# TESCOM

# TC-5063C Pneumatic 6 GHz TEM Cell

## *Operating Manual*

R121030

**http://www.tescom.co.kr**

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# Contents

## Figure of Contents

## Table of Contents

## WARRANTY

TESCOM 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, TESCOM will, at its discretion, either repair or replace defective products.

For the warranty service, customer must notify TESCOM 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 TESCOM or a service center designated by TESCOM. Customer shall pay for shipping charges as well as any other charges incurred outside of Korea. TESCOM 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. In such cases, TESCOM 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.

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

## Safety Considerations

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

- **Do Not Disassemble any part except replaceable parts**

- **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.

- **Provided Proper Ventilation**

  To prevent product overheating, provide proper ventilation.

- **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.

| Power ON | Power OFF | WARRING / CAUTION | Indicates earth (ground) terminal |

## Service and Support

If you have a problem with your TC-5063C, contact Tescom Technical Support specialists.

Any adjustment or repair of this product must be performed by qualified personnel.

### Contact Information

**Address:** TESCOM Company Limited, #927 Unitechvil 142, Ilsan-ro, Ilsandong-gu, Goyang-si, Gyeonggi-do, Korea [410-722]
**TEL:** 82-31-920-6600
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**Email:** tescom-sales@tescom.org,
**Internet:** http://www.tescom.co.kr

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# General Information

This section provides a general description of the Pneumatic 6 GHz TEM Cell and proper set-up procedures.

## 1.1 Instructions and Key Features

■ **Instructions**

TC-5063C Pneumatic 6 GHz TEM Cell generates the Electro-magnetic field for testing small RF devices such as mobile phones, WLAN, PDA, Bluetooth, DAB/DMB, RFID, etc. Through the RF input/output port, an external test signal may be applied to the TC-5063C to generate a predictable TEM test field inside the cell. The radiation field can also be picked up through the RF input/output 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**

- Reliable High RF Shielding up to 6 GHz
- Designed for long life
- Specifically designed for various types of mobile phones
- Pneumatic control of door open-close
- Absorbing materials for stable measurement results
- EMI filters on all data ports and power line
- Remote operation by RS-232C

## 1.2 Specifications

### General Specification

| | |
|---|---|
| VSWR | < 1.7, 700 MHz ~ 6 GHz |
| Path Loss | 25 dB Typical @1.8 GHz dipole |
| Effective Cell Height | 220 mm |
| Field Strength at Center of Cell | 13 dB $\mu$V/meter at 1 $\mu$V input |
| RF Connectors without module | 1 N(f) topside, 1 SMA(f) outside and SMA(f) inside |
| Remote control | RS-232C, 3 wire, DB9(p) |
| Line Voltage | 100 to 240 volt AC, 50/60 Hz, 15 watt max |
| Input air pressure | 5 bar to 10 bar |
| Main air connector | 6 mm OD hose, one-touch fitting |
| Dimension | |
|   Inside | 240(W) x 205(D) |
|   Outside | 344(W) x 420(D) x 725(H) mm, door closed. 614(D) mm, door open |
| Weight | 27 kg |
| *Packing | |
|   Size | 450(W) x 540(D) x 840(H) mm |
|   Weight | approx. 32.7 kg |

'*The size or weight of a package may vary on how to pack a package.

**Typical RF Shielding**

| | |
|---|---|
| 700 to 2000 MHz | > 80 dB |
| 2000 to 3000 MHz | > 70 dB |
| 3000 to 6000 MHz | > 60 dB |

# 1.3 Connectors

This section contains reference information for TC-5063C's connectors.

**[Table 1] TC-5063C Connectors**

| Connector | Specification |
|---|---|
| RS-232C | Working Voltage: 100 VDC<br>Dielectric Withstanding Voltage: 300 VDC |
| N Coaxial Connector | Impedance: 50 ohm<br>Voltage Rating: 1500 Vpeak<br>Dielectric Withstanding Voltage: 2500 Vrms |
| SMA Coaxial Connector | Impedance: 50 ohm<br>Voltage Rating: 250 Vpeak<br>Dielectric Withstanding Voltage: 750 Vrms |
| USB2.0 Connector | Data Rate: 480 Mbps |

