WirelessUSB™ Manufacturing Test Kit User's Guide

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1. INTRODUCTION

The WirelessUSB™ Manufacturing Test Kit (MTK) is designed to allow Cypress' 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 is such that there is very little that can go wrong in the assembly process. The device itself 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 likely assembly level failures (missing components, open/cold solder joints, and pin-to-pin shorts) will cause a large reduction in transmitted power or receive sensitivity, if the unit functions at all. As such, a simple functionality test at maximum range would eliminate most bad units.

To keep from having to test each unit over a long distance, and to prevent interference between multiple units that may be on the test floor simultaneously, the MTK is designed to simulate a limit-of-operation condition using shielded Test Fixture and enclosure.

2.   KIT DESCRIPTION

The MTK contains the following items.

- MTK Test Fixture
- 12" SMA to SMA coaxial cable
- 24" SMA to SMA coaxial cable
- SMA-F to SMA-F adapter
- (6) Fixed 50 ohm attenuators: 1dB, 2dB, 4dB, 7dB, 15dB, and 30dB
- SMA 2.4GHz antenna
- Power supply transformer
- CD-ROM with Firmware Source and documentation

See Photo #1 – Manufacturing Test Kit Contents, below.

Not included but required for use are: the Device Under Test (DUT) and an anechoic RF test chamber, sized appropriately for the DUT, with SMA pass-through connectors.

Optional, not included, equipment includes: a variable 50-ohm attenuator for calibration, an SMA torque wrench, a computer to download configuration and/or test start commands and, optionally, log test results, as well as an RS-232 serial cable or USB-to-serial adapter cable for connecting the computer to the 9-pin D connector of the MTK Test Fixture.

<Photo #1 – Manufacturing Test Kit Contents>

3.　　　　　HARDWARE SETUP

1) Attach the supplied antenna to the SMA pass-through connector of the test chamber.
   - o Use the SMA pass-through that is furthest away from the sides of the chamber if there is more than one.

   - o Orient the antenna at either 0 degrees or 90 degrees. (It is very important that the relative position and orientation of the fixed antenna and the DUT be kept the same for all tests. These can **greatly** affect the signal strength.)

   - o See Photo #2 – Fixed Antenna Mounting Example.

2) Attach one coaxial cable to the matching SMA on the outside of the chamber.
   - o Be sure 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.
   - o Please use an appropriate SMA torque wrench on all SMA connections or tighten finger tight, to avoid damaging the connectors. It is important that the connections are tight enough that good contact is made. Loose connections can greatly impact the repeatability of the test.

4) Place fixed or variable attenuators between the two cables.
   - o See the Appendix C, below for determination of the correct attenuation.

   - o If 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 computer.
   - o If a computer will be used for set up or testing, attach it to the serial port with a serial cable or a USB-to-serial adapter cable (not included).

   - o See Appendix B for the default setting of the serial port on the test fixture.

6) Insert power plug into the MTK test fixture.
   - o The MTK Test Fixture will go through a power-on self-check, which will light all of the LED indicators. Once the green PASS light is lit, the tester is ready for use or to receive serial commands.

Fixed attenuator to extend antenna beyond foam. Or use SMA-M to SMA-F extender.

<Photo #2 – Fixed Antenna Mounting Example>

<Photo #3 – Completed Installation>

4. EXECUTING THE 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 B for instructions on changing the Standard Test configuration.

Once the test environment is set up, put the device to be tested into manufacturing test mode and place it in the shielded container. The device under test (DUT) should respond to the Standard Test executed by the Tester.

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 will also help ensure that the DUT to antenna alignment is the same from test to test, which can make a very large difference in signal strength at the DUT. See photo #4 below:
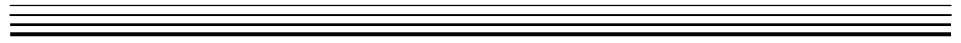

<Photo #4 – DUT Fixture>

Press the **START** button on the Tester. The **BUSY** light should come on for a short time. If the test is successful, then the **PASS** light will come on when the test is completed. If the test exceeded the error threshold settings, the Tester will indicate test failure by lighting the **FAIL** light.

APPENDIX A – FIRMWARE

1. FIRMWARE 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 below for more details.) Once 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.

