obtain answers in either dB/μV/m or dB/pT. The correction factor decreases as frequency increases from 30 Hz up to approximately 15 KHz, where the factor levels off and remains relatively constant up to 5 MHz.

The **Type 7334-1 Loop Antenna** is required by Test Method RE01 in Parts 2 through 6 of MIL-STD-461C and RE101 of MIL-STD-461D. These portions of the specification require magnetic field emission tests of cables, equipments, systems and sub-systems installed in, or used in, all phases of military vehicles, ships, submarines, aircraft (including helicopters), spacecraft, or ground-based operations.

TEST METHODS RE01 and RE101

The **Type 7334-1 Loop Antenna** is positioned 7 cm from the face of the equipment under test with the plane of the loop parallel to the equipment face. The best position to begin with is opposite or near a joint or seam.

The associated EMI meter is then scanned over the range 30 Hz to 100 KHz searching for emissions. At the frequencies where emissions are found, the loop antenna is moved about the surface seeking the strongest emission level. When a strong signal is detected, the loop is oriented on its axis for a maximum reading.

This procedure is repeated for all surfaces of the equipment under test. Although the specification is not clear on the point, it appears to indicate that all six sides (including the bottom) of an equipment must be tested in this manner.

When testing cables, the loop antenna is placed 7 cm from the cable with the plane of the loop parallel to the cable. The non-metallic base plate of the **Type 7334-1 Loop Antenna** provides a convenient means for establishing the correct 7 cm distance.

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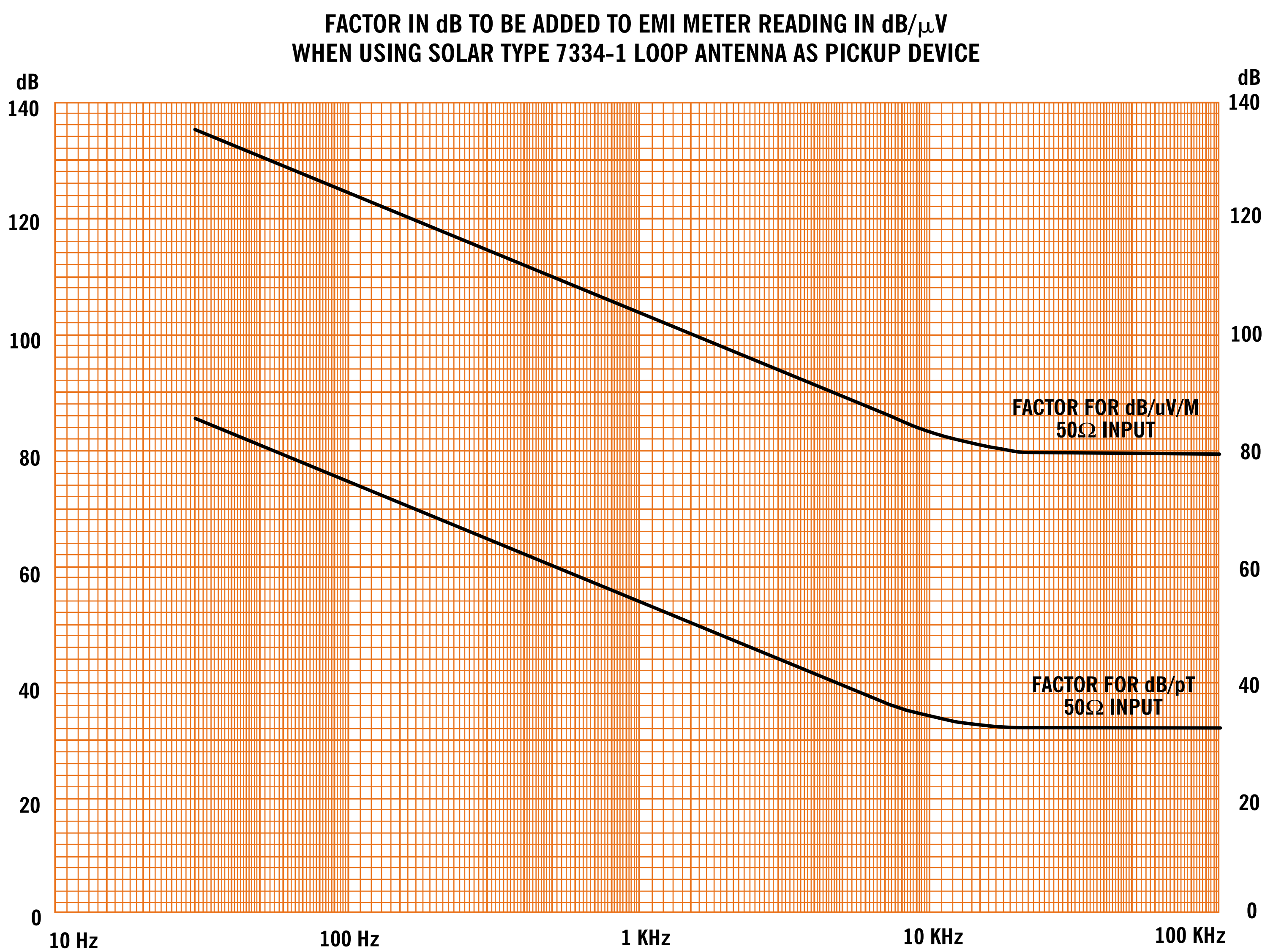
TYPE 7334-1 LOOP ANTENNA



TYPE 7429-1 LOOP ANTENNA

for RS01 magnetic field tests

APPLICATION

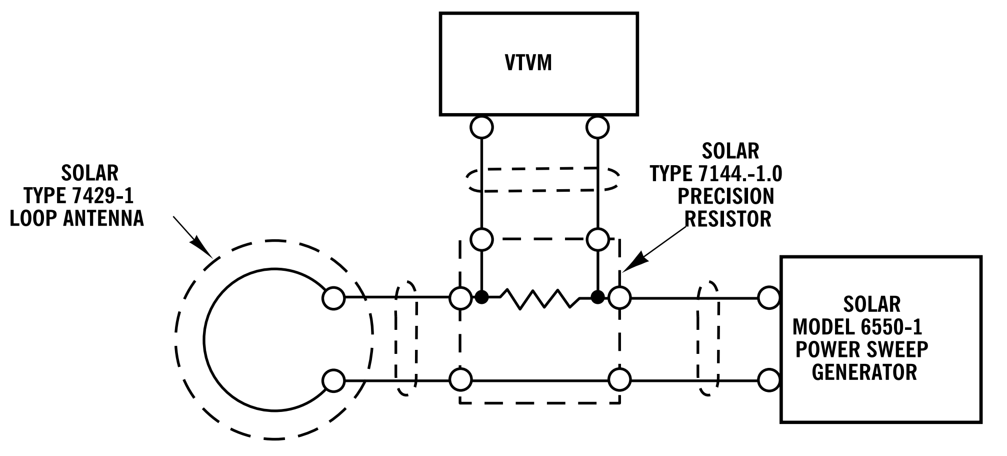
In a practical RS01 test setup, the loop antenna is supplied with the required current versus frequency by the Solar **Model 6550-1 Power Sweep Generator**. The current is measured with a voltmeter connected across the Solar **Type 7144-1.0 Precision Resistor** which is connected in series between the loop and the generator.

The a.c. current in the **Type 7429-1 Loop Antenna** to generate the magnetic field intensity required by test method RS01 at 5 cm from the loop winding is depicted on a graph supplied with the loop. The required current varies from a few microamperes to about 5 amperes as frequency is adjusted over the range 30Hz to 50 KHz.

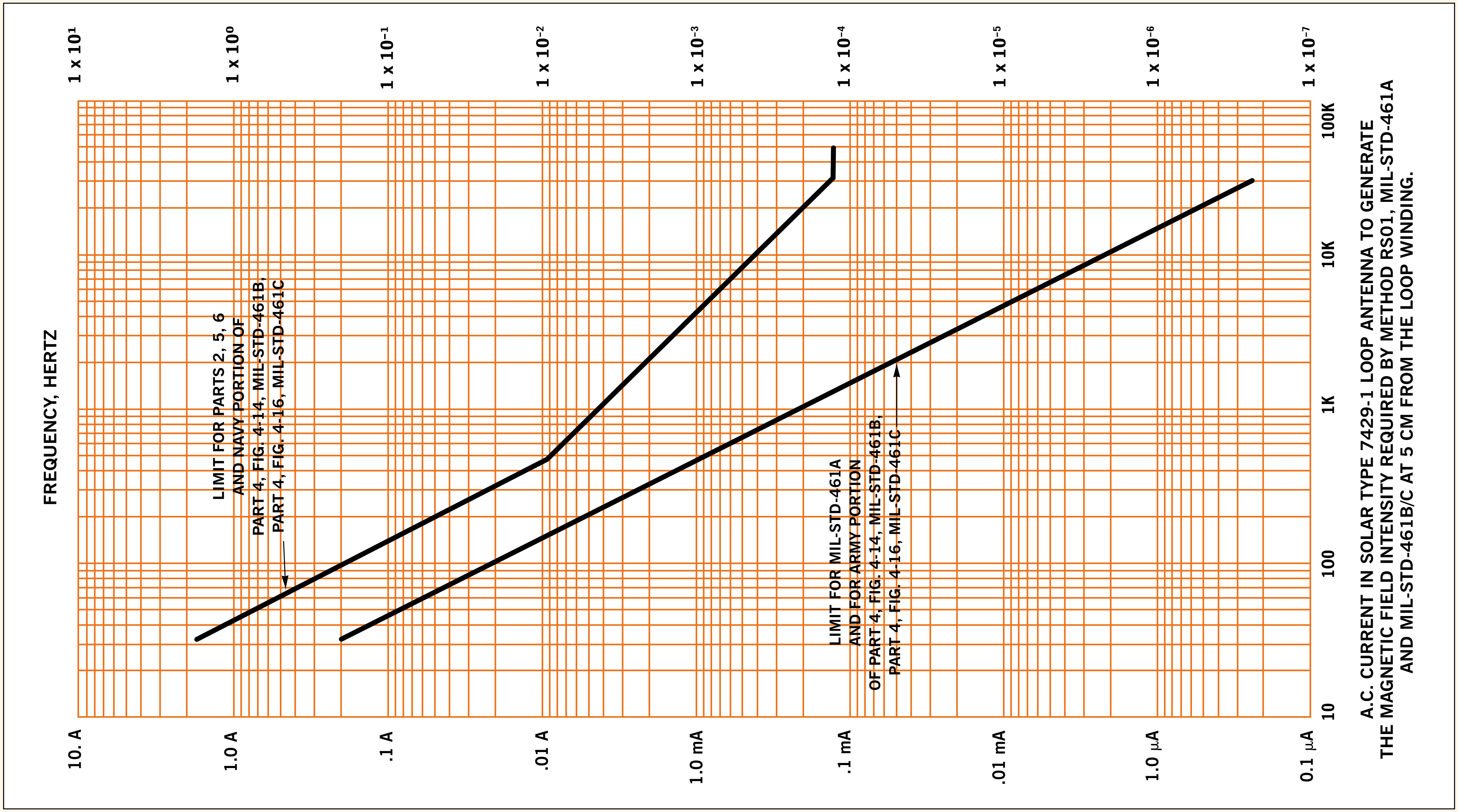
DESCRIPTION

The loop antenna used for generating radiated magnetic fields is fully described in Figure 1A of MIL-STD-461A. It consists of ten turns of number 16 A.W.G. wire on an insulated form 4.72" (12 cm) in diameter. The winding is placed on the form in a position which allows the form to be used as a spacer to place the winding 5 cm from the face of the item under test as required by test method RS01 of MIL-STD-462.

The **Type 7429-1 Loop Antenna** has been designed to the exact requirements of the specification. The loop winding is placed on a durable plastic form and is equipped with banana jack style terminals for connection to the test setup. The loop is not shielded.



TEST SETUP FOR RS01 MAGNETIC FIELD EMISSIONS


FREQUENCY, HERTZ
1 x 10¹
1 x 10⁰
1 x 10⁻¹
1 x 10⁻²
1 x 10⁻³
1 x 10⁻⁴
1 x 10⁻⁵
1 x 10⁻⁶
1 x 10⁻⁷
10. A
1.0 A
.1 A
.01 A
1.0 mA
.1 mA
.01 mA
1.0 µA
0.1 µA
10
100
1K
10K
100K
LIMIT FOR PARTS 2, 5, 6
AND NAVY PORTION OF
PART 4, FIG. 4-14, MIL-STD-461B,
PART 4, FIG. 4-16, MIL-STD-461C
LIMIT FOR MIL-STD-461A
AND FOR ARMY PORTION
OF PART 4, FIG. 4-14, MIL-STD-461B,
PART 4, FIG. 4-16, MIL-STD-461C
A.C. CURRENT IN SOLAR TYPE 7429-1 LOOP ANTENNA TO GENERATE
THE MAGNETIC FIELD INTENSITY REQUIRED BY METHOD RS01, MIL-STD-461A
AND MIL-STD-461B/C AT 5 CM FROM THE LOOP WINDING.

Application Information

USING THE SOLAR TYPE 7429-1 LOOP ANTENNA

TO ESTABLISH THE MAGNETIC FIELD INTENSITY REQUIRED BY TEST METHOD RS01 OF MIL-STD-461A

FORMULA FOR DETERMINING MAGNETIC FIELD INTENSITY

If we grind through the classic formula found on page 975 of Dr. Fred Terman's *Radio Engineers Handbook* (First Edition 1943) we find that the formula simplifies to:

$$I = 2.0 \times 10^{-8} \times 10^{\left(\frac{dB/pT}{20}\right)}$$

when using the dimensions of the Solar **Type 7429-1 Loop** and a distance of 5 cm as required by RS01.

