CMOSTEK

AN112

CMT2150A Configuration Guideline

Introduction

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 chip is part of the 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 RFPKD 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.

This document describes the details of how to configure the features/parameters of the CMT2150A with the RFPDK.

To help the user to develop their application with CMT2150A and CMT2250/51A easily, CMOSTEK provides **CMT2150A/2250(1)A One-Way RF Link Development Kits** that enables the user to quickly evaluate the performance, demonstrate the features and develop the application. The Development Kits includes:

- RFPDK
- USB Programmer
- CMT2150A-EM (Tx module)
- CMT2250A-EM (Rx on-off control module)
- CMT2251A-EM (Rx PWM control module)

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1. Getting Started

Install the RFPDK on the PC. The details of the installation can be found in Section 7.1 of "AN113 CMT2150A/2250(1)A One-Way RF Link Development Kits User's Guide".

Setup the Development Kits as shown in Figure 1 before configuring the CMT2150A. The application with CMT2150A can be CMT2150A-EM V1.0 provided by CMOSTEK, or PCB designed by the user with CMT2150A.

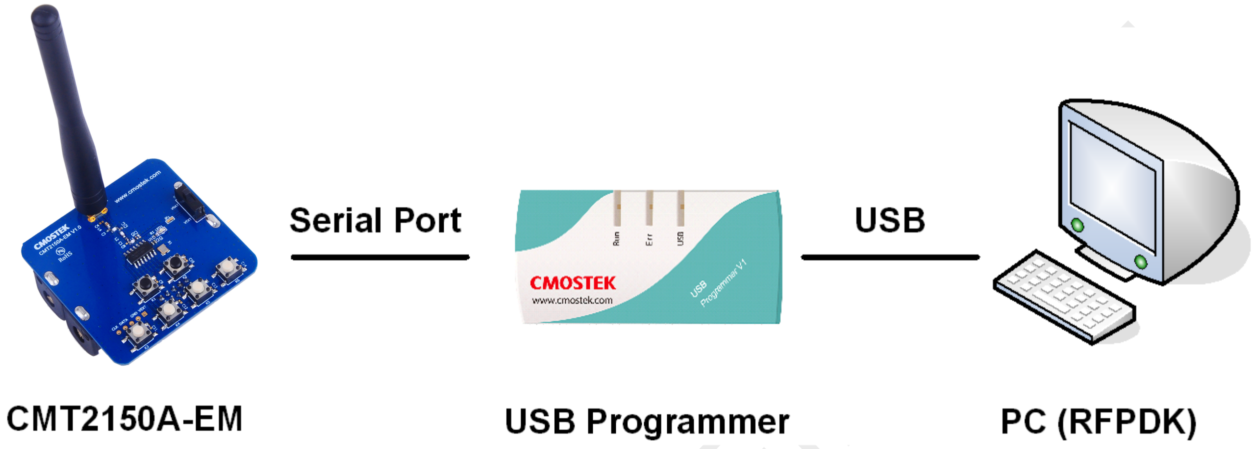

Figure 1. CMT2150A Configuration Setup

Start the RFPDK from the computer's desktop and select CMT2150A in the Device Selection Panel shown in Figure 2. Once a device is selected, the Device Control Panel appears as shown in Figure 3. Because the Advanced Mode covers all the configurable features / parameters while the Basic Mode only contains a subset, the Advanced Mode is described in this document.

