
Pairing CMT2150A and CMT2250(1)A

Introduction

This document points out the important aspects and guides the user through the process of pairing the CMT2150A with CMT2250(1)A in the development phase using the RFPDK.

The user can read the following three application notes for the understanding of all the configurable parameters of each device:

- AN112 CMT2150A Configuration Guideline
- AN118 CMT2250A Configuration Guideline
- AN119 CMT2251A Configuration Guideline

The CMT2150A is a true single-chip, highly flexible, high performance, OOK RF transmitter with embedded data encoder ideal for 240 to 480 MHz wireless applications.

The CMT2250A is a true single-chip, ultra low power and high performance device that consists of an OOK RF receiver, a data decoder and 4 data output pins for various 300 to 480 MHz wireless applications, while the CMT2251A is a true single-chip, ultra low power and high performance device that consists of an OOK RF receiver, a data decoder and 1 PWM output pin for various 300 to 480 MHz wireless applications. The decoder supports 1920, 1527 and 2262 formats.

These three devices are part of the CMOSTEK NextGenRF™ family, which includes a complete line of transmitters, receivers and transceivers.

The RFPDK (Radio Frequency Products Development Kit) is a PC application developed by CMOSTEK for the NextGenRF™ product line. Differing from traditional RF chip configuration methods, which usually require complex software programming and register-based controlling, the RFPDK revolutionarily simplifies the NextGenRF™ product configurations. The user can easily complete the product configuration by just clicking and inputting a few parameters. After that, the product can be directly used in the RF system without performing any further configurations.

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1. RF Settings

The following figures show the RF Settings parameters for the devices.

RF Settings			
Frequency(240-480) <input type="text" value="433.92"/> MHz	Modulation <input type="text" value="OOK"/>	TX Power <input type="text" value="-13"/> dBm	Xtal Cloud <input type="text" value="15.00"/> pF
Symbol Rate (0.5-40.0) <input type="text" value="4.8"/> ksps	LED Driving Capability <input type="text" value="5"/> mA	PA Ramping Time <input type="text" value="0"/> us	LBD Threshold <input type="text" value="2.4"/> V

Figure 1. CMT2150A RF Settings

RF Settings			
Frequency (300-480) <input type="text" value="433.92"/> MHz	Demodulation <input type="text" value="OOK"/>	Symbol Rate (0.1-40.0) <input type="text" value="4.8"/> ksps	Xtal Tolerance (0-200) +/- <input type="text" value="20"/> ppm
Xtal Stabilizing Time <input type="text" value="310"/> us			

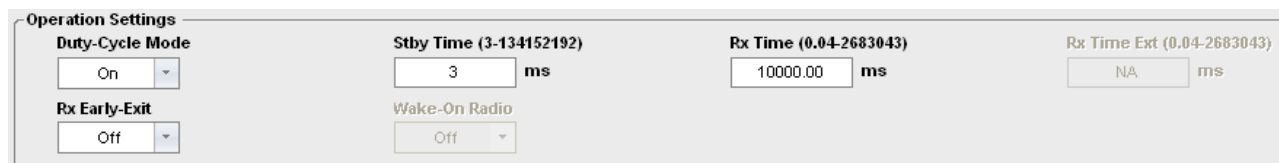
Figure 2. CMT2250(1)A RF Settings

The user should do the following:

- Set the Frequency to the same on the two devices.
- Set the Symbol Rate to the same on the two devices.
- Setup the other parameters according to the system requirements.

2. Operation Settings

The Operation Settings are only available on the receiver, as shown below:



Operation Settings			
Duty-Cycle Mode	Stby Time (3-134152192)	Rx Time (0.04-2683043)	Rx Time Ext (0.04-2683043)
On	3 ms	10000.00 ms	NA ms
Rx Early-Exit	Wake-On Radio		
Off	Off		

Figure 3. CMT2250(1)A Operation Settings

The goal of setting up the operation settings is to reduce the power consumption of the receiver while it guarantees the quality and reliability of the reception.

