Design Patent 237512

TC-5060A/B UHF TEM Cell

Operating Manual

R50723

WARRANTY

C***TS*** guarantees that this product will be free from defects in materials and workmanship for a period of six months from the date of shipment. During the warranty period, C***TS*** will, at its discretion, either repair or replace defective products.

For the warranty service, customer must notify C***TS*** of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. Customer shall be responsible for packaging and shipping the defective product to C***TS*** or a service center designated by C***TS***. Customer shall pay for shipping charges as well as any other charges incurred outside of Korea. C***TS*** shall pay shipping charge to return the product to customer.

This warranty shall not apply to consumable parts and any failure or damage caused by improper use or unauthorized service or articles of consumption. In such cases, C***TS*** may refuse to furnish service under the warranty.

LIMITATION OF WARRANTY

The foregoing warranty shall nor apply to defects resulting from improper or inadequate malignance by customer, Customer-supplied software or interfacing, unauthorized modification or misuse, accident or abnormal conditions of operations.

M***anufacturer*** responsibility to repair or replace deductive products is the sole and exclusive remedy provided to the customer for breach of this warranty. M***anufacturer*** will not be liable for any indirect, special, incidental, or consequential damages, despite any advance notice of the possibility of such damages.

In this manual…

Safety Considerations

Review the following safety precautions to avoid injury and prevent damage to this product or any product connected to it.

Do Not Operate in Wet/Damp Conditions
To avoid injury or fire hazard, do not operate this product in wet or damp conditions.

Do Not Operate in Explosive Atmosphere
To avoid injury or fire hazard, do not operate this product in an explosive atmosphere.

Do Not Operate With Suspected Failures
If there is damage to this product, have it inspected by qualified service personnel

Environmental Conditions
Refrain from using this equipment in a place subject to much vibration, direct sunlight, and where the surface is not level. Also, use it where the temperature is between 0 °C to 50 °C and relative humidity is less than 85%.

Safety Symbols and Terms

Terms in this manual:

WARNING: Identifies conditions or practices that could result in injury or loss of life.
CAUTION: Identifies conditions or practices that could result in damage to the product or other property.

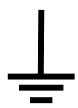
Terms on the product:

DANGER: Indicates an injury hazard immediately accessible as you read the marking.
WARNING: Indicates an injury hazard not immediately accessible as you read the marking.
CAUTION: Indicates a hazard to property including the product.

Symbols on the Product: The following symbols may appear on the product.

DANGER
Risk of electric shock

ATTENTION
Refer to Manual



Indicates earth
(ground) terminal

Service and Support

If you have a problem with your TC-5060A/B, contact C***TS*** Technical Support specialists.
Any adjustment or repair of this product must be performed by qualified personnel.

Contact Information

Address : C***oncentric Technology Solutions Inc.***
4017 Clay Avenue, Suite F   Fort Worth, Texas 76117

TEL : 8***17-503-8862***
FAX : 8***17-503-8866***
Email : sales@ctscorp-usa.com
http://www.ctscorp-usa.com

CONTENTS

General Information

This section provides a general description of the TEM Cell and proper set-up procedures.

I

Instructions and Key Features

Instructions

TC-5060A/B, economy UHF TEM Cell generates the Electro-magnetic field for testing small RF devices such as wireless pager, GPS Receiver, Portable phone, etc. Through the input port, an external test signal may be applied to TC-5060A/B to generate predictable TEM test field inside the cell. And the radiation field can also be picked up through the input port using a test receiver. The unique, compact economical design is intended for medium accuracy measurements beyond the standard TEM Cell frequency range.

Key Features

- Radiation and susceptibility test
- Broadband TEM Cell up to 3 GHz
- Small size, Small footprint for desktop application
- High effective shielding
- Specifically designed for all types of portable phones

Specifications

Specifications are listed in Appendix A.

Connectors

This section contains reference information for TC-5060A/B's connectors.

Table 1-1 TC-5060A/B Connectors

Connector	Specification
N Coaxial Connector	Impedance: 50 ohm Voltage Rating: 1500 Vpeak Dielectric Withstanding Voltage: 2500 Vrms
SMA Coaxial Connector	Impedance: 50 ohm Voltage Rating: 250 Vpeak Dielectric Withstanding Voltage: 750 Vrms
DB25 Data Connector	Working Voltage: 100 VDC Dielectric Withstanding Voltage: 300 VDC EMI Filter : 1000 pF Pi

TC-5060A/B Component Identification

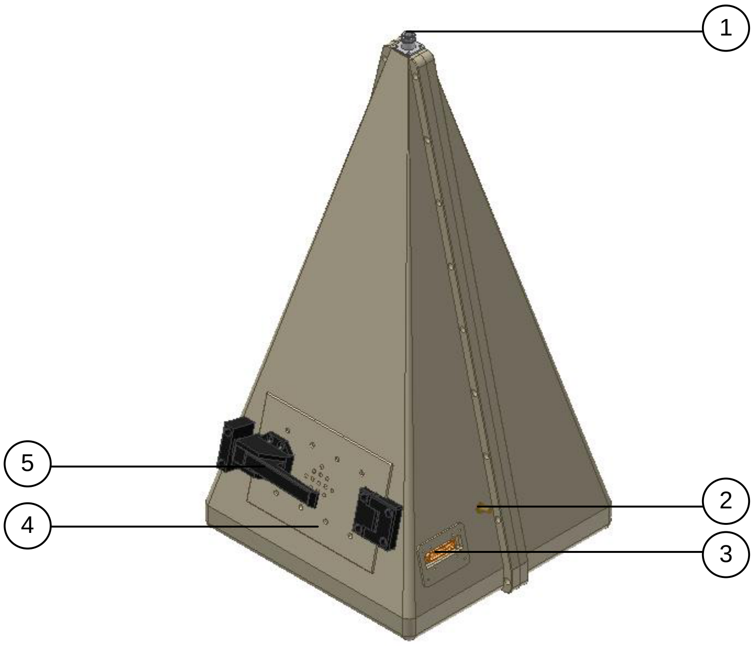


Figure 1-1 TC-5060A/B Component Identification

① N(f) RF Connector
② SMA(f) RF Connector
③ DB25(p) Data Connector
④ Door
⑤ Door Handle

Initial Inspection

This section provides the information for verifying proper shipment of the TC-5060A/B UHF TEM Cell.