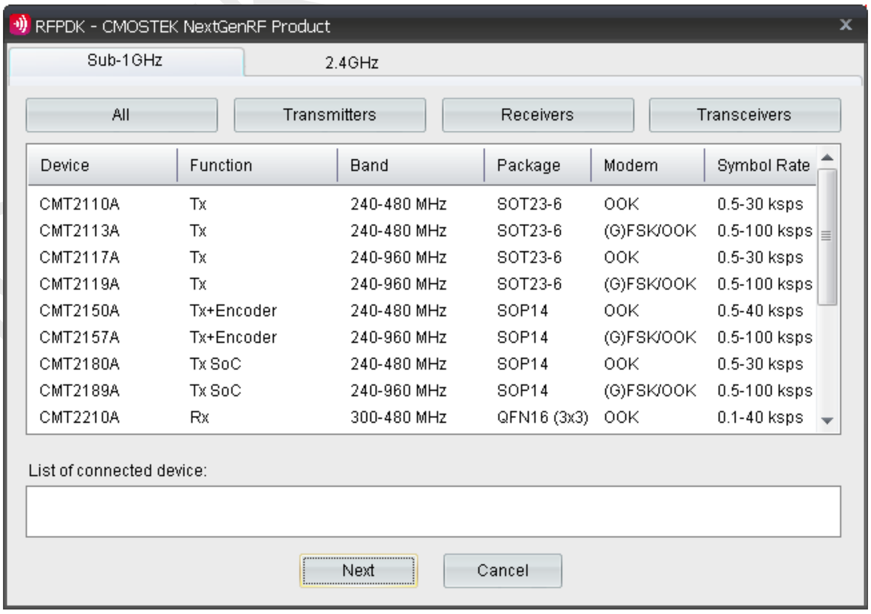

Figure 2. Device Selection Panel

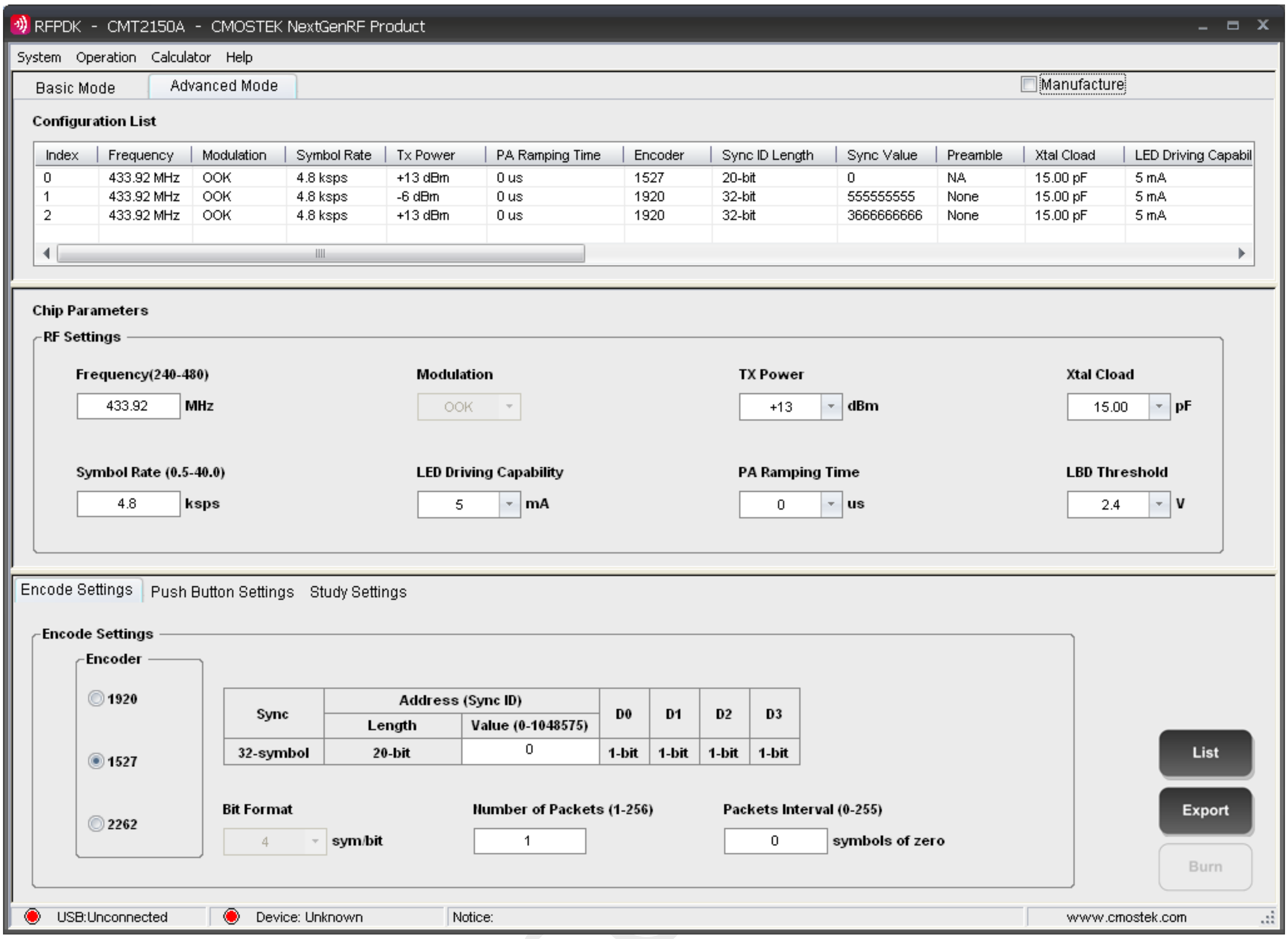

Figure 3. Advanced Mode of Device Control Panel

2. RF Settings

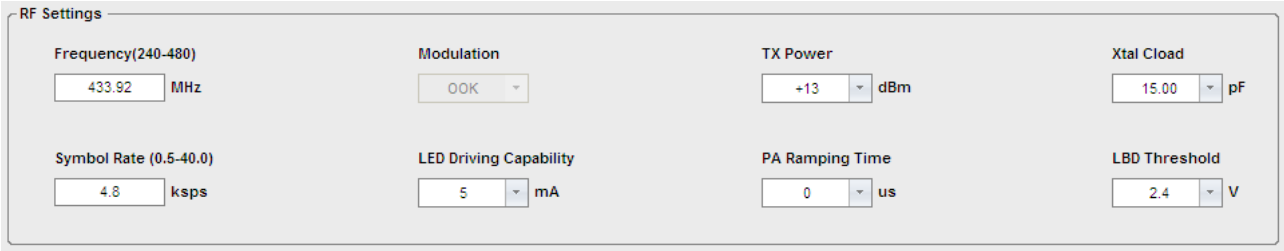

Figure 4. RF Settings

Table 1. RF Settings Parameters

Parameter	Descriptions	Default	Mode
Frequency[1]	To input a desired transmitting radio frequency in the range from 240 to 480 MHz.	433.92 MHz	Basic Advanced
Tx Power[2]	To select a proper transmitting output power from -10 dBm to +14 dBm, 1 dB margin is given above +13 dBm.	+13 dBm	Basic Advanced
Symbol Rate	The transmit symbol rate, the range is from 0.5 to 40.0 ksps, with resolution of 0.1 ksps.	4.8 ksps	Basic Advanced
Xtal Load[3]	On-chip XOSC load capacitance options: from 10 to 22 pF.	15 pF	Basic Advanced
PA Ramping	To control PA output power ramp up/down time, options are 0 and 2^n us (n from 0 to 10).	0 us	Advanced
LED Driving Capability	This defines the driving current of the LED pin. The options are: Disable, 5, 10, 15 or 20 mA.	5 mA	Advanced
LBD Threshold	This defines the Low Battery Detection threshold. The options are: Disable, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7 or 2.8 V.	2.4 V	Advanced

Notes:

[1]. CMT2150A RF frequency resolution is better than 198 Hz.

[2]. Proper PA matching network is required, see “AN111 CMT2150A Schematic and PCB Layout Design Guideline” for details of recommended matching network.

[3]. Recommended Xtal load capacitance is 12 to 20 pF. 2 pF margin is given in both ends in order to ensure the recommended load capacitance can be covered.

2.1 Frequency and Tx Power

The Frequency can be continuously configured from 240 to 480 MHz accurate to two decimal places. Tx Power can be configured from -10 dBm to +14 dBm in 1 dBm step size. The actual output power could be slightly different due to the user’s PCB layout and the components used for matching network differing from CMOSTEK’s recommendations. Therefore, the user should select the proper value from the Tx Power pull down menu to meet the system output power requirement according the actual measurement.

2.2 Symbol Rate

With OOK demodulation, CMT2150A supports 0.5 – 40.0 ksps symbol rate, with resolution of 0.1 ksps.

2.3 PA Ramping Time

The PA can be configured with different ramping time by setting the PA Ramping Time. The available options for the ramping (up and down) time are 0, 1, 2, 4, 8, 16, 32, 64, 128, 256, 512 and 1024 us. When the option is set to 0, the PA output power will ramp up or down to its configured value in the shortest possible time. See Figure 5 for different PA ramping times.

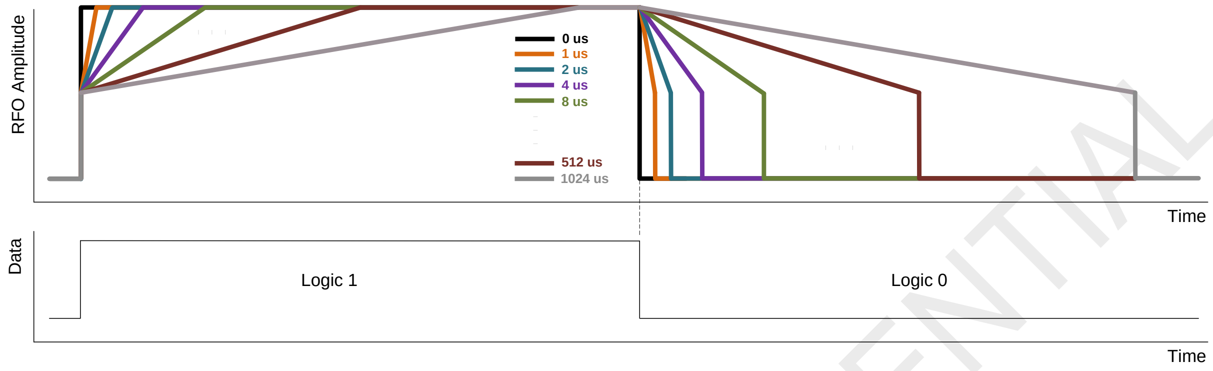

Figure 5. Different PA Ramping Time

2.4 Xtal Cload

The CMT2150A uses a 1-pin crystal oscillator circuit with the required crystal load capacitance integrated on the chip. The recommended specifications for the crystal are: 26 MHz with ±20 ppm frequency tolerance, ESR (Rm) < 60 Ω, load capacitance C_{LOAD} ranging from 12 to 20 pF. In order to cover the 12 to 20 pF load capacitance range, the parameter Xtal Cload pull down menu is intended to extend extra 2 pF margin in both ends. The recommended procedure to set the Xtal Cload is shown as Figure 6 below.

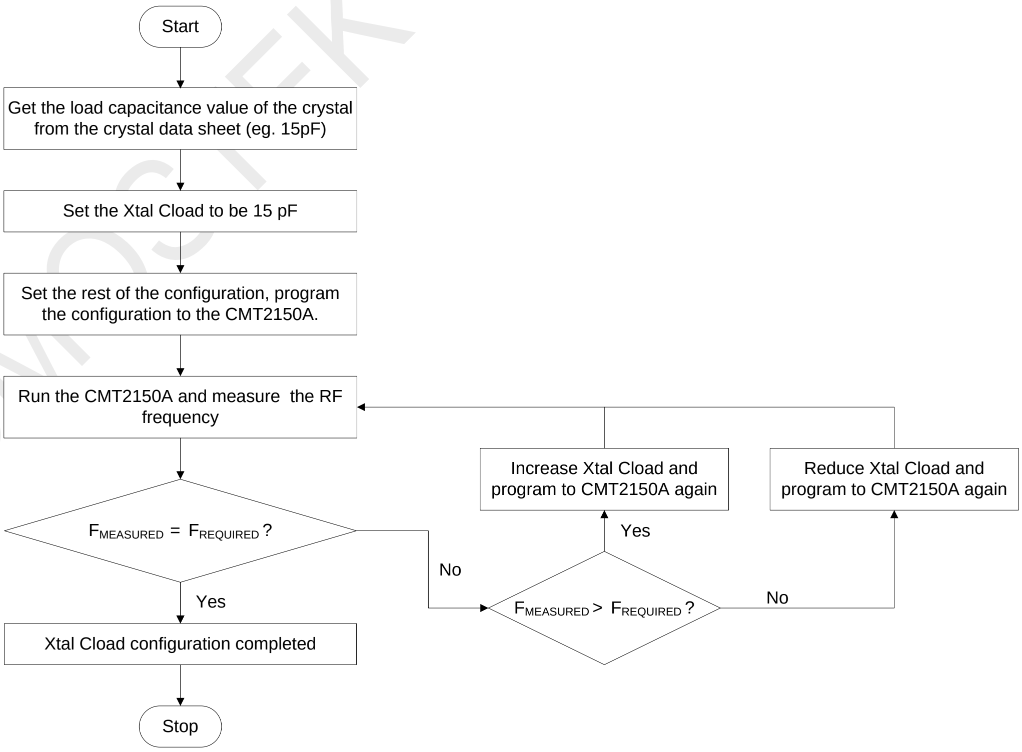

Figure 6. Procedure of Setting Xtal Cload

2.5 LED Driving Capability

This defines the driving current of the LED pin. Once the LED pin is enabled, it will light up or flash to indicate two issues:

- When the chip is transmitting data, the LED will light up until the transmission is finished to notify the user the chip is working.
- When the button(s) is/are pressed and low battery is detected, the LED will flash at the frequency of 6 Hz to notify the user the battery is running out.

2.6 LBD Threshold

This defines the Low Battery Detection threshold. Once the LBD is enabled, the chip will automatically check the battery status before each transmission. Once the chip finds that the battery output is less than the detection threshold, the LED will flash at the frequency of 6 Hz to notify the user. Once the LED flashes, the performance of the transmission is not guaranteed. The user should change the batteries to new ones.

