AN214909

OTP Programming and NVRAM Development Process for CYW4319 USB Embedded WLAN Devices

This application note describes how to create the nvram.txt file and use the file to test new board designs, optimize NVRAM values, and program the OTP using Cypress's MFGC manufacturing test tool.

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1 About This Document

1.1 Cypress Part Numbering Scheme

Cypress is converting the acquired IoT part numbers from Broadcom to the Cypress part numbering scheme. Due to this conversion, there is no change in form, fit, or function as a result of offering the device with Cypress part number marking. The table provides Cypress ordering part number that matches an existing IoT part number.

Table 1. Mapping Table for Part Number between Broadcom and Cypress

Broadcom Part Number	Cypress Part Number
BCM4319	CYW4319

1.2 Acronyms and Abbreviations

In most cases, acronyms and abbreviations are defined on first use. For a more complete list of acronyms and other terms used in Cypress documents, go to: http://www.cypress.com/glossary.

1.3 Purpose and Scope

The following information is provided in this document:

- Programming OTP Programming on page 3
- CYW4319 USB Windows Driver Installation on page 6
- Customizing the NVRAM.TXT Template File on page 3
- Programming a Blank OTP Board on page 10

For most host platforms running the Linux or Windows® XP operating system, it is not necessary to program the OTP during board bring-up and hardware tuning. Cypress recommends storing all required CIS information in the nvram.txt file.

Although OTP programming is not required for USB devices used on the host operating systems, nvram.txt file development is still required. Developing the nvram.txt file is a secondary purpose of this document.

1.4 System Requirements

- CYW4319 design package containing:
  - Chip-specific development board, board schematic, bill of materials, and layout
  - nvram.txt template file
- Windows XP or Linux® device driver for the targeted USB device
- ® Transmit Signal Strength Indicator (TSSI) calibration tool
  - Optional: LabView™ (graphical programming environment for developing measurement, test, and control systems)

2 IoT Resources

Cypress provides a wealth of data at http://www.cypress.com/internet-things-iot to help you to select the right IoT device for your design, and quickly and effectively integrate the device into your design. Cypress provides customer access to a wide range of information, including technical documentation, schematic diagrams, product bill of materials, PCB layout information, and software updates. Customers can acquire technical documentation and software from the Cypress Support Community website (http://community.cypress.com/).

3 Introduction

3.1 Overview

The Cypress CYW4319 is a single-chip, USB device for embedded applications. The CYW4319 supports IEEE 802.11a/b/g/n and has One-Time Programmable (OTP), nonvolatile memory for storing board-specific information such as the product ID, manufacturer ID, and MAC address.

Together, the OTP content and the NVRAM file, referred to in this document as the nvram.txt file, create a complete Card Information Structure (CIS) that host platforms use to load Cypress USB embedded devices.

4 Functional Description

The initial state of all OTP bits in an unprogrammed device is 0. Individual bits can be programmed to 1, but once programmed, they can never be reprogrammed back to 0. The entire OTP array can be programmed during a single write cycle using Cypress's MFGC manufacturing. This test tool available via the Cypress CSP (see Technical Support for Registered Customers on page 2). Alternatively, multiple write cycles can be used to selectively program specific fields, however, only bits that are still in the 0 state can be programmed to the 1 state during each programming cycle.

Caution! Do not program the OTP until the contents of the nvram.txt file have been verified. Because the OTP programming process is irreversible, development should be performed on boards with blank OTP, using the parameters in the nvram.txt file.

Cypress recommends finalizing all parameters before programming the OTP. Boards should be tested using the editable nvram.txt file. The parameters specified in the nvram.txt file can be loaded into the on-chip RAM, allowing the chip to be tested even if the OTP has not been programmed. This method allows RF components to be tuned and critical parameters to be altered while testing a board using different versions of the nvram.txt file. After critical parameter values have been finalized, they can be programmed into the OTP of the USB device during the second phase of the two-phase OTP programming procedure.

For board designs in which the host and USB device are permanently connected (typically done using a hardwired USB interface), programming the OTP during production is optional. It is equally acceptable to store the NVRAM parameters in the host firmware, keeping the OTP blank during production. For USB devices that may be installed on different hosts, program the OTP to protect the unique MAC address and prevent end users from altering power control parameters such as maximum output power and other power amplifier (PA) parameters.

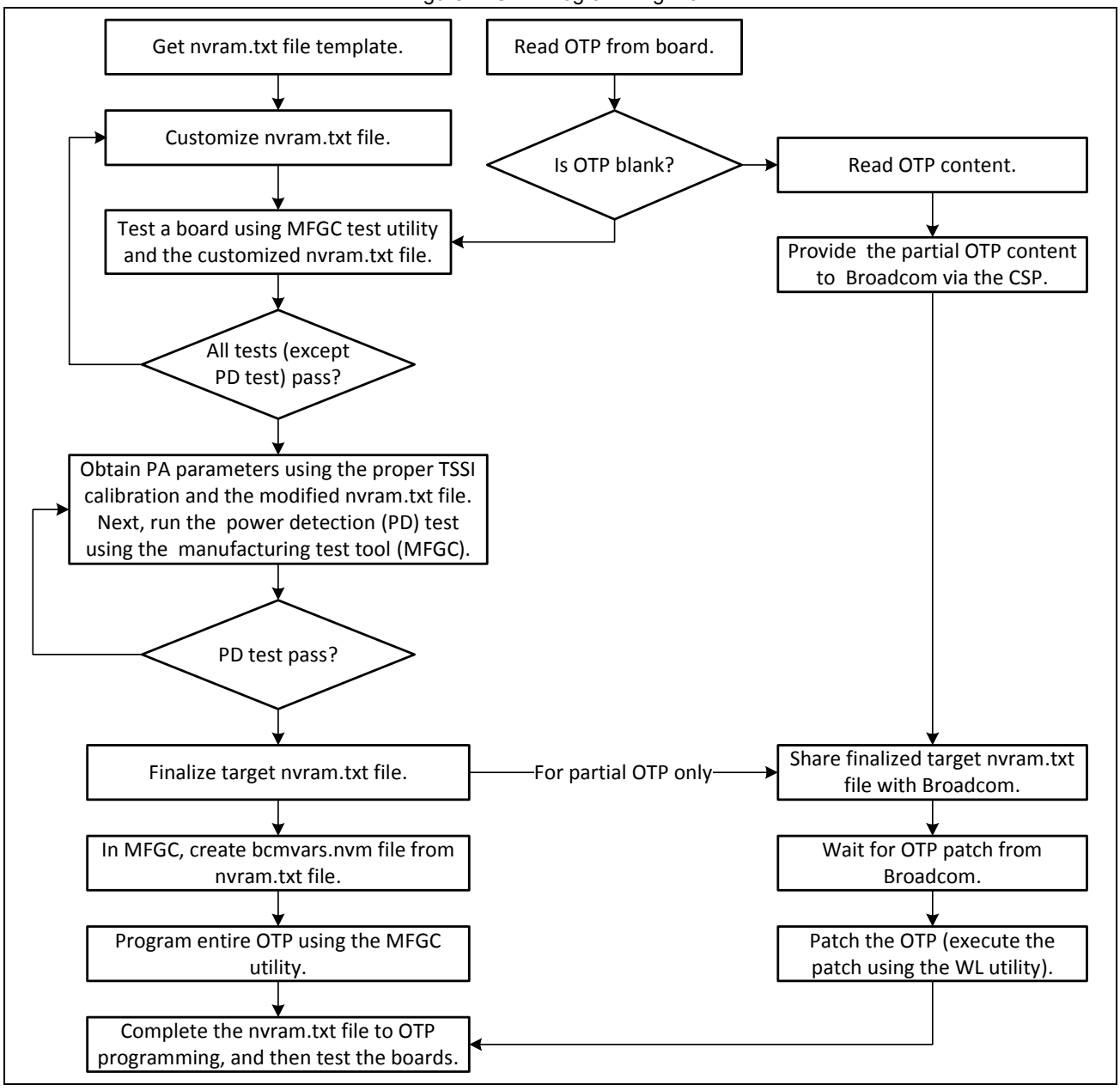
Note: If a parameter is present in both the on-chip OTP and the nvram.txt file, the value in the OTP will override the value in the nvram.txt file and the WLAN driver will ignore the corresponding value in the nvram.txt file.