Product Condition and Accessory Check

1. Upon receipt of the TC-5060A/B TEM Cell, check for damage that could have occurred during shipment.
2. Verify you have received all the standard accessories supplied with the TC-5060A/B, which are listed in Appendix B TC-5060A/B Accessories.

Operating Environment and Storage

Refrain from using this equipment in a place subject to excessive vibration, direct sunlight, or where corrosive gas is generated. Also, use it where the temperature is between 0 °C to 50 °C and relative humidity is less than 85%.

The storage temperature range for this equipment is –20 °C to 70 °C. When this equipment is not used for a long period of time, cover with vinyl or place in a cardboard box and store in a dry place away from direct sunlight.

Packing Instructions

This section addresses how to ship the product should you discover product damage resulting from shipment. Use the original packing materials when shipping this equipment. If the original materials are not available, pack the equipment as follows:

1. Wrap the equipment in appropriate shock absorbing materials, then place it in a corrugated cardboard box at least 5 mm thick. (If shipping to a m***anufacturer*** Service Office, attach a tag indicating the type of service required, return address, model number and full serial number.)
2. Wrap accessories separately in the same shock absorbing material, then place them in the corrugated cardboard box with the equipment.
3. Fasten the corrugated cardboard box with packing strings.
4. Mark the shipping container FRAGILE to specify careful handing.

TC-5060A/B Theory of Operation

II

Theory of operation

TC-5060 UHF TEM cell is made to work beyond the typical TEM Cell operating frequency range limited by cell resonance. A typical TEM Cell is a 2-port symmetrical device; RF voltage is applied to one port while the other port is terminated in 50 ohm while maintaining 50Ω characteristic impedance along the cell. Due to expansion and contraction parts of the cell, the wave propagation beyond certain frequency is no more propagated by TEM mode alone and creates resonance. To eliminate the resonance problem, the half of the cell is replaced by the wave absorbing material. One commercial implementation is G-TEM cell. The size of the G-TEM design is too large for typical small device applications due to the type of absorber used. Thi***s*** concept ***was borrowed from the*** G-TEM, but changed the termination implementation scheme, and designed a very compact broad band TEM Cell that can be used on a desktop.

The operation principle is essentially the same as TEM Cell. The E-H field inside the test volume is proportional to the input voltage and inversely proportional to the cell height. If a radiating object is inserted inside the cell, the radiated wave toward input port is guided by the transmission line and picked up at the input with a receiver such as a spectrum analyzer. With this method, RFI from a radiating Device can be measured quantitatively. Since this apparatus is very broadband, it has many applications in the area of EMI, EMS, receiver sensitivity test, etc.

Standard E-field Generation (Ref. 1, Figure 2.1)

Consider a case when a 50Ω output impedance Signal generator puts out V (Volt) of RF signal into the input connector of a TEM Cell. Then the E-field, E (Volt/meter), developed inside the TEM cell is found by the following formula.

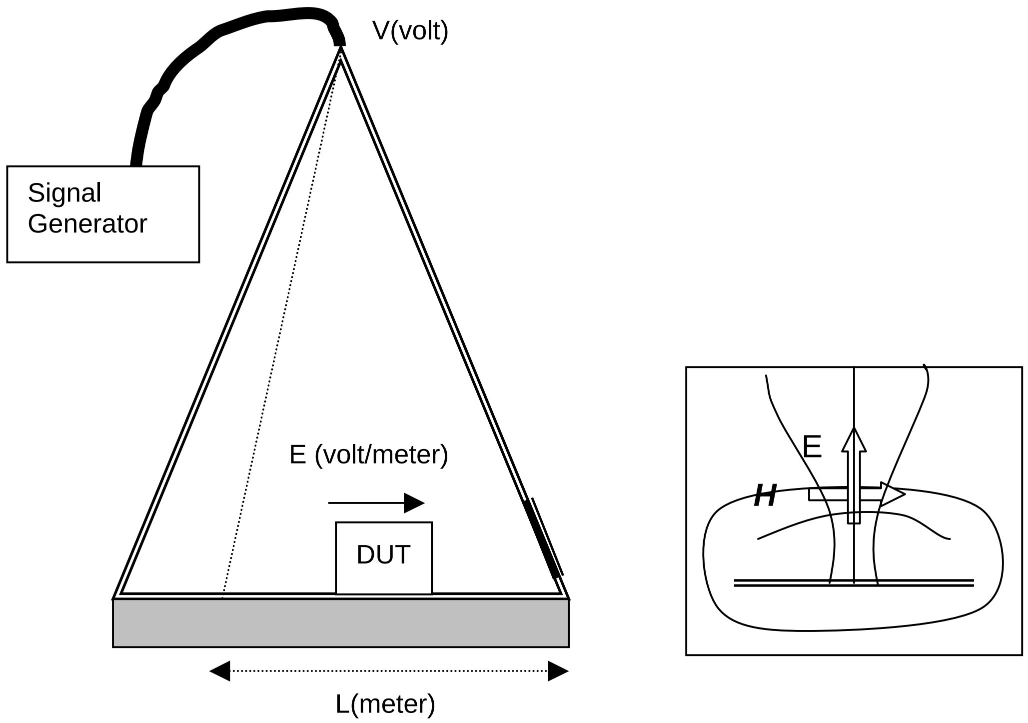
E (Volt/meter) = V (Volt) /L (meter) ………………… (1)

.