3. Encode Settings

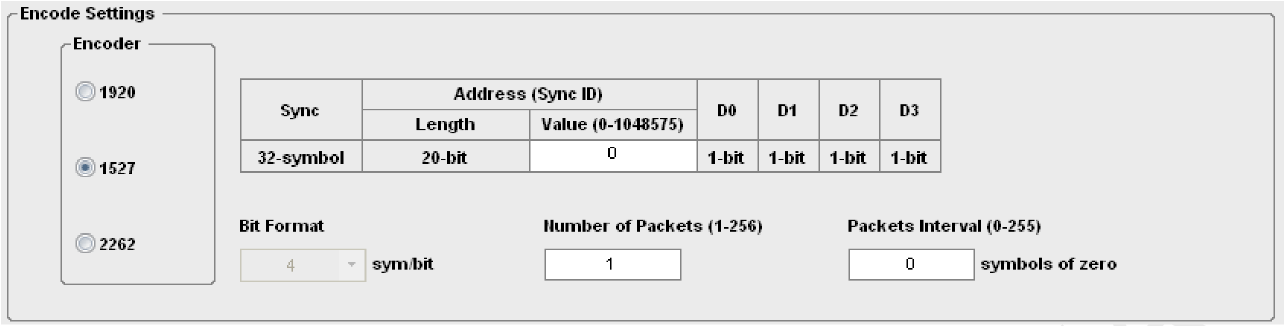

Figure 7. Encode Settings

Table 2. Encode Settings Parameter

Parameter	Descriptions	Default	Mode
Encoder	Select the packet encoding format, the options are: 1920, 1527 and 2262. See Table 4, Table 5 and Table 6 for the configurable parameters in each packet.	1527	Basic Advanced
Bit Format	This tells the device how many symbols are used to construct a single bit in the 1920 mode. The options are: 3, 4, 5 or 6 sym/bit. The Bit Format is fixed at 4 sym/bit in 1527 mode and 8 sym/bit in 2262 mode.	3	Basic Advanced
Number of Packets	This defines the number of packets to be continuously transmitted on each button-pressing event when Periodic Transmission is turned off, and the number of packets to be continuously transmitted in each cycle when Periodic Transmission is turned on. The range is from 1 to 256.	1	Advanced
Packet Interval	This defines the time interval amount two consecutive transmitted packets. The unit is in symbol, the range is from 0 to 255 symbols of zero.	0 symbols of zero	Basic Advanced

3.1 Encoder

The device supports 3 types of encoding formats: 1920, 1527 and 2262. The packets of these 3 modes have different structures as introduced in the below sub-sections. The following is a feature summary:

Table 3. Feature Summary of the 3 Encoding Formats

Format	Bit Format	Sync ID Length	Data Length	CRC	ID Study	Button Mode
1920	3/4/5/6 sym/bit	1 – 32 bits	1 – 7 bits	Support	Support	All
1527	4 sym/bit	20 bits	1 – 7 bits	NA	Support	All
2262	8 sym/bit	6 – 11 bits	1 – 6 bits	NA	Not Support	Normal Mode

In the below explanation (also on the RFPDK), the packet structural diagrams show all the elements in the packets, as well as the available options corresponding to each element.

Furthermore, some elements in the packet are measured in the unit of “symbol”, while some of them are measured in the unit of “bit”. For those which have the unit of “bit”, one “bit” is constructed (encoded) by several “symbols”. In the figures, “SYM” represents the word symbol.

3.1.1 1920 Normal Packet Structure

The normal packet is used to control the data pins of the CMT2250A or PWM output of the CMT2251A. It contains a 16-symbol Preamble, a 32-symbol Head_N indicating the current packet is a Normal packet, a Sync ID, a Configurable Data Field and an 8-symbol CRC.

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

Figure 8. 1920 Normal Packet Structure

Table 4. Configurable Parameters in 1920 Packet

Parameter	Descriptions	Default	Mode
Preamble	The size of the valid preamble, the options are: None or 16-symbol.	None	Basic Advanced
Address (Sync ID) Length	The range of the Sync ID Length is from 1 to 32-bit.	32-bit	Basic Advanced
Address (Sync ID) Value	The value of the Sync ID has the range from 0 to 2^{Length}-1.	0	Basic Advanced

- **Preamble**

The pattern of a 16-symbol preamble is shown below:

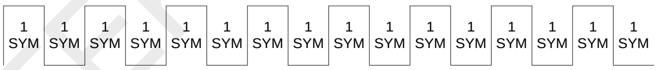

Figure 9. 1920 16-symbol Preamble Pattern

Typically, the preamble is used for the CMT2250/51A to perform Wake-On Radio (WOR) function. Please refer to the “AN118 CMT2250A Configuration Guideline” for the introductions of WOR.

- **Head_N**

The user does not need to control the Head_N because it is automatically generated by the CMT2150A and recognized by the CMT2250/51A. The pattern of Head_N is shown below.

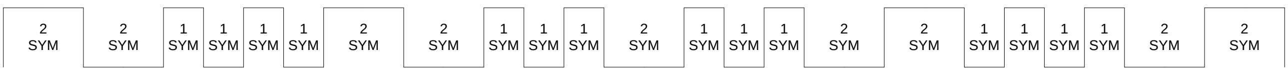

Figure 10. 1920 Head_N Pattern

■ Address (Sync ID)

The Sync ID is sent and received starting from the LSB. For example, if the "Sync ID Length" is set to 16 and the "Sync ID Value" is set to 1, the binary value of the Sync ID is "0000 0000 0000 0001". In this case, bit<0> = 1 is received first and bit<15> = 0 is received at the end of the Sync ID field.

■ D0, D1, D2, D3, D4, D5, D6

The number of data bits to be transmitted depends on the different "Button Mode":

Normal: The value of the "Number of Button(s)" is the number of data bits.
Matrix: The number of data bits is fixed at 4.
Toggle: The number of data bits is fixed at 4.
PWM: The number of data bits is fixed at 4.

Please see the "Chapter 4.1 Button Mode" for more details of the four button modes. In the data field, D0 is always transmitted first.

■ CRC

The 8-symbol CRC field can increase the reliability of the transmission, while it also increases the entire packet length. The CRC is calculated on the address (Sync ID) field and the data (D0 – D6) field of the Normal Packet, and is only calculated on the address (Sync ID) field of the Study Packet (See below section). The CRC polynomial is:

CRC Polynomial = $X^8 + X^5 + X^4 + 1$

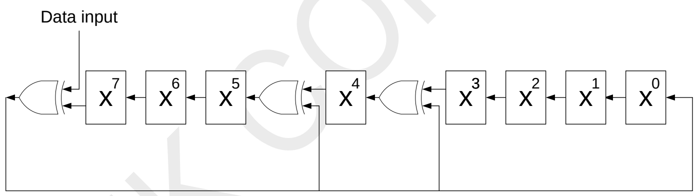

Figure 11. 1920 CRC Algorithm Structure

3.1.2 1920 Study Packet Structure

The study packet is used for the CMT2250/51A to learn the Sync ID from the CMT2150A in order to pair the two devices. It contains an optional Preamble, a 32-symbol Head_S, a Sync ID and an 8-symbol CRC.

Preamble 16-symbol	Head_S 32-symbol	Address (Sync ID) configurable 1-32 bits	CRC 8-symbol

Figure 12. 1920 Study Packet Structure

The Study Packet structure is not illustrated on the RFPDK since the settings of Preamble, Sync ID and CRC are identical to those of the Normal Packet. Differing from the Head_N in the Normal Packet, the Head_S indicates the current packet is a Study Packet. Also, the Study Packet does not contain the data field. The pattern of Head_S is shown below:

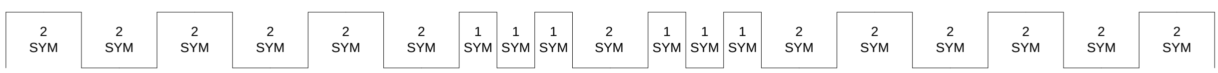

Figure 13. 1920 Head_S Pattern

3.1.3 1920 Bit Format

In 1920 packet, a single bit can be constructed (encoded) by 3, 4, 5 or 6 symbols. The user can select the desired value of the "Bit Format" parameter on the RFPDK. Please note that only the Sync ID field and the D0, D1, D2, D3, D4, D5, D6 have the unit of "bit".