The user should do the following:

- If the power consumption on the CMT2250(1)A is not an important issue, use the default values of these parameters.
- If the power consumption on the CMT2250(1)A is an important issue, calculate the length of the entire packet sent by the CMT2150A according to the selected symbol rate, encoding format and bit format, then start the calculation of the Sleep Time and Rx Time introduced in Chapter 3 of AN118.
- If Wake-On Radio (WOR) must be used to meet the power consumption requirement of the receiver, use CMT2110A with an external MCU to pair with the CMT2250(1)A. This is because the WOR is triggered by preamble detection, only a significantly long preamble sent by the MCU can satisfy the duty-cycle timing requirement. Please read Chapter 3 of AN118 for details.
- Please also use the spreadsheet "Duty Cycle Calculator.xlsx" to assist the calculation. The calculator can be obtained on the RFPDK or downloaded from CMOSTEK official website.

3. OOK Settings

The OOK Settings are only available on the receiver, as shown below:



The screenshot shows the OOK Settings configuration window. It contains the following fields and controls:

- Demod Method:** A dropdown menu with "Peak TH" selected.
- Fixed Demod TH (0-255):** A text input field containing "NA".
- Peak Drop:** A dropdown menu with "On" selected.
- Peak Drop Step:** A dropdown menu with "2" selected.
- Peak Drop Rate:** A dropdown menu with "1 step/4 symbols" selected.

Figure 4. CMT2250(1)A OOK Settings

The user should do the following:

- Use the default values because they fulfill most of the application requirements.

4. Encode and Decode Settings

The Encode Settings are available on the transmitter and the Decode Settings are available on the receiver. The user should do the following:

- Count how many data output pins are required on the Rx side, if more than 4 output pins are used, please use CMT2210A with an external MCU to pair with the CMT2150A.
- Decide which encoding/decoding format to be used, 1920, 1527 or 2262. See the below tables for the features comparison. The highlighted ones are different in the Tx and Rx due to that the number of data output pins on the Rx side is no more than 4. Do not use 2262 if ID Study is required in the application.

Table 1. Feature Summary of the 3 Encoding Formats in CMT2150A

Format	Bit Format	Sync ID Length	Data Length	CRC	ID Study	Button Mode
1920	3/4/5/6 sym/bit	1 – 32 bits	1 – 8 bits	Support	Support	All
1527	4 sym/bit	20 bits	1 – 8 bits	NA	Support	All
2262	8 sym/bit	6 – 11 bits	1 – 6 bits	NA	Not Support	Normal Mode

Table 2. Feature Summary of the 3 Decoding Formats in CMT2250(1)A

Format	Bit Format	Sync ID Length	Data Length	CRC	ID Study	Wake-On Radio
1920	3/4/5/6 sym/bit	1 – 32 bits	4 bits	Support	Support	Support
1527	4 sym/bit	20 bits	4 bits	NA	Support	Not Support
2262	8 sym/bit	8 – 11 bits	1 – 4 bits	NA	Not Support	Not Support

It is always recommended to use 1920 format because it has the following advantages:

- The maximum Sync ID Length is 32, less ID collision exist in the market.
- The Bit Format can be set to 3 symbols per bit, which make the packet length shorter, and therefore save the power.
- CRC can be used to increase the reliability of the communication.
- All button modes are supported on the CMT2150A.
- Wake-On Radio (WOR) is supported on CMT2250(1)A to ultimately save the power. If it is used, use CMT2110A with an external MCU to pair with the CMT2250(1)A.

The following sub-sections point out what should be noticed when pairing the devices using each of these 3 formats.

4.1 1920

The below show the encoding and decoding settings of 1920 for CMT2150A and CMT2250(1)A. Please note that the packet structures are exactly the same in CMT2250A and CMT2251A.