Here, L is the distance between septum and the top wall. In TC-5060A/B, L is 22 (cm).
Since TEM Cell produces TEM wave, an orthogonal H-field (ampere/meter) proportional to E-field exists. They are related by the free space wave impedance 377Ω.

H (Ampere/meter) = E (Volt/meter)/377 (Ohm) .... (2)

Field distribution inside the cell is shown in Figure 2.1(b).



(a) Field Generation (b) Field Pattern (Top View)

Figure 2.1 Field Generation and Field Pattern

<Example>

Connect the RF output of a signal generator to the input port of TC-5060A/B with a cable. Set the signal generator frequency (between 400MHz to 3GHz) and the signal level to 220mV. The E-field developed at the test point inside TC-5060A/B is then

E = 0.22(V) / 0.22(meter) = 1 (Volt/meter).

If the signal generator output is decreased to 2.2uV, the E-field inside TC-5060A/B becomes 10uV/meter at the center of the test volume.

Radiation Power Measurement (Ref.2, Figure 2.2)

When a radiating object is placed inside TEM cell, the radiated power Po (Watt) travels equally to both ends of TEM cell. The voltage measured, Vm (Volt) at one end can be expressed as follows:

Vm (Volt) = SQRT (Po x Zo/2) ……………...................... (3) or

Po (Watt) = 2 x $(Vm)^2$/Zo ....…………………................. (4)

Here, Zo is 50 Ohm, the characteristic impedance of the TEM cell.

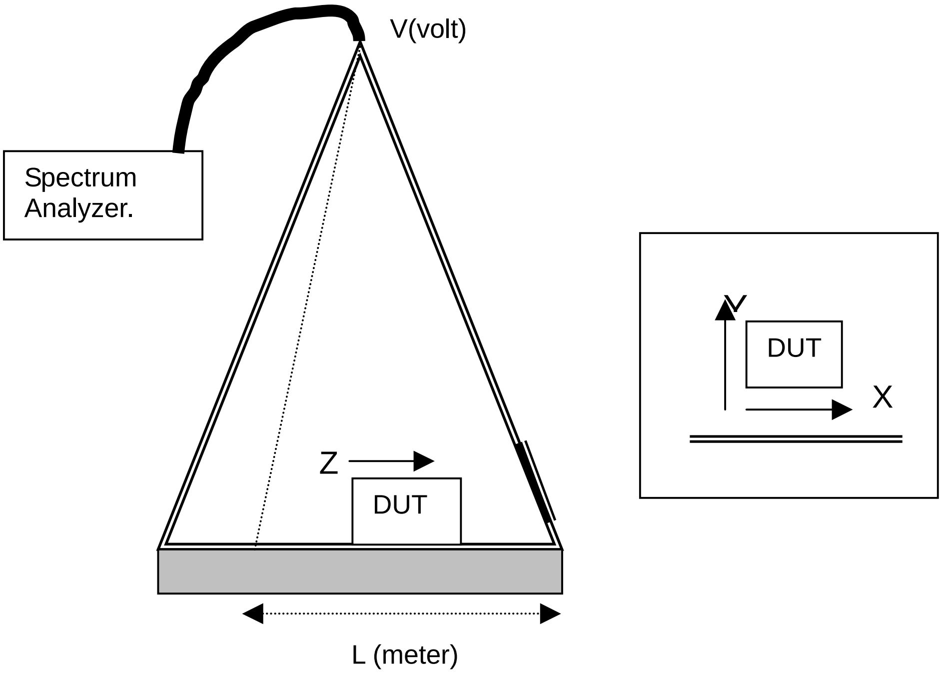


Figure 2.2 Radiation Power Measurement

Now, we can calculate the E-field radiation from the object assuming the object is in free space and has antenna gain G. We also assume that in our measurement the radiator size is sufficiently small compared to TEM cell such that there is no significant effect on radiation due to TEM Cell. Then the hypothetical maximum EMI field Er at distance D (meter) from the radiator would be

Er (Volt/meter)= 60 x (G /Zo) x (Vm/D)……………...................(5)

Vm is the maximum measured voltage that is the vector sum of the 3 voltages

measured by rotating DUT in x, y, and z-axis inside the TEM Cell.

(Ref.1) NBS Technical Note 1319, US Department of Commerce, NBS
(Ref.2) NBS Technical Note 1013, US Department of Commerce, NBS

TC-5060A/B Maintenance

This section contains information for keeping the instrument in good working order and checking its overall performance.

III

Maintenance of TC-5060A/B

TC-5060A/B is designed and built for long life and easy maintenance.

Optimal RF shielding is obtained using a wire mesh gasket between the case and door. It must be checked periodically for damage or excessive wear that would compromise the seal. Pressure on the gasket by the door results in a proper RF seal.

A black oxide deposit can build up in the cavity holding the wire mesh gasket. This oxide reduces conduction and degrades the performance of the RF seal. Periodic cleaning is required to remove any oxide buildup. The black stain can be removed using a WD-40 type lubrication oil and light scrubber such as 3M-green wool. Wipe out the stain and excess oil with a soft cloth, leaving the surface clean and lightly oiled.

NOTE : Preventive maintenance requires you check the RF gasket regularly for excessive wear. Also check the gasket cavity for any black oxide build-up.

