



CY3631

# WirelessUSB™ Manufacturing Test Kit User Guide

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# 1. Introduction



## 1.1 Introduction

The CY3631 – WirelessUSB™ Manufacturing Test Kit (MTK) enables Cypress's customers to test their WirelessUSB products in a manufacturing environment without the use of expensive RF test equipment. The highly integrated nature of the WirelessUSB radio device ensures that there are very few errors in the assembly process. The device is tested before it leaves the Cypress factory. There are only a few critical components on the customer's board that affect the operation of the radio. Most of the possible assembly level failures (missing components, open/cold solder joints, and pin-to-pin shorts) cause a large reduction in transmitted power or receive sensitivity if the unit functions. A simple functionality test at maximum range eliminates most bad units.

The MTK prevents testing each unit over long distance and interference between multiple units that may be on the test floor simultaneously. This is because the MTK is designed to simulate a limit-of-operation condition using a shielded test fixture and enclosure.

## 1.2 Kit Contents

The MTK contains the following items:

- MTK test fixture
- 12 SubMiniature version A (SMA) to SMA coaxial cables
- 24 SMA to SMA coaxial cables
- SMA-F to SMA-F adapter
- Six fixed 50-ohm attenuators: 1 dB, 2 dB, 4 dB, 7 dB, 15 dB, and 30 dB
- SMA 2.4-GHz antenna
- Power supply transformer
- CD with firmware source and documentation

Figure 1-1. Manufacturing Test Contents



## 1.3 Document Revision History

Table 1-1. Revision History

Revision	PDF Creation Date	Origin of Change	Description of Change
**	03/24/2011	NXZ	New kit guide
*A	11/03/2011	CSAI	Updated DUT test code section.
*B	02/27/2012	ELIN	No technical updates.

## 1.4 Documentation Conventions

Table 1-2. Document Conventions for Guides

Convention	Usage
Courier New	Displays file locations, user entered text, and source code: C:\...cd\icc\
<i>Italics</i>	Displays file names and reference documentation: Read about the <i>sourcefile.hex</i> file in the <i>PSoC Designer User Guide</i> .
<b>[Bracketed, Bold]</b>	Displays keyboard commands in procedures: <b>[Enter]</b> or <b>[Ctrl] [C]</b>
File > Open	Represents menu paths: File > Open > New Project
<b>Bold</b>	Displays commands, menu paths, and icon names in procedures: Click the <b>File</b> icon and then click <b>Open</b> .
Times New Roman	Displays an equation: $2 + 2 = 4$
Text in gray boxes	Describes cautions or unique functionality of the product.

## 2. Kit Operation



### 2.1 Hardware Setup

1. Attach the supplied antenna to the SMA pass-through connector of the test chamber.
  - a. Use the SMA pass-through that is furthest from the sides of the chamber if there are more than one.
  - b. Orient the antenna at either 0 degrees or 90 degrees. It is important that you keep the same relative position and orientation of the fixed antenna and the device under test (DUT) for all tests. These can affect the signal strength. See [Figure 2-1](#).
2. Attach one coaxial cable to the matching SMA outside the chamber.
  - a. Make certain to connect to the same pass-through that has the antenna installed.
3. Attach the other cable to the SMA on the MTK test fixture.
  - a. Use an appropriate SMA torque wrench on all SMA connections or tighten your finger to avoid damaging the connectors. It is important that the connections are tight enough so that proper contact is made. Loose connections can impact the repeatability of the test.
4. Place fixed or variable attenuators between the two cables.
  - a. Determine the correct attenuation.
  - b. If you are using the supplied fixed attenuators, use the female-to-female adapter to connect the male end of the attenuators to the cable.
5. (Optional) Attach a serial cable (not included) between the MTK test fixture and the computer.
  - a. If a computer is used for setup or testing, attach it to the serial port with a serial cable or a USB-to-serial adapter cable (not included).
  - b. See [Appendix - A on page 19](#) for the default setting of the serial port on the test fixture.
6. Insert the power plug into the MTK test fixture.
  - a. The MTK test fixture goes through a power-on self-check, which lights all of the LED indicators. After the green PASS light is lit, the test fixture is ready for use or to receive serial commands.