2. DUT TEST CODE

All packets received by the Device-Under-Test (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. Received packets of the correct length are then parsed for possible RF command packets.

The RF command packets exchanged between the MTK Tester 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 method to enter the Manufacturing Test Mode varies depending on the device and firmware version. The CY4632 RDK Bridge will enter the Manufacturing Test Mode when an SE1 condition (both D+ and D- are held high) is detected during power-on on all firmware versions from 1.2 and higher. The CY4632 RDK Mouse and Keyboard uses a compile time define to enter the test mode by detecting a specific grounded pin or a special key

sequence during power-up. See below for details on specific versions.

CY4632 RDK Keyboard Version 1.2, 1.21, 1.3
- MFG_ENTER_BY_KEY_NOT_PIN defined, enters Manufacturing Test Mode when the bind button and the suspend key are held during power-up.
- MFG_ENTER_BY_KEY_NOT_PIN not defined, enters Manufacturing Test Mode when the PORT 0 Pin 6 is grounded during power-up.

CY4632 RDK Keyboard Version 1.31 and higher
- MFG_ENTER_BY_PIN defined, enters Manufacturing Test Mode when the PORT 0 Pin 6 is grounded during power-up.
- MFG_ENTER_BY_PIN not defined, enters Manufacturing Test Mode when the bind button and the suspend key are held during power-up.

CY4632 RDK Mouse Version 1.2, 1.21
- MFG_ENTER_BY_KEY_NOT_PIN defined, enters Manufacturing Test Mode when the test mode 1 is selected. Holding both the right and left buttons during power-up enters the test selection mode. The LED turns off to indicated that the mouse in the test selection mode. Releasing both buttons and pressing the left button once to select the first test and then pressing the right button to start the first test.
- MFG_ENTER_BY_KEY_NOT_PIN not defined, enters Manufacturing Test Mode when the PORT 0 Pin 5 is grounded during power-up.

CY4632 RDK Mouse Version 1.3, 1.31 and higher
- MFG_ENTER_BY_PIN defined, enters Manufacturing Test Mode when the PORT 0 Pin 5 is grounded during power-up.
- MFG_ENTER_BY_PIN not defined, enters Manufacturing Test Mode when the test mode 1 is selected. Holding both the right and left buttons during power-up enters the test selection mode. The LED turns off to indicated that the mouse in the test selection mode. Releasing both buttons and pressing the left button once to select the first test and then pressing the right button to start the first test.

3. TEST FIXTURE FIRMWARE

The Test Fixture Firmware controls the standard test that is executed when the START button is pressed. It also provides for communication over the serial port. See Appendix B for details about the serial communication protocol. The source code for the PSoC in the MTK Test Fixture is included in the kit CD-ROM. The user may customize the test firmware as desired. The PSoC can be reprogrammed using the ISSP header on the board. See Photo #5 for the location of the header.