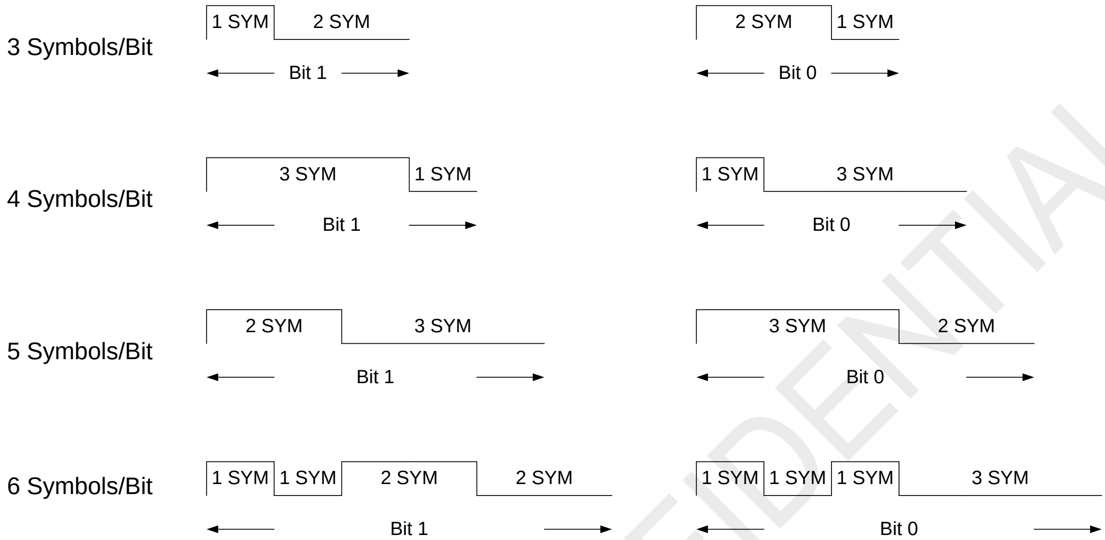

Figure 14. 1920 Bit Format Options

It must be noticed that the Bit Format setting of the receiver and the transmitter must be identical. In order to reduce the length of the entire packet and therefore increase the reliability and robustness of the wireless communication between the receiver and the transmitter, it is recommended to select 3 or 4 symbols per bit.

3.1.4 1527 Normal Packet Structure

The traditional 1527 packet contains a 32-symbol Sync, a 20-bit Address (Sync ID) and a configurable Data field. CMOSTEK has defined a 1527 Study Packet to support the ID study in 1527 mode. The traditional packet introduced here is called the "1527 Normal Packet". Also, CMT2150A allows more data bits (up to 7) to be transmitted in the Normal Packet.

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

Figure 15. 1527 Normal Packet Structure

Table 5. Configurable Parameters in 1527 Packet

Parameter	Descriptions	Default	Mode
Address (Sync ID) Value	The range of the Sync ID value is from 0 to 2^{20}-1. This is because the Sync ID Length is fixed at 20 for 1527.	0	Basic Advanced

In the traditional 1527 format, 8 OSC clocks are equal to 1 LCK, 4 LCK are equal to 1 symbol. By using the CMT2150A pairing with CMT2250/51A, the user does not need to adjust the OSC to determine the symbol rate, because the symbol rate is directly programmed. The Bit Format is fixed at 4 symbols (16 LCK) per bit.

- **Sync**

The Sync pattern is shown below:

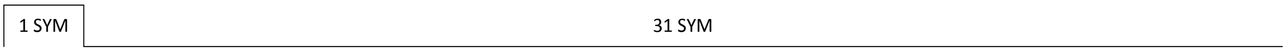

Figure 16. 1527 Sync Pattern

- **Address (Sync ID)**

The Sync ID is sent and received starting from the LSB. For example, if the “Sync ID Value” is set to 1, the binary value of the Sync ID is “0000 0000 0000 0000 0001”. In this case, bit<0> = 1 is received first and bit<19> = 0 is received at the end of the Sync ID field.

- **D0, D1, D2, D3, D4, D5, D6**

The number of data bits to be transmitted depends on the different “Button Mode”:

Normal: The value of the “Number of Button(s)” is the number of data bits.
Matrix: The number of data bits is fixed at 4.
Toggle: The number of data bits is fixed at 4.
PWM: The number of data bits is fixed at 4.

Please see the “Chapter 4.1 Button Mode” for more details of the four button modes. In the data field, D0 is always transmitted first.

3.1.5 1527 Study Packet Structure

The 1527 Study packet contains a 32-symbol Head_S and a 20-bit Address (Sync ID), as shown below.

Head_S 32-symbol	Address (Sync ID) 20 bits

Figure 17. 1527 Study Packet Structure

The Study Packet structure is not illustrated on the RFPDK since there is no option for the user to select. The Head_S indicating that the current packet is a study packet has the identical pattern to that of the 1920, as shown below:

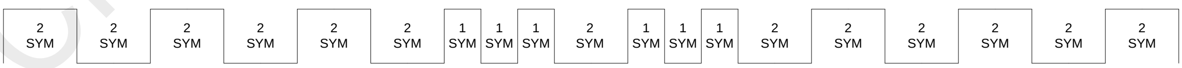

Figure 18. 1527 Head_S Pattern

3.1.6 1527 Bit Format

In 1527 packet, a single bit is constructed by 4 symbols, as shown below. The user can select the desired value of the “Bit Format” parameter on the RFPDK. Please note that only the Sync ID field and the D0, D1, D2, D3, D4, D5, D6 field have the unit of “bit”.

Figure 19. 1527 Bit Format Options

3.1.7 2262 Packet Structure

The traditional 2262 packet contains a configurable Address (Sync ID), a Data, and a 32-symbol Sync. In 2262 mode the device does not support ID study.

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

Figure 20. 2262 Packet Structure

Table 6. Configurable Parameters in 2262 Packet

Parameter	Descriptions	Default	Mode
Address (Sync ID) Length	This is the range of the Sync ID Length. The range is from 6 to 11 bits. This parameter also defines the number of data bits, because the total number of Sync ID and Data bits is fixed at 12.	8-bit	Basic Advanced
Address (Sync ID) Value	The value of each bit of the Sync ID can only be represented by 0, 1 or f.	00000000	Basic Advanced

In the traditional 2262 format, 4 OSC clocks (1 OSC clock cycle is notated as 1 α) are equal to 1 symbol. By using the CMOSTEK products, the user does not need to adjust the OSC to define the symbol rate, because the symbol rate is directly programmed. The Bit Format is fixed at 8 symbols per bit.

- **Address (Sync ID)**

The Sync ID is sent and received starting from the LSB. For example, if the “Sync ID Value” is set to 1, the binary value of the Sync ID is “00000001”. In this case, bit<0> = 1 is received first and bit<7> = 0 is received at the end of the Sync ID field. The value of Sync ID bits can be 0, 1 or f, where “f” represents the floating status according to the original 2262 definitions. For example, if the Sync ID Length is set to 8, the user can enter the value of 10f0f101 into the Address (Sync ID) Value on the RFPDK.

- **Data**

These are the length-configurable data bits received to control the D0, D1, D2, D3, D4, D5 data bits. The number of data bits is determined correspondingly by the Sync ID Length. The total number of Sync ID and Data bits is always fixed at 12. On the RFPDK, the number of data bits is automatically obtained and shown on the 2262 packet structure diagram. The value of data bits can be 0 or 1. Please note that, differing from the 1920 and 1527, the MSB of data is transmitted first, e.g. if 4 data bits are transmitted, D3 is transmitted first.

■ **Sync**

Unlike the 1527, the Sync of 2262 locates at the end of the packet. The Sync pattern is shown below:

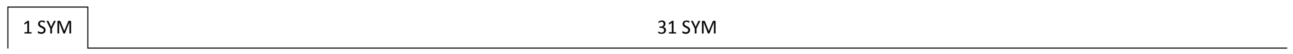

Figure 21. 2262 Sync Pattern

3.1.8 2262 Bit Format

In 2262 packet, a single bit is constructed by 8 symbols, as shown below. Please note that only the Address (Sync ID) field and the Data field have the unit of "bit". In the below diagram, 1 OSC clock cycle is notated as 1 α referring to the original 2262 timing descriptions.

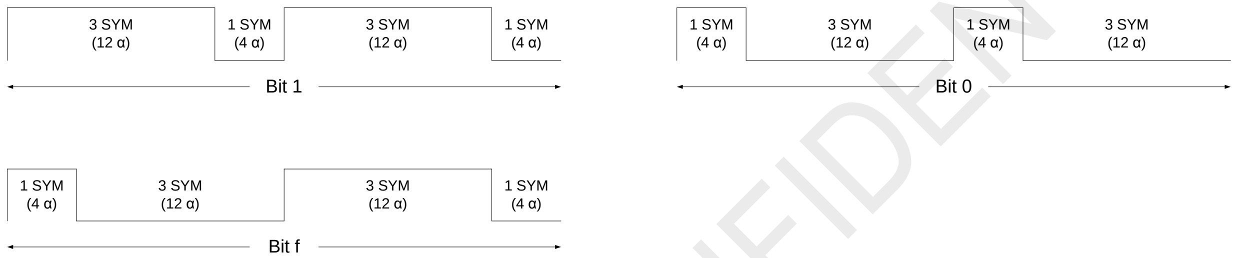

Figure 22. 2262 Bit Format Options

3.2 Bit Format

In 1920 packet, a single data bit can be constructed (encoded) by 3, 4, 5 or 6 symbols. The user must configure this parameter according to the bit format of the receiver. For the conventional 1527 packet, the bit format is 4 sym/bit. For the 2262 packet, this parameter is unavailable and the bit format is fixed at 8 sym/bit.

3.3 Number of Packets

When Periodic Transmission is turned off, this defines the number of packets to be continuously transmitted on each button-pressing event. It is available in all 1920, 1527 and 2262 modes. The range is from 1 to 256.

