
Wireless High Frequency Transceiver Module (RF GFSK)



Version History

Version	Date	Changes
V1.01	Jun 13, 2007	1 st . Edition
V1.02	Aug 20, 2007	2 nd . Edition
V1.03	Mar 15, 2008	3 rd . Edition
V1.04	May 7, 2008	4 th . Edition
V1.05	Feb 28, 2011	5 th Edition
V2.00	May 12, 2011	Add in direct mode

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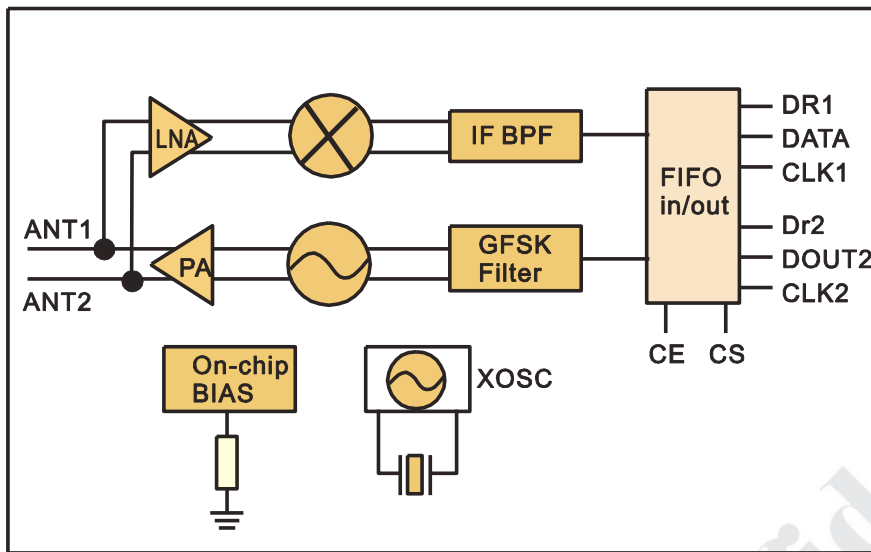
1 Product Description

TRW-24G is a wireless transceiver module which adopts 2.4G ISM band with printed antenna on board to provide the optimal transmission and reception in signal. TRW-24G is a good solution for short and median range applications, such as Wireless Joysticks, cordless phone, wireless earphone, wireless mouse and keyboard, due to its adjustable transmission power level. It is also suitable for surveillance system because of its frequency hopping technology which provides a safe

1.1 Key Feature

- Frequency Range: 2.4~2.527GHz
- Modulation: GFSK
- Work Voltage: 3V
- Channel No.: 128 CH
- Output Power: Max. 0 dBm.
- Active Mode : ShockBurst Mode and Direct Mode
- Data Rate: 1 Mbps at ShockBurst Mode
250 Kbps at Direct Mode
- Transmission range : 150M at ShockBurst Mode
280M at Direct Mode
- Max two channels active simultaneously
- Built-in antenna.
- Low Power consumption: Active@1Mbps: 25 mA
Standby: 12 uA
- Operating Temperature: -10~+70°C
- Application : Wireless Joysticks, Wireless Speaker, Wireless Earphone , Wireless Cell phone , Wireless Intercom , Wireless Mouse, Wireless Keyboard , Surveillance and security system and Data Communication.

2 Block Diagram



This block diagram details the whole structure of this module which allows user to adopt two channels simultaneously without adding any extra components except micro-controller. We shall have reference schematic how this module works with micro-controller in the subsequence.

3 Pin Function

Pin	Name	Category	I/O	Description
1	CLK1	Digital	Input/Output	For channel 1 clock TX: Clock input RX: Clock input/output
2	CS	Digital	Input	Chip selection activates Configuration Mode
3	CLK2	Digital	Input/Output	For channel 2 clock Rx: Clock input/output
4	CE	Digital	Input	Chip Enable to active RX / TX mode H: TX mode L: Rx mode
5	GND	Power		Ground
6	VCC	Power		Power supply
7	DR2	Digital	Output	Data ready for channel 2 to output (*) H: Data ready for accessing
8	DOUT	Digital	Output	Channel 2 Data output
9	DR1	Digital	Output	Data ready for channel 1 to output (*) H: Data ready for accessing
10	DATA	Power	Input/output	DATA pin can act as channel 1 data output and configuration data input pin. CS = H, Configuration data input CS = L, Channel 1 data output

* DR1 & DR2 are only available for ShockBurst mode.