# 1.4 Component Identification



① N(f) RF Connector
② Door
③ Door Bracket
④ USB Data Connector
⑤ Handle
⑥ SMA (f) connector
⑦ Air Inlet
⑧ RS-232C connector
⑨ Remote control switch port
⑩ AC input connector and Switch (AC 100 V ~ 240 V)
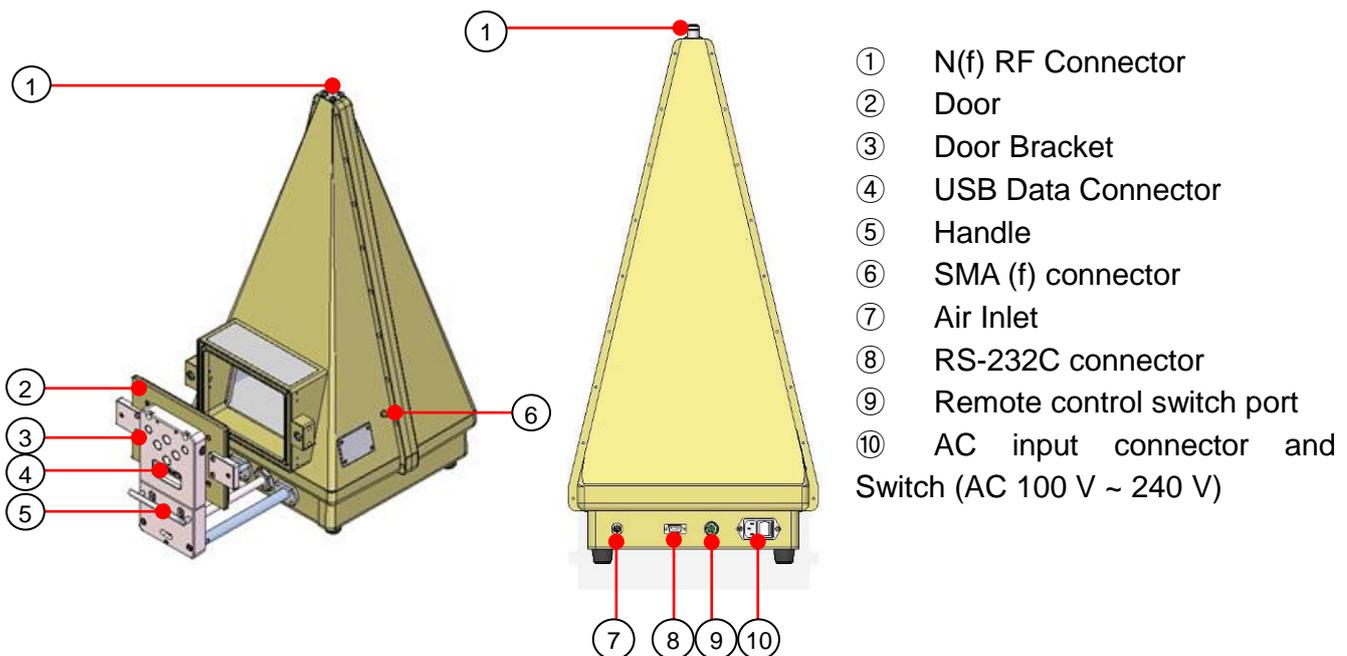
**[Figure 1] TC-5063C Component Identification**

## 1.5 Initial Inspection

This section provides the information for verifying proper shipment of the TC-5063C.

■ **Product Condition and Accessory Check**
1. Upon receipt of the TC-5063C, check for any damages that could have occurred during shipment.
2. Verify you have received the accessories supplied with the TC-5063C and module, which are listed in Table 2.

**[Table 2] TC-5063C Accessories list**

| Part Number | Name | Spec. | Quantity |
|---|---|---|---|
| | Operating Manual | | 1 |
| | Test Report | | 1 |
| 1901-0002 | SMA 50 Ω termination | | 1 |
| 4003-0001 | RS-232C Cable | DB9(s) to DB9(s), 2 m | 1 |
| 4008-0017 | USB A(p) – USB A(p) 4C | USB 2.0, 1 m | 1 |
| 4011-0019 | RF Cable | SS402, N(m)-N(m), 2 m | 1 |
| 4601-0003 | Remote control switch | | 1 |
| 9703-0020 | VALVE, HAND | | |
| | Power Cable | 2 m | |

⚠ **CAUTION**   To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to the equipment.

13

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# Installation

This section provides the information required to install the TC-5063C Pneumatic 6 GHz TEM Cell.
This includes information regarding the power requirements and environment.

## 2.1 Power Requirement

- **Input voltage:** 100 ~ 240 VAC, Max. 0.4 A

- **Frequency:** 50/60 Hz

- **Power Consumption:** Less than 15 watt

## 2.2 Compressed Air Requirement

- **Input air pressure**
  5.5 bar to 10 bar

- **Main air connector**
  6 mm OD hose, one-touch push-on fitting

| | |
|---|---|
| *NOTE* | It is highly recommended that the compressed air system must be used in conjunction shown in figure 2. Low air quality may cause deterioration of performance. |
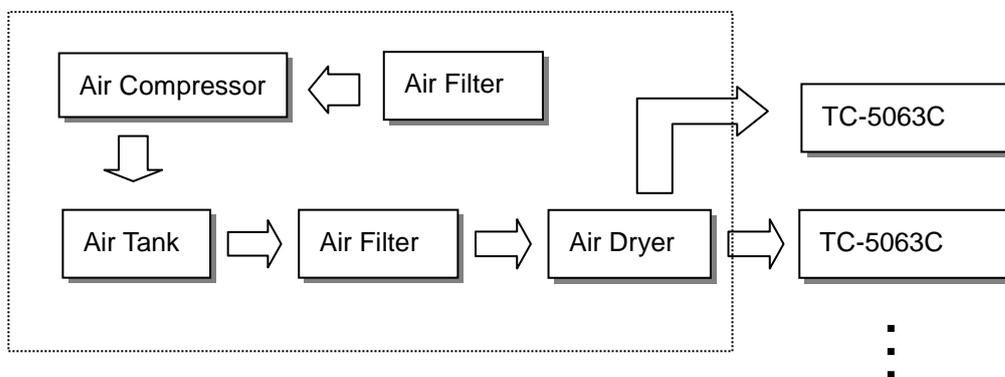


**[Figure 2] General Compressed Air Connection System**

## 2.3 Storage

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.