When Periodic Transmission is turned on, this defines the number of packets to be continuously transmitted in each cycle. Please note that the Periodic Transmission is not supported in 2262 mode. See Section 4.5 for details of Periodic Transmission.

Also, when pairing with CMT2250/51A, please consider the timing requirement of the duty cycle, as well as the value of the "Valid Reception" parameter while setting up the number of transmitted packets. Please refer to "AN118 CMT2250A Configuration Guideline" for the details of duty cycle mode and "Valid Reception" parameter.

3.4 Packets Interval

Once the button(s) is/are pressed, the data transmission will start. The transmission does not stop until the button(s) is/are released. The packets interval defines the time gap between two consecutive packets. This time interval has the unit of symbols, range from 0 to 255. While the button is released, if a packet is being transmitted, that packet will be completely transmitted before the transmission stops.

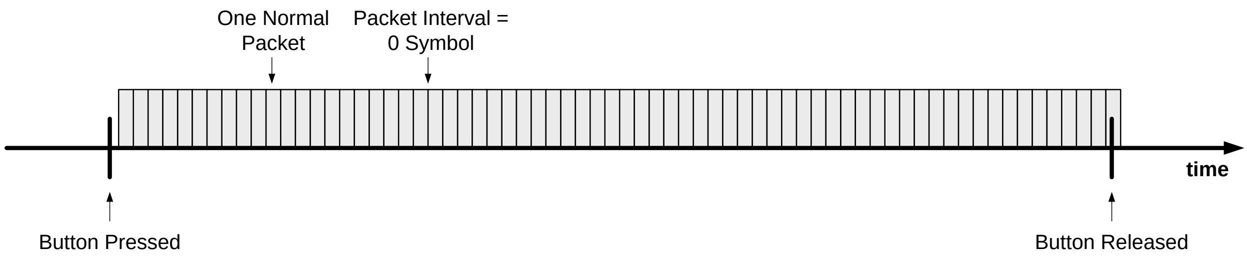

Figure 23. Transmission with Packet Interval is 0 Symbol

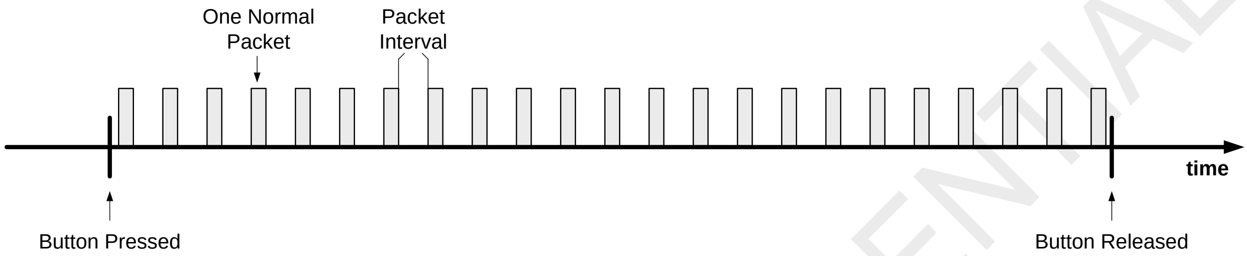

Figure 24. Transmission with Packet Interval is not 0 Symbol

4. Push Button Settings

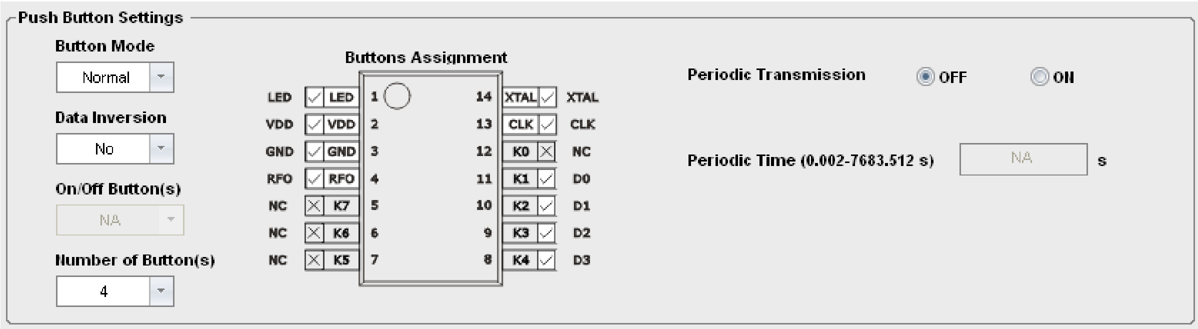

Figure 25. Push Button Settings

Table 7. Push Button Settings Parameter

Parameter	Descriptions	Default	Mode
Button Mode	Select the button encoding mode, the options are: Normal, Matrix, Toggle and PWM. For 1920 and 1527 format, all these button modes are supported; For 2262 format, only Normal button mode is supported.	Normal	Basic Advanced
On/Off Button(s)	Select the numbers of on/off button for Toggle and PWM button modes, the options are: Single or Separated.	Single	Basic Advanced
Number of Button(s)	This option is only available in Normal Button Mode, and Encoder is set to 1920 and 1527. It defines the number of activated button(s) to be used in the application. The range is from 1 to 7.	4	Basic Advanced
Data Inversion	Allow the user to select whether or not to inverse the transmitted data bits values in the Normal and Toggle Button Mode. The options are: No or Yes.	No	Advanced
Periodic Transmission	Turn on/off the periodic transmission mode of the device. The options are: On or Off.	Off	Advanced
Periodic Time	This parameter is only available when Periodic Transmission is turned on. It defines the periodic time for transmitting a fixed set of data. The range is from 2 to 7683.512 s, accurate to 3 decimal points.	1.000 s	Advanced

4.1 Button Mode

The device supports 4 button modes: Normal, Matrix, Toggle and PWM. The below sub-sections introduce these different button modes.

4.1.1 Normal

The Normal Button Mode is supported in 1920, 1527 and 2262 format. In this mode, the buttons are directly mapped to the data field of the packet. Multiple buttons can be pressed at the same time.

For 1920 and 1527, the largest number of buttons is 7 which are defined by the parameter "**Number of Button(s)**" (See Chapter 4.3 for the introduction of this parameter). For 2262, the largest number of buttons is 6, which is determined by the Sync ID Length (See Chapter 3.1.7 for details).

In normal button mode, the number of button(s) to be used determines the number of data bits in the packet. The K to D mapping is the same for 1920 and 1527, and is different for 2262.

- **K to D Mapping for 1920 and 1527**

On the RFPDK, when the Number of Button(s) is set to 4, it can be seen that the 4 buttons are assigned to pin 11 (K1) – pin 8 (K4), and respectively mapped to the data D0 – D3 in sequence. The table below shows the mapping from button(s) to data while the number of button(s) is set to 4. Setting K to 1 means the corresponding button(s) is/are pressed down.

Table 8. Mapping from K1-K4 to D0-D3 in Normal Button Mode

Push Buttons				The Data Bits			
K1	**K2**	**K3**	**K4**	**D0**	**D1**	**D2**	**D3**
1	0	0	0	1	0	0	0
0	1	0	0	0	1	0	0
1	1	0	0	1	1	0	0
0	0	1	0	0	0	1	0
1	0	1	0	1	0	1	0
0	1	1	0	0	1	1	0
1	1	1	0	1	1	1	0
0	0	0	1	0	0	0	1
1	0	0	1	1	0	0	1
0	1	0	1	0	1	0	1
1	1	0	1	1	1	0	1
0	0	1	1	0	0	1	1
1	0	1	1	1	0	1	1
0	1	1	1	0	1	1	1
1	1	1	1	1	1	1	1

Below is another example of that the Number of Button(s) is set to 5. It can be seen that the 5 buttons are assigned to pin 11 (K1) – pin 7 (K5), and respectively mapped to the data D0 – D4 in sequence.

Table 9. Mapping from K1-K5 to D0-D4 in Normal Button Mode

Push Buttons					The Data Bits				
K1	**K2**	**K3**	**K4**	**K5**	**D0**	**D1**	**D2**	**D3**	**D4**
1	0	0	0	0	1	0	0	0	0
0	1	0	0	0	0	1	0	0	0
1	1	0	0	0	1	1	0	0	0
0	0	1	0	0	0	0	1	0	0
1	0	1	0	0	1	0	1	0	0
0	1	1	0	0	0	1	1	0	0
1	1	1	0	0	1	1	1	0	0
0	0	0	1	0	0	0	0	1	0
1	0	0	1	0	1	0	0	1	0
0	1	0	1	0	0	1	0	1	0
1	1	0	1	0	1	1	0	1	0
0	0	1	1	0	0	0	1	1	0
1	0	1	1	0	1	0	1	1	0
0	1	1	1	0	0	1	1	1	0
1	1	1	1	0	1	1	1	1	0
1	0	0	0	1	1	0	0	0	1
1	0	0	0	1	1	0	0	0	1
0	1	0	0	1	0	1	0	0	1
1	1	0	0	1	1	1	0	0	1
0	0	1	0	1	0	0	1	0	1
1	0	1	0	1	1	0	1	0	1
0	1	1	0	1	0	1	1	0	1
1	1	1	0	1	1	1	1	0	1
0	0	0	1	1	0	0	0	1	1
1	0	0	1	1	1	0	0	1	1
0	1	0	1	1	0	1	0	1	1
1	1	0	1	1	1	1	0	1	1
0	0	1	1	1	0	0	1	1	1
1	0	1	1	1	1	0	1	1	1
0	1	1	1	1	0	1	1	1	1
1	1	1	1	1	1	1	1	1	1

From the above two examples, it can be seen that, regardless of the number of button(s) to be used, K1 is always fixed at pin 11 and directly mapped to D0. If K7 is used, it is always fixed at pin 5 and mapped to D6. K0 is not used.