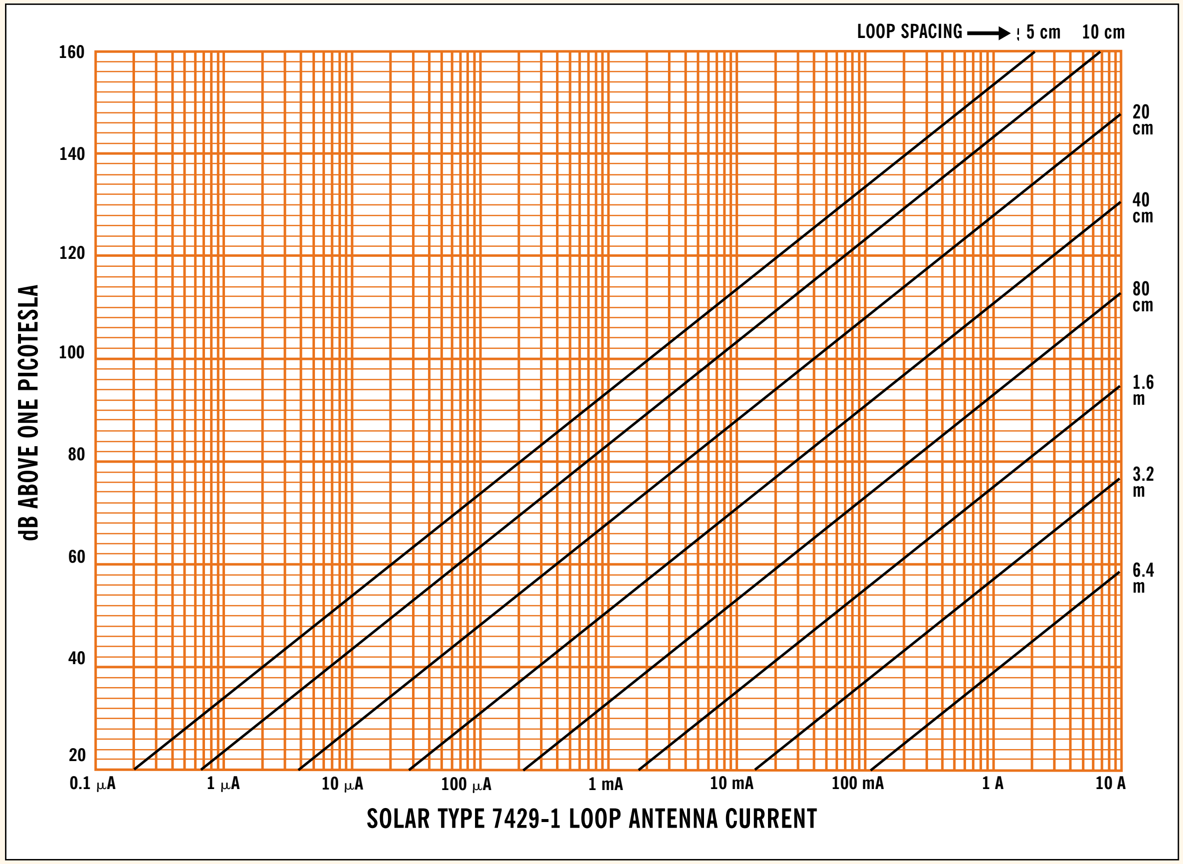
In other words, plugging in the required dB/pT will give the current needed through the loop to establish the magnetic field of the specification.

The current-versus-frequency required to meet the levels specified in the test method RS01 has been determined by this method and plotted on the graph on the **Type 7429-1** catalog sheet.

MAGNETIC FIELD INTENSITY AT VARIOUS DISTANCES FROM LOOP

Originally, the **Type 7429-1 Loop Antenna** was intended for generating a stipulated magnetic field at a distance of 5 cm as required by Test Method RS01 of MIL-STD-461A. However, EMI engineers in the field have asked for information concerning the amount of current through the loop to achieve magnetic fields at distances greater than 5 cm.

The graph to the right indicates how the current through the loop varies with distance and with magnetic field levels which may be required by other programs. For distances greater than 20 cm and a given current, as the distance is doubled, the field intensity becomes 18 dB less. As the current is multiplied by ten, the field intensity increases by 20 dB. In other words, the field intensity change in dB is twenty times the log of the change in current at a given distance.



CALIBRATION OF LOOP ANTENNAS

INTRODUCTION

There are at least four different methods of calibrating shielded loop antennas. The method described here is the spaced loop technique where a loop is used as a transmitting antenna spaced a known distance from the loop being calibrated. The particular instructions given below apply specifically to the calibration of the Solar **Type 7334-1 Loop Sensor** used for RE01 and RE04 magnetic field emission tests (MIL-STD-461).

BASIC CONCEPT

The test setup is shown in Figure 1. The transmitting loop in this case is the Solar **Type 7429-1 Loop Antenna**, normally used in making RS01 magnetic field susceptibility tests. A specific r.f. current is established in the transmitting loop, measured with a series resistor and a voltmeter. At a given distance away, the field intensity generated by the current in the loop can be calculated. In the setup shown, for a distance of 13.25" (33.65 cm) from the periphery of the transmitting loop winding to the center of the receiving loop winding, the field intensity is calculated to be 178 volts-per-meter when a current of one ampere is flowing in the transmitting loop.

SETUP DETAILS

Since dimensions are critical, it is important to recognize that the 13.25" (33.65 cm) is not the distance between the edges of the loops, but is from the periphery of the **Type 7429-1** loop *winding* to the center axis of the **Type 7334-1** loop. These end points are not readily determined because the **Type 7429-1** loop winding is inside a piece of plastic and the center of the **Type 7334-1** loop winding is difficult to determine due to the metal shield. Figure 2 shows a dimension of 10.65" (27 cm) between the faces of the loops when the 13.25" (33.65 cm) dimension is established at the theoretical points.

In setting up this dimension, take care to maintain the loops on the same axis and to orient them to face each other in a parallel fashion. A non-metallic fixture should be used to maintain the proper physical conditions. The setup should be arranged so that no metallic objects are in the vicinity of the loop antennas. The signal generator and the EMI meter should be at opposite ends of the setup so that the EMI meter is not receiving the signal by some other path than by way of the **Type 7334-1** loop.

ELECTRICAL DETAILS

It is not possible to obtain one ampere of r.f. current in the transmitting loop over the range of 30 Hz to 30 KHz with an ordinary signal generator. Figure 1 shows the Solar **Model 6550-1 Power Sweep Generator** being used to deliver the required current level.

When the physical dimension is maintained and the current through the loop is adjusted at each test frequency, the voltage received by the **Type 7334-1** loop is measured with the EMI meter. In most test locations there are strong magnetic fields at the power frequency and its harmonics. It is desirable to avoid these frequencies by using a very narrow bandwidth in the EMI meter. A simple check on the validity of the received level would be to disconnect the signal generator from the transmitting loop. If the received signal is still present, the signal is arriving at the **Type 7334-1** loop from some other source.

DETERMINING LOOP FACTORS

It is desirable to obtain the correction factor for the loop in decibels, since the limits of RE01 are in terms of decibels above a picoTesla. For this reason it is convenient to measure the received voltage in dB above (or below) one microvolt.

The field intensity in this setup is 177.83 volts-per-meter (165 dB/μV/meter) which equates to 115.5 dB/pT. The measured level at each frequency in dB/μV is subtracted from 165 to obtain the correction factor for field intensity in decibels with reference to one micro-volt-per-meter (dB/μV/m). The measured level is subtracted from 115.5 to obtain the correction factor for field intensity in decibels with reference to one picoTesla (dB/pT).

As an example, assume that the EMI meter reading is 82 dB/μV at 10 KHz. Subtracting 82 from the 165 reference yields 83, the factor for field intensity in dB/μV/m.

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At this frequency, the 83 dB factor must be added to the EMI meter reading to obtain the final answer in dB/µV/m.

For answers in volts-per-meter

Reference	165.
EMI meter reading	– 82.
Field Intensity:	83. dB/µV/m

When the answer is to be in dB/pT, derive the factor by subtracting the 82 dB in this example from 115.5 to yield a correction factor (in dB) of 33.5.

For answers in Teslas

Reference	115.5
EMI meter reading	– 82.0
Field Intensity:	33.5 dB/pT

When using the **Type 7334-1** loop in the RE01 test, add the 33.5 correction to the EMI meter reading (in dB) to obtain the field intensity expressed in dB/pT.

CONVERSION TO OTHER TERMS

To convert µV/m to picoTeslas, multiply by 3.33×10^{-3}.

To convert pT to µV/m, multiply by 3×10^{2}.

To convert dB/µV/m to dB/pT, subtract 49.5 dB.

To convert dB/pT to dB/µV/m, add 49.5 dB.

REFERENCE INFORMATION

The following expressions may be used in checking the accuracy of this test method and may be used in obtaining values for testing loop antennas of other types.

$$E = (47.15\, N\, d^{2}\, I) \div D^{3}$$

Where: E = electric field intensity in volts-per-meter at the center of the receiving loop.

N = number of turns in the transmitting loop.

d = diameter of transmitting loop, in meters.

I = r.f. current flowing in the transmitting loop, in amperes.

D = hypotenuse distance "h" from the periphery of the **Type 7429-1** loop winding to the center of the **Type 7334-1** loop at the axis in meters.

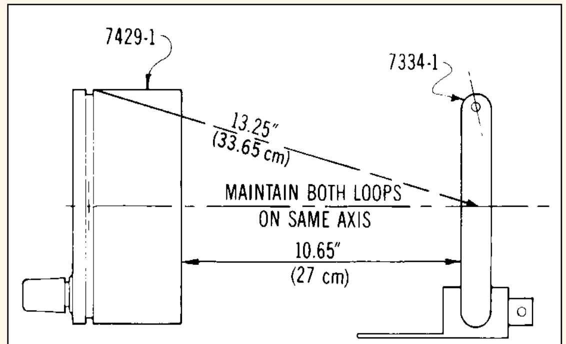


FIG. 2 PHYSICAL PLACEMENT OF LOOPS

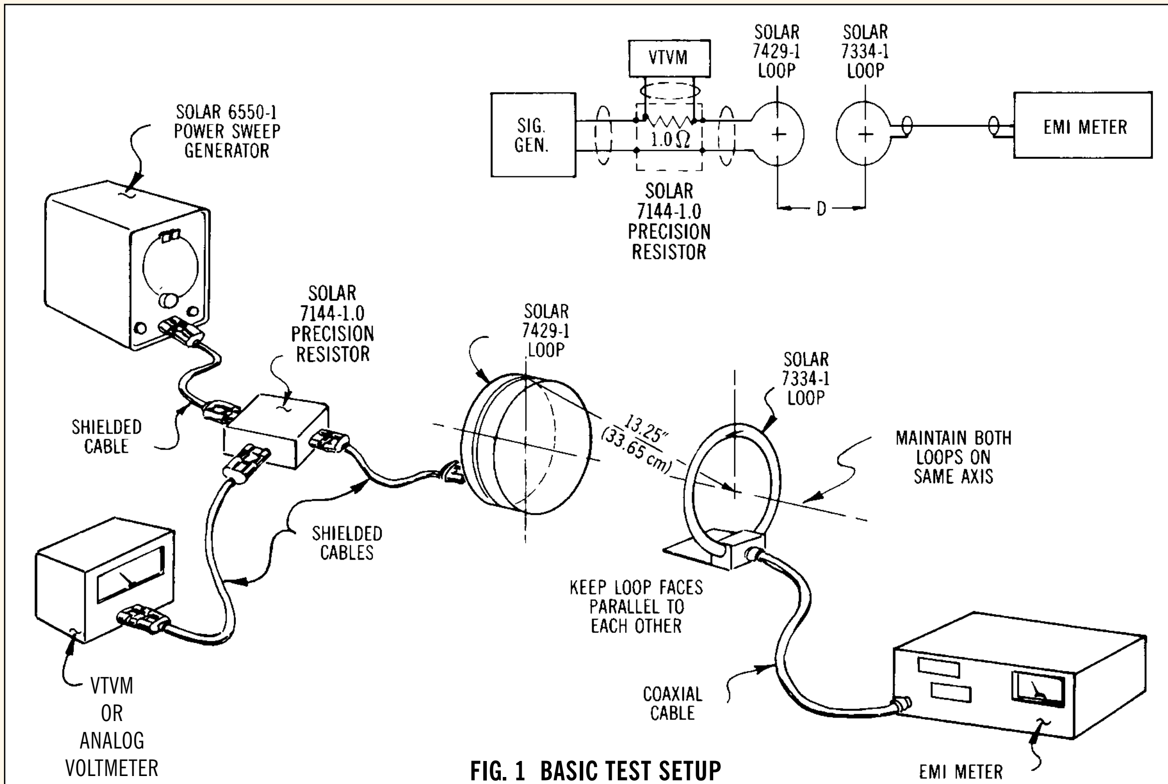


FIG. 1 BASIC TEST SETUP

TYPE 9130-1 LOOP ANTENNA

for receiving or generating magnetic fields, 10 KHz to 3 MHz

DESCRIPTION

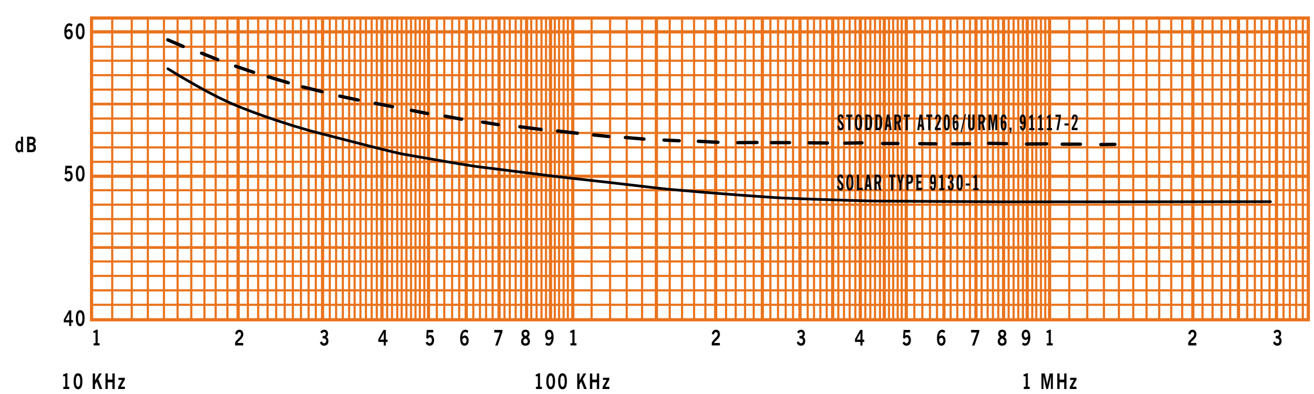
This antenna was designed as a replacement for Eaton 94608-1. It is similar to Stoddart 91117-2, 30-inch diameter loop, supplied with AN/URM-6B and NM-10A EMI receivers. In addition to operating as a receiving antenna, the **Type 9130-1 Loop Antenna** is capable of carrying ten amperes in test setups for generating magnetic fields.