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# Operation

This section provides important information regarding TC-5063C operation and sample operating programs for the TC-5063C.

## 3.1 Operation

### 3.1.1 TC-5063C Operation Procedure

1. Connect compressed air to "Air Inlet".
2. Connect the AC power cord to a 100 to 240 VAC outlet, Turn the power on.
3. Open the door and place the DUT correct position.(Connect 4601-0003 cable to the remote control switch port. To close the door, press two buttons at the same time. To open the door, press one button only.)
4. Operation with the Remote Control Switch is done in the same sequence as above.

## 3.2 Theory of operation

TC-5063C Pneumatic 6 GHz TEM Cell is made to work well 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 at 50 ohm while maintaining 50 ohm characteristic impedance along the cell. Due to the expansion and contraction parts of the cell, the wave propagation beyond a certain frequency is no more propagated by TEM mode alone and creates resonance. To eliminate the resonance problem, 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. Tescom borrowed the concept of 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 with the 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 the 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.

## 3.2.1 Standard E-field Generation (Ref. 1, Figure 3)

Consider a case when a 50 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.

$$E \text{ (Volt/meter)} = V \text{ (Volt)} / L \text{ (meter)} \quad \ldots\ldots\ldots\ldots\ldots \quad (1).$$

Here, L is the distance between the septum and the top wall. In TC-5063C, L is 22 (cm). Since TEM Cell produces a TEM wave, an orthogonal H-field (ampere/meter) proportional to E-field exists. They are related by the free space wave impedance 377 .

$$H \text{ (Ampere/meter)} = E \text{ (Volt/meter)} / 377 \text{ (Ohm)} \quad \ldots\ldots \quad (2)$$

Field distribution inside the cell is shown in Figure 3.



**(a) Field Generation**        **(b) Field Pattern (Top View)**
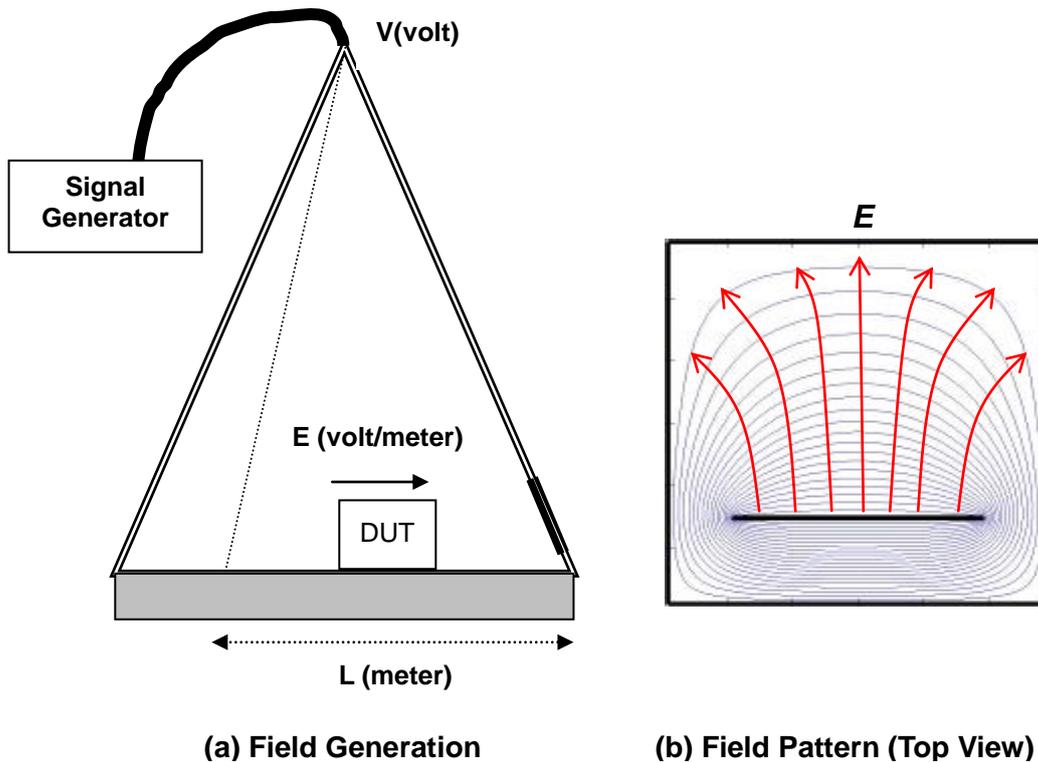
**[Figure 3] Field Generation and Field Pattern**

**<Example>**

Connect the RF output of a signal generator to the input port of TC-5063C with a cable. Set the signal generator frequency (between 100 MHz to 6 GHz) and the signal level to 220 mV. The E-field developed at the test point inside TC-5063C is then:

$$E = 0.22(V) / 0.22(meter) = 1 \text{ (Volt/meter)}.$$

If the signal generator output is decreased to 2.2 uV, the E-field inside TC-5063C becomes 10 uV/meter at the center of the test volume.