CAUTION : Do not clean this equipment with organic solvents such as benzene, toluene or acetone as they will damage the plastic parts. Use alcohol to clean and maintain parts of the equipment.

Performance Test

Th***e 5060A/B*** TEM Cell are precision RF devices built very sturdy. Their electrical performance can, however, deteriorate with mechanical damages. Worn out shielding gaskets, as well as metal corrosion or oxidation at the lid contact, can significantly reduce the effectiveness of the TEM Cell. This section describes the test and calibration procedure for the TC-5060A/B.

NOTE: You must performance test and verify TEM Cell specifications every time maintenance is performed on a test cell such as replacing the gasket during routine maintenance. Also performance test the TEM Cell if you suspect mechanical damage.

Calibration Period

Shielding Effectiveness: <6 months
VSWR and Insertion Loss: 1 year

Required Equipment

1 Spectrum Analyzer: HP8562B or equivalent

2 Signal Generator: HP8648C or equivalent

3 Network Analyzer: HP8753A or equivalent

4 Test Dipole Antenna: TC-92020A(900MHz~1.8GHz) TC-92040A(2.4GHz)

Test Procedure

Shielding Effectiveness Measurement: > 80dB up to 2GHz, > 70dB 2GHz~3GHz

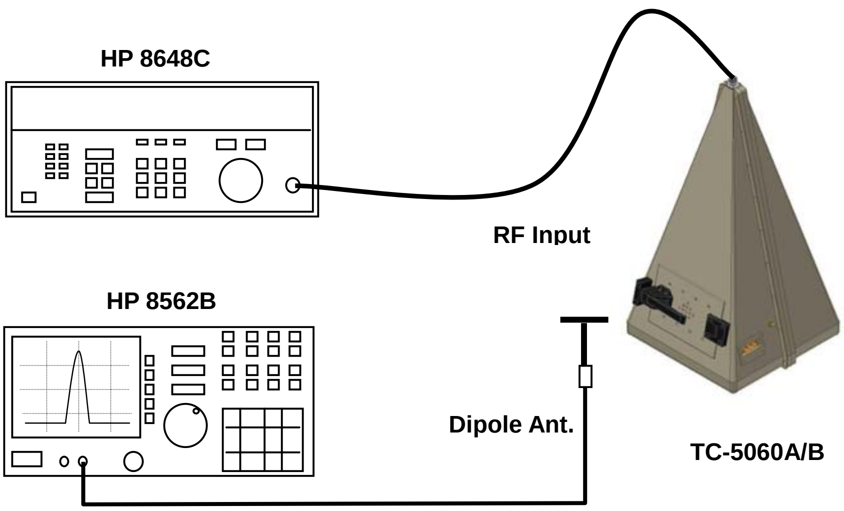


Figure 3-1 TC-5060A/B Shielding Measurement Test Set Up

NOTE : Before making a measurement, visually inspect the shielding gasket around the door. Replace the gasket if there is any visible damage or excessive wear. Look for a black oxide deposit on the aluminum contact surface around the gasket. If an oxide deposit is found, remove the oxide with a cloth or 3M household scrubber saturated with WD-40 or alcohol.

1. Connect the HP8648C Signal Generator output to the RF connector of the TC-5060A/B.
2. Set the HP8648C Signal Generator to CW 900MHz, 14dBm output.
3. Set the HP8562B Spectrum Analyzer as follows:
   - CF: 900MHz(1.8GHz, 2.4GHz)
   - Span: 1MHz
   - Resolution BW: 10kHz
   - 10dB/div

4. Connect the 900MHz Dipole Antenna to the Spectrum Analyzer with RF cable.
5. Open the door of the TC-5060A/B and move the antenna around the TC-5060A/B to find the location where the maximum field is found (Center of the TEM Cell). Fix the location of antenna for maximum field.
6. Adjust the spectrum analyzer input range and set the signal level to the top display line.
7. Remove the test Dipole Antenna from TC-5060A/B. Close the door.
8. Probe around the lid gasket seams, RF connections, and cable joints. Look for RF leakage.
9. Maximum field(a) should not be greater than -80dB(c) from the top reference line(b). Figure 3-2
10. Change frequency to 1.8GHz and repeat the test described above.
    (In this case, Maximum field should not be greater than -80dB from the top reference line)
11. Change frequency to 2.4GHz and repeat the test described above.
    (In this case, Maximum field should not be greater than -70dB from the top reference line)

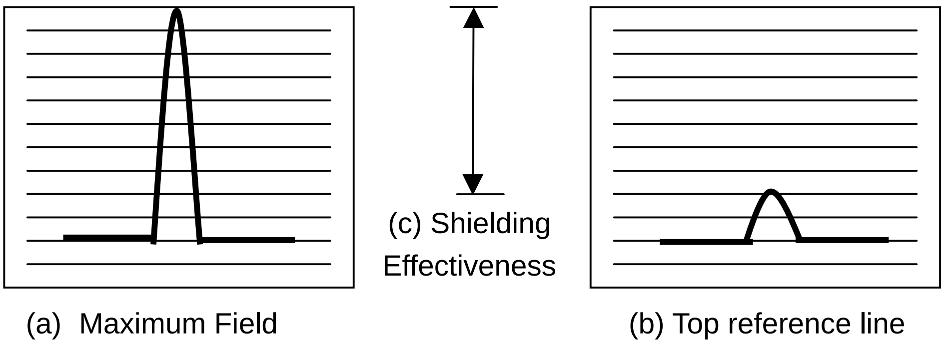


Figure 3-2 Spectrum Analyzer Display

Input VSWR (unloaded): Spec.< 1.7, 400 MHz- 3 GHz (TC-5060A), 100MHz - 3GHz (TC-5060B)

1. HP8753A setting

	TC-5060A	TC-5060B
Start	300kHz	100kHz
Stop	3000MHz	3000MHz
Measure	SWR	

2. Calibrate S11 using Network Analyzer Calibration Standard at the end of the test cable.
3. Connect the calibrated end of the cable to the input port of TC-5060A/B and measure VSWR.
4. In case VSWR is out of specification, verify the cable connections and check for damage in the connectors and the cable. Correct the problems if necessary.