4 Hardware Specification

4.1 Specification

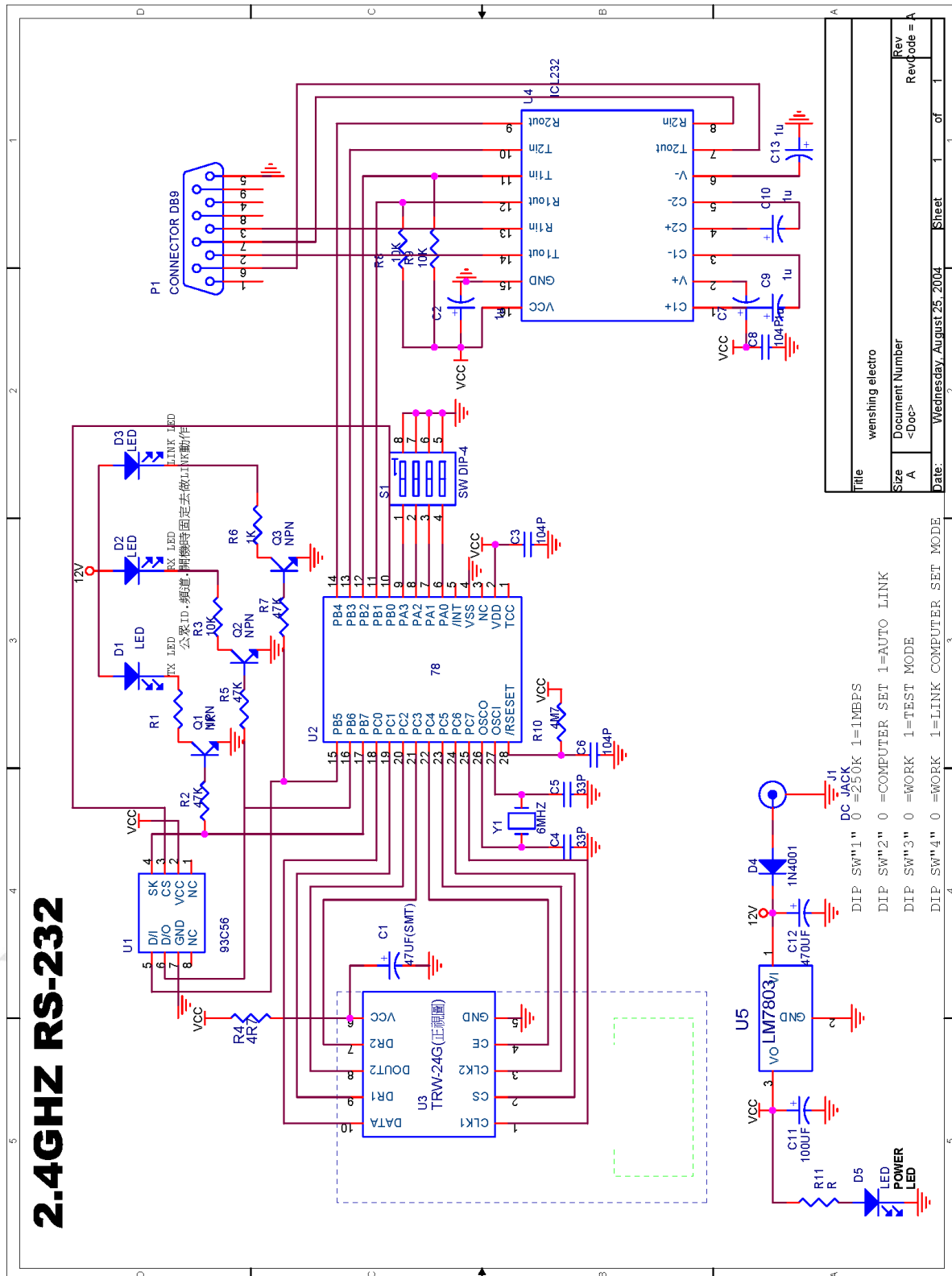
Conditions: VDD = +3V, VSS = 0V, TA = - 40°C to + 85°C