- **K to D Mapping for 2262**

On the RFPDK, when the Number of Button(s) is set to 4, it can be seen that the 4 buttons are assigned to pin 11 (K1) – pin 8 (K4), and respectively mapped to the data D3 – D0 in sequence. The table below shows the mapping from button(s) to data while the number of button(s) is set to 4. Setting K to 1 means the corresponding button(s) is/are pressed down.

Table 10. Mapping from K1-K4 to D3-D0 in Normal Button Mode

Push Buttons				The Data Bits			
K1	K2	K3	K4	D3	D2	D1	D0
1	0	0	0	1	0	0	0
0	1	0	0	0	1	0	0
1	1	0	0	1	1	0	0
0	0	1	0	0	0	1	0
1	0	1	0	1	0	1	0
0	1	1	0	0	1	1	0
1	1	1	0	1	1	1	0
0	0	0	1	0	0	0	1
1	0	0	1	1	0	0	1
0	1	0	1	0	1	0	1
1	1	0	1	1	1	0	1
0	0	1	1	0	0	1	1
1	0	1	1	1	0	1	1
0	1	1	1	0	1	1	1
1	1	1	1	1	1	1	1

From the table above, it can be seen that:

K1 is mapped to D3
K2 is mapped to D2
K3 is mapped to D1
K4 is mapped to D0

Below is another example of that the Number of Button(s) is set to 3. It can be seen that the 3 buttons are assigned to pin 11 (K1) – pin 9 (K3), and respectively mapped to the data D2 – D0 in sequence.

Table 11. Mapping from K1-K3 to D2-D0 in Normal Button Mode

Push Buttons			The Data Bits		
K1	K2	K3	D2	D1	D0
1	0	0	1	0	0
0	1	0	0	1	0
1	1	0	1	1	0
0	0	1	0	0	1
1	0	1	1	0	1
0	1	1	0	1	1
1	1	1	1	1	1

From the table above, it can be seen that:

K1 is mapped to D2
K2 is mapped to D1
K3 is mapped to D0

Please note that, in order to pair the CMT2150A with the CMT2250/51A, in Normal Button Mode the Number of Button(s) must be set to 4, which also means the number of data bits in the packet is fixed at 4.

The data value generated by the pressed button is determined by the parameter "**Data Inversion**". If the Data Inversion is set to "No", the pressed button generates data 1 in the corresponding data bit; if it is set to "Yes", the pressed button generates data 0 in the corresponding data bit. The following table shows several examples for better understanding of the Normal Button Mode.

Table 12. Examples of the Normal Button Mode

Encoder	Number of Button(s)	Data Inversion	Pressed Button(s)	D0	D1	D2	D3
1920	4	No	K1	1	0	0	0
1920	4	Yes	K1	0	1	1	1
1527	4	No	K1, K3	1	0	1	0
1527	2	Yes	K1, K2	0	0	NA	NA
2262	1	No	K1	1	NA	NA	NA
2262	3	Yes	K1	0	1	1	NA

Please note that the "Data Inversion" must be set to "No" when paring with CMT2250/51A.

4.1.2 Matrix

The Matrix Button Mode is supported in 1920 and 1527 format. In the Matrix Button Mode, the number of buttons is fixed at 5. On the RFPDK, it can be seen that the 5 buttons are assigned to pin 11 (K1) – pin 7 (K5). In this mode, the largest number of buttons can be pressed at the same time is two.

The user is able to use the 5 buttons K1 – K5 to generate different combinations of the data D0 – D3 to be transmitted. The number of data bits to be transmitted is fixed at 4. The table below shows the matrix. For the K1 – K5 buttons, 1 means the corresponding button(s) is/are pressed down.

Table 13. Mapping from K1-K5 to D0-D3 in Matrix Button Mode

Push Buttons					The Data Bits			
K1	K2	K3	K4	K5	D0	D1	D2	D3
1	0	0	0	0	**1**	0	0	0
0	**1**	0	0	0	0	**1**	0	0
0	0	**1**	0	0	**1**	**1**	0	0
0	0	0	**1**	0	0	0	**1**	0
0	0	0	0	**1**	**1**	0	**1**	0
1	**1**	0	0	0	0	**1**	**1**	0
1	0	**1**	0	0	**1**	**1**	**1**	0
1	0	0	**1**	0	0	0	0	**1**
1	0	0	0	**1**	**1**	0	0	**1**
0	**1**	**1**	0	0	0	**1**	0	**1**
0	**1**	0	**1**	0	**1**	**1**	0	**1**
0	**1**	0	0	**1**	0	0	**1**	**1**
0	0	**1**	**1**	0	**1**	0	**1**	**1**
0	0	**1**	0	**1**	0	**1**	**1**	**1**
0	0	0	**1**	**1**	**1**	**1**	**1**	**1**

Please note that the "Data Inversion" is fixed at "No" in the Matrix Button Mode.

4.1.3 Toggle

The Toggle Button Mode is supported in 1920 and 1527. In this mode, 5 or 6 buttons are used. Four buttons directly mapped to the data D0 – D3 are used to control the data. Besides, a single button or two separated buttons used to turn on/off the data can be chosen by the parameter "**On/Off Button(s)**". In this mode, only one button can be pressed at the same time. The following tables show the pin functions. Note that Pin 12 (K0) and Pin 5 (K7) are never used in this mode.

Table 14. Pin Mappings in Toggle Button Mode Using Single On/Off Button

Pin Number	**Pin 11**	**Pin 10**	**Pin 9**	**Pin 8**	**Pin 7**	**Pin 6**
Pin Name	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**
Pin Function	ON/OFF	Unused	D0	D1	D2	D3

Table 15. Pin Mappings in Toggle Button Mode Using Separated On/Off Buttons

Pin Number	**Pin 11**	**Pin 10**	**Pin 9**	**Pin 8**	**Pin 7**	**Pin 6**
Pin Name	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**
Pin Function	ON	OFF	D0	D1	D2	D3

For the 4 data buttons mapped to D0 – D3, every time a button is pressed, the generated data bit toggles. For example, if the default value of D1 is 0, press K4 down, the D1 is set to 1 in the current transmission, release the K4 and press it down again, the D1 is set to 0 in the current transmission, and so on. This is what it means by "Toggle".

If K1 is used as the On/Off Button, the default values of D0 – D3 are 0, press it down once, D0 – D3 are all set to 1 (On), release and press it down again, D0 – D3 are all set to 0 (Off), and so on. In this case, K1 is also a "Toggle" button.

If the K1 is used as the On Button and K2 is used as the Off Button, pressing K1 sets D0 – D3 to all 1 (On), pressing K2 sets D0 – D3 to all 0 (Off). In this case, K1 and K2 is not "Toggle" buttons.

Please note that, in the above descriptions, we've assumed the default values of the data are all 0. In fact, the default values, which are treated as the "Off" status, are determined by the parameter "**Data Inversion**". If the Data Inversion is set to "No", the default values are all 0; if it is set to "Yes", the default values are all 1. The below tables give examples for better understand of these settings.

Table 16. Examples of the Toggle Button Mode

Data Inversion	**On/Off Button(s)**	**Pressed Button (Times)**	**D0**	**D1**	**D2**	**D3**
No (Default Data are all 0)	Single (K1 is On/Off)	Press K4 (D1) – 1st Time	0	1	0	0
		Press K4 (D1) – 2nd Time	0	0	0	0
		Press K4 (D1) – 3rd Time	0	1	0	0
		Press K1 – 1st Time (On)	1	1	1	1
		Press K1 – 2nd Time (Off)	0	0	0	0
		Press K1 – 3rd Time (On)	1	1	1	1
No (Default Data are all 0)	Separated (K1 is On K2 is Off)	Press K4 (D1) – 1st Time	0	1	0	0
		Press K4 (D1) – 2nd Time	0	0	0	0
		Press K4 (D1) – 3rd Time	0	1	0	0
		Press K1 (On)	1	1	1	1
		Press K2 (Off)	0	0	0	0
		Press K1 (On)	1	1	1	1

Data Inversion	On/Off Button(s)	Pressed Button (Times)	D0	D1	D2	D3
Yes (Default Data are all 1)	Single (K1 is On/Off)	Press K4 (D1) – 1st Time	1	0	1	1
		Press K4 (D1) – 2nd Time	1	1	1	1
		Press K4 (D1) – 3rd Time	1	0	1	1
		Press K1 – 1st Time (On)	0	0	0	0
		Press K1 – 2nd Time (Off)	1	1	1	1
		Press K1 – 3rd Time (On)	0	0	0	0
Yes (Default Data are all 1)	Separated (K1 is On K2 is Off)	Press K4 (D1) – 1st Time	1	0	1	1
		Press K4 (D1) – 2nd Time	1	1	1	1
		Press K4 (D1) – 3rd Time	1	0	1	1
		Press K1 (On)	0	0	0	0
		Press K2 (Off)	1	1	1	1
		Press K1 (On)	0	0	0	0

Please note that the “Data Inversion” must be set to “No” when paring with CMT2250/51A.