Appendices

A. TC-5060A/B Specification

B. TC-5060A/B Accessories

C. Test Data

D. Technical Note 007 – TEM Cell in portable phone testing

E. Technical Note 008

Testing Transmitters and Receivers in bench-top shielded enclosures

TC-5060A/B Specifications

- VSWR : < 1.7, 400MHz ~ 3GHz (TC-5060A); < 1.7, 100MHz ~ 3GHz (TC-5060B)
- Path Loss : 22dB Typical

  Measured with dipole antenna from cell center :

  - TC-5060A : 19±1dB at 900MHz, 21±1.5dB at 1.8GHz
  - TC-5060B : 20±1dB at 900MHz, 22.5±1.5dB at 1.8GHz
- Effective Shielding : > 80dB up to 2GHz, > 70dB 2GHz ~ 3GHz
- Effective Cell Height : 220 mm
- Field Strength at Test Point : 13 dBuV/m at 1 uV input
- Data Connector : DB25(p) outside, DB25(s) inside
- RF Connector : N(f) outside, SMA(f) outside and SMA(f) inside
- Dimension : 344(W) x 380(D) x 675(H) [mm]
- Door Size : 160(W) x 100(H) [mm]
- Weight Total : 19 Kg

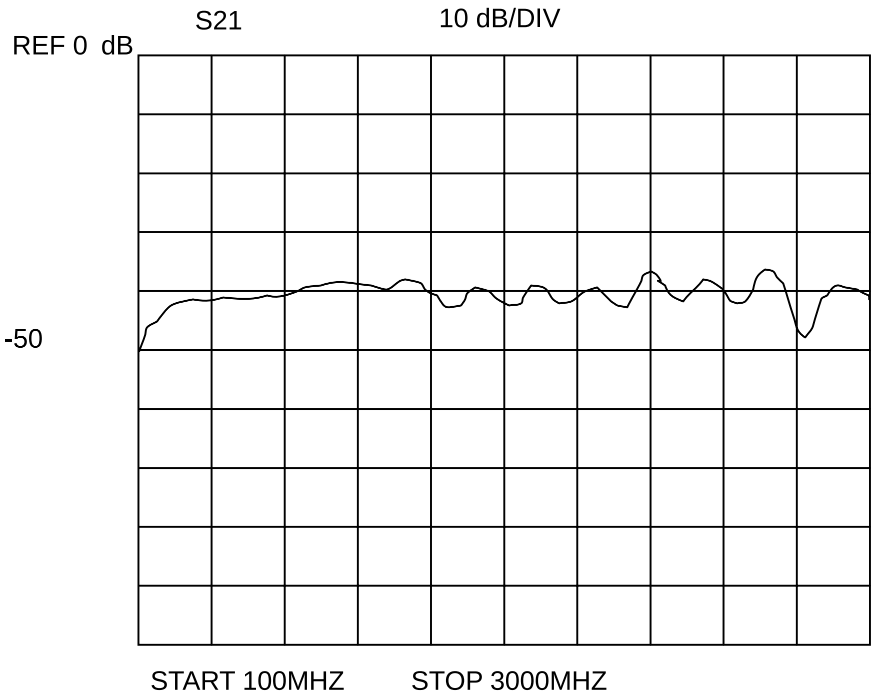
TC-5060A Accessories

No	Part Number	Name	Specification	Quantity
1	4003-0005	DB25(p) to DB25(s) Cable	1m	1
2	4006-0002	N(m) to N(m) Cable	RG400S, 2m	1
3		Operating Manual		1
4		Test Report		1

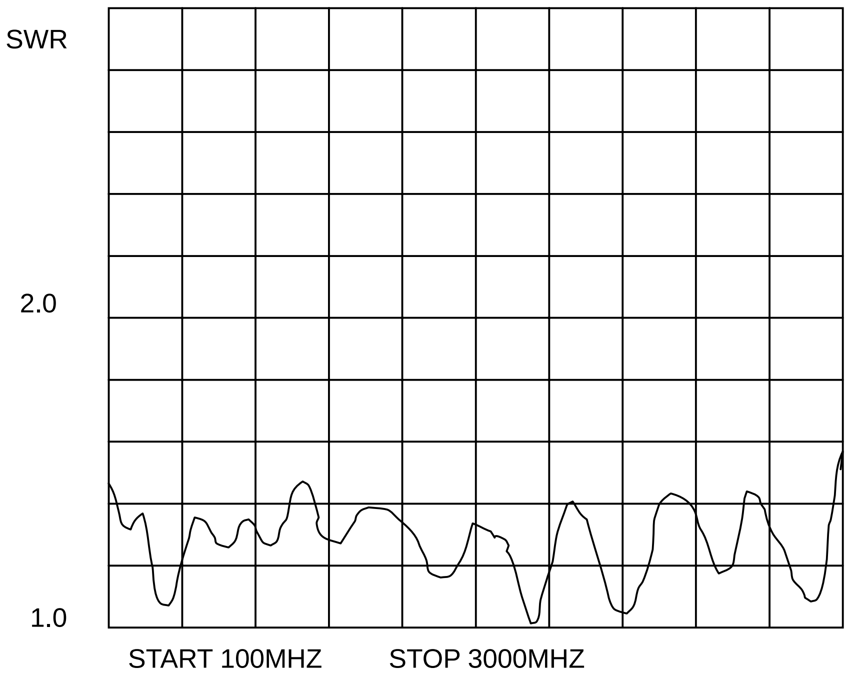
TC-5060B Accessories

No	Part Number	Name	Specification	Quantity
1	1901-0002	SMA 50Ω Termination		1
2	4003-0005	Data Connection Cable	DB25(p) to DB25(s), 1m	1
3	4006-0002	N(m) to N(m) Cable	RG400S, 2m	1
4		Operating Manual		1
5		Test Report		1