Figure 2-1. Fixed Antenna Mounting Example

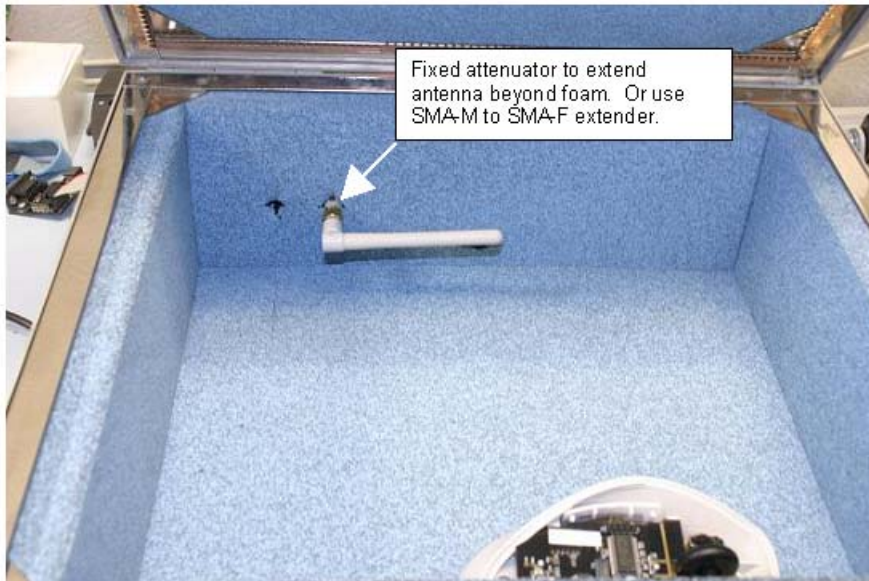


Figure 2-2. Completed Installation



## 2.2 Standard Test

The standard test is defined by sending a number of packets over one or more channels. The bit errors are counted and compared against an error threshold number and the pass/fail result is displayed. See [Appendix - A on page 19](#) for instructions on changing the standard test configuration.

After the test environment is set up, put the device to be tested into manufacturing test mode and place it in the shielded container. The DUT should respond to the standard test executed by the test fixture. Note that the foam in some shielded test boxes is conductive. The bare DUT board (if testing a bare PCB) should be placed in a fixture, not directly on the foam of the box. This also helps ensure that the DUT to antenna alignment is the same from test to test, which can make a large difference in signal strength at the DUT. See [Figure 2-3](#).



Figure 2-3. DUT Fixture



Press the **START** button on the test fixture. The **BUSY** light comes on for a short time. If the test is successful, then the **PASS** light comes on when the test is completed. If the test exceeds the error threshold settings, the test fixture indicates test failure by lighting the **FAIL** light.

## 2.3 Calibration

The test station is calibrated by using one or more known good reference devices to determine the maximum attenuation that the system can have installed before the radio loses good contact. This must be done periodically to compensate for environmental effects, and at least once any time the DUT design is changed or the test station is switched to testing a different device model.

Antenna distance and orientation, to each other and to the walls of the test chamber, are important for signal attenuation. Therefore it is vital that the calibration and test procedure be run with the antenna and DUT installed in the same location and orientation every time. It is recommended that you use a test fixture, or some other means, to ensure proper placement of the DUT each time. If alignment guides are added to the chamber, they should be kept to a very low profile and they should be constructed out of a non reflecting material. One option is to cut a shallow impression in the foam at the bottom of the chamber that holds the DUT in the proper alignment.

Note that the foam in some test chambers is conductive. While testing bare boards, be sure to use a fixture or some other means to insulate the board from the foam. A test fixture that holds the board in exactly the same place every time is strongly recommended.

Any wires or battery packs that are placed in the chamber to power the DUT also need to be in the same location every time, as these can reflect the RF energy and change the overall attenuation of the signal. Batteries should ideally be used and placed in their final location, as they will be in the finished product. The battery position can affect the test results. If the battery is not in the finished product's position, the test works fine, as long as the batteries are in the same position each time the test is run.