## 3.2.2 Radiation Power Measurement (Ref.2, Figure 4)

When a radiating object is placed inside the 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:

$$Vm \text{ (Volt)} = SQRT \text{ (Po x Zo/2)} \dots\dots\dots\dots\dots\dots\dots\dots \text{ (3) or}$$
$$Po \text{ (Watt)} = 2 \text{ x (Vm) 2/Zo} \dots\dots\dots\dots\dots\dots\dots\dots \text{ (4)}$$

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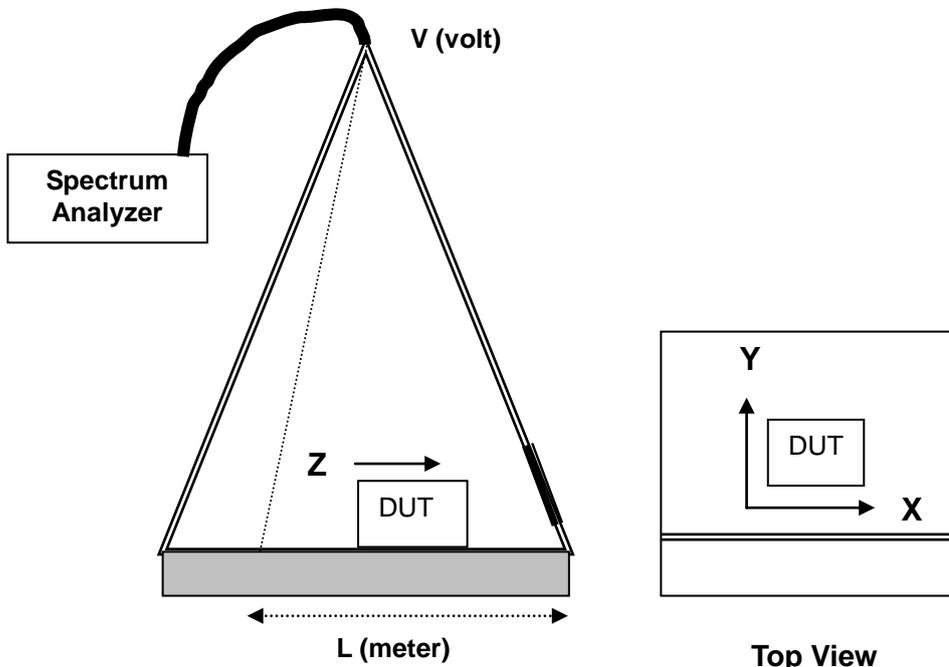


**[Figure 4] Radiation Power Measurement**

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

$$Er \text{ (Volt/meter)}= 60 \times (G / Zo) \times (Vm/D)\ldots\ldots\ldots....................(5)$$

Vm is the maximum measured voltage which 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

## 3.3 Remote Operation Using RS-232C

TC-5063C supports high speed RS-232C serial interface for remote operation under PC control. A standard 9-pin RS-232C connector is located at the rear. Any communication program (such as WINDOW XP/7 Hyper Terminal) could be used for simple tasks. Complex tasks can be automated using PC programming.

### 3.3.1 RS-232C Connection

A 9-pin standard connector is used in the TC-5063C for a RS-232C connection. To make a connection to the 25-pin RS-232C connector, a 9-pin to 25-pin adapter can be used. The cable pin configuration is shown below.

**[Figure 5] RS-232C Connection**

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# 3.4 PC Control Using Communication Program

## 3.4.1 Windows Hyper Terminal

1. Check for the Hyper Terminal installation on your PC. Click Start → Program → Accessories → (Communications). If Hyper Terminal folder is not found in the Accessories list, it must be installed. Insert Windows XP or 7 CD ROM and install hyper terminal program.