Encode Settings

Encoder

1920

1527

2262

Preamble	Head_ID	Address (Sync ID)		D0	D1	D2	D3	D4	CRC
		Length (1-32)	Value (0-4294967295)						
None	32-symbol	32-bit	0	1-bit	1-bit	1-bit	1-bit	1-bit	8-symbol

Bit Format sym/bit

Packets Interval (0-255) symbols of zero

Figure 5. 1920 Encoding Setting in CMT2150A

Decode Settings

Decoder

1920

1527

2262

Preamble	Head_ID	Address (Sync ID)		D0	D1	D2	D3	CRC
		Length (1-32)	Value (0-4294967295)					
None	32-symbol	32	0	1-bit	1-bit	1-bit	1-bit	Disable

Data Pin Reset Code = D0 D1 D2 D3

Bit Format sym/bit

Valid Reception packet(s)

Pulse Mode

Pulse Time (1-16383) ms

Figure 6. 1920 Decoding Setting in CMT2250A

Decode Settings

Decoder

1920

1527

Preamble	Head_ID	Address (Sync ID)		D0	D1	D2	D3	CRC
		Length (1-32)	Value (0-4294967295)					
None	32-symbol	32	0	1-bit	1-bit	1-bit	1-bit	Disable

Bit Format sym/bit

Valid Reception packet(s)

PWM Rate kHz

PWM Default Ratio (0.0-100.0) %

PWM Step Size (0.0-50.0) %

Figure 7. 1920 Decoding Setting in CMT2251A

The user should do the following:

- If Wake-On Radio is not used, leave the Preamble to "None" on both of the Tx and Rx side.
- Set the Sync ID Length to the same on the Tx and Rx side according to the application requirements.
- Set the Sync ID Value to the same on the Tx and Rx side. To experience the ID Study function (See Chapter 5), the Sync ID Value can be set to different on the Tx and Rx side.
- Enable/disable the CRC validation on the CMT2250(1)A according to the application requirements. Enabling it makes the communication more reliable.
- Set the Bit Format to "3 sym/bit" on both of the Tx and Rx side unless particular requirements exist.

- Leave the Data Inversion to “No” on the CMT2150A. It can only be set to “Yes” while CMT2150A is not paired with CMT2250(1)A.
- Leave the Packets Interval to “0 symbols of zero” on the CMT2150A unless particular requirements exist.
- While pairing CMT2150A with CMT2250A, set the Data Pin Reset Code to all 0 on CMT2250A when the Button Mode (see Chapter 6) is not set to “Normal” on CMT2150A. If Normal Button Mode is used on CMT2150A, define this code to a non-zero value according to the application requirements.
- Set the Valid Reception to “2 Packets” on CMT2250A and “1 Packets” on CMT2251A unless particular application requirements exist.
- Setup the other parameters according to the application requirements.

4.2 1527

The below show the encoding or decoding settings of 1527 for CMT2150A and CMT2250(1)A. Please note that the packet structures are exactly the same in CMT2250A and CMT2251A.

Encode Settings

Encoder

1920

1527

2262

Sync	Address (Sync ID)		D0	D1	D2	D3
	Length	Value (0-1048575)				
32-symbol	20-bit	0	1-bit	1-bit	1-bit	1-bit

Bit Format: sym/bit

Packets Interval (0-255): symbols of zero

Figure 8. 1527 Encode Settings in CMT2150A

Decode Settings

Decoder

1920

1527

2262

Sync	Address (Sync ID)		D0	D1	D2	D3
Tolerance	Length	Value (0-1048575)				
+/- 13 symbols	20-bit	0	1-bit	1-bit	1-bit	1-bit

Data Pin Reset Code = D0 D1 D2 D3

Bit Format: sym/bit

Valid Reception: packet(s)

Pulse Mode:

Pulse Time (1-16383): ms

Figure 9. 1527 Decode Settings in CMT2250A

Decode Settings

Decoder

1920

1527

Sync	Address (Sync ID)		D0	D1	D2	D3
Tolerance	Length	Value (0-1048575)				
+/- 13 symbols	20-bit	0	1-bit	1-bit	1-bit	1-bit

Bit Format: sym/bit

PWM Rate: kHz

Valid Reception: packet(s)

PWM Default Ratio (0.0-100.0): %

PWM Step Size (0.0-50.0): %

Figure 10. 1527 Decode Settings in CMT2251A

The user should do the following:

- Leave the Sync Tolerance to “+/- 13 symbols” on the CMT2250(1)A unless particular requirements exist.
- Set the Sync ID Value to the same on the Tx and Rx side. To experience the ID Study function (See Chapter 5), the Sync ID Value can be set to different on the Tx and Rx side.
- Leave the Data Inversion to “No” on the CMT2150A. It can only be set to “Yes” while CMT2150A is not paired with CMT2250(1)A.
- Leave the Packets Interval to “0 symbols of zero” on the CMT2150A unless particular requirements exist.
- While pairing CMT2150A with CMT2250A, set the Data Pin Reset Code to all 0 on CMT2250A when the Button Mode (see Chapter 6) is not set to “Normal” on CMT2150A. If Normal Button Mode is used on CMT2150A, define this code to a non-zero value according to the application requirements.
- Set the Valid Reception to “2 Packets” on CMT2250A and “1 Packets” on CMT2251A unless particular application requirements exist.
- Setup the other parameters according to the application requirements.

4.3 2262

The below show the encoding or decoding settings of 2262 for CMT2150A and CMT2250A.

Encode Settings

Encoder

1920

1527

2262

Address (Sync ID)		D3	D2	D1	D0	Sync
Length (6-11)	Value					
8-bit	00000000	1-bit	1-bit	1-bit	1-bit	32-symbol

Bit Format: sym/bit

Packets Interval (0-255): symbols of zero

Figure 11. 2262 Encode Settings in CMT2150A

Decode Settings

Decoder

1920

1527

2262

Address (Sync ID)		D3	D2	D1	D0	Sync
Length (8-11)	Value					Tolerance
8	bit(s) 00000000	1-bit	1-bit	1-bit	1-bit	+/- 13 symbols

Data Pin Reset Code = D0 D1 D2 D3

ID Study Pulse Mode Pulse Time (1-16383) ms

Figure 12. 2262 Decode Settings in CMT2250A

The user should do the following:

- Set the Sync ID Length to the same on both of the Tx and Rx side.
- Set the Sync ID Value to the same on the Tx and Rx side. To experience the ID Study function (See Chapter 5), the Sync ID Value can be set to different on the Tx and Rx side.
- Leave the Sync Tolerance to “+/- 13 symbols” on the CMT2250A unless particular requirements exist.
- Leave the Data Inversion to “No” on the CMT2150A. It can only be set to “Yes” while CMT2150A is not paired with CMT2250A.
- Leave the Packets Interval to “0 symbols of zero” on the CMT2150A unless particular requirements exist.
- While pairing CMT2150A with CMT2250A, set the Data Pin Reset Code to all 0 on CMT2250A when the Button Mode (see Chapter 6) is not set to “Normal” on CMT2150A. If Normal Button Mode is used on CMT2150A, define this code to a non-zero value according to the application requirement.
- Setup the other parameters according to the application requirements.

5. Study Settings

The Study Settings are available on CMT2150A and CMT2250(1)A. They are different but related.

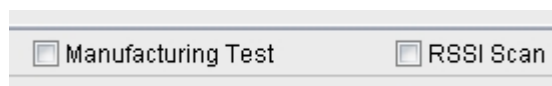
Figure 13. CMT2150A Study Settings

Figure 14. CMT2250(1)A Study Settings

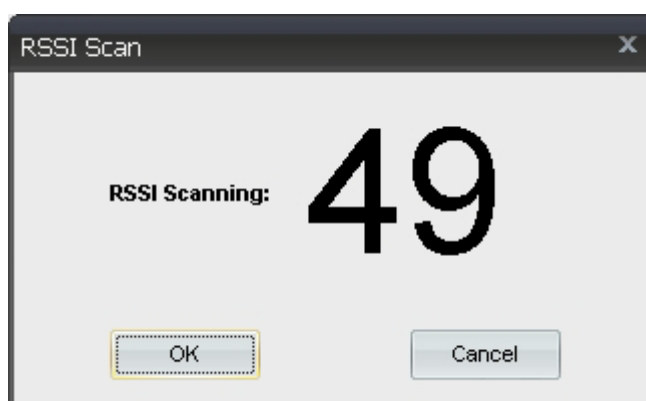
The user should do the following:

- Understanding these parameters by reading Chapter 5 of AN112 and Chapter 6 of AN118. Remember that the ID Study is only supported in 1920 and 1527 mode.
- Set the ID Study to “On” in both of the Tx and Rx side.
- Leave the Factory Code to “Not Support” unless a factory code is assigned to the user by CMOSTEK.
- Choose which button is used to trigger the study in Study Button on the CMT2150A
- Leave the Study Time to “5 seconds” on the CMT2150A unless particular requirements exist.
- Leave the Study Time Window to “20 seconds” on the CMT2250(1)A unless particular requirements exist. If other value is used, it must be ensured that the value is at least 5 seconds longer than the Study Time configured on the CMT2150A.
- The Study Power on CMT2150A and Study RSSI TH on CMT2250(1)A are used to adjust the communication distance between the Tx and the Rx during the study process. The proper values can be obtained by on-field testing with the application dependent PCB design and antenna used. The following methodology can be used to setup these 2 parameters. It assumes that the other parameters are all properly paired on the Tx and Rx side.

1. Set the **TX Power** and the **Study Power** to “-6 dBm” on the CMT2150A. Note that this is only for the purpose of adjusting the distance. In normal application, the **TX Power** is not necessarily identically to the **Study Power**.
2. Connect CMT2250(1)A to the USB Programmer, open the RFPDK, select the “RSSI Scan” on the top as shown below:



3. An RSSI Scan window pops up as shown below.



4. As long as the user stay in this window, the CMT2250(1)A enters the receive state and dynamically scan the real-time RSSI level that has the range from 0 to 255. The RFPDK immediately reflects the value of RSSI on the screen.
 5. Hold the offline CMT2150A device which has been successfully burned, press the button(s) to continuously transmit the data, move away from the CMT2250(1)A, the RSSI level shall decrease while the distance between the 2 devices increases.
 6. Find out how the RSSI changes with the distance. Choose a desired distance and record the RSSI level shown on the screen, click OK to exist the RSSI scan.
 7. The recorded RSSI level is the desired **Study RSSI TH** on the CMT2250(1)A. Once it is burned into the device, if the distance is too long during the ID Study, the RSSI detected by the device will be lower than the threshold and therefore the ID Study will be disallowed.
 8. If it is found that the RSSI drops to a very low value before reaching the desired distance, go back to Step 1 and increase the **TX Power** and the **Study Power** on the CMT2150A, then try Step 2 to 7 again. If it is found that in a very long distance the RSSI value is still very large shown on the screen, go back to Step 1 and decrease the **TX Power** and the **Study Power** on the CMT2150A, then try Step 2 to 7 again. Ultimately the desired **Study Power** can be obtained.
 9. Last but not the least, when the test is finished, the **TX Power** no longer needs to be identical to the **Study Power**.
- Do the following steps to experience the ID Study:
 1. Use either 1920 or 1527 mode, burn the same Sync ID value into the Tx and Rx. Other parameters should all be

properly configured. Power up the 2 devices and make sure they are successfully paired and can be communicated. Also, make sure the Study Power on the CMT2150A and Study RSSI TH on the CMT2250(1)A are set to the desired values so that the distance for ID Study is known.

2. Reconnect the devices to the RFPDK, use either 1920 or 1527 mode, burn different Sync ID value into the Tx and Rx. However, the Sync ID Length must be the same. Other parameters should all be properly configured. Remember which button on the CMT2150A is defined as the Study Button.
3. Remove the devices from the USB programmer. Power up the CMT2150A first, then power up the CMT2250(1)A. Remember that after the CMT2250(1)A is power up, the Study Time Window limit the time for ID Study. If it is set to a relatively short time, the user should immediately perform the next step.
4. Make sure the two devices are placed within the distance which is determined by the Study Power on the CMT2150A and Study RSSI TH on the CMT2250(1)A. Press the study button on the CMT2150A and hold it for over the Study Time, the study packets will be transmitted and captured by the CMT2250(1)A.
5. Release the study button. Press any of the effective buttons defined on the CMT2150A, if the ID Study is successful the CMT2250(1)A shall response to that immediately.