Although the antenna it is replacing is circular (30 inches in diameter), the **Type 9130-1 Loop Antenna** is almost square, 28.5" x 29.75" with 6.31" radius at each corner (12.4 cm x 75.5 cm with 16 cm radius). This larger area results in an improved pickup factor. The loop is wound with larger wire than the original, so that it can carry more current in the transmitting mode. Fitted with Type N connector.

APPLICATION

As a receiving antenna the **Type 9130-1** is more sensitive than the original 30-inch diameter loops. The graph below shows the comparison when connected to a receiver with 50 ohm input impedance.

When used to generate magnetic fields, the **Type 9130-1 Loop Antenna** is capable of carrying up to ten amperes through its eleven turns, making 110-ampere turns. With one ampere flowing through the winding, the magnetic field generated is over 277.5 volts-per-meter at one meter distance from the plane of the loop and 12.6 volts-per-meter at three meters distance. With ten amperes flowing, the field intensity is 126 volts-per-meter at three meters distance.



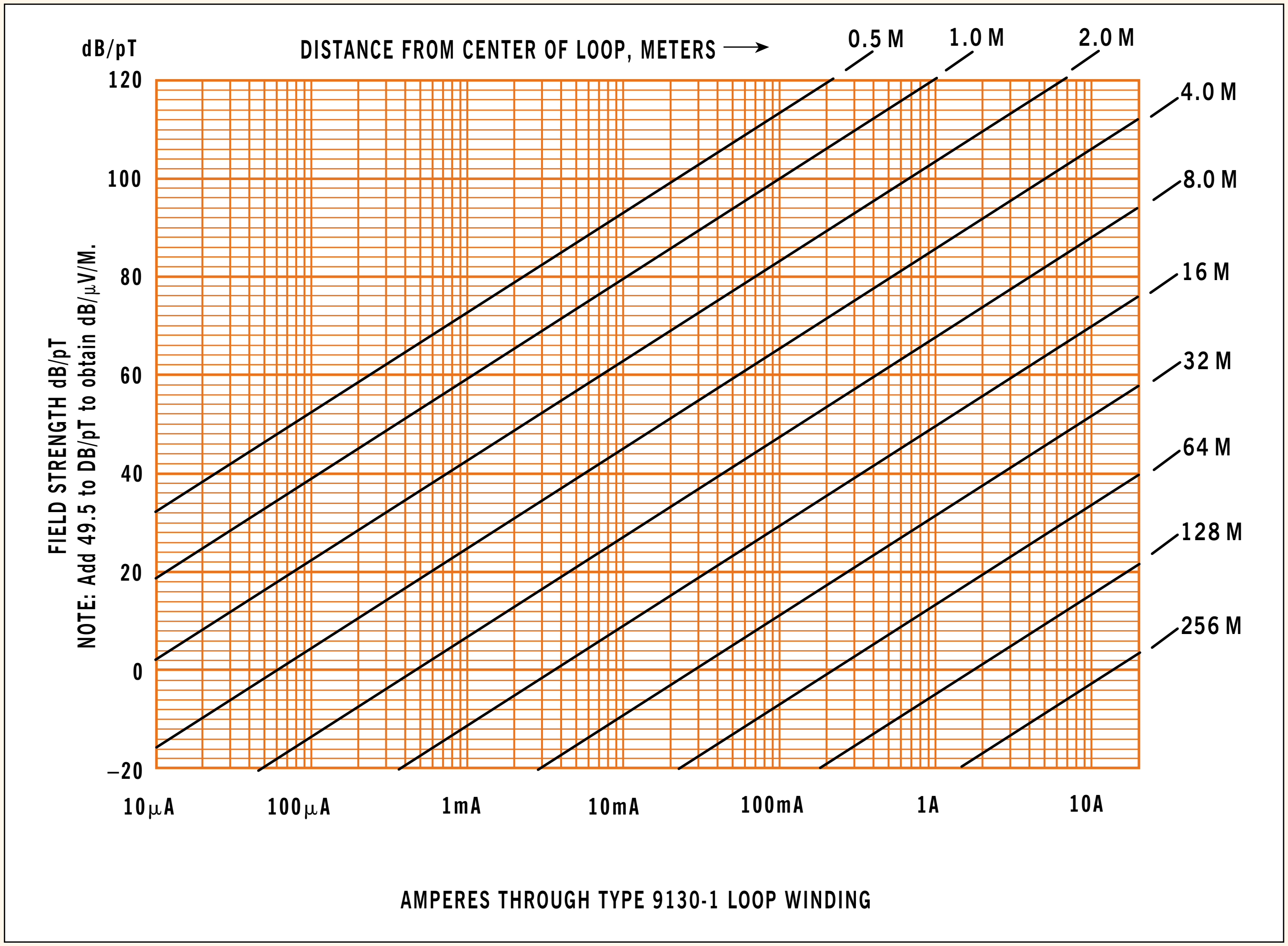
CORRECTION FACTOR IN dB FOR LOOP INTO 50 OHMS TO OBTAIN dB/µV/M

APPLICATION INFORMATION FOR TYPE 9130-1 LOOP ANTENNA

The **Type 9130-1 Loop Antenna** can be used for receiving radiated magnetic fields as well as generating a stipulated magnetic field at a specified distance. The generated magnetic field is a function of the current flowing in the loop and the distance from the loop to the point of measurement.

The graph on this page indicates how the current through the loop varies with distance and magnetic field levels. For 18 dB increase in field intensity at a given current, the distance is divided by two. Conversely, at a given current as the distance is doubled, the field intensity becomes 18 dB less. As the current is multiplied by ten, the field intensity increases by 20 dB. In other words, the field intensity change in dB is twenty times the log of the change in current at a given distance.

Note that the **Type 9130-1 Loop Antenna** is wound with wire suitable for carrying up to ten amperes. For higher currents, apply the current for short intervals. Allow the winding to cool off.



TYPE 6220-1A AUDIO ISOLATION TRANSFORMER

for conducted audio frequency susceptibility testing

APPLICATION

The **Type 6220-1A Audio Isolation Transformer** was especially designed for screen room use in making conducted audio frequency susceptibility tests as required by MIL-STD-461/462 and other EMI specifications.

The transformer may also be used as a pickup device to measure low frequency EMI currents at lower levels than conventional current probes.

In addition, its secondary may be used as an isolating inductor in the power line during transient susceptibility tests. (See Application Note AN622001.)

DESCRIPTION

The transformer is capable of handing up to 200 watts of audio power into its primary over the frequency range 30 Hz to 250 KHz. The turns ratio provides a two-to-one step down to the special secondary winding. The secondary will handle up to fifty amperes of a.c. or d.c. without saturating the transformer.

Another secondary winding is connected to a pair of binding posts suitable for connecting to a.c. voltmeter as directed by the applicable EMI specifications. This winding serves to isolate the voltmeter from power ground. Neither the primary nor the secondary windings are connected to the end bells of the core. The transformer may be used as a 4-ohm primary and 1-ohm secondary or 2.4-ohm primary and 0.6-ohm secondary or 2-ohm primary and 0.5-ohm secondary.

FEATURES

- Provides a convenient bench model unit with three-way binding posts on primary and output voltmeter leads. Standard 0.75" spacing of binding posts allows use of standard plugs. High current secondary uses 1/4-20 threaded studs.
- Capable of handling the audio power required by EMI specifications and up to 50 amperes of a.c. or d.c. through the secondary in series with the test sample.
- May be used as a pickup device or an isolating inductor in other tests.
- Suitable for fastening to the bench top in permanent test setups.

ADDITIONAL MODELS

Type 6220-2 100 amperes high current transformer.

Type 6220-4 50 amperes 4 KV transient voltage HV transformer.

Type 9707-1 10 amperes low current transformer.

SPECIFICATIONS

Primary: Less than 5 ohms.

Secondary: One-fourth the primary impedance.

Frequency Response: 30 Hz to 250 KHz.

Audio Power: 200 watts.

Dielectric Test: 600 volts d.c. primary to secondaries and each winding to end bells.

Secondary Saturation: 50 amperes a.c. or d.c. maximum.

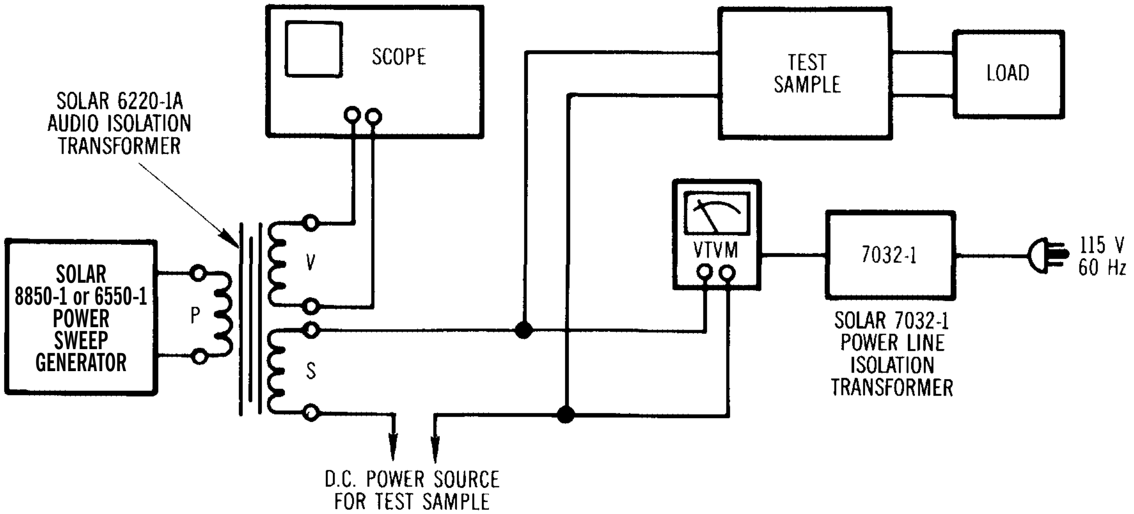
Turns Ratio: Two-to-one step down.

Secondary Inductance: Approximately 1.0 mH (unloaded).

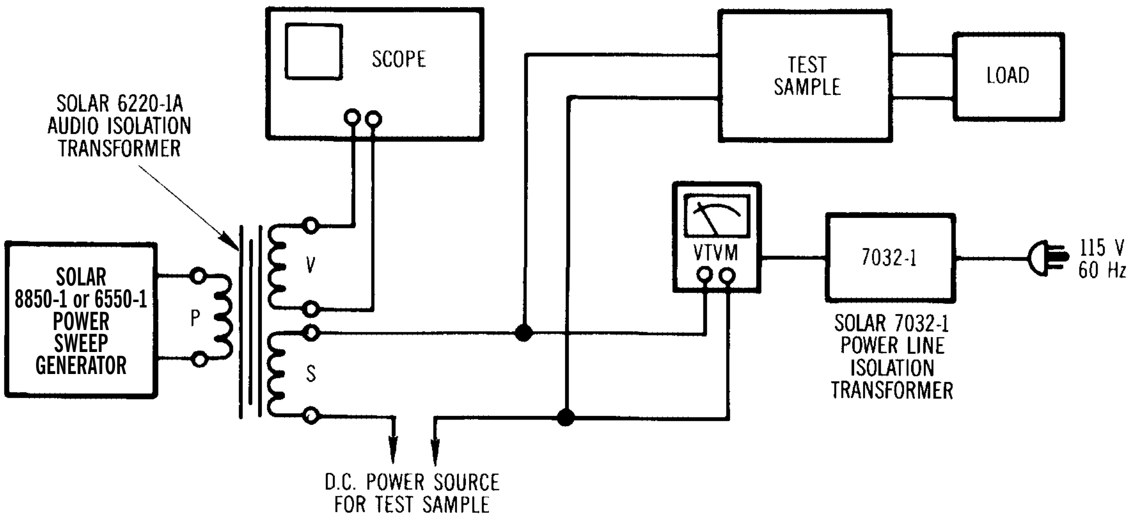
Weight: 18 pounds.

Size: 4.5" wide, 5.25 " high, 6.25" deep plus terminals. (114 mm x 133 mm x 159 mm.)

TYPE 6220-1A AUDIO ISOLATION TRANSFORMER



AUDIO SUSCEPTIBILITY TEST SETUP FOR D.C. LINES



TEST SETUP FOR MEASURING LOW FREQUENCY, LOW AMPLITUDE EMI CURRENT

See Application Note 622001

APPLICATION NOTE AN622001

USING TYPE 6220-1A TRANSFORMER FOR THE MEASUREMENT OF LOW FREQUENCY EMI CURRENTS

INTRODUCTION

"There is more than one way to skin a cat" your great grandfather and my father used to say. The evolution of methods of measuring conducted interference illustrates this homely expression in a distorted kind of way.

To start with, a clever and versatile propulsion engineer named Alan Watton at Wright Field early in WWII created an artificial line impedance which represented what he had measured on the d.c. buss in a twin-engined aircraft. Probably a DC-3, but memory is dim on this point. Watton's work was sponsored by a committee headed by Leonard W. Thomas (then of Buships) with active participation by Dr. Ralph Showers of University of Pennsylvania and others.

So the Line Impedance Stabilization Network (LISN) was born. It was a pretty good simulation of that particular aircraft and the electrical systems it included. But then someone arbitrarily decided to use this artificial impedance to represent **any** power line.