2. Start Hyper Terminal: Click Start → Program → Accessories → (Communications) and then click "Hyper Terminal"
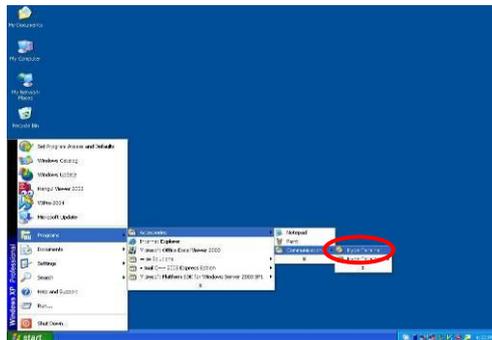


3. In "Name" block, on "New Connections" screen, enter "TC-5063C". On "Connect To" screen, click "▼" in "Connect Using:" block, select "Direct to COM1" and then click "OK".
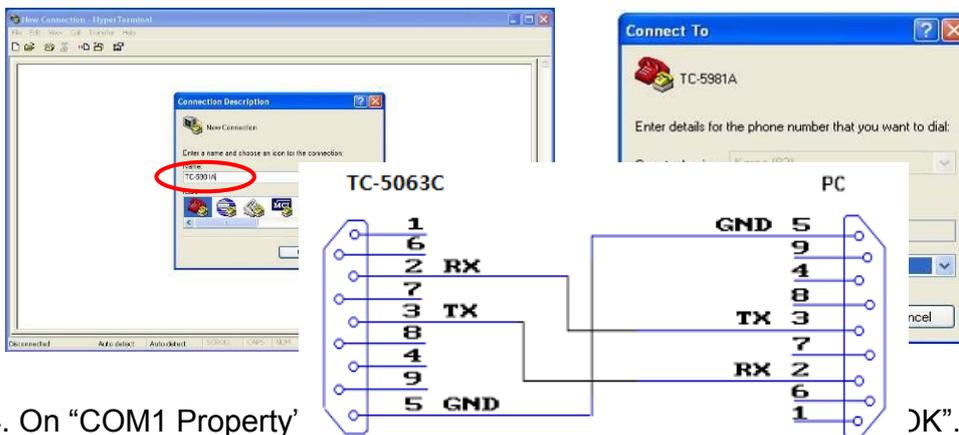


4. On "COM1 Property"_____OK".
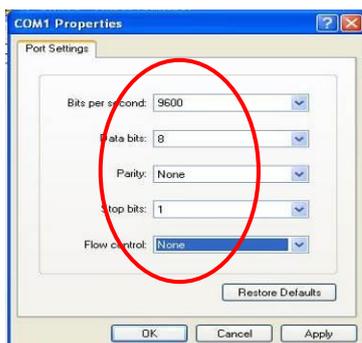


| Bits per Second | 9600 bps |
|---|---|
| Data bits | 8 bit |
| Parity | None |
| Stop bits | 1 bit |
| Flow controls | None |

5. Click "FILE" on menu bar and select "Property". You should see the "TC-5063C Properties" screen. Select "Setting" tab.
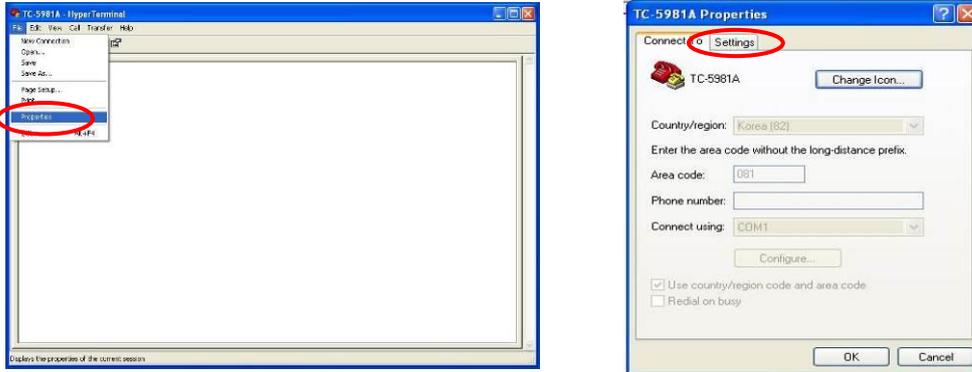


6. Click "ASCII Setup" button
   1) Check "Echo typed characters locally"
   2) Check "Append line feeds to incoming line ends"
   3) Check "Wrap lines that exceed terminal width" And click "OK", Click "OK" again.
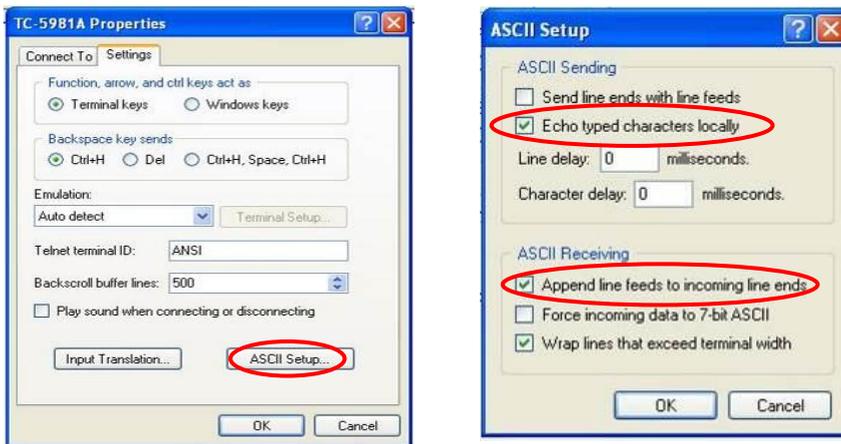