The initial calibration is easily done using a variable attenuator rather than the fixed attenuators provided in the kit. This is shown in [Figure 2-4](#). If the variable attenuator used does not have sufficient range, it may be necessary to install both the variable and some fixed attenuation. The amount of fixed attenuation must be determined by trial and error.

Figure 2-4. Calibration Setup



The calibration begins by testing a known good DUT sample (golden DUT) with a ‘best guess’ attenuation value. Based on our experience, this is typically in the 40 dB range. The test starts, and should pass at this initial setting. If it does not, the attenuation may need to be reduced by 10 dB. If a second test with this reduced attenuation still does not pass, check all the connections to be sure that everything is connected correctly. If this still does not fix the problem, attach the antenna directly to the SMA on the MTK test fixture and test the golden DUT in free air (no chamber). If this still does not pass, make sure that the test fixture has power, press the reset button (the self-test should pass and the green LED remain lit), and make sure that the golden DUT has good batteries installed and is in MTK test mode.

After a base line is established by passing the test, the attenuation is increased and the test repeated. Doing this several times, increasing the attenuation each time, eventually reaches the level where the golden DUT fails the test repeatedly at a given attenuation. There may be an intermediate attenuation value at which the test passes only sometimes. Use your discretion on how to determine the limit value. One option is to consider the test passing (for calibration only) if it passes three or more of five tests. As long as the method used is consistent, the results will be consistent.

It may be helpful to repeat the test with additional known good units recording the attenuation limit for each, especially for a new product. Eventually, a “worst of the best” unit can be retained for future calibration use. This is a unit that, while good and passing all the requirements, exhibits the lowest attenuation limit ever seen in a good unit.

Now that a limit has been found, the fixed attenuation should be installed in the cable. The total attenuation should be selected such that it is lower than the limit value found using the golden units by some guard band (–3 dB, for example.) The type of defect results in far greater than 3 dB of reduction in either transmit power or receive sensitivity.

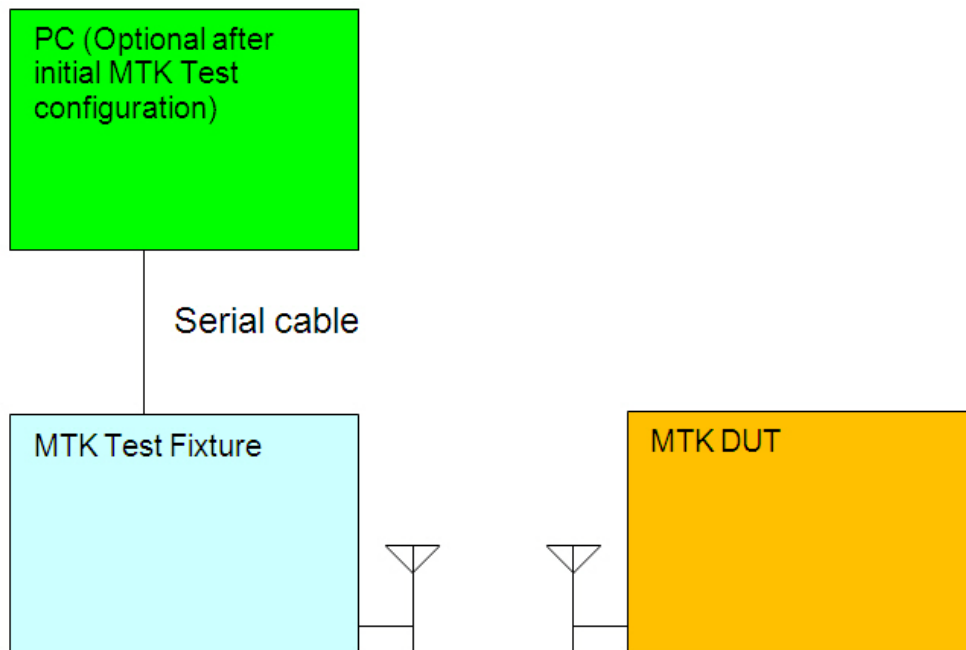
Finally, the golden DUT should be tested once more with the fixed attenuation installed to ensure that the setup is still working. The test should pass repeatedly. If it does not, check the attenuation value and all connections again.