TEST Data



Relative Gain (100MHz to 3000MHz), Scale 10dB/Div



VSWR (100MHz to 3000MHz), Scale 0.2/Div

TECH NOTE 007 **REV042099**

TC-5060A/B Pyramid TEM Cell in Portable Phone Testing

1. Introduction

Presently, millions of portable phones are manufactured every day worldwide. The competition is fierce among manufacturers and the test efficiency is one of key competitive factors. In most production lines, the test system is usually made of automated screen boxes and cable connections. RF is tested through RF cable. The test signal is picked off before the antenna. This test method results in good accuracy data for product control but its major drawback is that the antenna problem is not accounted for. In this application note, we discuss an improved test methodology that employs TC-5060A/B, Pyramid TEM Cell (Fig.1.). With this method, the actual RX/TX performance of a portable phone, which includes the antenna efficiencies, may be measured.

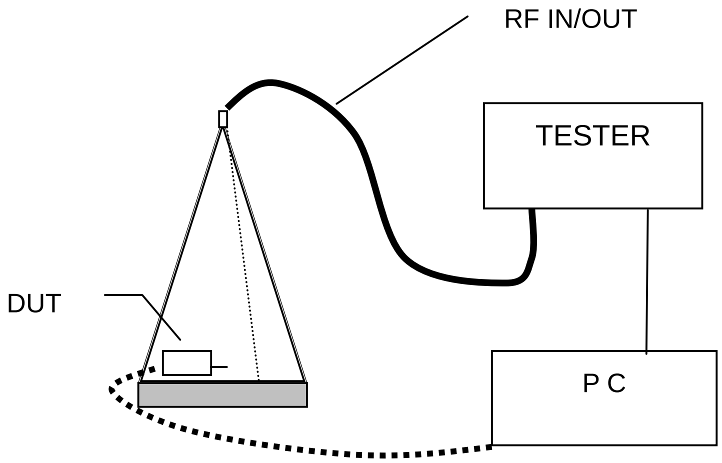


Fig. 1 Test Configuration

2. Theory of Pyramid TEM Cell

Concept

TC-5060A/B Pyramid TEM Cell is a wide band TEM Cell with absorber termination. The large absorber wall eliminates potential resonance inside the cell and makes wide band operation. When a small radiating object is placed at the test position, a part of its radiated energy couples into TEM mode and the guided wave appears as a voltage at the TEM Cell input port. Inversely, if RF test signal is injected into the TEM Cell input port, predictable TEM mode field is generated at the test position. Since the system is passive and reciprocal, the transfer function from the input port to the antenna port maintains the two-port S-parameter relations given by:

S12=S21, for any antenna………………………..(1)

or AF x C12=AF x C21……………………………….(2)

where AF is the Antenna Factor of the radiator, while C12 (= C21) is the ratio of Field Strength [volt/meter] at the test position to the voltage [volt] at the TEM Cell input port. The TEM Cell conversion factor C12 (= C21) is determined by the TEM Cell size. In ideal TEM Cell, C12=1/H, where H is height of TEM Cell. The actual values may be verified using a calibrated field probe.

Transmitter Test -Equivalent Radiated Power (ERP)

ERP of a transmitter is defined as the input power that yields the same field strength when its antenna is substituted with an isotropic dipole antenna.. ERP is obtained readily using a reference dipole and a signal source as shown in Fig. 2...

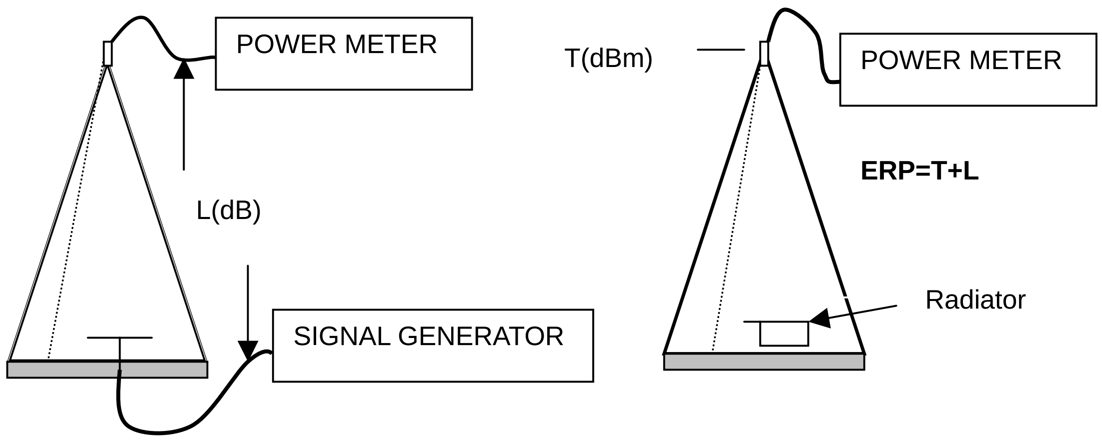


Fig. 2 ERP Measurement

L(dB) is the insertion loss measured from TEM Cell input port to the input of the reference dipole antenna as shown in Fig 2. The value L is approximately constant over wide frequency range for a TEM Cell. At lower frequencies, the size of the reference dipole may be too large to be tested in a given TEM Cell and a small field probe may be substituted for calibration. Replacing the reference antenna with a transmitter under test, ERP is obtained.