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6. Push Button Settings

The Push Button Settings are only available on the receiver, as shown below:

Push Button Settings

Button Mode

Data Inversion

On/Off Button(s)

Number of Button(s)

Buttons Assignment

LED	<input checked="" type="checkbox"/>	LED	1	<input type="checkbox"/>	14	XTAL	<input checked="" type="checkbox"/>	XTAL
VDD	<input checked="" type="checkbox"/>	VDD	2	<input type="checkbox"/>	13	CLK	<input checked="" type="checkbox"/>	CLK
GND	<input checked="" type="checkbox"/>	GND	3	<input type="checkbox"/>	12	K0	<input checked="" type="checkbox"/>	D0
RFO	<input checked="" type="checkbox"/>	RFO	4	<input type="checkbox"/>	11	K1	<input checked="" type="checkbox"/>	D1
NC	<input checked="" type="checkbox"/>	K7	5	<input type="checkbox"/>	10	K2	<input checked="" type="checkbox"/>	D2
NC	<input checked="" type="checkbox"/>	K6	6	<input type="checkbox"/>	9	K3	<input checked="" type="checkbox"/>	D3
NC	<input checked="" type="checkbox"/>	K5	7	<input type="checkbox"/>	8	K4	<input checked="" type="checkbox"/>	NC

Periodic Transmission OFF ON

Periodic Time (0.002-7683.512 s) s

Number of Packets (1-256)

Figure 15. CMT2150A Push Button Settings

The user should do the following:

- Remember that 1920 and 1527 support 4 button modes, while 2262 only support “Normal” button mode.
- Remember that in “Normal” button mode, 2262 has different K to D mapping from the 1920 and 1527.
- The Normal, Toggle and Matrix button modes of CMT2150A are designed for pairing with CMT2250A, while the PWM button mode is designed for pairing with CMT2251A.
- Remember that for 1920 and 1527, the Number of Button(s) can only be configured when the Button Mode is set to “Normal”. When pairing with CMT2250(1)A, the number of button must be set to 4, which also set the number of data bits to 4 in the packet.
- Remember that for 2262, the Number of Button(s) cannot be configured; instead it is determined by the number of data bits which is determined by the Sync ID Length in the Encode Settings.
- Remember that the Data Pin Reset Code must be set to all 0 on CMT2250A when the Button Mode is not set to “Normal” of CMT2150A.
- Remember that only in “Normal” button mode the Periodic Transmission can be turned on. Once it is turned on, the transmitted data D0, D1, D2 and D3 is fixed at 1110. If ID study is turned on, K3 is used as study button. Also, only CMT2250A is able to pair with CMT2150A while using the periodic transmission. The **Pulse Mode** of CMT2250A must be used and the **Pulse Time** must be set shorter than the **Periodic Time** of CMT2150A.
- Remember that when the CMT2250(1)A and CMT2150 is connected to the USB Programmer, they are in the configuration mode in which the normal functions cannot be seen. After the configuration the USB Programmer must be removed to allow the devices to work properly.

7. Manufacturing Test

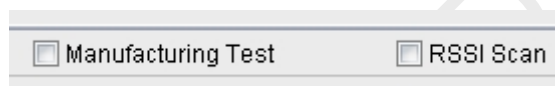
The manufacturing test mode is designed to test the CMT2250(1)A during the manufacturing phase. There are two methods to perform the manufacturing test:

- Dout Observation – can be applied to CMT2250A and CMT2251A.
- LED Flashing – can be applied to CMT2250A.

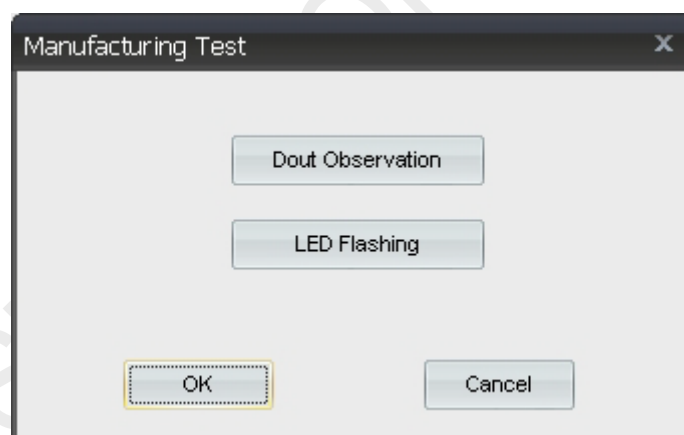
RFPDK allow the user to experience these two methods in the lab.