## 3. Hardware



The manufacturing testing system involves three major components: MTK test fixture, MTK device under test (DUT), and an optional PC to monitor and control the MTK test fixture.

Figure 3-1. System Diagram



### 3.1 Theory of Operation

By default the MTK test fixture executes a set of standard tests when you push the START button. It sends predetermined test packets to the MTK DUT and expects the MTK DUT to reply to the same packet with the RX status. LEDs on the test fixture indicate if the test succeeds or fails.

To change the parameters for standard tests, such as channel number, number of packets, packet length, and so on, it can be done through a control PC. The MTK test fixture provides a RS232 port and its firmware runs command line protocol. You can use any serial communication application such as a HyperTerminal to send commands to and receive status from test fixture. See [Command Line Interface on page 17](#) for details.

### 3.2 Schematic

The MTK test fixture's main board schematic is included in the kit under <CD/DVD>/Hardware.



# 4. Firmware



## 4.1 Overview

The MTK test firmware is divided into two parts: the Test Fixture firmware and the DUT Test Code. The DUT test code is a small bit of additional code that resides in the DUT memory and can be accessed only by placing the DUT into a special test mode (see section [4.2 DUT Test Code](#) for more details). In test mode, the DUT in the test chamber exchanges packets with the test fixture. The data packet from the test fixture to the DUT is checked for errors by the DUT and the error count recorded. The DUT then sends a data packet back to the test fixture that includes the error count information. The test fixture uses this information, as well as information it collects about errors in the received data packet from the DUT, to determine if the test passes or fails.

## 4.2 DUT Test Code

All packets received by the DUT are 'echoed' with the addition of a byte that contains the count of invalid bits for the received packet. Extra bytes in packets that are larger than what the DUT can support are ignored. Received packets of the correct length are then parsed for possible RF command packets. The RF command packets exchanged between the MTK test fixture and the MTK DUT contain two or more bytes. The first byte contains the command type and the remaining bytes contain the parameter value. All commands are executed after the received packets are 'echoed'.

The DUT manufacturing test code adds approximately 500–800 bytes depending on the device and firmware version. The CY4672 PRoC LP RDK Bridge enters the Manufacturing Test Mode when the Bind button on the Bridge is pressed during power on. The CY4672 RDK mouse and keyboard use a compile time define to enter the test mode by detecting a specific grounded pin or a special key sequence during power-up. The following sections provide the details (the process of testing the CY4636 WirelessUSB LP RDK is also the same).

### 4.2.1 CY4672 PRoC LP RDK Bridge

The manufacturing test module may be conditionally compiled to provide manufacturing test support. The module configures the radio for reception and then enters a loop waiting for command packets to be sent from the tester. The test echoes all echo command packets appended with the number of invalid bits received and all other 'valid' command packets (no invalid bits). The manufacturing test code can only be exited by cycling power.

You can enter the manufacturing test mode on the PRoC LP RDK Bridge using the following methods depending on the compile time configuration:

1. Press the **Bind** button during dongle insertion into the USB Host.
2. Force a SE1 condition (D+ and D– are both high) on the USB bus and, at the same time, apply power to the bridge.
3. Ground the P0.7 pin during dongle insertion into the USB Host.

#### 4.2.2 CY4672 PRoC LP RDK Mouse

The manufacturing test module may be optionally compiled, at the expense of code space, by defining the macro `MFG_TEST_CODE`. In addition, a more complete version may be compiled by defining `MFG_TX_MODES`. The TX modes include the code to perform a carrier test and a random data test. Entry into this mode on the mouse is performed by placing a shorting block over pins 4 and 5 of the ISSP programming header and then inserting the batteries. To exit the test mode, remove the batteries and the shorting block.