At any rate, this impedance suddenly began appearing in specifications which demanded its use in each ungrounded power line for determining the conducted EMI (then known as RFI) voltage generated by any kind of a gadget. The resulting test data, it was argued, allowed the government to directly compare measured RFI/EMI voltages from different test samples and different test laboratories. No one was concerned about the fact that filtering devised for suppressing the test sample was based on this artificial impedance in order to pass the requirements, but that the same filter might have no relation to reality when used with the test sample in its normal power line connection.

Not until 1947, that is. At that time, this same Alan Watton, a propulsion engineer having no connection with the RFI/EMI business, decided to rectify the comedy of errors which had misapplied his original brainchild. He was in a position to place a small R and D contract with Stoddart for the development of two probes; a current measuring probe and a voltage measuring probe. Obviously, he felt that one needed to know at least two parameters for a true understanding of conducted interference. The current probe is not only a measure of EMI current, it is a measure of the magnetic field radiation from the wire or cable under test. This is a more meaningful measure of magnetic radiation, particularly at the lower frequencies, since the coupling between power leads at low frequencies is inductive, not capacitive.

As it turned out, Stoddart was successful in developing a current probe based on Alan Watton's suggestions regarding the torodial transformer approach which is still the primary basis used today. However, the development of the voltage measurement probe suffered for lack of sensitivity. Watton's hope had been to provide a high impedance voltage probe with better sensitivity than was then available for measurement receivers designed for rod antennas and 50 ohm inputs. Since this effort failed and Watton's funds (and probably his interest in the subject) faded out of the picture, the program came to a halt.

This meant that the RFI/EMI engineer could either measure EMI voltage across an artificial impedance which varied with frequency, or he could measure EMI current flowing through a circuit of unknown r.f. impedance. Either way, the whole story is not known. In spite of the unknown impedance, the military specifications began picking up the idea of measuring EMI current instead of voltage. The test setup was simpler and the current probe was not as limited as the LISN in its ability to cope with large power line currents. And the current probe measurement was also a measurement of magnetic field radiation. The current probe was somewhat better than the LISN for measurements below 150 KHz and above 25 MHz but, even so, the technique was not very sensitive at the lower frequency end of the spectrum.

A young Boeing EMI engineer named Frank Beauchamp was the first to apply the current probe to wideband measurements from 30 Hz to 20 KHz. He was smart enough to realize some of the problems in this range so he incorporated the sliding current probe factor into the method of measurement he spelled out in the Minuteman Specification, GM-07-59-2617A. The test method required that the probe factor existing at 20 KHz should be used for obtaining the wideband answer in terms of "per 20 KHz" bandwidth. This meant that the specified limit was not a constant throughout the 20 KHz bandwidth, but was varying as the inverse of the probe factor. A very sensible solution at the time. Regrettably, later specifications did not follow this lead.

When later EMI specifications extended the need for measurement of EMI currents down to 30 Hz **without** taking into account the sloping probe factor, the problem of probe sensitivity became critical. Attempts to compensate for the poor current probe response at low frequencies by using active element suffer from dynamic range difficulties and the possibility of overload.

This led to another way of "skinning the cat," with the aid of the Audio Isolation Transformer already available and in use for susceptibility testing. The technique described in the following paragraphs indicates how to obtain considerably greater measurement sensitivity for conducted narrowband EMI currents and a means for obtaining a flat frequency characteristic without the use of active elements for broadband or "wideband" EMI current measurements.

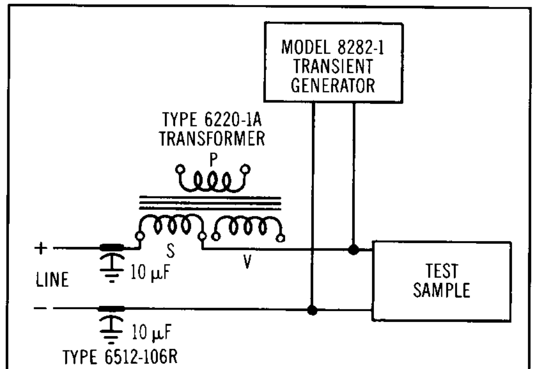


FIGURE 1 — TRANSFORMER SECONDARY USED AS ISOLATING INDUCTOR

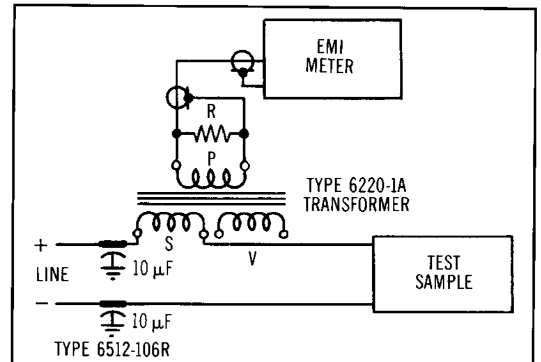


FIGURE 2 — TEST SETUP FOR MEASURING LOW FREQUENCY, LOW AMPLITUDE EMI CURRENT

BASIC CONCEPT

The application described herein has grown out of a suggestion by Sam Shankle of Philco Ford in Palo Alto. He and his capable crew first tried this scheme using H-P Wave Analyzers as the associated voltmeter. Our work with the idea has concentrated on conventional EMI meters with 50 ohm inputs.

Basically, the test method consists of using the secondary (S) of the Solar Type 6220-1A Audio Isolation Transformer as the pickup device. The transformer winding normally used as the primary (P) is used as an output winding in this case. The method provides a two-to-one step up to further enhance the sensitivity.

USE OF THE TYPE 6220-1A TRANSFORMER IN GENERAL

Since the transformer is connected in series with each ungrounded power input lead (sequentially) for performing the audio susceptibility tests, it can be used for two additional purposes while still in the circuit. First, the secondary winding can act as the series inductor suggested for transient injection tests to prevent the transient from being short-circuited by the impedance of the power line. In this application all other windings are left open. See Figure 1. Secondly, the transformer can be used for measuring EMI current as described herein. See Figure 2. At other times, if it is not needed in the circuit, short ciciuting the primary winding will effectively reduce the secondary inductance to a value so low that the transformer acts as if it isn't there.

ACHIEVING MAXIMUM SENSITIVITY FOR CONDUCTED EMI CURRENT MEASUREMENTS

The basic circuit in Figure 2 provides the most pickup and transfer of energy over the frequency range 30 Hz to 150 KHz. Curve #1 of Figure 3 shows the correction factors required to convert narrowband signals to dB above one microampere. Since the sign of the factor is negative for most of the range, the sensitivity is considerably better than that of conventional current probes. The sensitivity achieved by this technique is better than .05 microamperes at frequencies above 5 KHz when using an EMI meter capable of measuring 1.0 microvolt into 50 ohms. For EMI meters such as the NM-7A and the EMC-10E, the meter sensitivity is a decade better and it is possible to measure EMI currents of .005 microamperes at 5 KHz and above.

FLATTENING THE RESPONSE

At a sacrifice of sensitivity, the upper portion of the frequency vs. correction factor curve can be flattened to provide a constant correction factor from about 1 KHz up to 150 KHz. This is depicted in curve #2 of Figure 3, where a -20 dB correction is suitable over this part of the frequency range. The flattening is obtained by loading the primary with a suitable value or resistance. The resistance value used in this example is 10 ohms. The flattening still allows the measurement of a 0.1 microampere signal when using an EMI meter with 0.1 microvolt sensitivity. An advantage of this response curve is the sloping correction at frequencies below 1KHz which acts like a high pass filter to remove some of the power line harmonics from wideband measurements.

If you are only interested in frequencies above 150 Hz, a 2 ohm resistor is all that is needed. See curve #3.

STILL MORE FLATTENING

Like the girdle ads say, you can firmer and flatter, with a loss in sensitivity , by further reducing the value of the shunt resistor. This is illustrated in curve #4 of Figure 3 where a 0.5 ohm shunt resistor (**Solar Type 6920-0.5**) is connected across the transformer primary winding used as an output winding to the EMI meter. The overall flatness is achieved at the sacrifice of considerable sensitivity, but the sensitivity is well under the requirements of existing specifications and the correction network utilizes no active elements.

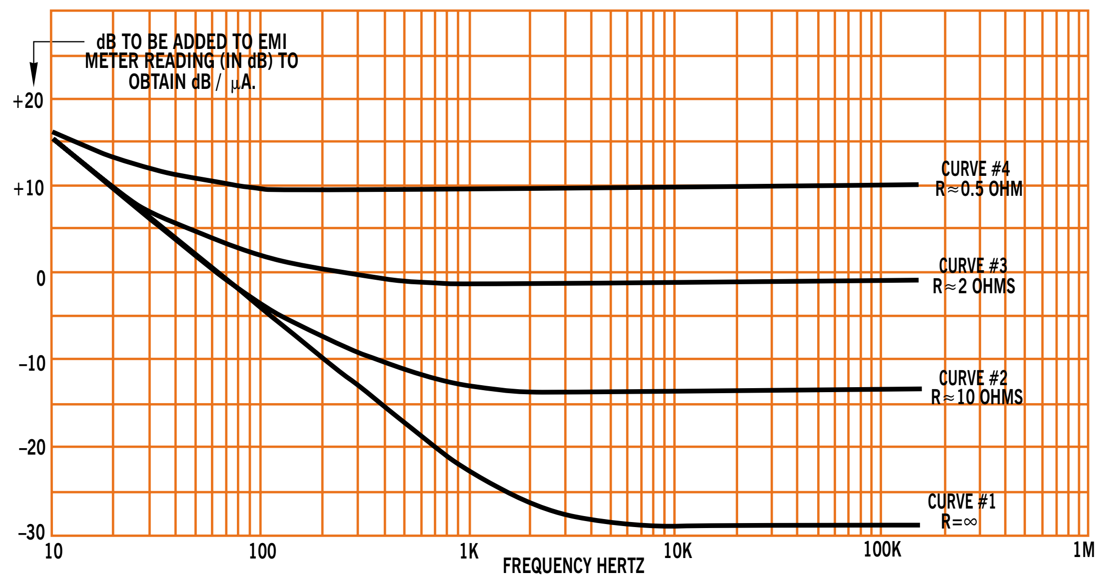


FIGURE 3 – TYPICAL CORRECTION DATA VS. FREQUENCY

LIMITATIONS OF THE METHOD

When measuring EMI current on d.c. lines, there are no problems, but on a.c. lines there are limitations. The a.c. voltage drop across the winding (S) due to power current flowing to the test sample is the principal problem. This voltage induces twice as much voltage in the output winding (P) at the power frequency. Since we prefer to limit the power dissipation in the 50 ohm input to the EMI meter so that it will not exceed 0.5 watts, the induced voltage must be kept below a safe limit. For 400 Hz lines, the power frequency current must not exceed 16 amperes to avoid too much 400 Hz power dissipation in the input to the EMI meter. Also, the resistance 'R' used across the output winding (P) must be at least a 50 watt rating on 400 Hz lines. This resistor should be noninductive to avoid errors due to inductive reactance.

THINGS TO BE WARY OF

The 10 µF feed-thru required by present day specs has appreciable reactance at 30 Hz (≈54 ohms) and acts to reduce the actual EMI current flowing in the circuit. This means less trouble in meeting the spec, but when calibrating the test method described herein, it is wise to short circuit the capacitor.

In the case where the input circuit to the EMI meter is reactive, such as the EMC-10E, it is necessary to use a minimum loss 'T' pad at the input to the meter. The Eaton NM-7A and NM-12/27A units do not require this pad and its loss.

DETERMINING THE NARROWBAND CORRECTION FACTOR

The test setup of Figure 4 describes the simple method of determining either the transfer impedance or the correction curve, whichever is desired. Actually, there is no need to plot the answer as transfer impedance, since the desired end product is the correction factor to be applied to the meter reading to obtain decibels above one microampere. The correction must be obtained for each configuration. In other words, if you want to use the method for maximum sensitivity, the calibration is performed with just a 50 ohm load on the primary winding simulating the EMI meter. If the flattening networks will be used, then they must be connected to the primary winding during the calibration and must be further loaded with 50 ohms to simulate the EMI meter input.

At each test frequency, the output of the audio signal generator is adjusted for a level which delivers the same current to the secondary (S) of the transformer. This is accomplished by setting a constant voltage across the 10 ohm resistor. A convenient level is 0.1 volt across 10 ohms which is 10,000 microamperes (80 dB/uA).

Adjust the gain of the EMI meter to assure a one microvolt meter reading for a one microvolt R.F. input from a standard signal generator. Then connect the 50 ohm input circuit of the EMI meter to the primary of the 6220-1A. If the EMC-10E is used, insert a 10 dB pad in series with the input. If the calibration is for maximum sensitivity, no additional loading is necessary. If the calibration is for the flattened versions discussed above, the appropriate resistance must be connected across the primary of the transformer.

At the frequency of the test, set the output of the signal source to obtain 1.0 volt across the 10 ohm resistor. Carefully tune the EMI meter to the test frequency and note the meter reading on the dB scale. The difference between the meter reading in dB and 80 dB represents the correction necessary to convert the meter reading to dB above one microampere for narrowband measurements. In most cases, the correction will have a negative sign. For example, at 100 Hz the EMI meter may read 88 dB above one microvolt. Since the reference is 80 dB above one microampere, the correction is -8 dB to added algebraically to the meter reading to obtain the correct reading in dB above one microampere.

If the 10 dB pad has been used, this loss must be accounted for in deriving the correction. If the pad will be used in the actual test setups, its loss becomes part of the correction factor. In this case, the meter reading obtained in the foregoing example would be 78 dB above one microvolt and the correction factor would be +2 dB for narrowband measurements.

Repeating this procedure at a number of test frequencies will produce enough data to plot a smooth curve for use when actual tests are being conducted.

DERIVING THE BROADBAND CORRECTION FACTOR

When making broadband measurements as required by MIL-STD-461A in terms of "dB above one microampere per megahertz," use the average of the narrowband factors over the range 30 Hz to 14 KHz and add a bandwidth correction factor of 37 dB.