5 OTP Programming

5.1 Programming OTP Programming

The nvram.txt file development and the two-phase OTP programming process are illustrated in Figure 5.1.1. Relevant details on each phase of the process are discussed in Programming OTP on page 10.

Figure 1. OTP Programming Flow



5.1.1 Customizing the NVRAM.TXT Template File

5.1.1.1 NVRAM Text File Sample Template

If the schematic for the board was copied from a Cypress reference design, testing and tuning can be performed using the nvram.txt file template provided with the design package. To test and tune a board with a different schematic, customize the nvram.txt file template as described in instructions provided in this section.

Note: The nvram.txt file (customized, if necessary) is required during board installation in a Windows XP test environment.

During the board development phase, start with the default PA parameters provided in the nvram.txt template. The PA parameters will eventually be optimized using Cypress's Transmit Signal Strength Indicator (TSSI) calibration tools.

Table 2 on page 4 describes a sample nvram.txt file with parameters common to Cypress USB single-band, 2.4 GHz reference design boards. Additional parameters are required to support 5 GHz functions in dual-band (2.4 and 5 GHz) board designs. For the detailed information on 5 GHz NVRAM parameters, contact your Cypress application engineering representative.

After customizing the nvram.txt file, copy it to the C:\WINDOWS\system32\drivers directory, overwriting any previous file with the same name. The file name must be nvram.txt.

If the OTP space is not large enough to store all of the parameters necessary for nonvolatile storage, designs can maintain an nvram.txt file external to the chip. During chip initialization, OTP and host controller supplied parameters in the nvram.txt file are saved to on-chip RAM.

Table 2. Common Single-Band 2.4 GHz NVRAM Parameters

NVRAM Parameter	Example Data	Description
boardtype	0x4e7	Board type Note: See Boardtype Parameters on page 5 for details.
boardrev	0x1517	Board revision. This parameter provides the board revision of the actual application board.
boardflags	0x200	Board flags for board configurations Note: See Boardflags Parameters on page 6 for details.
sromrev	3	SROM revision
xtalfreq	30000	Onboard XTAL or oscillator frequency in KHz
pa0b0	0x17c4	PA parameters in hexadecimal format
pa0b1	0xfa86	
pa0b2	0xfeb3	
pa0itssit	62	Power detector dynamic range (fixed at 62)
pa0maxpwr	76	Maximum output power setting (measured at the antenna port) Resolution = 0.25 dBm per step Nominal target power in dBm for CCK packets: (0.25 × pa0maxpwr) – 1.5 dB (± 1.5 dB variation)
cckpo	0x2222	Maximum CCK back-off from the maximum output power (defined by pa0maxpwr) Resolution = 0.5 dB per step Values applied to 11, 5.5, 2.0, and 1.0 Mbps transmission rates.
ofdmpo	0x44444444	OFDM back-off from the maximum output power (defined by pa0maxpwr) Resolution = 0.5 dB per step Values applied to 54, 48, 36, 24, 18, 12, 9, and 6 Mbps transmission rates.
aa2g	3	Number of antennas in 1's hot format binary (i.e., 1=01b for one antenna; 3=11b for two antennas)
ag0	2	Antenna gain in dB
tri2g	78	T/R switch isolation in quarter (1/4) dB
rxpo2g	0	Rx power offset
rssismf2g	0	RSSI midpoint select and board switch architecture
rssismc2g	11	
rssisav2g	3	
bxa2g	1	
ccode	0	Country code
cctl	0	Front-end switch control
macaddr	00:90:4c:fe:${maclo}	iLO MAC address format enables firmware to use the default MAC address for blank OTP.

5.1.1.2 NVRAM.TXT File Modification

Table 2 on page 4 describes a sample nvram.txt file with parameters common in Cypress USB, single-band, 2.4 GHz reference design boards. Some parameter values in these Cypress wireless embedded designs must be modified in order to comply with the board's configuration and design requirements.

For board configurations that provide power topology choices and off-chip component specifications, the following NVRAM parameters must be verified or changed:

`boardtype` (see Boardtype Parameters on page 5)

`boardrev`

`boardflags` (Boardflags Parameters on page 6)

`xtalfreq`

`aa2g`

`ag0`

`tri2g`

For the design requirements, the following NVRAM parameters must be verified or changed:

`pa0maxpwr`

`cckpo and ofdmpo`

`ccode`

`cctl`

The values of the following PA parameters are greatly influenced by the characteristics and layout of the printed circuit board (PCB):

`pa0b0`

`pa0b1`

`pa0b2`

Note: Cypress strongly recommends having the PA parameter values specified in the NVRAM text file verfied by Cypress engineering before saving the values to the OTP.

For more information, see Develop and Verifiy PA Parameters on page 11.

5.1.1.3 Boardtype Parameters

To maintain backward compatibility with earlier driver versions, boardtype values (see Table 3) should be saved to the nvram.txt file.