#### 4.2.3 CY4672 PRoC LP RDK Keyboard

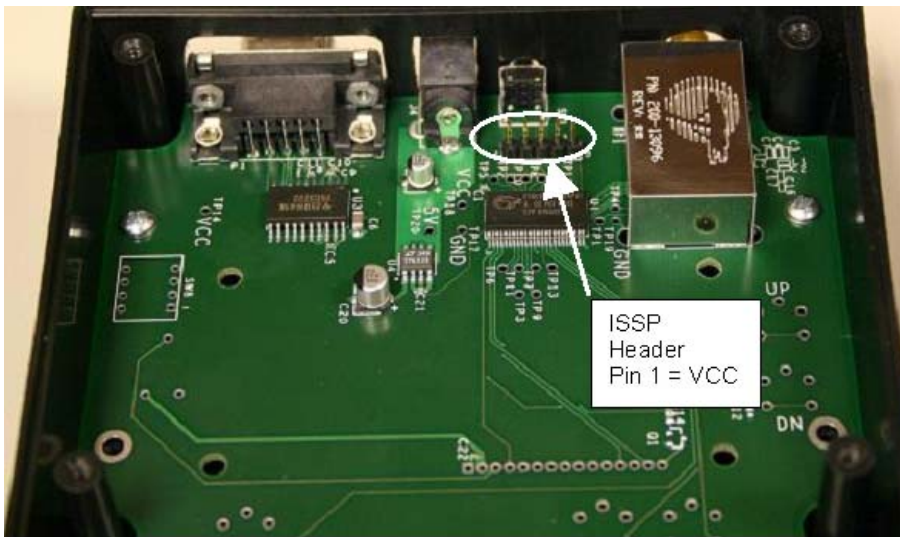
The RDK provides a compile time option to add a manufacturing test mode to the keyboard. If `MFG_TEST_CODE` is defined and `ENTER_BY_PIN` is not defined, you can enter the manufacturing test mode by holding down the system sleep key and the Bind button, while inserting the batteries into the keyboard.

If `MFG_TEST_CODE` and `ENTER_BY_PIN` are both defined, you can enter the manufacturing test mode by connecting pins 4 and 5 on the ISSP header with a shunt and then inserting the batteries into the keyboard. The only way to exit this mode is to cycle power.

### 4.3 Test Fixture Firmware

The test fixture firmware controls the standard test that is executed when the START button is pressed. It also enables communication over the serial port. The source code for PSoC<sup>®</sup> in the MTK test fixture is included in the kit CD-ROM. You may customize the test firmware as desired. PSoC can be reprogrammed using the ISSP header on the board. [Figure 4-1](#) shows the location of the header.

Figure 4-1. ISSP Header Location



## 4.4 RF Protocol

Command packets received by the DUT are “echoed” with the addition of an added byte that contains the count of invalid bits for the received packet. Extra bytes in packets that are larger than what the DUT can support are ignored. Commands other than “Echo Packet” are only “echoed” and executed if the number of invalid bits are zero.

The RF command packets exchanged between the MTK test fixture and the MTK DUT contain two bytes. The first byte contains the command type and the subsequent byte(s) contain the parameter values as shown in [Table 4-1](#).

Table 4-1. RF Commands

Description	Command	Parameter
Echo packet	0x00	N/A
Set new configuration	0x61	Channel (0–77) PN code index (0–7) PA (0–7) Correlator Threshold (0–16)
Transmit carrier	0x66	Time in seconds (0–255) Note: A zero runs the test continuously until a reset.
Transmit random pattern	0xA3	Time in seconds (0–255) Note: A zero runs the test continuously until a reset.

**Note** The “Transmit carrier” and “Transmit random pattern” test modes can be conditionally compiled with the definition “MFG\_TX\_MODES”.





# 5. Command Line Interface



## 5.1 Serial Command Line Interface

The MTK test fixture implements a text-based protocol over an RS232 serial port to provide both a configurable standard test and script-based testing.

All commands listed under the standard test set a configuration value that is stored in nonvolatile storage. All remaining serial commands only affect the current setting and are not stored (reset across power cycles). [Table 5-1](#) describes the serial port protocol in the PC to test fixture direction.