4.1.4 PWM

The PWM Button Mode is only supported for 1920 and 1527 encoder. In this mode, 2 buttons are used to send out commands to increase or decrease the duty ratio of the PWM output of the CMT2251A. A single on/off button, or two separated on/off buttons can be chosen by the parameter “**On/Off Button(s)**”. The “On” command sets the PWM output of the CMT2251A to 100% of duty ratio, while the “Off” command sets the PWM output to 0% of duty ratio. In this mode, only one button can be pressed at the same time. The following tables show the pin functions. Note that Pin 12 (K0), Pin 9 (K3), Pin 6 (K6) and Pin 5 (K7) are never used in this mode.

Table 17. Pin Mappings in PWM Button Mode Using Single On/Off Button

Pin Number	Pin 11	Pin 10	Pin 8	Pin 7
Pin Name	**K1**	**K2**	**K4**	**K5**
Pin Function	ON/OFF	Unused	INC	DEC

Table 18. Pin Mappings in PWM Button Mode Using Separated On/Off Buttons

Pin Number	Pin 11	Pin 10	Pin 8	Pin 7
Pin Name	**K1**	**K2**	**K4**	**K5**
Pin Function	ON	OFF	INC	DEC

If K1 is used as the On/Off Button, press it down once, the “On” command is transmitted, release and press it down again, the “Off” command is transmitted, and so on. In this case, K1 is a “Toggle” button.

If the K1 is used as the On Button and K2 is used as the Off Button, pressing K1, the “On” command is transmitted; pressing K2, the “Off” command is transmitted.

The “Data Inversion” is fixed at “No” in this mode. The commands of On, Off, Increase and Decrease are represented by D0 – D3, as shown in the below table:

Table 19. PWM Commands

Commands	D0	D1	D2	D3
On	1	1	0	0
Off	1	1	1	1
Increase	0	0	1	0
Decrease	0	0	0	1

The CMT2251A only listens to these four commands.

4.2 Data Inversion

This option allows the user to inverse the data bits values in the Normal and Toggle Button Mode. Please refer to the "Chapter 4.1 Button Mode" for the details of how the "Data Inversion" affects the data bits values in these 2 button modes.

Please note that in the case of paring the CMT2150A with CMT2250/51A, the "Data Inversion" shall always set to "No", e.g. no inversion is performed on the data bits.

4.3 On/Off Button(s)

This parameter defines whether to use a single button or two separated buttons as the on/off button(s) in Toggle and PWM button modes.

4.4 Number of Button(s)

This parameter defines the number of button(s) to be used in the 1920 and 1527 mode. In 2262, the number of button(s) is equal to the number of data bits, which is determined by the number of the Sync ID bits.

4.5 Periodic Transmission

The CMT2150A can enter a Periodic Transmission mode that it periodically transmits 4-bit of data without the need of pressing any buttons and any external controls. The transmitted data D0, D1, D2 and D3 have the value of 1110. The packet format is still defined in the "Encode Settings".

The periodic transmission mode can only be enabled while using the normal button mode in 1920 and 1527 format.

When periodic transmission is turned on, the push button still takes effect. However, only K3 is available to use. Whenever the user presses K3, the device immediately transmits the same packet containing D0 – D3 which is equal to 1110. If ID study is supported, K3 is used as the study button. Pressing other button(s) will lead to unexpected behavior of the device.

Without any push buttons(s) event, the device only periodically wakes up to transmit the data.

4.6 Periodic Time

This parameter defines the time for the device to periodically wake up and transmit the data. The figure below shows the timing characteristics of periodic transmission. Each time the device wakes up 5 normal packets are transmitted.

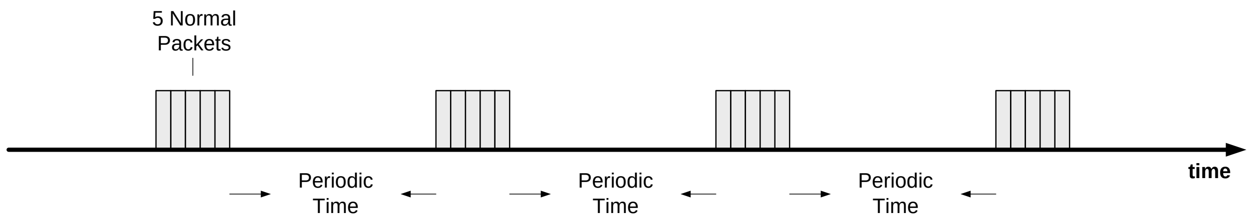

Figure 26. Timing Characteristics of Periodic Transmission

The precision of the periodic time computation varies with the input time values, as shown below:

Table 20. Precision of Periodic Time

Input Time Values	Precision of Periodic Time
0 – 16.383 s	1 ms
16.384 – 64.020 s	4 ms
64.021 – 1923.896 s	128 ms
1923.897 – 7683.512 s	512 ms

5. Study Settings

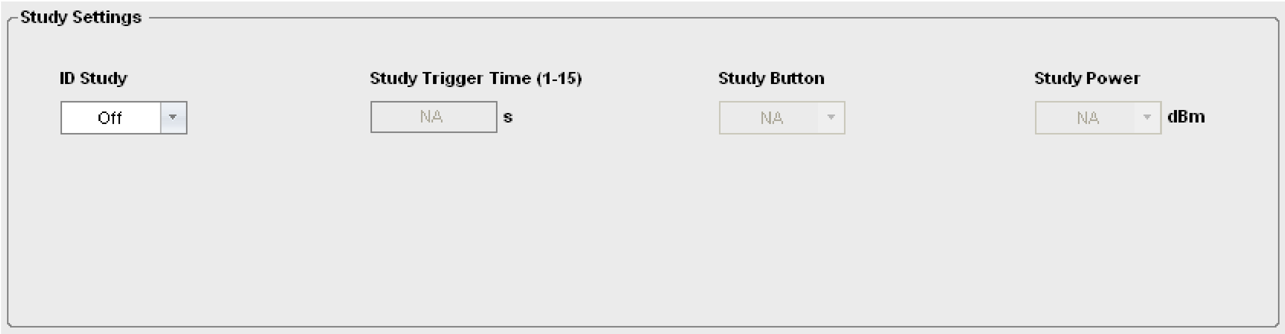

Figure 27. Study Settings

Table 21. Study Settings Parameter

Parameter	Descriptions	Default	Mode
ID Study	Turn on/off the Sync ID study function, the options are: On or Off. The ID Study is only supported in 1920 and 1527 mode.	Off	Advanced
Study Trigger Time	This parameter is only available when ID Study is turned on. It defines the time from the instance of pressing the study button to the instance at which the device starts to transmit the study packets. The range is from 1 to 15 second(s).	5 s	Advanced
Study Button	This parameter is only available when ID Study is turned on. It defines which button is used to trigger the transmission of the study packets. The options are the current buttons used in the Push Button Settings.	Pin 11 (K1)	Advanced
Study Power	This parameter is only available when ID Study is turned on. It defines the PA power when the device is transmitting the study packets. The range is from – 10 to +14 dBm.	-6 dBm	Basic Advanced

5.1 ID Study

The ID Study function, which is supported in 1920 and 1527 modes, allows the CMT2250/51A to receive the Sync ID sent by the CMT2150A and burns it into the local EEPROM. Since then, the CMT2250/51A's Sync ID is identical to that of the CMT2150A and therefore two devices are paired. The Sync ID, which is one of the elements of the packet, is sometime called Addressed in some communication protocols. The lengths of the Sync ID are different in the different packet formats. In 1920 format, it is from 1 to 32 bits. In 1527 format, it is fixed at 20 bits.

The ID Study is initialized by the CMT2150. It is done by executing the flowing steps:

1. Pressing the Study Button on the CMT2150A and hold it over the time defined by the "Study Trigger Time".
2. CMT2150A starts to transmit the Study Packets, wait 1-2 seconds then release the Study Button.
3. Try to press a certain button on the CMT2150A to check if the CMT2250/51A react correctly.

5.2 Study Trigger Time

This defines the time from the instance of pressing the study button to the instance at which the CMT2150A starts to transmit the study packets. During this time the button must not be released. The below diagrams illustrate the timing characteristics of the transmissions triggered by pressing a non-study button, or a study button.