Table 3. CYW4319 Boardtype Parameter Examples

Boardtype	Description
0x4e6	PALDO usage[a]
	CBUCK regulator[b]
	External LNA[a]
	USB interface
0x4e7	PALDO usage[a]
	CBUCK regulator[b]
	External LNA[a]
	USB interface
0x508	PALDO is used
	CBUCK regulator[b]
	External LNA[a]
	USB interface

a. Depends on boardflags.

b. Specifies if used/not used.

Boardflags Parameters

The boardflags parameters are used by the USB driver to configure the USB device's hardware settings and implementations. All the hexadecimal format values are OR logical calculated for the boardflags parameters. For example, if the internal PMU PALDO is used and it supports Afterburner mode and Front End Module, the boardflags should be set to boardflags = 0x2000a00.

Table 4. Boardflags Parameters

Name	Value	Description
BFL_AFTERBURNER	0x0000 0200	Board supports Afterburner mode.
BFL_FEM	0x0000 0800	Board supports the front-end module.
BFL_EXTLNA	0x0000 1000	Board has an external LNA.
BFL_3TSWITCH	0x0008 0000	Board uses a triple throw switch shared w/Bluetooth®.
BFL_BUCKBOOST	0x0020 0000	Power topology uses Buck/Booster.
BFL_NOCBUCK	0x0080 0000	Power topology does not use CoreBUCK.
BFL_PALDO	0x0200 0000	Power topology uses on-chip PA LDO.

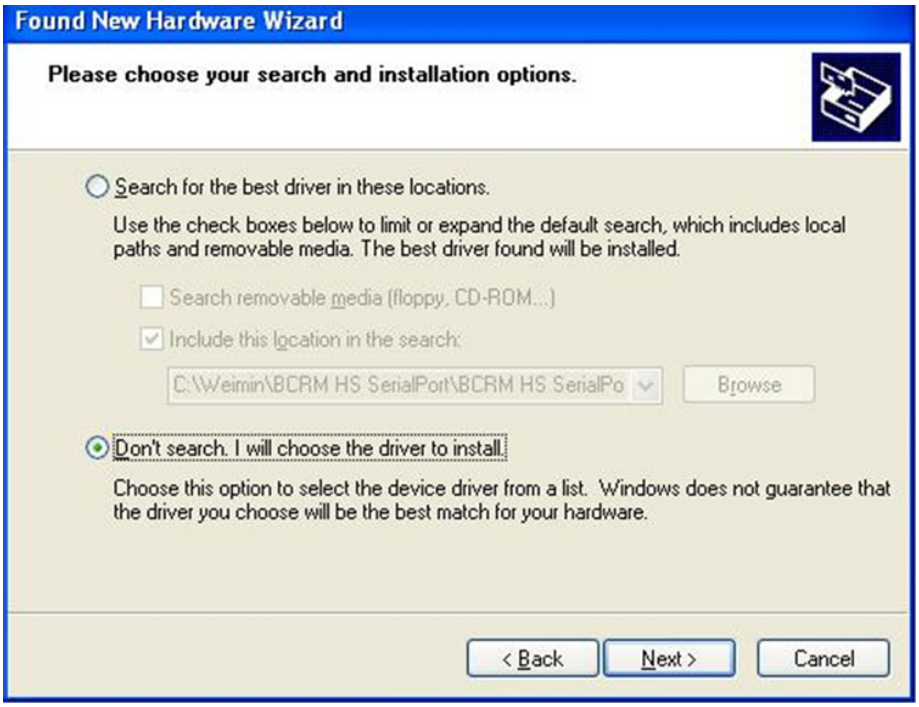
5.2 CYW4319 USB Windows Driver Installation

To install the CYW4319 USB driver files, complete these steps:

1. Copy the following CYW4319 USB driver files and save them to a directory on a local PC running Windows XP.
   Bcm94319b0usb.bin.trx
   Bcmusbdhd.inf
   Bcmusbdhdxp.sys
   Bcmvars.nvm
   Brcm_wlu.dll
   Wlm.dll
   Wlm.lib
2. Connect the CYW4319 device under test to a USB port on the local PC.
   Windows launches the Found New Hardware Wizard.
3. Choose **Install from a list or specific location (Advanced)**, and then click **Next**.



4. Choose **Don't search. I will choose the driver to install.**, and then click **Next**.



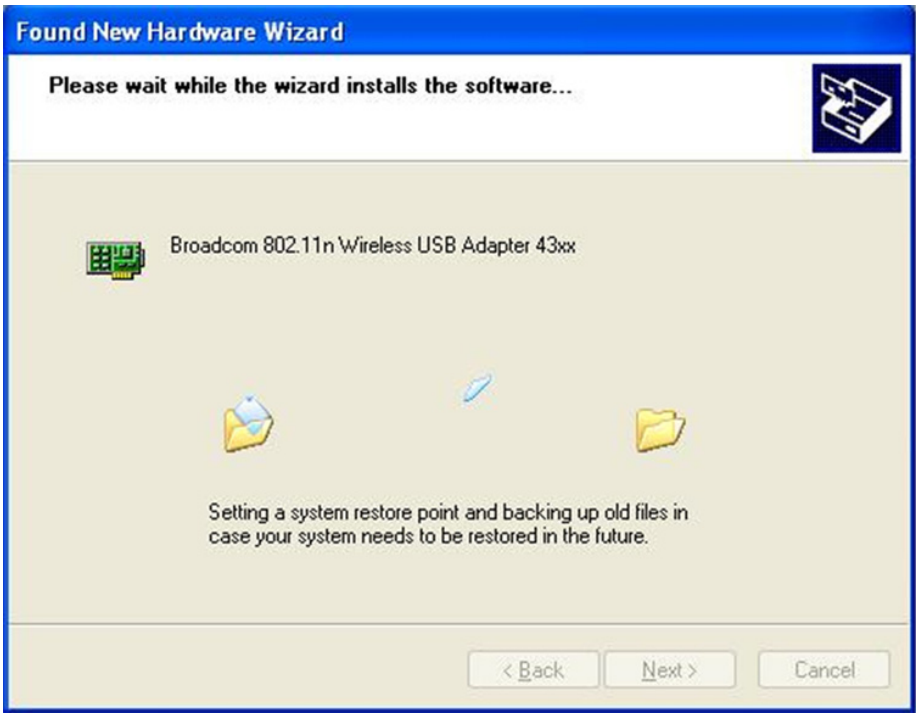
5. Browse to the directory where the driver files are stored, and then click **OK**.



6. In the Hardware Installation confirmation window that appears, click **Continue Anyway** to continue the installation process.