Table 5-1. Serial Command Protocol

Command	Command Description
ST	Start standard test
PN <PN code>	Configure pin code index (0–7)
TT <tx error threshold>	Configure TX error threshold (0–65535) units of bit errors
RT <rx error threshold>	Configure RX error threshold (0–65535) units of bit errors
C1 <channel>	Configure channel (0–77)
C2 <channel>	Configure second channel (0–77)
C3 <channel>	Configure third channel (0–77)
CB <# of bytes>	Configure number of bytes/packet payload (0–15)
TC <time>	Transmit carrier (0–255)
TR <time>	Transmit random (0–255)
SC <channel> <PN code> <power level> <correlator threshold>	Set communication (0–77) (0–7) (0–7) (0–16)
PD <packet data>	Set packet data (ASCII representation of hexadecimal numbers without any prefix, that is, 5A 34 CB)
CA <crystal adjust>	Set crystal frequency adjust value (0–63)
RE	Restore NVRAM defaults
CS	Show current configuration
HE	Show help menu

Every serial command issued by the PC is returned with a response after the command is complete. The valid responses are shown in [Table 5-2](#).

Table 5-2. Serial Response Protocol

Report	Report Description
OK	Command complete
CE	Command error
TE <transmit error count>	TX error count (units of bit errors)
RE <receive error count>	RX error count (units of bit errors)

All serial commands must end in either a carriage return or carriage return and linefeed. All responses end with a carriage return and linefeed.

The serial port settings for the MTK test fixture are shown in [Table 5-3](#). Neither software nor hardware handshake is supported.

Table 5-3. Serial Port Parameter Settings

Serial Port Parameter	Setting
Baud rate	9600
Parity	None
Number of data bits	8
Number of stop bits	1

# 1. Appendix



## 1.1 Appendix - A

### 1.1.1 Using the Command Line Interface

The default serial port settings for the test fixture are 9600, N, 8, 1, NONE, with local echo turned on in the terminal emulator of choice. When power is applied to the test fixture, the following welcome banner comes up in the terminal window.

```
*****  
WirelessUSB Tester - v1.0  
  
For help, type: he  
*****
```

MTK>

If this banner is not displayed, then recheck the serial port connection and settings.

All serial port commands are case insensitive. While the help menu displays commands in upper case, they may be entered in lower case. The PD command requires parameters to be entered in hexadecimal format without any prefix or postfix characters (see the help menu for an example.) The letters in the hexadecimal numbers may be lowercase as well.

A listing of all the supported commands with parameter limits is displayed by typing the command HE as shown in the welcome banner. Following is an output example of the help menu.

MTK> he

TESTER HELP MENU

```
*****  
All commands and parameters are case insensitive. The following commands are executed immedi-  
ately:  
Show This Help Menu ..... HE  
Show Current Tester Settings ..... CS  
Execute Standard Test ..... ST  
Set Channel, PN Code, Power, Correlator ..... SC <0-77> <0-7> <0-7>  
<0-16>  
Transmit Carrier for N seconds, 0 = infinite .. TC <0-255>  
Transmit Random for N seconds, 0 = infinite ... TR <0-255>  
Send Data to DUT, e.g. PD 5A 00 0A FF 34 ..... PD <B1 B2 ... B15>  
Tester Crystal Adjust (stored in EEPROM) ..... CA <0-63>  
Crystal Clock Output ON=1/OFF=0 ..... XO <0-1>  
Restore Default Settings to EEPROM ..... RE
```

The following commands save values to EEPROM for standard test configuration:

```

Configure Correlator Threshold ..... CO <0-16>
Configure Power Level ..... CL <0-7>
Configure PN Code ..... PN <0-7>
Configure First Channel, 255 to disable ..... C1 <0-77, 255>
Configure Second Channel, 255 to disable ..... C2 <0-77, 255>
Configure Third Channel, 255 to disable ..... C3 <0-77, 255>
Configure Tx Error Threshold ..... TT <0-65535>
Configure Rx Error Threshold ..... RT <0-65535>
Configure Packet Payload Length ..... CB <0-15>
Configure Number of Packets Sent on Channel ... CP <0-255>

```

All commands return one of the following:

```

OK ..... Command Success
CE ..... Command Error

```

Commands PD and ST also return:

```

TE <number> ..... DUT Receive Error Rate
RE <number> ..... Tester Receive Error Rate
*****
OK
MTK>

```

All commands return either OK (successful command completion) or CE (command error.) A successful command completion in the case where DUT interaction is involved does not necessarily mean that the DUT successfully completed the request.