7. Connect 9 pin D type RS-232C Cable between PC COM 1 port and TC-5063C
8. Type in a RS-232C command (Ex: "OPEN") on "TC-5063C Hyper Terminal" screen and press Enter on PC keyboard. TC-5063C returns OK or Error Data signal.
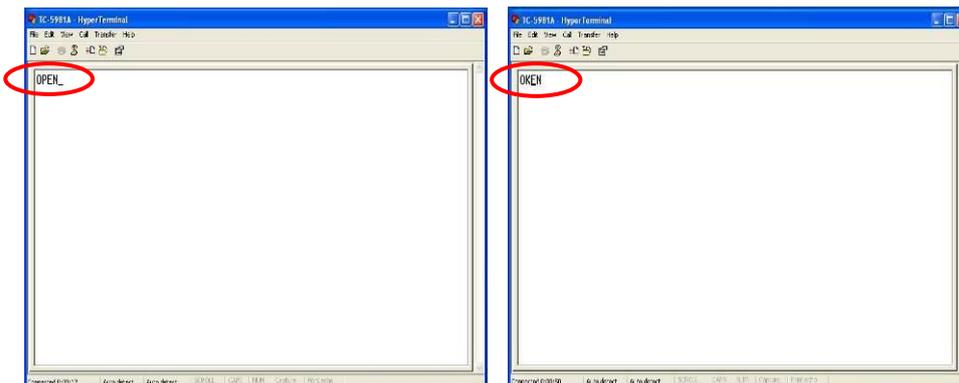
## 3.4.2 Programming Windows XP

### 1. Programming Procedure
1) Port select (COM1-COM4)
2) Set-up Baud Rate (9600 bps), Parity Bit (None), Data Bit (8 bit), Stop Bit (1 bit)
3) Open selected COM Port.
4) Send RS-232C Command string to the COM Port.
5) Wait until the response data is received.
6) When confirmed, send the next command

---

*NOTE*  Another option is to program sufficient wait time between commands

---

### 2. Command and Response Message
- TC-5063C returns the response message (Response Data + $0A + $0D) after some delay.
- In case of error, TC-5063C returns the error message (Error Data + $0A + $0D).

### 3. Programming Example
The following examples are written in Visual Basic.

#### Example 1) OPEN the Mini Test Cell

```
Private Sub Form_Load()
        MSComm1.CommPort = 1   ' select COM1'
        MSComm1.Settings = "9600, N, 8, 1"
                ` Baud Rate(9600 bps), Parity Bit(None), Data Bit(8 bit), Stop Bit(1 bit)
        MSComm1.PortOpen = True    ' Open Com Port.
        MSComm1.Output = "OPEN" + Chr(13)   ` send command.
        MSComm1.PortOpen = False   ` Close Com Port.
    End Sub
```

#### Example 2) Check "OK" is received in input Buffer

```
Private Sub MSComm1_OnComm()
        ` Triggers when TX or RX event occurs
        If MSComm1.CommEvent = 2 Then   ` event in input Buffer
        Text1.Text = MSComm1.Input       ' read the input string and check later if it is
        "OK"   End If
    End Sub
```

## ▌ RS-232C Command

**[Table 3] Error Data**

| Error Data | Description |
|:---:|:---|
| ERR10 | Syntax error |
| ERR40 | Status error |

**[Table 4] RS-232C Basic Command**

| RS-232C Commands | Response Data | Description |
|:---|:---|:---|
| OPEN | OK | Door OPEN |
| CLOSE | READY | Door CLOSE |
| DOOR? | OPEN or CLOSE | Read the current status of TC-5063C |
| COUNT? | Numeric 7digit (ex: 0000001) | The cumulative frequency of Open/Close query |

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# Maintenance

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

# 4.1 Maintenance of TC-5063C

TC-5063C is designed and built for long life and easy maintenance.

Optimal RF shielding is obtained using a 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 lid results in a proper RF seal.

A black oxide deposit can build up in the cavity holding the gasket. This oxide reduces conduction and degrades the performance of the RF seal. Periodic cleaning is required to remove any oxide buildup.

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

## 4.1.1 Cleaning

Periodically wipe the case with a damp cloth mild detergent; do not use abrasives or solvents. Keep the power supply free of dust. Clean the power inlet regularly. If dust accumulates around the power pins, there is a risk of fire.

Clean the input terminal as follows:
1. Turn the TC-5063C off and remove all test leads.
2. Shake out any dirt that is in the terminals.
3. Soak a new swab with alcohol and work around in each terminal.

## 4.1.2 Check List for Maintenance

1. Check for loose screws and tighten with proper tools, if necessary.
2. Check for a loose connection. If a loose connector is found, tighten the connector with proper tools.
3. Check for a damaged cable, especially near the connector-cable neck. Replace any damaged cables found.
4. Visually inspect the RF seal between the Mini Test Cell and door for excessive wear.
   - A worn gasket will not have as much height protruding from the cavity as a new or good gasket.
   - A worn gasket may exhibit a frayed mesh. Replace the gasket if excessive wear is observed.