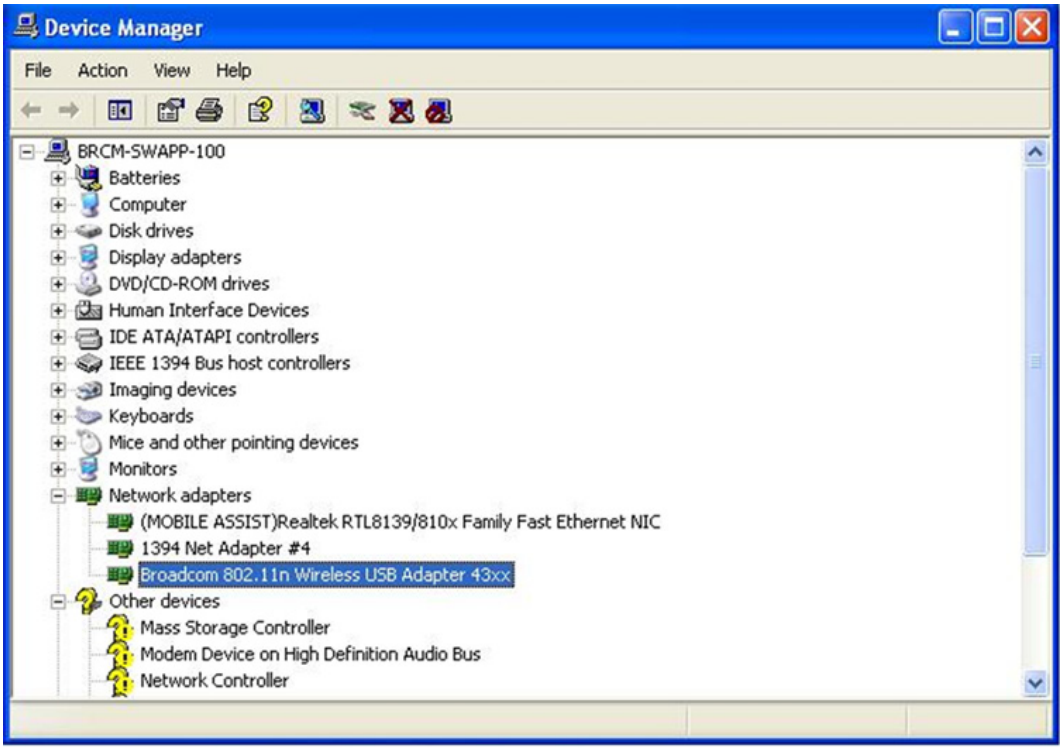
The installation wizard installs the software.



7. When the driver installation process completes successfully, click **Finish** to close the wizard.



8. Under Network adapters in Device Manager, make sure **Cypress 802.11n Wireless USB Adapter 43xx** is listed.



5.3 Programming OTP

5.3.1 USB Dongle CYW4319 Devices

Note: The information in this section applies to USB dongle embedded CYW4319 devices with a USB interface.

After the NVRAM text file is modified (based on the board configuration), the Cypress MFGC manufacturing test tool can be used to convert the NVRAM text file to a serial format file (bcmvars.nvm).

The bcmvars.nvm file allows the USB test driver to be loaded with the specified NVRAM parameters, enabling the MFGC manufacturing test tool to run tests without writing the OTP content or hard-coding those NVRAM parameter variables in the driver.

The path to the bcmvars.nvm file nonvolitile memory file is specified in a SROMImagePath registry.

Note: The default location of the SROMImagePath registry is \SystemRoot\system32\drivers\ bcmvars.nvm.

5.3.2 Programming a Blank OTP Board

To program a blank OTP board, complete the following tasks in the following order:

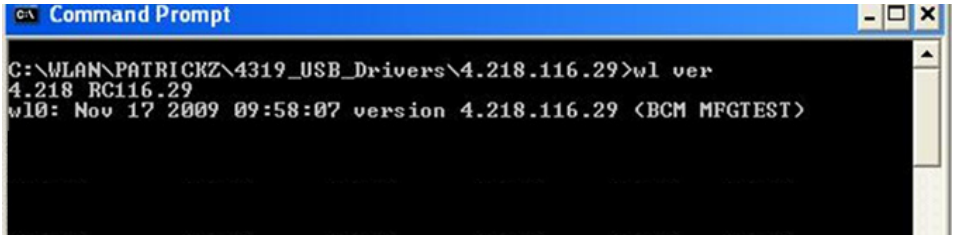
1. 5.3.2.1 Confirm OTP Is Blank (see page 11)
2. Develop and Verifiy PA Parameters on page 11
3. Locate the bcmvars.nvm File on page 12
4. Add MAC Address and Convert NVRAM Text File on page 14
5. Program Blank OTP on page 16
6. Verifiy OTP Programming on page 17

5.3.2.1 Confirm OTP Is Blank

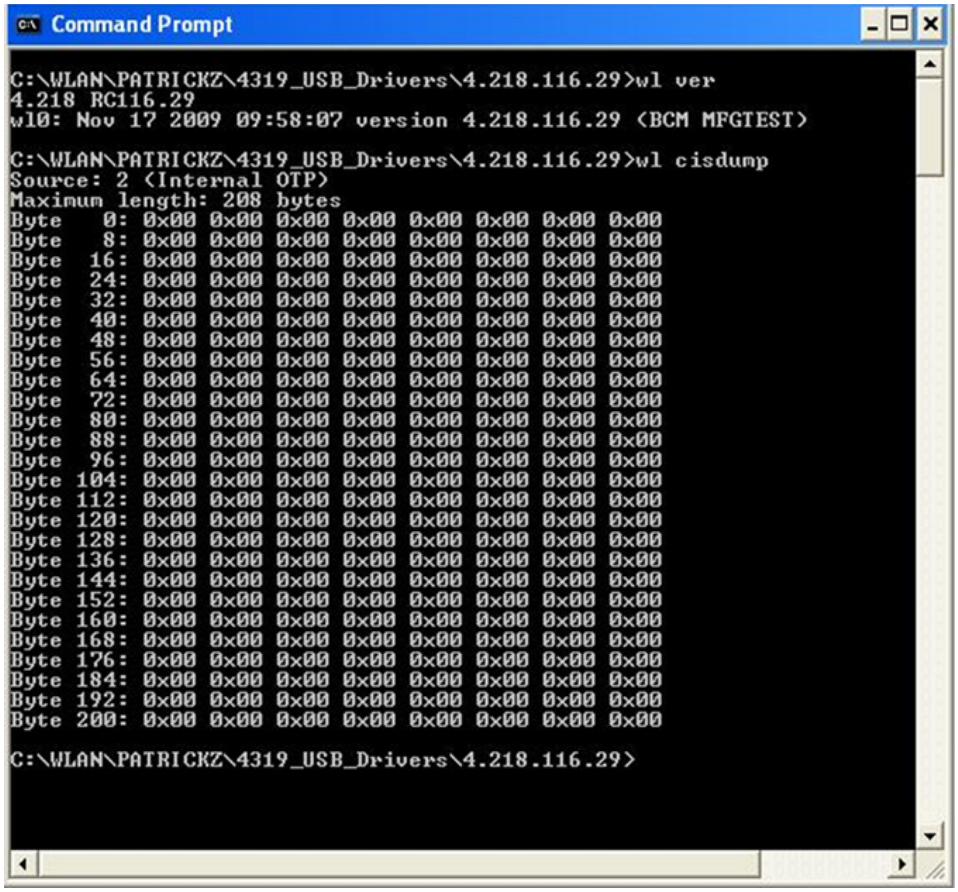
To verify the OTP is blank, complete these steps:

1. Under Network adapters in Device Manager, enable the device under test.
2. Open a Command Prompt window, go to the directory where the wl.exe utility is located, and then run the `wl ver` command to list the WL utility and USB driver versions.

Note: The first line in the response provides the WL utility version (i.e., 4.218 RC116.29), the second line provides the USB driver version (i.e., 4.218.116.29.)



3. Run the **wl cisdump** command to determine if content is present in the OTP (an internal CIS of blank OTP should be all zeros).



5.3.2.2 Develop and Verifiy PA Parameters

An appropriate TSSI calibration is required to optimize the PA parameters.

Note:

- The following options are available for obtaining TSSI calibrated PA parameters:
- Request assistance from the Cypress Applications Engineering team (for Cypress to provide assistance, customers must provide at least ten evaluation boards (with USB or JTAG access).

- Download the LabView TSSI calibration tool and generate the PA parameters (TSSI test tool, in LabView format, is available via the Cypress Customer Support Portal (CSP)).

To download software or to request technical support, go to the Cypress CSP at http://www.cypress.com/support

To request Cypress to optimize the PA parameters based on the information contained in customer-generated TSSI calibration log files, contact your Cypress engineering or technical representative (normally, technical support requests are submitted via Cypress'sCSP at http://www.cypress.com/support).

After receiving optimized PA parameters from Cypress (or using or LabView TSSI calibration), complete these steps:

1. Replace the following PA parameters in the nvram.txt file with the TSSI-calibrated values.

   ```
   pa0b0

   pa0b1

   pa0b2
   ```

2. Convert the nvram.txt file to the bcmvars.nvam file to make the updated PA parameters effective (for instructions, see Add MAC Address and Convert NVRAM Text File on page 14).
3. To verify the PA parameters, in the command window, navigate to the directory that contains the wl.exe file.
4. Run the following WL commands to make sure target output power is within ±1.5 dB of the value set by nvram.txt file:

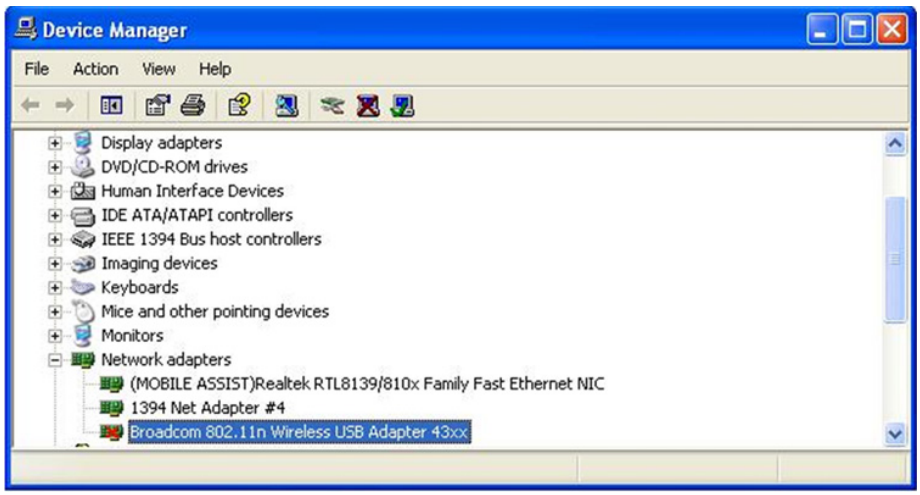
```
> wl mpc 0
> wl rate 54
> wl rateset 54b
> wl channel 1
> wl down
> wl up
> wl pkteng_start 00:22:33:44:55:66 tx 1000 1024 0
```

Note: Optionally, output power can be checked by using the MFGC manufacturing test tool to run a Power Detection (PD) test.

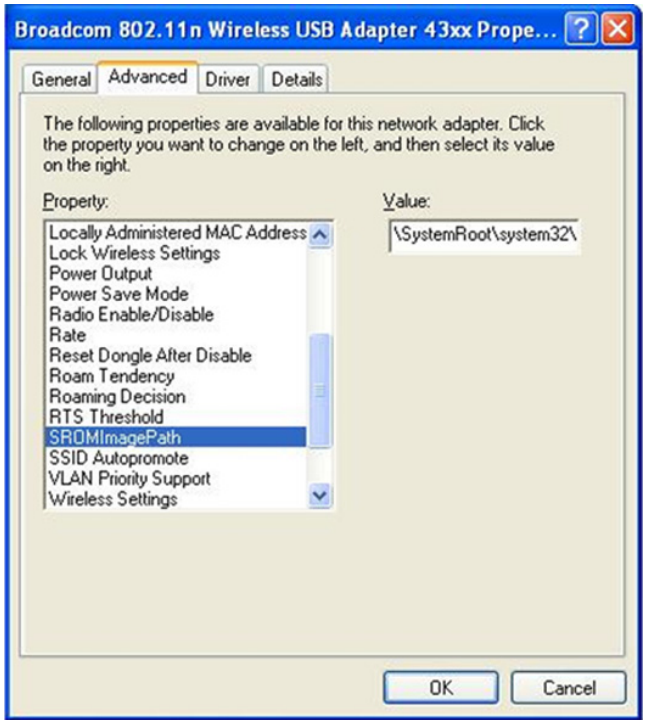
5.3.2.3 Locate the bcmvars.nvm File

To verify the location of the bcmvars.nvm file, complete these steps:

1. Under Network adapters in Device Manager, right-click **Cypress 802.11n Wireless USB Adapter 43xx**, and then choose **Properties**.