In the case of Method CE01 of MIL-STD-461A, use the 20 KHz wideband mode of the EMI meter, determine the average of the narrowband factors over the range 30 Hz to 20 KHz and use this figure as the bandwidth correction factor.

When using high pass filters at the input to the EMI meter to eliminate the first few harmonics of the power line frequency as allowed by MIL-STD-461A, the range covered will depend upon the cutoff frequency of the filter. For example, on 60 Hz power lines and using **Solar Type 7205-0.35 High Pass Filter** between the 6220-1A Transformer and the EMI meter, obtain the average narrowband correction between 350 Hz and 14 KHz and add the bandwidth correction factor of 37 dB. On 400 Hz lines when using the **Solar Type 7205-2.4 High Pass Filter** between the transformer and the EMI meter, determine the average of the narrowband factors in the range of 2.4 KHz and 14 KHz and add the bandwidth correction factor of 38.5 dB.

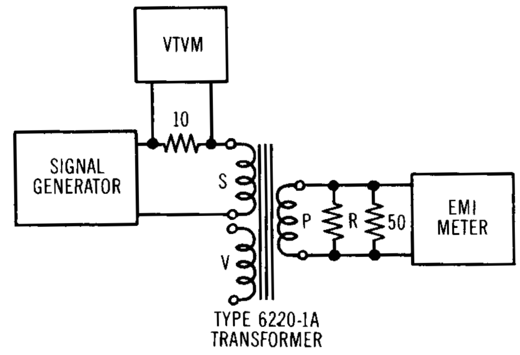


FIGURE 4 – TEST SETUP FOR DETERMINING CORRECTION FACTOR

SUMMARY

Some of the material given in this Application Note is terse and given without much explanation. If your are confused by this simplification, just call us. Incidentally, the Signal Corps liked this method so well that they included it in Notice #3 to MIL-STD-462 date 9 Feb 71.

TYPE 6512-106R FEED-THRU CAPACITOR

for RFI/EMI test setups

APPLICATION

The **Type 6512-106R Feed-Thru Capacitor** was especially designed for use in RFI/EMI test setups as required by MIL-STD-461/462 and other specifications. In this application it provides a low r.f. impedance across the power source so that EMI currents produced by a test sample can be accurately measured with current probes.

The 10 µF feed-thru capacitor can also be used as a power line filter installed in the wall of a shielded enclosure or equipment cabinet. The capacitor provides adequate insertion loss without suffering the power current saturation limitation of conventional filters which employ toroidal inductors.

DESCRIPTION

The **Type 6512-106R Feed-Thru Capacitor** is a highly reliable and ruggedly constructed unit for general use in screen rooms or other environments. The 3.375" square case with four husky mounting inserts lends itself to convenient installation with a minimum of effort. The ¼-28 UNF threaded feed-thru stud will easily accommodate power currents in excess of 100 amperes without heating or voltage loss. The capacitance value is 10 µF ±10%. The **Type 6512-106R** voltage rating is 600 volts d.c., 275 volts at 60 Hz, and 250 volts at 400 Hz. Low dissipation factor, high temperature rating, high insulation resistance, doubly rated dielectric strength, and long life characterize this versatile device. To satisfy safety requirements, a bleeder resistance is included in the **Type 6512-106R Feed-Thru Capacitor** which serves to discharge the capacitor when the applied voltage is removed.

FEATURES

- High insulation resistance over wide temperature range.
- Excellent stability with long life.
- Built-in discharge resistor for safety.
- Designed for bulkhead or bench mounting.

SPECIFICATIONS

Capacitance: 10 microfarads.

Tolerance: ±10% at 25°C.

Voltage Rating: 600 volts d.c.
275 volts r.m.s. at 60 Hz.
250 volts r.m.s. at 400 Hz.

Current Rating: Limited by the heat of the ¼-28 threaded terminal stud. Easily handles 100 amperes of power current. Can be used for currents in excess of 200 amperes intermittent duty.

Temperature: Will operate at full rated voltage from -55°C to 100°C. To +125°C with 50% voltage derating.

Dissipation Factor: Less than 1% at 25°C.

Dielectric Strength: Will withstand the application of twice rated voltage at 25°C for a period not to exceed two minutes.

Insulation Resistance: At rated voltage or less for a period two minutes, the insulation resistance will exceed 2500 megohms at 25°C. However, insulation in excess of 500,000 ohms cannot be measured due to the bleeder resistor built into the unit.

Bleeder Resistance: An internal bleeder resistor of 500,000 ohms is included as specified in SAE document ARP-936.

Life Test: Will withstand the application of 600 volts at 85°C for 250 hour.

Construction: Extended foil coaxial winding protected with a thin mylar film. Hermetically sealed with ceramic to metal seals.

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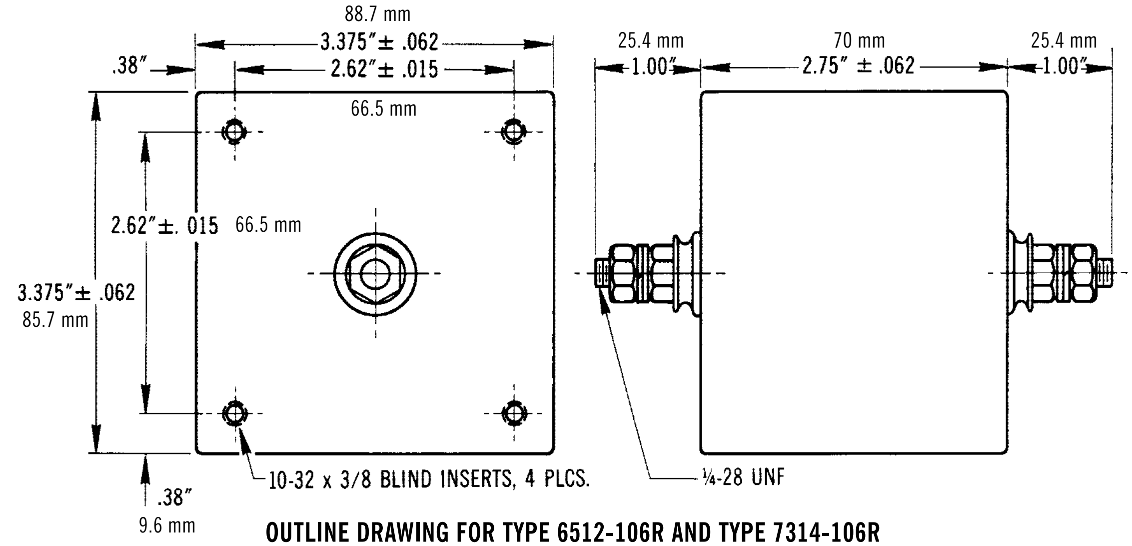
FAX (818) 755-0078

NEED HIGHER CURRENT OR HIGHER 400 Hz VOLTAGE RATING?

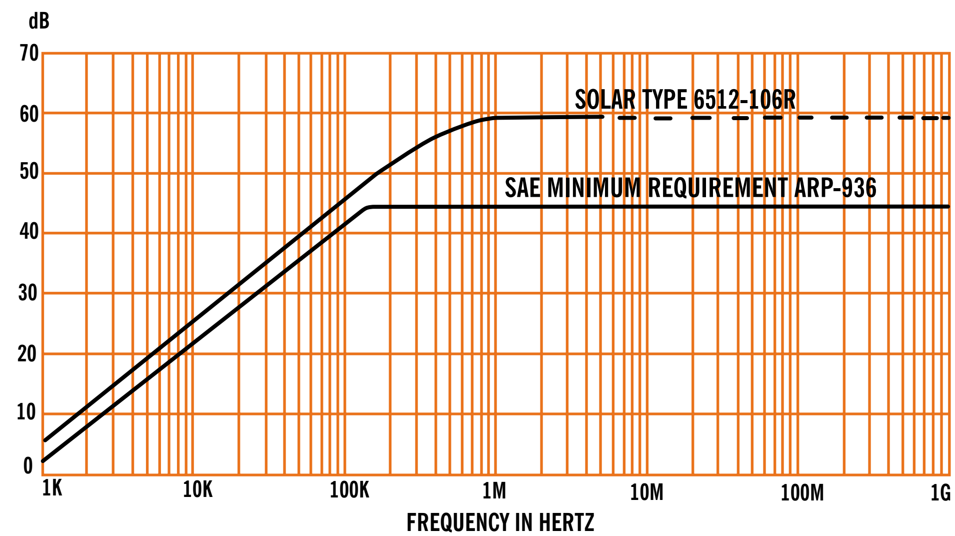
Type 7012-106R, 10 µF, 500 V at 400 Hz, 200 amperes. Size: 5" x 5" x 6" (127 mm x 127 mm x 152 mm) with ³⁄₈-16 feed-thru stud.

Type 7113-106R, 10 µF, 500 V at 400 Hz, 500 amperes. Size: 5" x 5" x 6" (127 mm x 127 mm x 152 mm) with ½-20 feed-thru stud.

Type 7314-106R, 10 µF, 300 V at 400 Hz, 100 amperes. See drawing.

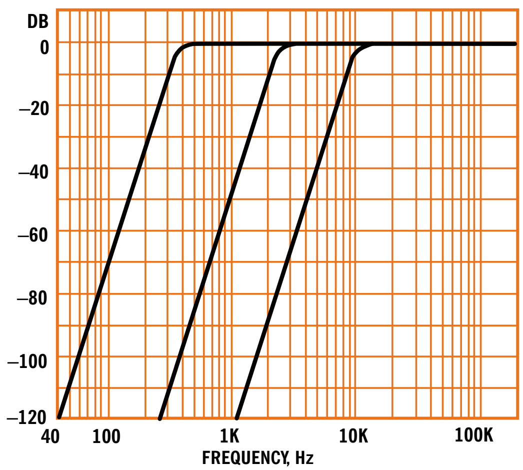


OUTLINE DRAWING FOR TYPE 6512-106R AND TYPE 7314-106R



INSERTION LOSS MEASURED IN 50 OHM CIRCUIT PER MIL-STD-220A

WAVE FILTERS: LOW PASS, HIGH PASS, BANDPASS, BAND REJECT



TYPICAL INSERTION LOSS
HIGH PASS FILTER, 50 OHM CIRCUIT

DESCRIPTION

All kinds of wave filters are useful in audio, r.f. and EMI programs to isolate selected portions of the frequency spectrum.

Custom designed wave filters are readily available in different impedance values and with different response slopes outside the pass or reject bands. The slope of response outside of the passband depends on the number of poles (circuit elements). Butterworth style filters are usually preferred since the ripple in the passband is negligible. For Butterworth designs, the frequency slope outside the passband is:

7 pole, approximately 42 dB per frequency octave
9 pole, approximately 54 dB per frequency octave
11 pole, approximately 66 dB per frequency octave

When any kind of wave filter is ordered, the number of poles or the steepness of the skirts of the response curve must be specified. It is also necessary to specify the impedance of the circuit where the filter will be inserted.

The cutoff frequency (fc) must be stipulated. This is the -3 dB point on the response curve which establishes the frequency limit of the pass or reject band. In Butterworth designs, the "knee" of the curve is rounded as it merges into the pass or reject band.

Most of the filters listed on the other side of this page were designed using the Butterworth method due to the absence of ripple in the passband. The Chebycheff design is also available, and usually can be held to less than 1.0 dB ripple in the passband. The Chebycheff design provides much steeper slopes. It is sometimes preferred when a sharper demarcation is needed between the frequencies of the passband and the frequencies which lie outside the band **and** when some ripple is tolerable. Fifteen poles is a practical limit.

LOW PASS FILTERS

Low pass filters are needed in test setups for Methods CS03, CS04, CS05, CS08 and RS04 of MIL-STD-462. To eliminate spurious harmonics and other frequencies above the range of interest, use Solar Electronics Low Pass Filters which provide more than 100 dB of insertion loss at three times the cutoff frequency. Eleven reactive components. Ripple in passband less than 0.5 dB. Use in 50 ohm circuits.

HIGH PASS FILTERS

When applied to a.c. powered equipment. Test Methods CE01 and CE03 of MIL-STD-462 require the elimination of the fundamental power frequency and the second, third and fourth harmonics. Notch filters have too much insertion loss in the passband and you need four of them. A high pass filter is the only practical answer. Used at the input to EMI meter, Solar Electronics High Pass Filters provide more than 100 dB insertion loss at the power line frequency and a very steep response.

BANDPASS FILTERS

Bandpass filters are useful for selecting a mid-range portion of the frequency spectrum with rejection slopes above and below the selected range. The low frequency cutoff can be as low as 10 Hz. The high frequency cutoff can be as high as 50 MHz.

BAND REJECT FILTERS

The inverse of bandpass filters, these units provide rejection of frequencies between two selected points in the spectrum. The sloping response between the low and high cutoff frequencies is as steep as the number of poles permits. For eleven pole filters, the slope is approximately 66 dB per frequency octave.

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Bandpass and band reject filters use two reactive elements for each pole. This makes them physically larger and more costly.

For F.C.C., V.D.E., C.I.S.P.R., or the U.S. Army NOTICE 3 version of MIL-STD-462, where LISNs are used for conducted emission tests, a portion of the a.c. line voltage to the EUT is present at the r.f. jack of the LISN.

To prevent damage to the EMI meter or spectrum analyzer used used for these tests, it is recommended that a high pass filter be connected between the LISN and the meter.

HIGH PASS FILTERS FOR USE WITH LISNs

For 50 Hz power frequency, use 7205-0.30. For 60 Hz power frequency, use 7205.0.35. For 400 Hz power frequency, use 7801-2.4 or 7930.-2.4. For Army Notice 3, MIL-STD-462 or for F.C.C., use 7801-8 or 7930.8.

SIGNAL LINE LOW PASS FILTERS FOR CS03, CS04, CS05, CS08 AND RS04 OF MIL-STD-462 AND OTHER SPECS.