ERP (dBm) = L (dB)+ T(dBm)………………...(3)

where T is the power measured at the TEM Cell input port with the transmitter placed at the test position. Normally, the transmitter is positioned for the maximum coupling. ERP indicates the equivalent transmitter power supplied to the antenna assuming the antenna is a 1/2 dipole, therefore it includes the efficiency of the transmitter antenna. If the actual antenna has very high gain, ERP would be much larger than the actual transmitter power applied to the antenna.

Receiver Test –Equivalent Received Signal Strength (ERSS)

As in the case of transmitter test, standard receiver sensitivity can be defined in terms of ERSS. If the reference antenna of Fig 2 is replaced with a receiver under test and a RF signal is applied to TEM Cell, the RF signal level at the receiver input is found in terms of ERSS. Assume that TEM Cell input level is R(dBm). We define the receiver input in terms of ERSS as follows:

$$\text{ERSS (dBm)} = \text{R(dBm)} - \text{L (dB)} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

The sensitivity of a receiver expressed in terms of ERSS (dBm) indicates the minimum required signal level at the receiver input assuming the antenna is the reference dipole antenna. This value reflects the performance of a receiver system including the antenna efficiency. If the antenna is poorer than the reference antenna, the equivalent sensitivity will decrease for the same receiver.

3. Application to Portable Phone Testing

The procedure of calibrating and testing a portable phone using a Pyramid TEM Cell is outlined below.

1) Obtain Path Loss L(dB)

Mount the reference antenna #1(850MHz) and measure the insertion loss between TEM Cell inputs to the antenna output. Repeat the same for the reference antenna #2(1750MHz). TESCOM produces the reference antenna for CDMA and PCS bands. Use a network analyzer or signal generator/power meter for this test. The path loss L of TC-5060A/B is approximately 24dB at cellular and PCS bands

2) Compensate Path Loss Value for the Portable Phone Tester

Then enter the path loss value of L(dB) to the portable phone tester (Cellular or PCS Tester). The measured values of transmitter power and receiver sensitivity are in terms of ERP and ERSS. The values would be very good performance indicators for the phone under test including antenna efficiencies for both transmitter and receiver.

3) Cross Check with Direct RF Connection Values

ERP and ERSS values can be converted to the actual TX power and RX input level before the antenna by the following equations:

TX Power (dBm)= ERP(dBm) – G(TX) + G(Ref)……….(5)
RX Level (dBm)= ERSS(dBm) – G(Ref) + G(RX)………..(6)

where G(TX): Antenna gain for the transmitter of portable phone
G(RX): Antenna gain for the receiver of portable phone.
G(Ref): Reference antenna gain.

If the TX and RX antenna gains of a portable phone are approximately the same as the gain of the reference antenna, then ERP and ERSS would be the same as the values obtained from direct connection (after path loss compensation). If the antenna gains of portable phones are lower than that of the reference antenna, ERP would be lower than the actual transmitter power and ERSS would be higher than the actual RX Level measured by direct connection.

4. Summary and Conclusion

Testing portable phones with Pyramid TEM Cell is as natural as testing pagers with TEM Cell. Reference antenna calibration method provides path loss value L. By entering path loss compensation to the tester, the measured TX power and received signal strength data are automatically represented in term of ERP and ERSS, which are compensated values for the effect of antenna. If the phone antenna has the same gain as the reference antenna, the data would be identical to that obtained by the direct RF connection method.

Most portable phones allow OTA(over the air) test control under linked condition. Thus, it is not really necessary to use the bulky umbilical cord for test control. With self-contained battery, all the tests could be done wireless inside TC-5060A/B. The great benefit of this simple elegant solution is that the system can be automated very inexpensively with high reliability by eliminating many complicated mechanisms. One potential drawback of this approach may be inability of testing hands-free operation, but this is becoming less important. Furthermore, adaptation of emerging IrDA technology to the future phones would also help eliminate the mechanical connection altogether. There is no doubt that portable phone manufacturers can benefit greatly using Pyramid TEM Cells similar to pager manufacturers who use TEM Cells for pager testing.

TECH NOTE 008 ***REV091399***

Testing Transmitters and Receivers in Bench-top Shielded Enclosures.

1. Overview

Testing portable phones or 2-way pagers requires EMI shielding from external RF sources such as nearby base stations or adjacent test systems. The purpose of shielding is not only to prevent the unwanted interference signal affecting the device under test (DUT) but also to stop the DUT transmitter signal from jamming the base station receivers. This is usually accomplished by adopting some kind of metal enclosure scheme. In some cases, however, this creates another problem; highly reflective metal enclosure could resonate and introduce uncertainties to measurements. Therefore, some scheme to reduce or quantitatively control the internal reflection is needed. This is very important technical issue when the size of the enclosure is small. This note is intended to help the RF test engineers understand and solve their shielding problems by choosing proper types of shielded enclosure.

2. Interactions between Metal Enclosure and DUT

Let's examine an idealized model, where a small DUT made up of an antenna and a signal source is placed inside an enclosure. We assume that the enclosure is made of an ideal conductor such that all the radiated energy from DUT can not escape and the energy has to be recaptured by the DUT. The energy density inside the cell would keep increasing until the rate of radiation and the recapturing reach equilibrium. In this case the followings will hold.