2. Click on the **Advanced** tab.



3. Under Property, click **SROMImagePath** to display the location of the bcmvars.nvm file (default location is \SystemRoot\system32\drivers\bcmvars.nvm).

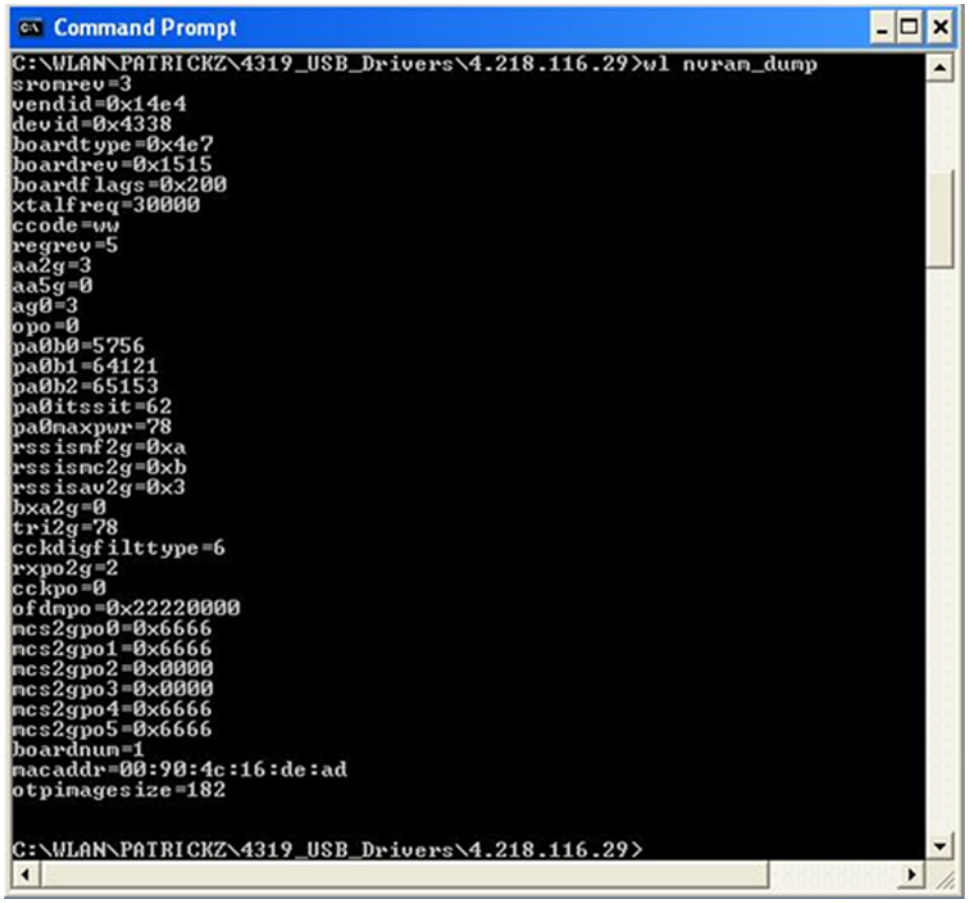
Note: The current CIS image uses the default bcmvars.nvm file located in the driver directory. To convert the verified nvram.txt file to bcmvars.nvm, see Add MAC Address and Convert NVRAM Text File on page 14.

4. Click **OK** to close the Properties window.

5.3.2.4 Add MAC Address and Convert NVRAM Text File

To convert the NVRAM text file to the bcmvars.nvm file, complete these steps:

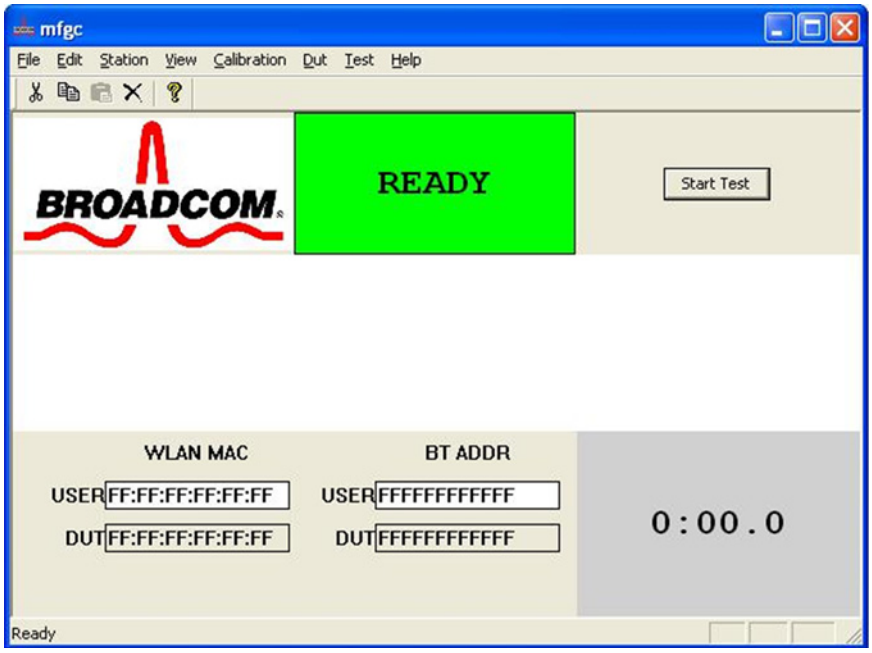
1. (Optional) To verify the NVRAM parameters before converting the NVRAM text file, open a command prompt window, go to the driver directory, and then run the **wl nvram_dump** command.



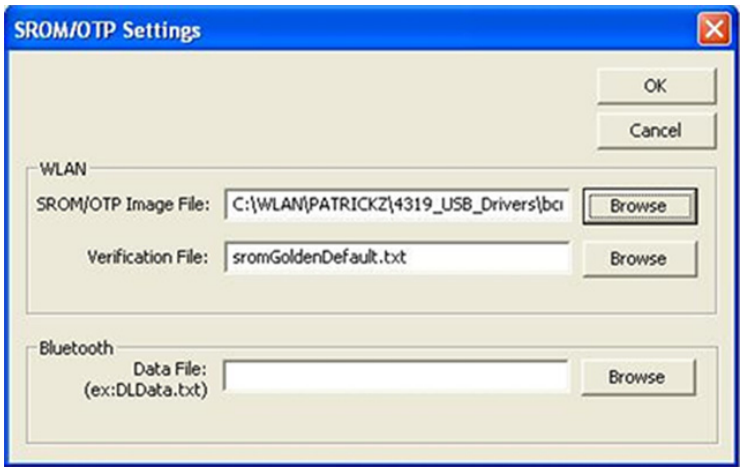
2. Launch the MFGC manufacturing test tool.
3. In the USER field (under WLAN MAC), enter the device's MAC address (for this case example, the MAC is 00:11:22:33:44:55).