Type No.	-3 dB	-100 dB	Type No.	-3 dB	-100 dB
6623-0.1	0.1 MHz	0.3 MHz	6623-5.0	5.0 MHz	15 MHz
6623-0.2	0.2 MHz	0.6 MHz	6623-10	10.0 MHz	30 MHz
6623-0.5	0.5 MHz	1.5 MHz	6623-20	20.0 MHz	60 MHz
6623-1.0	1.0 MHz	3.0 MHz	6623-30	30.0 MHz	90 MHz
6623-2.0	2.0 MHz	6.0 MHz	6623-50	50.0 MHz	150 MHz

HIGH VOLTAGE 50 OHM HIGH PASS FILTER STYLES

7801-( ) Rated at 125 V.A.C., Type N connectors
7930-( ) Rated at 270 V.A.C., Type N connectors
8130-( ) Rated at 270 V.A.C., Type BNC connectors
8131-( ) Rated at 125 V.A.C., Type BNC connectors

The cutoff frequency in KHz is appended as a dash number to the basic part number. For these four styles (only) the cutoff frequency must be greater than 2.3 KHz. Example: 7801-2.4.

NOTES: When filters will be permanently installed, add dash FL to part number to specify a mounting flange on each end of filter can.

Connectors are Type N unless otherwise noted. Filters rated 50 V.A.C. unless otherwise noted.

Type	**FILTERS, 50 OHM LOW PASS**
6623-( )	For signal lines. Dash number = fc = MHz, 11 pole Butterworth
7836-( )	For signal lines. Dash number = fc = MHz, 11 pole Butterworth
7907-( )	Isolated from case. Dash number = fc = MHz, Tri-ax connectors
8016-( )	For signal lines. Dash number = fc = KHz, 15 pole Chebycheff, BNC
8304-( )	Same as 7836-( ) except banana jacks each end
8305-( )	7 pole Butterworth. Dash number = fc = MHz, BNC
	FILTERS, 50 OHM HIGH PASS
7205-( )	For signal lines. Dash number = fc = KHz, 11 pole Butterworth
7720-( )	For signal lines. Dash number = fc = MHz, 11 pole Butterworth
7801-( )	Rated: 125 V.A.C. Dash number = fc = KHz. (fc must be > 2.3 KHz)
7930-( )	Rated: 270 V.A.C. Dash number = fc = KHz. (fc must be > 2.3 KHz)
8018-( )	Same as 7720-( ) except with BNC connectors
8130-( )	Same as 7930-( ) except with BNC connectors (fc must be > 2.3 KHz)
8131-( )	Same as 7801-( ) except with BNC connectors (fc must be > 2.3 KHz)
8209-( )	15 pole Chebycheff. Dash number = fc = MHz. BNC connectors
8310-( )	Same as 7205-( ) except with BNC connectors
	H.P. and L.P. FILTERS WITH IMPEDANCES OTHER THAN 50 OHMS
6824-( )	600 ohm High Pass. Dash number = fc = KHz, 11 pole Butterworth
7914-( )	600 ohm Low Pass. Dash number = fc = KHz, 11 pole Butterworth
8206-( )	75 ohm Low Pass. Dash number = fc = KHz, 15 pole Chebycheff, male BNC on one end, female BNC on the other end
	BANDPASS FILTERS (BUTTERWORTH)
7829-*/*	600 ohm Bandpass filter, 7 poles, BNC connectors
7830-*/*	50 ohm Bandpass filter, 7 poles, BNC connectors
7843-*/*	50 ohm Bandpass filter, 9 poles, BNC connectors
7844-*/*	600 ohm Bandpass filter, 9 poles, BNC connectors
7845-*/*	600 ohm Bandpass filter, 11 poles, BNC connectors
8106-*/*	150 ohm Bandpass filter, 7 poles, BNC connectors
8311-*/*	50 ohm Bandpass filter, 11 poles, BNC connectors
	BAND REJECT FILTERS (BUTTERWORTH)
8227-*/*	50 ohm Band Reject filter, 7 poles, BNC connectors
8229-*/*	50 ohm Band Reject filter, 9 poles, BNC connectors
8231-*/*	50 ohm Band Reject filter, 11 poles, BNC connectors

/ The dash number appended to the part number of Bandpass and Band Reject filters describes the -3dB points in Hertz. Example: -300/3K = -3 dB points at 300 Hertz and 3 Kilohertz. Dash number can be as low as 10 Hz on the low end and as high as 50MHz on the high end.

ACCESSORIES and MISCELLANY for the EMI LAB

Necessary . . . useful . . . practical items which make life in the screen room easier for the EMI engineer.

When setting up a shielded room for full compliance with EMI specifications, it is often discovered that there are incidental items which are needed, but which have not been considered in the overall planning. Some of these items are indicated on the catalog pages under the subheading USEFUL ACCESSORIES.

This page details other items which have a useful purpose in any well managed test facility.

Type 6920-0.5 Resistive Network. This unit consists of a 0.5 ohm resistor in a special housing designed to plug directly into the primary terminals of the Type 6220-1A Audio Isolation Transformer. It is used to flatten the responsive curve of the test method described in Application Note 622001. The method uses the transformer as a pickup device, in lieu of a current probe, for frequencies too low for conventional EMI current probes.

Type 7032-3 Isolation Transformer. There are times when it is necessary to step up the power line voltages from 115 volts to 230 volts or step down 230 volts to 115 volts. This transformer is equipped with a male connector on the 115 volt winding and a female connector on the 230 volt winding. The connectors are the international style IEC-320/CEE 22. Mating plugs not supplied. Rated at 800 watts, 50-60 Hz.

Type 7144-1.0 Precision Resistor. A 50 watt, one ohm resistor used in Test Method RS01 to measure the current in the Type 7429-1 radiating Loop Antenna. This device is mounted in a special housing with terminals for a voltmeter. Since the resistance value is one ohm plus or minus five percent, the voltage measured on these terminals is equal to the current flowing in the circuit, up to 100 KHz.

Type 7144-10 Precision Resistor. A 50 watt, ten ohm resistor used in Test Method RS02, Notice 3, U.S. Army version of MIL-STD-462 and Test Method CS09, Notice 4, U.S. Navy version of MIL-STD-462. This resistor can be used where 'R' is designated in Figure CS09-1 with a voltmeter connected across it to determine the required one ampere of current. Useful, because it can cover the required frequency range and can be used up to 300 KHz. Most EMI current probes are deficient at the low end of the range.

Type 7835-891 Coupling Network. A capacitive coupler for line-to-line EMI voltage measurements as required by Test Method CE07, Notice 3, U.S. Army version of MIL-STD-462. Equivalent to CU-891/URM-85. Rated at 500 V.D.C. Intended for use with 50 ohm EMI meter from 150 KHz to 30 MHz.

Type 7835-892 Coupling Network. A capacitive coupler similar to 7835-891 except presents 500 ohm to the circuit under test when used with a 50 ohm EMI meter. Equivalent to CU-892/URM-85.

Type 7835-896 Coupling Network. A capacitive coupler similar to 7835-891 except used from 20 MHz to 1 GHz. Equivalent to CU-896/URM-85.

Type 8121-1 Adapter for Type 7021-1 Phase Shift Network. Plugs into the terminals of the network and provides heavy duty terminals capable of carrying 200 amperes to the Equipment Under Test. Used when the EUT draws in excess of 50 amperes.

Type 8128-1 Adapter. Converts two single LISNs, Type 8028-50-TS-24-BNC, to a dual unit. Consists of an insulated panel fitted with banana plugs to mate with the binding posts of two LISNs.

It provides connections to a parallel blade receptacle with a U shaped grounding pin. The receptacle is identical to that used in the USA for power connections. When the Equipment Under Test contains a standard power cord, the cord can be plugged into the receptacle.

Type 9133-1 Three Phase Capacitor Assembly for Line-to-Line Capacitance in Delta-Connected Power Systems. This handy device contains three capacitors, ten microfarads each, connected to provide capacitance from phase A to B, A to C, and B to C. The capacitors are rated at 270 volts A.C. As a safety feature, each capacitor is paralleled with a 500K resistor to prevent a voltage charge from remaining on the assembly after power is disconnected. It is fitted with1/4-28 feedthru studs to facilitate making connection from three phase power to a three phase load up to 100 amperes. The **Type 6512-106R** capacitor can be used for the neutral in wye-connected power systems.

Dimensions: 3.5" x 6.0" x 3.75" high.
(89 mm x 152 mm x 95 mm)

Type 8801-1.6 Inductor. An air core inductor, 1.6 millihenries, for use with VDE specification 0871 A1-April 1984, DIN 57871-A1. Capable of carrying ten amperes. Three way-binding posts.

Dimensions: 2.88" x 3.8" x 2.12" high.
(73 mm x 96 mm x 54 mm)

Type 8814-1.5 Resistive Load. A 300 watt 1.5 ohm load resistor designed to plug directly into the primary of the **Type 6220-1A Audio Isolation Transformer** when used with **Type 8850-1 Power Sweep Generator.** Maximum input voltage 21 volts. Although some audio power is spent in the resistor, this device stabilizes the impedance presented to the load in the CS-01 test setup.

Type 8814-2.4 Resistive Load. A 200 watt 2.4 ohm load resistor designed to plug directly into the primary of the **Type 6220-1A Audio Isolation Transformer** when used with **Type 8850-1 Power Sweep Generator.** Maximum input voltage 22 volts. Some of the audio power is used up in this resistor, but it will stabilize the impedance presented to the load in CS-01 tests.

Type 8806-1 Pulse Stretching Network. When used with **Type 8282-1 Transient Pulse Generator** and associated pulse transformer, **Type 8406-1** will provide a 20 microsecond spike up to 1,000 volts into a 50 ohm load.

TYPE 7415-3 R.F. COUPLER AND HIGH PASS FILTER

There are those who disagree with the r.f. conducted susceptibility test setup of Method CS02 of MIL-STD-462. Homemade rigs have sprouted to comply with the coupling capacitor requirement, each with it own disadvantage. Our little **Type 7415-3 R.F. Coupler** is the answer. A neat little box with BNC connectors and a pair of binding posts, it is rated at 270 V.A.C. at the LINE terminals and 20 volts PMS into the GEN port. Looks good and does a fine job.

The test setup diagram of the specification will result in power frequency voltages at the voltmeter terminals. If an untuned voltmeter is used, it is difficult to measure a one volt r.f. signal in the presence of the a.c. line voltage. It is not practical to use an EMI meter for this, unless the **Type 7415-3** is placed in series with it. Otherwise, the power frequency voltage can damage the input circuit of the EMI meter.

The **Type 7415-3** contains a high pass filter in series with the detector circuit to eliminate power frequency voltages and allow r.f. signals from 50 KHz to 400 MHz to pass to the EMI meter as required. The high pass filter consists of three stages of an R-C network using series capacitors and shunt resistors. Using resistors instead of inductors enables the unit to cover a wide frequency range, with a 40 dB insertion loss in the pass band. This makes it necessary to multiply the detected voltage by a factor of 100 for the measurement of the injected voltage.

The series capacitor in the **Type 7415-3** consists of several styles of capacitors in parallel. Mica, ceramic and wrapped capacitors exhibit different characteristics versus frequency and the combination eliminates the need to change the value of the capacitor as frequency changes from 50 KHz to 400 MHz.

A tuned voltmeter such as an EMI meter is recommended as the detector for further isolation of unwanted frequencies, such as harmonics of the signal generator. If the generator waveform is "clean." An untuned meter can be used if it is terminated in 50 ohms and preserves a 50 ohm coaxial circuit throughout the frequency range.

The reactance of the built-in series capacitor from the generator to the power line terminal presents very little loss at 50 KHz. At 400 Hz its reactance is about 362 ohms. Therefore, it represents a path by which 400 Hz power voltages can be fed back to damage the output circuit of the signal generator.

To avoid this, one suggestion is to use an isolating transformer at the output of a low impedance signal source. Figure 1 shows the use of the **Model 6552-1A Audio Amplifier** and the **Type 7033-1 Impedance Matching Transformer.** This arrangement can be used for injection levels up to 20 volts r.m.s. from 50 KHz to 500 KHz with satisfactory results.

At frequencies above 500 KHz, we recommend that a 50 ohm signal generator be used as indicated in Figure 2 except that a small capacitor must be connected in series between the generator and the **Type 7415-3 R.F. Coupler.** Solar **Type 7525-1** is 0.1 microfarad, fitted with BNC connectors.

The reactance of this series capacitor reduces the power frequency voltage to a safe limit so that the output circuit of the generator will not be damaged. At 500 KHz, the r.f. signal is not greatly attenuated.

At frequencies above 20 or 30 MHz, the connections from the banana jacks to the test sample will create discontinuities that cannot be removed from the setup. It is recommended that the wires from the banana jacks be less than one inch long to minimize VSWR anomalies.

DIMENSIONS

2.0" (51 mm) X 2.5" (63.5 mm) plus mounting flanges x 1.25" (31.25 mm) high.

TYPE 9132-1 R.F. COUPLER AND HIGH PASS FILTER

This unit is a high voltage version of the **Type 7415-3**. It is electrically similar, but in a larger case and with a rating of 500 VAC at the LINE terminals and 20 volts rms into the GEN. Port.

Dimensions: 2.88" (73 mm) x 3.06" (78 mm) plus mounting flanges x 2.0" (51 mm) high.

TYPE 9407-1 A THREE PHASE R.F. COUPLING NETWORK

MIL-STD-462 notice 5, method CS02 requires simultaneous coupling of the r.f. susceptibility signal into all three wires of a three phase power system. The **Type 9407-1** network provides this capability in a neat little box. The unit includes a high pass filter for the elimination of power frequency voltages. Rating of 270 VAC at the LINE terminals and 20 volts rms into the GEN. Port.

Dimensions: 2.88" (73 mm) x 3.06" (78 mm) plus mounting flanges x 2.0" (51 mm) high.

Test Method CS02 requires injection of the signal from a 50 ohm generator capable of seven volts output. This is equivalent to a one watt source. There are two conditions which could inhibit the injection of one volt r.f. into the Equipment Under Test:

1) If the r.f. impedance looking into the power terminals of the Equipment Under Test is considerably lower than 50 ohms at the injection frequency, the injected signal will be shunted and it may not be possible to achieve the required injection voltage with a one watt source.