To experience the **Dout Observation** method, the user should do the following:

1. Use the CMT2110A with an external MCU to build a transmitter for testing. Set the symbol rate of the transmitter to 0.8 ksps, let it continuously transmit a preamble-like data of 10101010....
2. Connect CMT2250(1)A to the USB Programmer, open the RFPDK, select the “Manufacturing Test” on the top as shown below:



3. A Manufacturing Test window pops up as shown below. Click on the “Dout Observation” button:



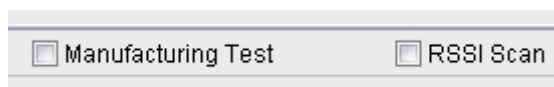
4. The “Dout Observation” fixes the symbol rate of the CMT2250A to around 0.8 ksps regardless of its original configurations.
5. Use a logic analyzer to monitor the pin DATA0 of CMT2250A or pin PWM of CMT2251A. The demodulated data of 10101010... should be sent out on these pins if the devices work properly.
6. Exit the test by clicking OK on the window. The device will be reset back to its original configurations.

To experience the **LED Flashing** method, the user should do the following:

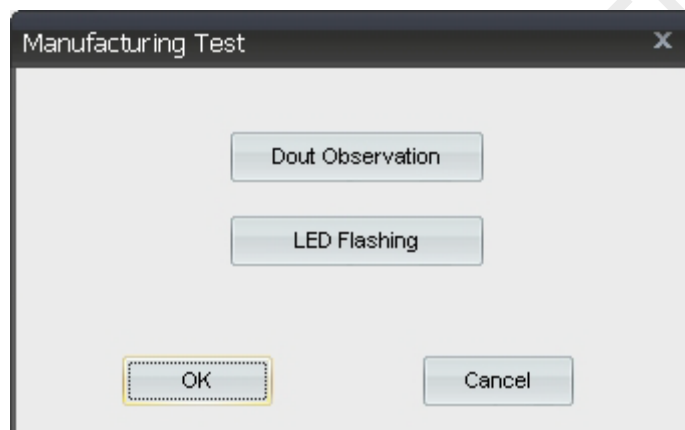
1. Pair the CMT2150A and CMT2250A. Set the **Sync ID Value** of CMT2150A to its maximum value. For example, if the

Sync ID Length of 1920 format is 24 bits, the value should be $2^{24} - 1 = 16777215$; if the **Sync ID length** in 2262 format is 8 bit, the value should be 11111111. The **Sync ID** of CMT2250A is not necessarily set to the same to that of CMT2150. This is because the manufacturing of the devices are usually done prior to the ID study. Once entering the LED Flashing manufacturing test mode, the CMT2250A only responds to the CMT2150A that contains a **Sync ID** described above. Therefore, as long as the other parameters are properly configured, any CMT2250A devices can be tested without pairing the **Sync ID**.

2. Connect CMT2250A to the USB Programmer, open the RFPDK, select the “Manufacturing Test” on the top as shown below:



3. A Manufacturing Test window pops up as shown below. Click on the “LED Flashing” button:



4. The “LED Flashing” enables the Pulse Mode on the CMT2250A and fixes the Pulse Time to 10 ms, regardless of its original configurations.
5. Connect DATA0 – DATA3 of CMT2250A to 4 LEDs. Press any valid button(s) on the CMT2150A, the corresponding LED(s) will flash at the rate of 100 Hz. Please note that the responding LED(s) are determined by the **Button Mode** of the CMT2150A.
6. Exit the test by clicking OK on the window. The device will be reset back to its original configurations.

8. Document Change List

Table 3. Document Change List

Revision	Chapter	Description of Changes	Date
0.8		Initial released version	2014-07-29
1.0		-	2014-08-13

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9. Contact Information

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