ISSP
Header
Pin 1 = VCC

<Photo #5 – Location of the ISSP Header>
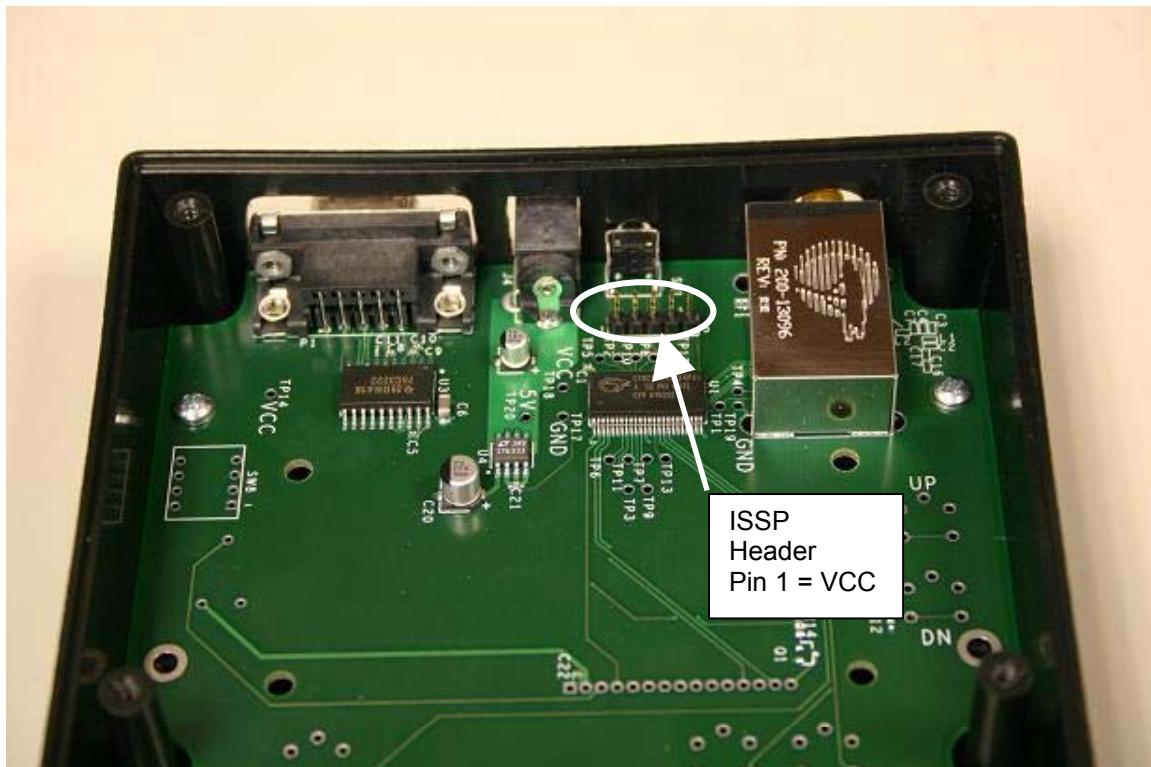
APPENDIX B – USING THE SERIAL INTERFACE

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

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

MTK>
```

If this banner is not displayed, then re-check the serial port connection and settings.

All serial port commands are case insensitive. While the help menu displays commands in uppercase, 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 immediately:

  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 Tester by using the *contents* of the returned packet from the DUT. If a response to a data packet is not received by the Tester, then 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 Tester. These values are saved in non-volatile storage and remembered across power cycles. The saved values only take affect when the Standard Test is executed.

The current configuration of the Tester 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 set to 255 and all following channels will not be tested.
The results will be displayed in the terminal similar to the following.

```
MTK> st

TE 864
RE 1008

OK

MTK>
```

The above error results are typical of a non-responding DUT.

Also note that when pressing the **START** button on the tester 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.

APPENDIX C - 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 needs to 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.

Since antenna distance and orientation, both to each other and to the walls of the test chamber, play such an important role in signal attenuation, 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 a test fixture, or some other means, be used to ensure proper placement of the DUT each time. If alignment guides are added to the chamber, they should be kept to as low a profile as possible and they should be constructed out of a non-reflecting material. One option would be to cut a shallow impression in the foam at the bottom of the chamber that will hold the DUT in the proper alignment.

Note that the foam in some test chambers is conductive. If testing bare boards, be sure to use a fixture or some other means to insulate the board from the foam. A test fixture that will hold 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. Ideally, batteries should be used and placed in their final location, as they will be in the finished product. The battery position can greatly affect the result of the test. If the battery is not in the finished product's position, the test will work just fine, as long as the batteries are in the same position each time the test is run.

The initial calibration is most easily done using a variable attenuator rather than the fixed attenuators provided in the kit. This is shown in Photo #6 – Calibration Setup, below. 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 will have to be determined by trial and error.

<Photo #6 – 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 will typically be in the 40dB range. The test starts, and should pass at this initial setting. If it does not, the attenuation may need to be reduced by 10dB. 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.

Once 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, will eventually reach 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 will pass only some of the time. It is up to the user's discretion 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 (-3dB for example.) The type of defect we expect to be encountered will result in far greater than 3dB 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.

APPENDIX D – TEST CHAMBERS

An anechoic RF test chamber, sized appropriately for the Device Under Test (DUT), with SMA pass-through connectors is required.

There are several important factors to consider when buying a chamber. 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.

Requirements:

- Attenuation of incoming RF energy: ≥ 30dB @ 2.4GHz

- Attenuation of reflected RF energy: ≥ 15dB @ 2.4GHz (≥ 7.5dB each direction)

- Connectors: One (1) SMA minimum

Many vendors sell test chambers that will work. Below are some examples of units that we have used before.

- Micronix 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.)