2) If the connections to the power source are heavily by-passed as in the case of screen room testing, this will also shunt the injection voltage so that the required level cannot be reached. This can be prevented by inserting an inductor in the power line as indicated in Figure 1 and Figure 2. The secondary of the **Solar Type 6220-1A Transformer** can be used as this inductor.

Therefore, the test setup must be carefully monitored to keep the signal source from exceeding the required seven volts. If the Equipment Under Test does not malfunction with a seven volt signal from a 50 ohm source, it is deemed to have passed the test. Even though the signal input port of the **Type 7415-3** is rated at 20 volts, **it is not recommended that the power of the signal source be increased beyond one watt in an effort to reach a one volt injection level.**

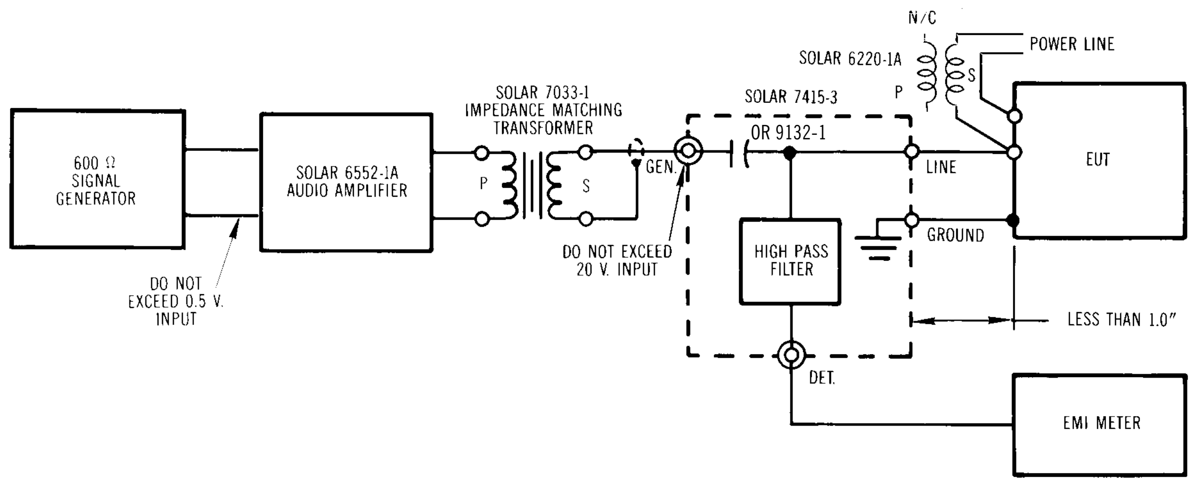

FIG. 1 TEST SETUP FOR FREQQUENCIES FROM 50 KHz - 500 KHz

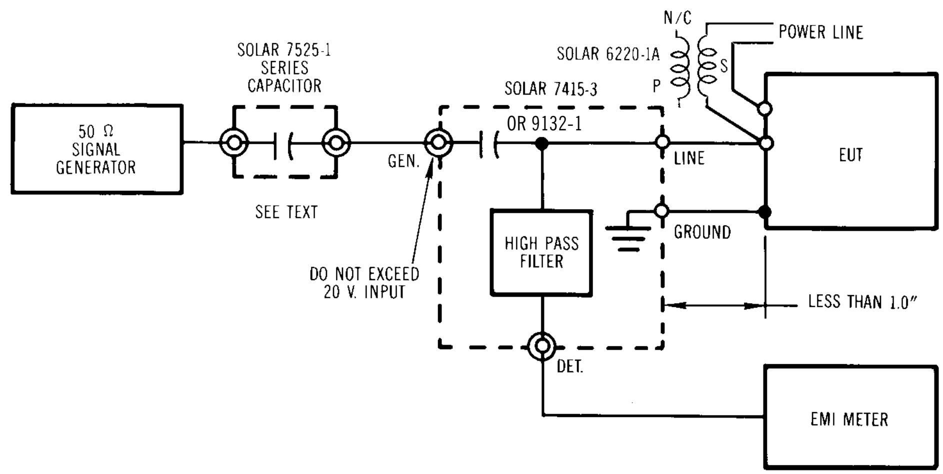

FIG. 2 TEST SETUP FOR FREQQUENCIES FROM 500 KHz - 400 MHz

Application Information on High Voltage Spark Tests

USING TYPE 7115-1 OR 7115-2

HIGH VOLTAGE TRANSIENT PULSE TRANSFORMER AND TYPE 7510-1 SPARK GAP

The **Type 7115-1 Transient Pulse Transformer** is designed to be plugged into the SERIES output terminals of the **Model 6254-5S Transient Generator** to step up the transient or "spike" voltage. The **Type 7115-2 Transient Pulse Transformer** is designed to be plugged into the SERIES terminals of the **Model 8282-1 Spike Generator.** When specifications require a static discharge to the shield or case of the equipment under test, the **Type 7510-1 Spark Gap** can be useful.

The Pulse Transformers are in an insulated case measuring 3" x 3.8125" x 4" and fitted with banana plugs on the primary for insertion in the output terminals of the transient generator.

The **7510-1 Spark Gap** is designed to be mounted directly on the output terminals of the **Type 7115-1** or **7115-2** transformer, or used at a remote point by means of interconnecting leads. The basic setup is shown on the back of this page.

The **Type 7510-1 Spark Gap** is supplied with electrodes which are pointed on one end and spherical on the other, so that either style may be used by reversing the way they are mounted.. A spacer block can be made to a given dimension and used as a jig to position the points the correct distance apart. The gap dimension should never exceed 0.5" since the spark will then tend to jump across the structure of the **Type 7510-1** instead of the gap.

Using the amplitude adjustment on the spike generator, the output of the **Type 7115-1** or **7115-2** can be raised from about 500 volts to 15 kilovolts peaks. The shape of the transient is essentially the same as that produced by the generator unless the voltage breaks down the gap between the output terminals of the transformer (or gap in wiring connected to the terminals). The output terminals are ceramic insulated with metal parts separated by at least 0.5".

The transient pulse or resultant spark across a circuit is adjustable from 0.5 to 500 p.p.s. using the repetition rate controls on the spike generator.

Since the output of the transformer is a very high impedance, any capacitance across it will reduce the available output voltage. Ideally, keep the interconnecting leads less than 6". The wire from the transformer to the spark gap should be spaced away from any wire or structure which acts as a ground plane. The spark gap can be either mounted directly to the case of the equipment under test or connected with a very short wire.

The applied spark voltage can be adjusted by properly spacing the spark gap distance. WIth a spark gap in dry air at sea level and room temperature, the approximate voltage required to break down the gap is:

Peak Voltage	7510-1 Needle Gap	7510-1 Spherical Gap
5 KV	0.15" (3.8 mm)	0.049" (1.24 mm)
10 KV	0.33" (8.4 mm)	0.10" (2.54 mm)
15 KV	0.60"(15.2 mm)	0.17" (4.32 mm)

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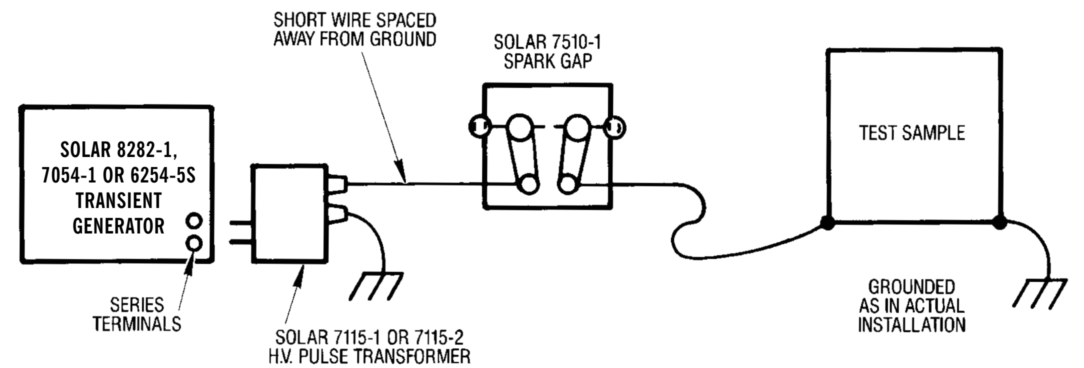
After the gap distance has been adjusted. set the controls of the spike generator to 1 p.p.s. and minimum amplitude. Turn on the generator and slowly increase the amplitude until a consistent spark jumps the gap once every second. Increasing beyond this level will not increase the voltage since the breakdown of the gap limits the voltage. At faster repetition rates it is possible to reduce the amplitude after a few seconds since the air in the gap ionizes and breaks down at a lower voltage. It is recommended that the test be performed at low repetition rates or with the pushbutton for manually applied single discharges.



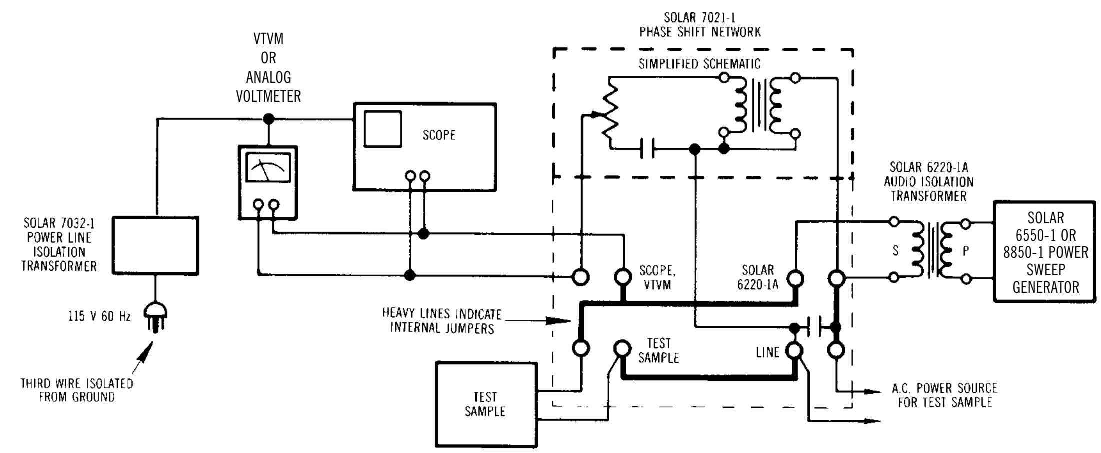
TEST SETUP FOR SPARK DISCHARGE INTO CASE OR CHASSIS

TYPE 7021-1 PHASE SHIFT NETWORK

The **Type 7021-1 Phase Shift Network** phases out the power frequency without disturbing the injected frequency seen by the VTVM, analog voltmeter, or scope in Method CS01 of MIL-STD-462. The network prevents the power frequency from reaching the indicating device, but doesn't interfere with the normal power connection to the test sample. Properly adjusted, it has no effect on the injected frequency, so the voltmeter or scope will indicate the injected level. Contains variable resistance and capacitance in a bridge-type circuit which is manually adjusted for null before the injected signal is applied. Does a fine job on 50 Hz, 60 Hz, and 400 Hz power lines. Either 115 volt or 230 volt operation.

The various terminals on the **Type 7021-1** are interconnected internally as shown by the heavy lines drawn on the panel. These connections are capable of carrying up to 50 amperes of power current. For power currents up to 200 amperes, the **Type 8121-1 Adapter** can be plugged into the terminals of the **Type 7021-1** unit. The adapter provides .375" threaded studs for carrying the larger power current to the test sample. (The adapter must be ordered separately.) **Safety precautions must be observed since all power terminals are exposed.**

The operation of the Phase Shift Network is relatively simple. With the audio source connected, but its level reduced to minimum, adjust the resistance elements (the two upper knobs on the **Type 7021-1**), and the capacitive elements (the step switches) for a null or minimum indication on the scope and voltmeter.



TEST SETUP FOR AUDIO SUSCEPTIBILITY TEST ON A.C. LINES

There is some interaction of these controls and when one is adjusted, the other should be readjusted and this action repeated several times. With careful attention to this, it should be possible to reduce the levels to below 300 millivolts on the voltmeter. Then, the audio source can be increased until the voltmeter indicates the voltage required by the susceptibility specification.

In the test setup shown above, the purpose of the power line isolation transformer, **Type 7032-1**, is to eliminate the power ground or chassis earth connection of the voltmeter and the oscilloscope. The chassis of these units floats on the power leads and must be isolated to prevent short circuits. **Operating personnel should avoid touching the case or chassis at the same time they are in contact with earth connected items.**

Application Information

TYPE 6693-3L/3R RF-DC ISOLATOR NETWORK

FOR INSERTION LOSS TEST OF EMI FILTERS WITH D.C. CURRENT FLOWING THROUGH THE FILTER

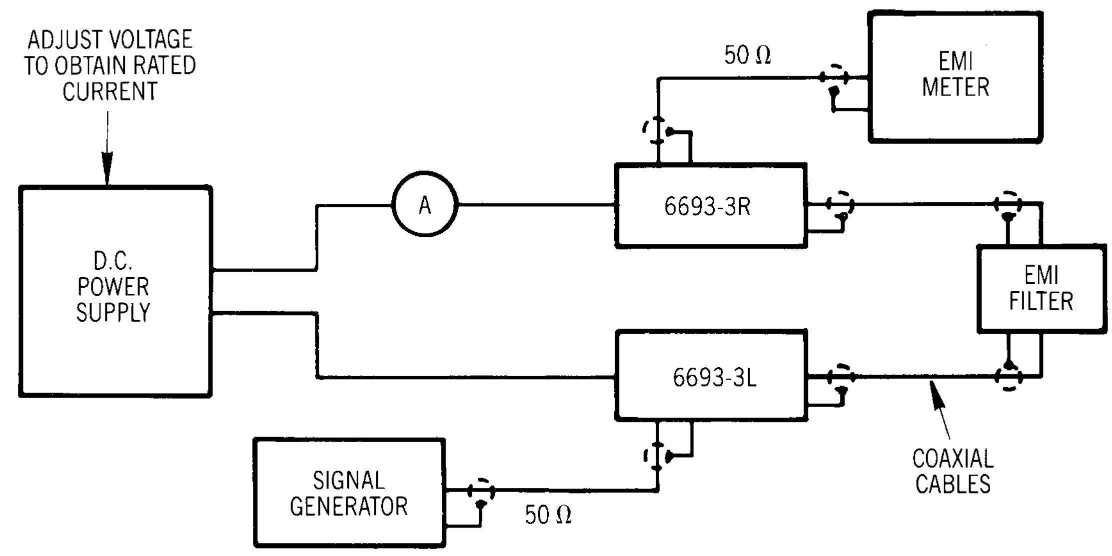
The **Type 6693-3L/3R RF-DC Isolator Network** consists of two units used as "buffer" networks in performing insertion loss tests on EMI filters while power current is flowing through the filter. The networks provide a high impedance in series with the power source so that r.f. signals will not be deteriorated by the low impedance of the power source.