Note: If the MAC address is not entered correctly, the MFGC manufacturing test tool cannot continue and returns an error message.

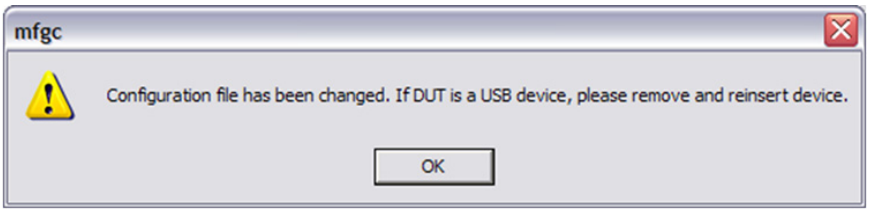
4. Click device under test (DUT) and select **SROM/OTP Settings**.



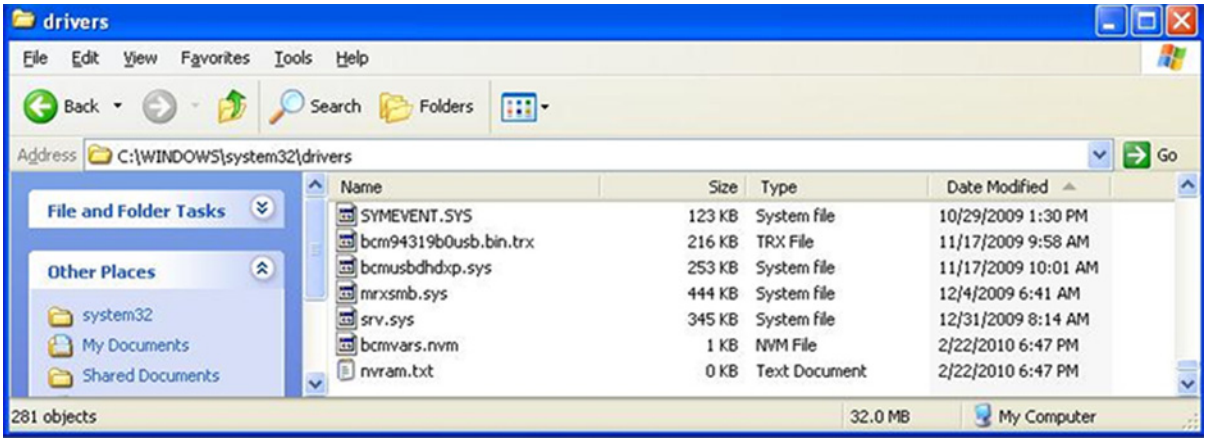
5. In the WLAN SROM/OTP Settings window, click the WLAN SROM/OTP Image FIle **Browse** button, and then navigate to the NVRAM text file path.



6. In the notification dialog that appears, click **OK**, then remove and reinsert the USB device (DUT) being tested.



7. In Windows Explorer, go to the C:\Windows\system32\drivers directory.
8. Check the timestamp of the bcmvars.nvm file to verify that it was just recently generated.



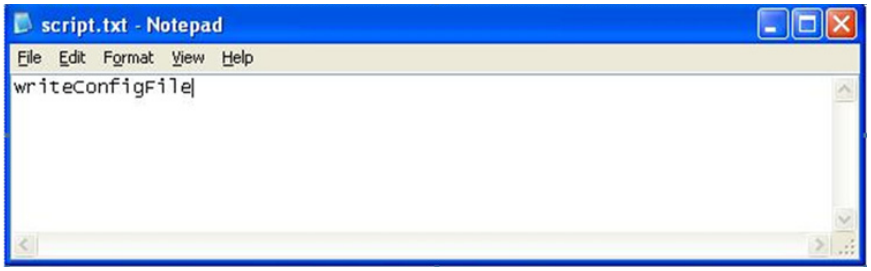
5.3.2.5 Program Blank OTP

To program the OTP using the MFGC manufacturing test tool, complete these steps:

1. In the MFGC manufacturing test tool, open the **Edit** edit menu, and then locate and open the script text file (script.txt).

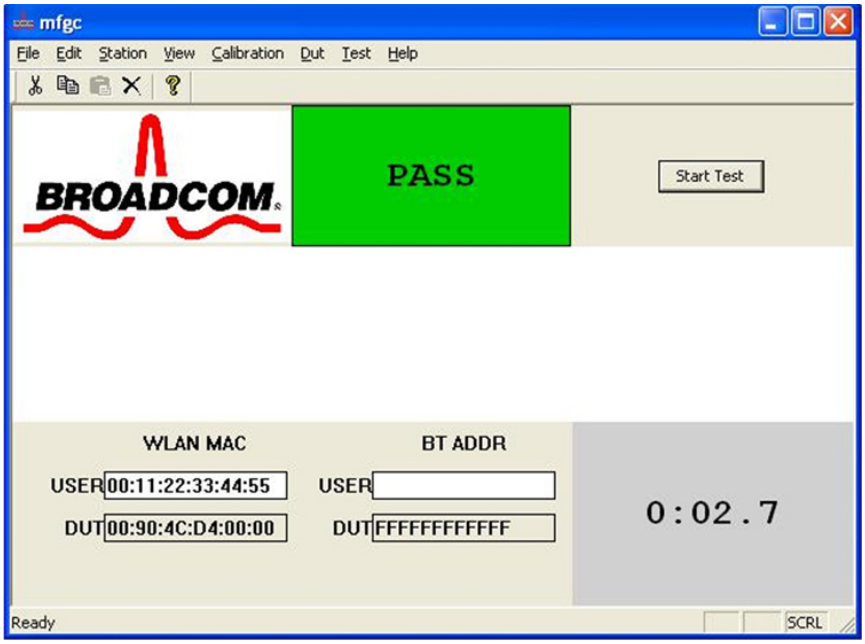
   The script.exe file opens in Notepad.