The RF gasket is an important element of optimum shielding. It must be checked periodically for damage or wear.

Periodic cleaning of the aluminum contact surface where the gasket touches is important for optimum shielding performance.
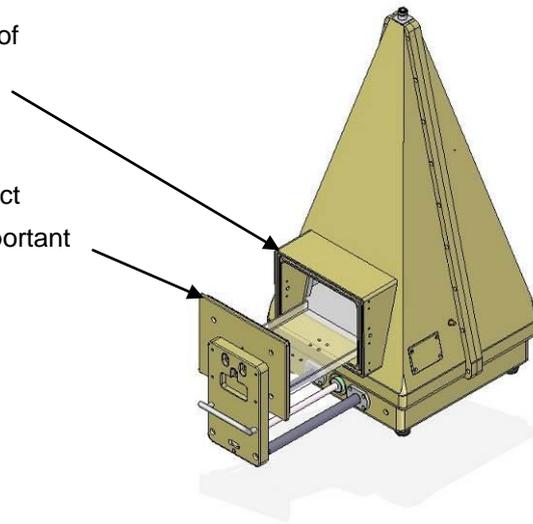


**[Figure 6] TC-5063C RF Gasket**

| ⚠️ 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. |
|---|---|

![TESCOM]

## 4.2 Performance Test

The 6 GHz Mini Test Cell is a precision RF device which is 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 Mini Test Cell. This section describes the test and calibration procedure for the TC-5063C.

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**NOTE**

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

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### 4.2.1 Calibration Period

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

### 4.2.2 Required Equipment

- Spectrum Analyzer: 6 GHz
- Network Analyzer: 6 GHz
- Signal Generator: 6 GHz
- Dipole Antenna: Tescom 900 MHz, 1.8 GHz, 2.4 GHz, 5.8 GHz

### 4.2.3 Test Procedure

- Shielding Effectiveness Measurement Specification:
  > 80 dB up to 2 GHz, > 70 dB 2 GHz ~ 3 GHz, > 60 dB 3 GHz ~ 6 GHz
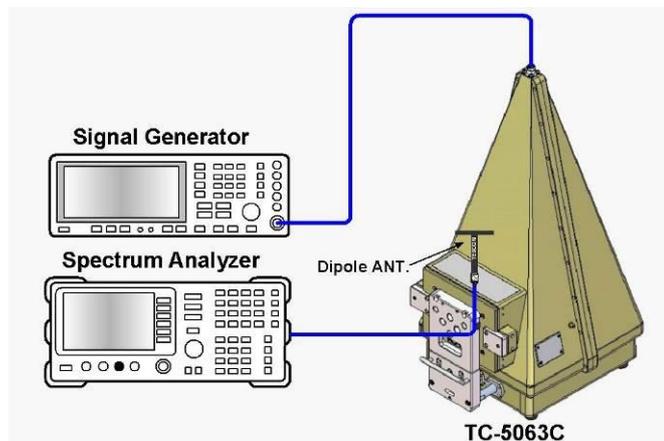


**[Figure 7] TC-5063C Shielding Measurement Test Set Up**

> **NOTE**
>
> Before making a measurement, visually inspect the shielding gasket around the lid. 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 alcohol.

1) Connect the Signal Generator output to the RF connector of the TC-5063C.
2) Set the Signal Generator to CW 900 MHz, 10dBm output.
3) Set the Spectrum Analyzer as follows:
   - CF: 900 MHz
   - Span: 1 MHz
   - Resolution BW: 10 kHz
   - Scale 10 dB/div
4) Connect the 900 MHz Dipole antenna to the Spectrum Analyzer with RF cable.
5) Open the door of the TC-5063C and move the antenna around the TC-5063C to find the location where the maximum field is found. 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) Close the lid and probe around the lid gasket seams, RF connections and cable joints. Look for RF leakage.
8) Maximum field should not be greater than -80 dB from the top reference line.
9) Change frequency to 1.8 GHz and repeat the test described above.
10) Change frequency to 2.4 GHz and repeat the test described above.
11) Change frequency to 5.8 GHz and repeat the test described above.