MIL-STD-220A requires insertion loss measurements using this method up to 20 MHz. The **Type 6693-3L/3R Isolator Networks** are usable at frequencies from 150 KHz to several hundred megahertz. The loss isn't bad up to 500 MHz. Standing waves give it some irregularity from 500 MHz to 1,000 MHz. This is measured in a 50 ohm circuit as required by MIL-STD-220A.

The wide range of frequencies is made possible by a special coil design and a transmission line connection from r.f. input to output. Unfortunately, the coil design does not lend itself to large amounts of power current. These units are rated at 15 amperes d.c. maximum.

Two styles are used in the test setup as shown in the diagram on this page. The two units, 6693-3L and 6693-3R, are identical except that one is physically the mirror image of the other for convenience in making the test setup. Although the jack on one side of one is marked SIGNAL GENERATOR and the jack on the opposite side of the other unit is marked R.F. VOLTMETER, these two connections can be interchanged if it makes your setup easier to use.

The shielded cable connection between the connector marked TO FILTER UNDER TEST and the filter is a matter which must be arranged to fit the particular terminal or connector on the filter. There are many different configurations and no "standard" is possible. Ideally, the shield should terminate in a metallic fitting which completely shrouds the filter terminal, to avoid inadvertent coupling at the higher frequencies.



TEST SETUP FOR LINE-TO-CASE INSERTION LOSS PER MIL-STD-220A

Application Information

CABLE INDUCED TRANSIENTS

FOR SPACE SHUTTLE PROGRAM

The design requirements for electrical equipment on board the Space Shuttle vehicle include cable induced currents, called "indirect lightning effects" as described in Rockwell International Specification MF0004-002. A system for providing "component number one" described in Figure 15(b) of that specification has been developed and includes three items as follows:

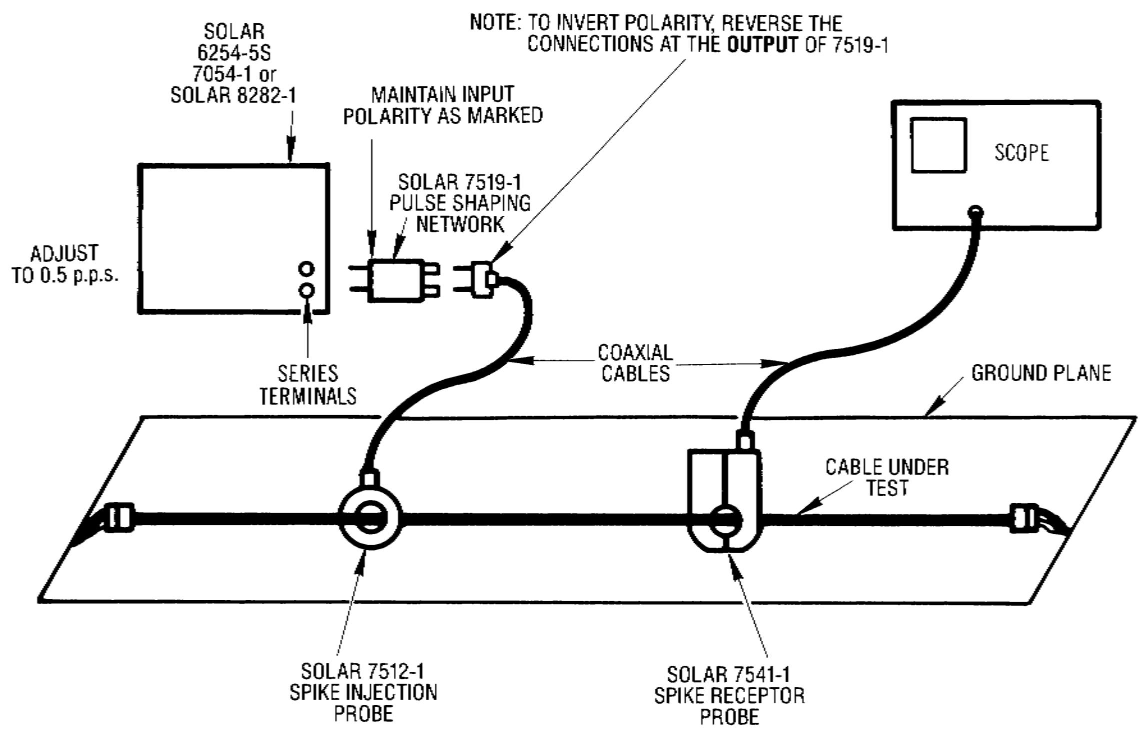
Type No.	Description
7512-1	Spike Injection Probe
7519-1	Pulse Shaping Network (for use with Model 6254-5S, Model 7054-1 or Model 8282-1 Spike Generator)
7541-1	Spike Receptor Probe (calibrated for use with oscilloscope)

The test method described in paragraph 4.2.7.2 and Figure 16 of the specification requires two probes which are torodial transformers using the cable under test as the coupling between them. The injection probe and the receptor probe are different in character and cannot be used interchangeably. When using the **Model 6254-5S** or **7054-1** or the **8282-1** (in 10 µS mode) **Spike Generator** as the signal source, it is necessary to modify the shape of the pulse to comply with the waveform shown in Figure 15(b). The **7519-1 Pulse Shaping Network** is used between the spike generator and the injection probe to provide the appropriate waveform. The block diagram on the back of this page depicts the arrangement. A brief description of the three ancillary items follows:

Type 7512-1 Spike Injection Probe — Since it is possible to pass the test cable through the window of the injection probe, it is not a split construction, but it is a complete toroid fitted with a BNC connector. The core used in this probe has been specially selected to adequately transmit the low and high frequency components of the required spike waveform. The inside diameter of the injection probe is 1.25", suitable for most cable diameters. Because it is necessary to feed the cable through the window of the probe, the connector on the cable must be less than 1.25" diameter or the connector must be removed before inserting the cable through the probe.

Type 7519-1 Pulse Shaping Network — The waveform of **Model 6254-5S**, **Model 7054-1** and **Model 8282-1** (in 10 µS mode) **Spike Generators** decays to zero in approximately 10 microseconds. Since the waveform of Figure 15(b) for component number one is longer, the basic waveform is stretched by the **7519-1** network at the expense of rise time and amplitude. However, the generators have sufficient range in peak amplitude to overcome the loss and the slightly lengthened rise time is still within the requirements. The shaping network and the injection probe have each been designed so that short circuit current of 10 amperes flows through the cable under test. This is achieved at a generator setting which delivers 50 volts when the cable under test is open circuited at the receptor end.

Type 7541-1 Spike Receptor Probe — The receptor probe is assembled with a hinged construction allowing it to be placed around the cable under test. The design of this probe includes a calibrating resistor mounted in the housing. This resistor has been adjusted so that the display on the associated oscilloscope accurately indicates the value of spike current detected. **The vertical amplitude in volts/cm is converted to amperes/cm by multiplying the displayed peak value by a factor of ten.** The waveshape displayed on the oscilloscope should be similar to the requirement specified in Figure 15(b) of specification MF0004-002, decaying to zero in approximately 100 to 120 µS.



TEST SETUP FOR CABLE INDUCED TRANSIENTS

THE ENGINEER'S CLOCK

We don't mean to imply that engineers are clock watchers, but . . .
this clock has a face you'll never stop watching!

INSTANT CONVERSION:
Two large scales display the relation of decibels to 20 times the log (base 10) of any number from 1 to 1,000.

GRAPHIC:
Dispels the illusion that twice as many decibels means twice as much of any quantity.

EDUCATIONAL:
Explain to the boss that you are not clock-watching, but diligently memorizing decibel equivalents to voltage and current ratios.

VERSATILE:
Most engineers can even tell time with this clock.

ICE-BREAKER:
Even with this large diameter clock, people will ask, "Do you have the time?"

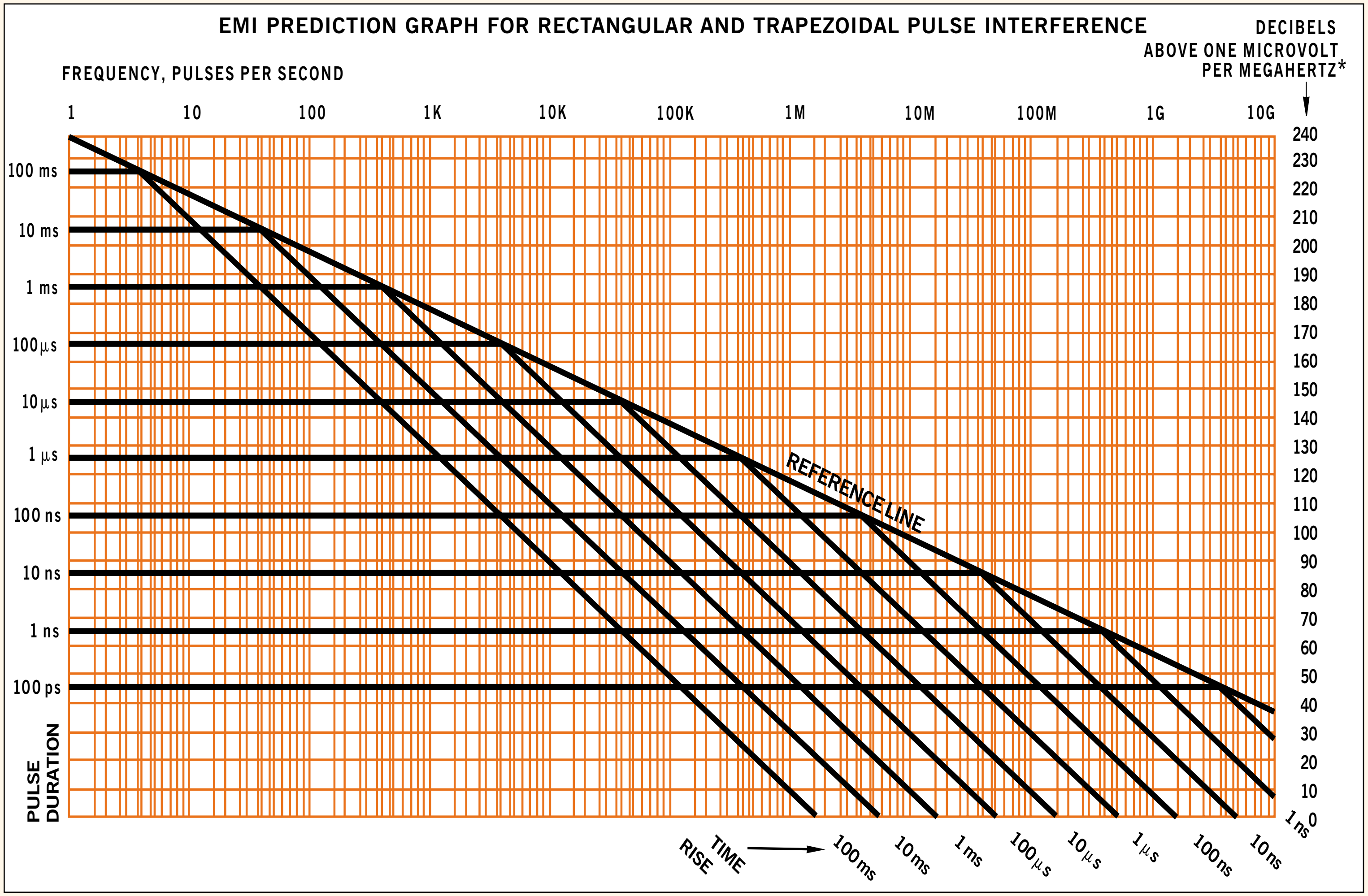
COMPATIBILITY:
Guaranteed to be EMI-free.

DIMENSIONS:
This clock face is large enough to be seen and analyzed even when mounted on the far wall of the lab or the screen room.

SOLAR ELECTRONICS COMPANY
Innovative EMI Solutions Since 1960
e-mail: sales@solar-emc.com www.solar-emc.com
A division of A.T. Parker, Inc.
(800) 952-5302
(818) 755-1700
FAX (818) 755-0078

EMI PREDICTION GRAPH

for rectangular and trapezoidal pulse interference



FOURIER PREDICTION OF EMI ENVELOPE

Given rise time, duration and amplitude of basic pulse, determine the envelope of EMI voltages measured at EMI meter input as follows:

Work from right to left. Find the sloping line which represents rise time and follow it up to intersect with the basic reference line. Follow the reference line up to intersect with the horizontal line representing the duration of the pulse. Follow the horizontal line to the left to the lowest frequency of interest.

For transient or "worst case" when pulse information is not available, use the basic reference line to define the EMI envelope.

For EMI **voltage*** levels, read the right edge for decibels above one microvolt per megahertz bandwidth.

For **voltages other than one volt***, find the number of dB equivalent to 20 times the log of the new voltage. Add this number of dB to the right hand scale.

*** For EMI current predictions, substitute "ampere" for "volt" and "microampere" for "microvolt." Right-hand scale becomes "Decibels above one microampere per megahertz."**

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e-mail: sales@solar-emc.com www.solar-emc.com

A division of A.T. Parker, Inc.

(800) 952-5302

(818) 755-1700

FAX (818) 755-0078