The PD command and the Standard Test command ST both report additional information of bit error rates. The TE result is the number of bit errors counted by the DUT and is computed on the test fixture by using the contents of the returned packet from the DUT. If a response to a data packet is not received by the test fixture, then a 100% bit error rate is assumed on the sent packet. The RE result is computed using the received packet from the DUT.

A portion of the commands are used to configure the Standard Test that is executed by pressing the START button on the test fixture. These values are saved in nonvolatile storage and remembered across power cycles. The saved values only take affect when the Standard Test is executed.

The current configuration of the test fixture can be reported by typing the command CS at the command prompt. Following is an example of the output from this command.

```

MTK> cs
TESTER CONFIGURATION
*****
Radio Configuration:
Channel ..... 2
PN Code ..... 1
Power Level ..... 7
Correlator threshold ..... 2
Crystal adjust ..... 3
Crystal clock output ..... OFF
Standard Test Configuration:
Channel 1 ..... 1
Channel 2 ..... 255
Channel 3 ..... 255
PN Code ..... 1
Power Level ..... 7
Correlator threshold ..... 2

```



```
Tx error threshold ..... 1000
Rx error threshold ..... 1000
Packet payload length .... 5
Packets per channel ..... 128
```

```
*****
```

```
WUSB LS Radio Registers
Output format in hex: addr:val
```

```
00:07 01:04 02:4a 03:00 04:06 05:01 06:0b 07:03
08:00 09:00 0a:00 0b:00 0c:00 0d:01 0e:00 0f:00
10:ff 11:dc 12:c0 13:6b 14:b8 15:2b 16:09 17:bb
18:b2 19:02 1a:1e 1b:10 1c:00 1d:01 1e:00 1f:00
20:64 21:04 22:00 23:07 24:42 25:00 26:0f 27:00
28:00 29:00 2a:00 2b:10 2c:fa 2d:f0 2e:80 2f:00
30:00 31:00 32:41 33:41 34:f7 35:00 36:00 37:63
38:64 39:00 3a:00 3b:00 3c:d3 3d:8a 3e:d5 3f:3e
```

```
*****
```

```
OK
```

```
MTK>
```

The standard test can be executed from the PC by typing the ST command at the command prompt in the terminal window. The first channel is set to 255 and all following channels are not tested. The results are displayed in the terminal similar to the following.

```
MTK> st
TE 864
RE 1008
OK
MTK>
```

The error results in the previous paragraph are typical of a non responding DUT.

Note that when pressing the START button on the test fixture that the test results are displayed in the terminal window without the command response and command prompt as follows.

```
TE 864
RE 1008
```

The commands not related to the Standard Test configuration are executed immediately from the command prompt. These are used for interactive testing/debug or with a script for extended automated testing.

## 1.2 Appendix - B

### 1.2.1 Test Chambers

An anechoic RF test chamber, sized appropriately for the DUT with SMA pass through connectors is required.

There are several important factors to consider when buying a chamber, such as the attenuation of RF energy that comes into the box from outside, the attenuation of RF energy that is reflected from the inside of the box, and the connectors for passing signals through the walls.

The requirements are as follows:

- Attenuation of incoming RF energy:  $\geq 30$  dB at 2.4 GHz
- Attenuation of reflected RF energy:  $\geq 15$  dB at 2.4 GHz ( $\geq 7.5$  dB each direction)
- Connectors: One (1) SMA minimum

Many vendors sell test chambers that work. Following are some examples of units used before:

- Mironix model ME8662E
- Ramsey Electronics model STE2200 with optional CONN157. (A small box nicely sized for a mouse or dongle, or small bare boards.)
- Ramsey Electronics model STE3300 with optional CONN157.
- Ramsey Electronics model STE4400 with optional CONN157. (Large enough for a full size keyboard in plastic.)

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