(a) Maximum Field          (b) Maximum Field
   (Lid Opened)               (Lid Closed)

Shielding Effect
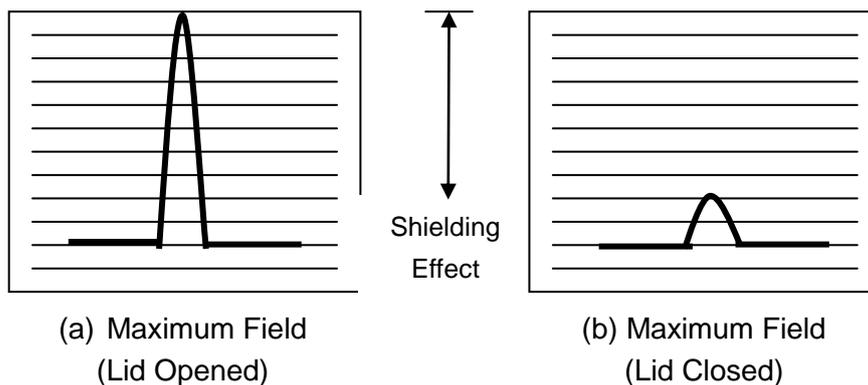
**[Figure 8] Spectrum Analyzer Display**

- **Input VSWR (unloaded) Specification: < 2.5 800 MHz ~ 1 GHz, 1.5 GHz ~ 6 GHz**

1) Set the Network Analyzer as follows:
   - Start: 30 kHz
   - Stop: 6000 MHz
   - Measure: S11
   - Format: SWR
2) Calibrate the Network Analyzer in order to measure S11.
3) Connect the calibrated cable to the input port of TC-5062C and measure SWR.
4) Verify S11 SWR of-5062C meets its specification.

## 4.2.4 Typical VSWR of TC-5063C

**VSWR (30 KHz to 6000 MHz), Scale 1/Div**
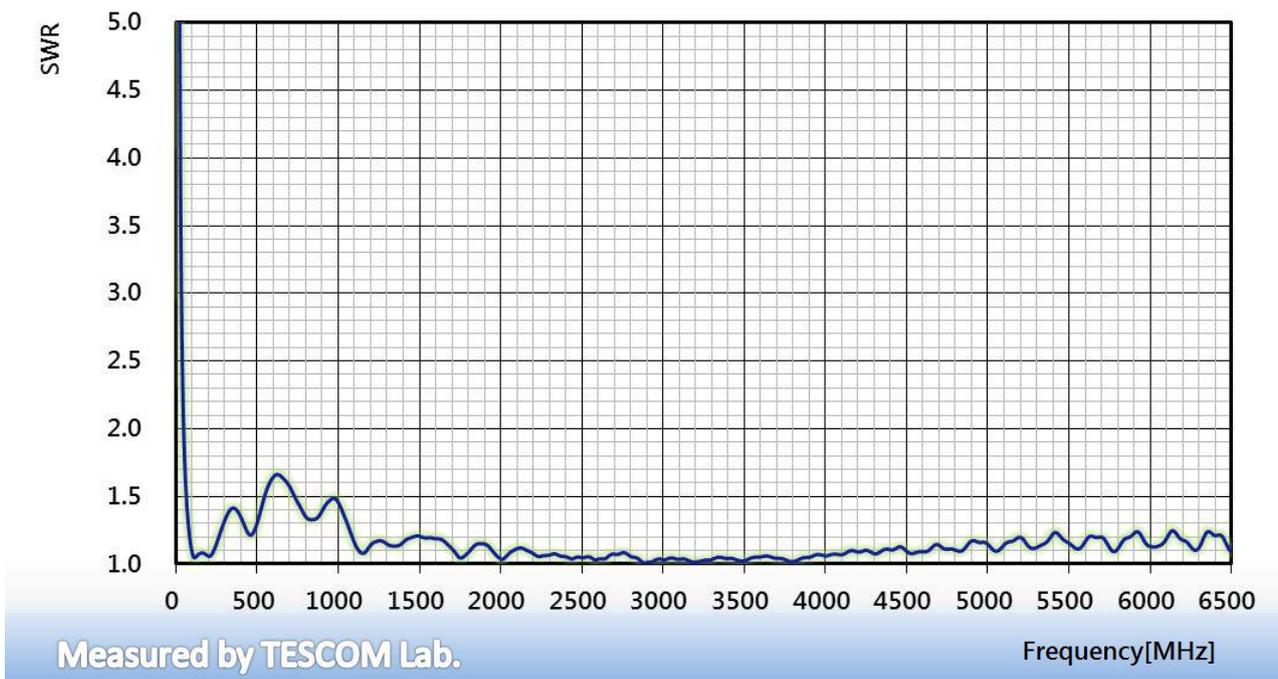


**[Figure 9] Typical VSWR of TC-5063C**

## 4.3 Check List for Common Problems

This section provides a brief checklist of common failures.

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**NOTE**

First verify that the problem is not a result of an external connection before considering the problem is with the Mini Test Cell. Then isolate the failure to the Mini Test Cell before troubleshooting or repairing the TC-5063C. Verify the Mini Test Cell performance is to specification while troubleshooting the problem.

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1. Verify that the power cord is connected to the TC-5063C.
   Make sure that the power cord is firmly plugged into the power module. Also make sure that the power source for the TC-5063C is energized.
2. Verify that the TC-5063C power switch is depressed.
3. Verify the line voltage.
   The line voltage to the power source should be 100 ~ 240 VAC.
4. Verify the compressed air and air cables.
   The compressed air to the TC-5063C should be 5 ~ 10 bar.
5. Verify external cables provide good connections.