2. Verify that the script.exe file only contains one line for running the writeConfigFile command.



3. Click **Start Test** to write the NVRAM parameter values (including the MAC address) to the OTP.

4. To make the changes effective, after the test completes successfully (Pass), remove, and then reinsert the USB DUT.

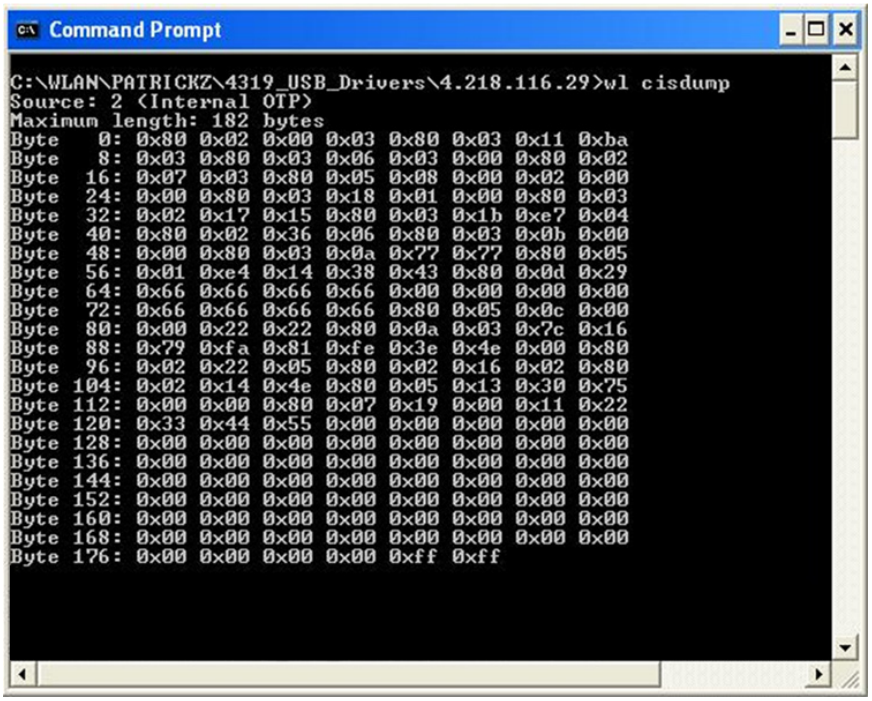


5.3.2.6 Verifiy OTP Programming

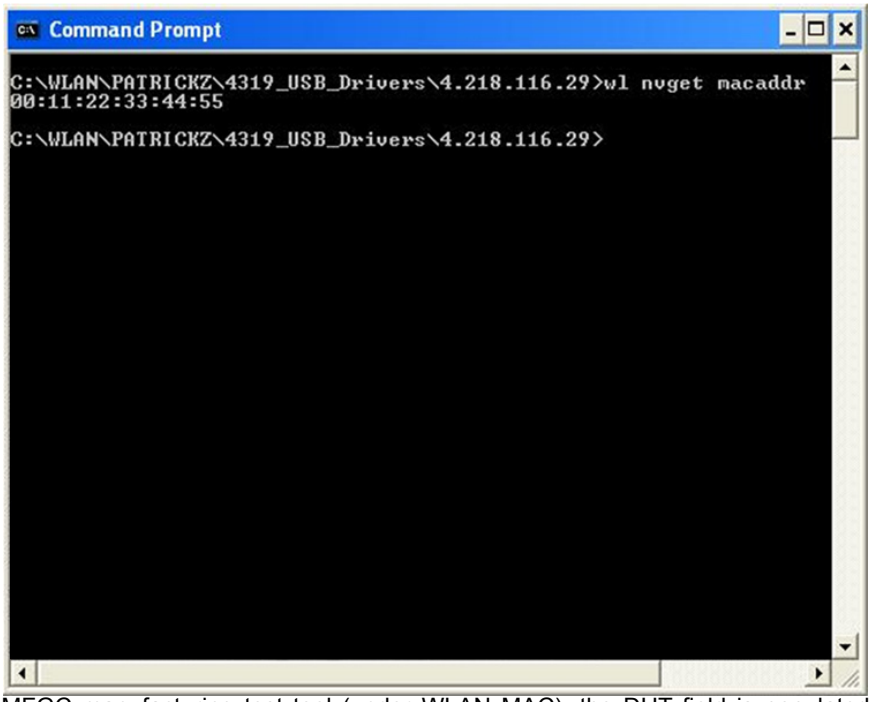
To write the MAC address to the OTP, complete these steps:

1. After the test completes successfully (Pass), remove and re-insert the USB DUT to make the changes effective.

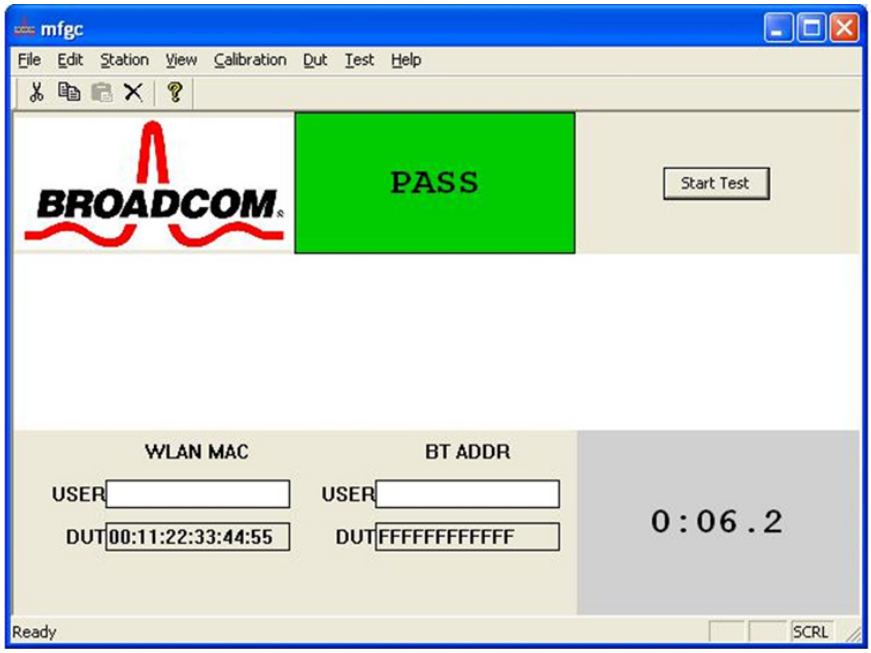
2. In the command prompt window, run the **wl cisdump** command and verify that the updated MAC address has been added to the previous OTP content (starting at the point where the OTP content ended).



3. Run the **wl nvget macaddr** command to retrieve the MAC address (from driver point of view).



In the MFGC manufacturing test tool (under WLAN MAC), the DUT field is populated with the updated MAC address.



Document History Page

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Rev.	**ECN No.**	**Orig. of Change**	**Submission Date**	**Description of Change**
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*A	5454387	UTSV	09/29/2016	Updated to Cypress template
*B	5882693	AESATMP9	09/13/2017	Updated logo and copyright.

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