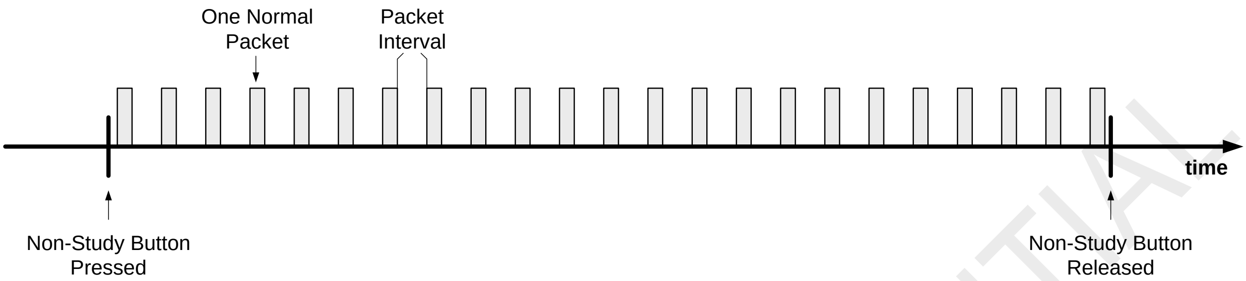

Figure 28. Timing of Non-Study Button Pressing Event

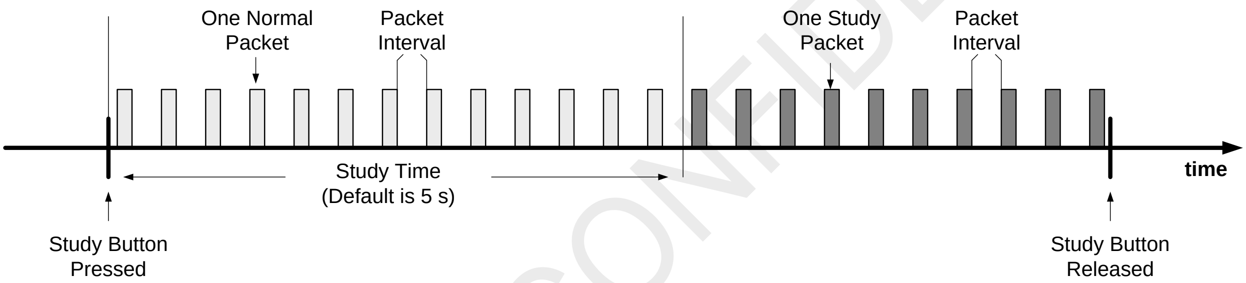

Figure 29. Timing of Study Button Pressing Event

It can be seen that, while a study button is pressed and hold for more than the "Study Trigger Time", the CMT2150A starts transmitting the study packets instead of the normal packets. Once the CMT2250/51A captured the study packets, the Sync ID recording (burning) is processed inside the CMT2250/51A. After that, the CMT2150A and CMT2250/51A are successfully paired.

Please note that, the CMT2250/51A has the parameters of "Study Time Window" to limit the time in which the device is allowed to study after it is powered up. Also, it has a parameter of "Study RSSI TH" to allow/disallow study by detecting the receiving RSSI level. Please refer to the "AN118 CMT2250A Configuration Guideline" for more details of setting up the CMT2250A, and "AN115 Pairing CMT2150A and CMT2250/51A" for how to pair CMT2150A with CMT2250/51A.

5.3 Study Button

This defines which button is used as the study button. A study button can trigger the device to transmit study packets as introduced previously. The study button can be selected amount the buttons which have been selected on the Push Button Setting panel. RFPDK automatically tells the user which study button can be selected.

5.4 Study Power

This defines the PA power when the device is transmitting the study packets. The reason to control the study power is to allow adjusting the communication distance between CMT2150A and CMT2250/51A when the study is being processed. The Study Power and TX Power are not necessarily the same. Below shows an example in which the Study Power is set to -10 dBm and TX Power is set to 0 dBm.

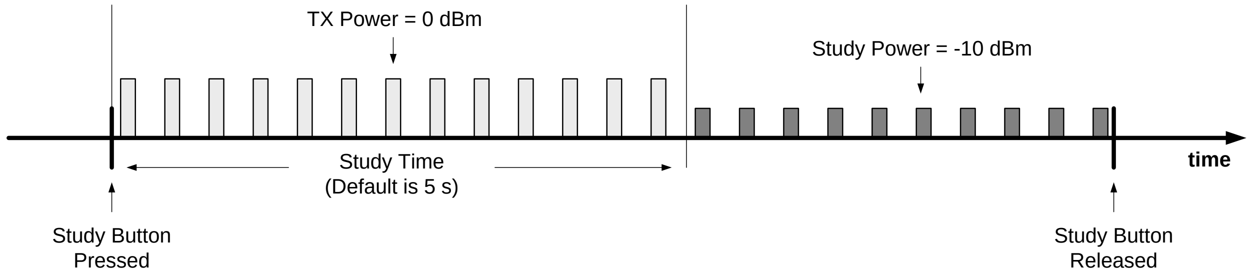

Figure 30. TX Power and Study Power Characteristics During Study

Please refer to the “AN115 Pairing CMT2150A and CMT2250/51A” for how to pair CMT2150A with CMT2250/51A.

6. Manufacture

A manufacture option is available on the upper-right corner of the RFPDK to support the small quantity production, as shown in the figure below.

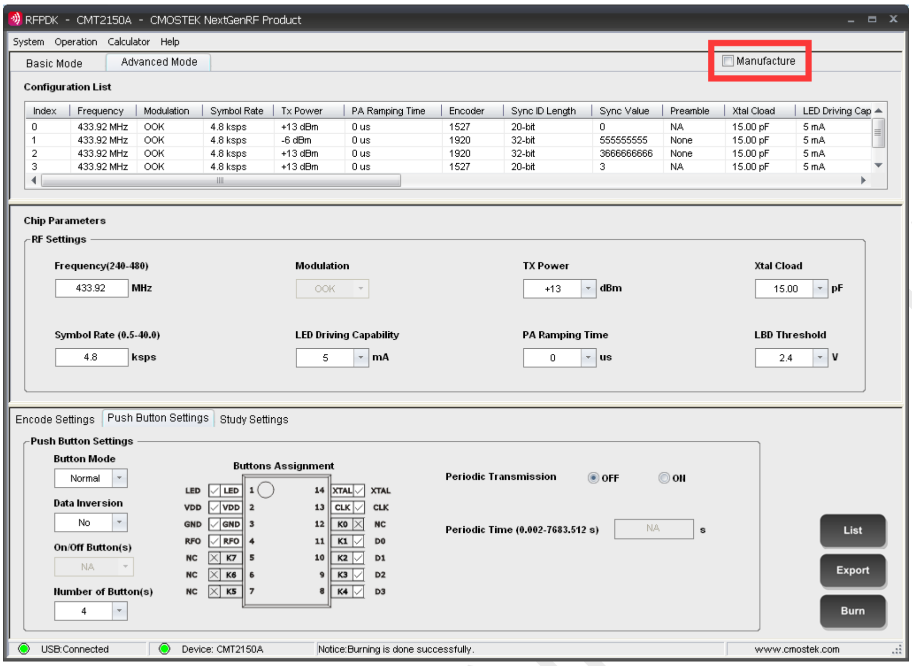

Figure 31. Manufacture Option

With the option selected, an information window is popped out with the current configuration listed in. “Current Sync ID” on the bottom shows the Sync ID to be written into the device by clicking the “Burn” button next to it, as shown in the figure below. After each Burn action, the number of Current Sync ID will increase by 1 automatically without the need of manually change. For other requirement on the Sync ID change in mass production, the user can use the CMOSTEK Writer.

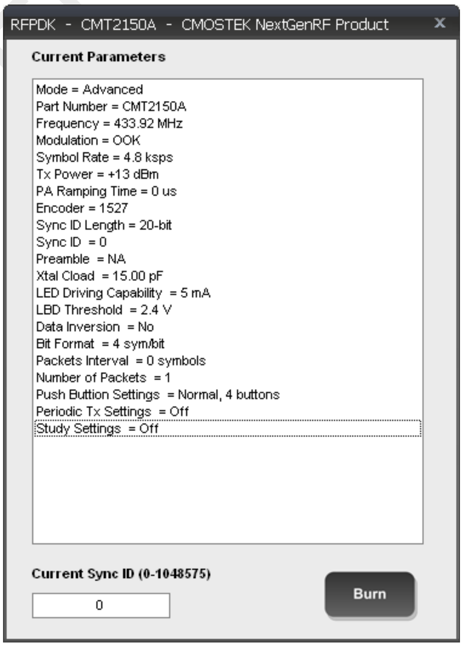

Figure 32. Manufacture Window

7. Document Change List

Table 22. Document Change List

Revision	Chapter	Description of Changes	Date
0.8		Initial released version.	2014-07-29
1.0	4	Adding Table 8 to Table 11 and related descriptions.	2014-08-13
1.1	3, 4, 5	Update default settings according to the RFPDK V1.31, which leaves K0 unused.	2015-01-16

8. Contact Information

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