1). The power loss occurs only in the source resistance.
2). The reactive energy stored in the cell is either $\frac{1}{2}CV^2$ or $\frac{1}{2}LI^2$, where **C** or **L** is the reactive impedance seen from the source.
3). At low frequencies where the cell size in wave length is not large enough to support cavity resonance, the effect would be mostly capacitive and the stored energy would be small.
4). At high frequencies where cell size in wavelength is greater than 1/2, cell resonance would occur. At resonance frequencies, large amount of energy may be stored in the cavity cell with standing waves.
5). If an absorber that has much larger effective aperture than the DUT antenna is placed in the cell, most of the stored energy is dissipated in the absorber material rather than reabsorbed by the DUT.

3. Simple Shielded Enclosure –Low RF Leakage System

We now apply our observations to real life examples. Typical setup for hand set test requires an RF connection between DUT and the tester; connected with RF cable or non-contact over-the-air coupling. In case of direct cable connection, the percentage of leaked RF power compared to the signal power is very small. Therefore, the maximum contribution of the leaked RF power to the test result would be relatively small and a simple EMI shielding scheme may be used.

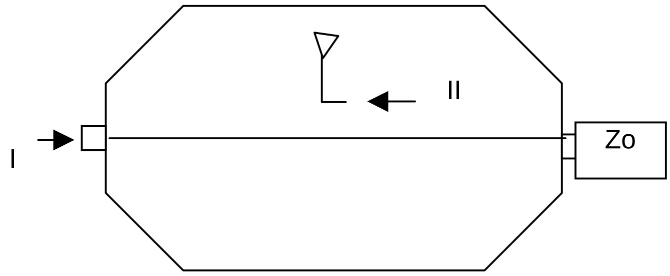
In case of non-contact RF coupling using a probe or a near field antenna, the situation can be different. If the RF coupler has a very tight coupling coefficient as used in the TC-5935A, Handy Test Cell, the situation is no different from that of direct cable connection. But if the coupler takes only small portion of RF power of the source for testing, the amount of stray RF energy inside enclosure could build up high and the effect of shielded enclosure to the test result may not be ignored.

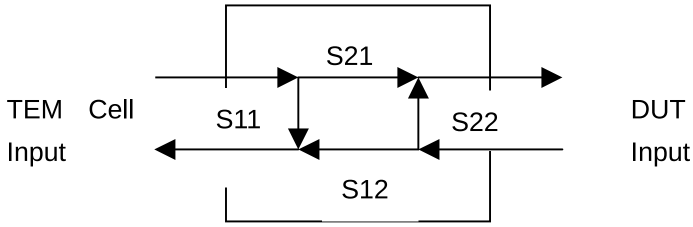
4. Absorptive Shielded Enclosure

Although shielding may solve the RF interference problem, it can also create large measurement error, if major portion of the RF power from DUT is allowed radiate into the enclosure. It is because the stray RF signal could be resonating in the chamber with high VSWR such that the field strength at the point of coupling may wildly vary with frequency. In this case, an absorber lining must be used to mitigate the problem.

5. TEM Cell as a RF coupler and Shielded Enclosure, Mini-TEM Cell TC-5010B

TEM Cell is an accurate, broad band RF coupler that can also offer high quality shielding as well. Applying a voltage to the input of TEM Cell generates TEM test field for DUT. Inversely, a DUT transmitter inside TEM Cell can generate TEM field and couples the signal to the TEM Cell input port. The reciprocity theorem assures that the gains/attenuation in both directions, S21 and S12, are exactly the same, i.e., for the receiver testing and transmitter testing. This situation is illustrated below.





Under normal conditions, S11~0, |S22|~1, and S21=S12. The device sees highly reflective environment until high order mode resonance is excited. The high order mode resonance can create large current loss that may introduce significant change in coupling values (S21, S12). Otherwise, the coupling between the device antenna input to the TEM Cell input remains the constant regardless of direction of energy flow.

6. Transmitter Measurement and Potential Non-linear Problems

When a standard TEM Cell is used as antenna coupler for a transmitter characterization, DUT sees highly reflective load that is different from free space case. Then the load reflection could cause non-linear interaction in the transmitter. For example, insufficiently buffered transmitter oscillator may suffer load pull effect. High VSWR load can cause increased IMD or harmonic distortion if the output voltage or current overdrives the output device. In some cases, spurious may look bigger. Well-designed small power transmitters, however, should not suffer these kind of problem.

7. Absorber Lined TEM Cells, TC-5061A

Applying a large aperture absorber inside TEM Cell can drastically reduce the transmitter problems described previously. Some TEM Cells such as G-TEM or Pyramid Cells use an absorber wall for broad-band termination to eliminate reflections and to increase the operating frequency. In this case, the DUT transmitter sees much smaller overall reflections, i.e. S22 ~0 in the two-port model of TEM Cell described before. Since the TC-5061A/B is broad-band and has absorber-lined wall, it is well suited for general transceiver characterization. Transmitter ERP (Effective Radiated Power) and receiver ERSS (Effective Received Signal Strength) which includes the effect of DUT antenna can be measured. Refer to Technical Note 007.

8. Summary

W***e*** provide wide range of bench-top test chambers optimized for small RF device testing, especially for Pagers and Portable Phones. The simple rugged shielded enclosures such as TC-5940/5941/5942 series are optimized for applications where the tester may be directly connected to DUT by cable. When DUT such as a portable phone lacks RF connector for testing, low-loss coupling can still be attained through the tubular type antenna coupler used in the TC-5935A Handy Test Cell. To test transceiver characteristic of small RF devices such as pagers, TC-5010B standard TEM Cell would be ideal.

TC-5060A/B is an absorber lined broadband TEM Cell which can be used for a wide range of applications. This product provides small internal reflection that is required for testing a transmitter suspected of non-linear effect. TC-5060A/B is specifically designed for characterization of portable phones and pagers up to 3GHz range. <> Ydk091299