Symbol	Parameter (condition)	Notes	Min.	Typ.	Max.	Units
Operating conditions						
VDD	Supply voltage		1.9	3.0	3.6	V
TEMP	Operating Temperature		-40	+27	+85	°C
Digital input pin						
V _{IH}	HIGH level input voltage		VDD- 0.3		VDD	V
V _{IL}	LOW level input voltage		V _{SS}		0.3	V
Digital output pin						
V _{OH}	HIGH level output voltage (I _{OH} =-0.5mA)		VDD- 0.3		VDD	V
V _{OL}	LOW level output voltage (I _{OL} =0.5mA)		V _{SS}		0.3	V
General RF conditions						
f _{OP}	Operating frequency	1)	2400		2524	MHz
f _{XTAL}	Crystal frequency	2)	4		20	MHz
Δf	Frequency deviation			±156		kHz
R _{GFSK}	Data rate ShockBurst™		>0		1000	kbps
R _{GFSK}	Data rate Direct Mode	3)	250		1000	kbps
F _{CHANNEL}	Channel spacing			1		MHz
Transmitter operation						
P _{RF}	Maximum Output Power	4)		0	+4	dBm
P _{RFC}	RF Power Control Range		16	20		dB
P _{RFCR}	RF Power Control Range Resolution				±3	dB
P _{BW}	20dB Bandwidth for Modulated Carrier				1000	kHz
P _{RF2}	2 nd Adjacent Channel Transmit Power 2MHz				-20	dBm
P _{RF3}	3 rd Adjacent Channel Transmit Power 3MHz				-40	dBm
I _{VDD}	Supply current @ 0dBm output power	5)		13		mA
I _{VDD}	Supply current @ -20dBm output power	5)		8.8		mA
I _{VDD}	Average Supply current @ -5dBm output power, ShockBurst™	6)		0.8		mA
I _{VDD}	Average Supply current in stand-by mode	7)		12		μA
I _{VDD}	Average Supply current in power down			400		nA
Receiver operation						
I _{VDD}	Supply current one channel 250kbps			18		mA
I _{VDD}	Supply current one channel 1000kbps			19		mA
I _{VDD}	Supply current two channels 250kbps			23		mA
I _{VDD}	Supply current two channels 1000kbps			25		mA
RX _{SENS}	Sensitivity at 0.1%BER (@250kbps)			-90		dBm
RX _{SENS}	Sensitivity at 0.1%BER (@1000kbps)			-80		dBm
C/I _{CO}	C/I Co-channel	8)		10/4		dB
C/I _{1ST}	1 st Adjacent Channel Selectivity C/I 1MHz	8)		-20/0		dB
C/I _{2ND}	2 nd Adjacent Channel Selectivity C/I 2MHz	8)		-37/-20		dB
C/I _{3RD}	3 rd Adjacent Channel Selectivity C/I 3MHz	8)		-43/-30		dB
RX _B	Blocking Data Channel 2			-45/-41		dB

- 1) Usable band is determined by local regulations
- 2) The crystal frequency may be chosen from 5 different values (4, 8, 12, 16, and 20MHz) which are specified in the configuration word, see Table 9. 16MHz are required for 1Mbps operation.
- 3) Data rate must be either 250kbps or 1000kbps.
- 4) Antenna load impedance = 100W+j175W
- 5) Antenna load impedance = 100W+j175W. Effective data rate 250kbps or 1Mbps.
- 6) Antenna load impedance = 100W+j175W. Effective data rate 10kbps.
- 7) Current if 4 MHz crystal is used.
- 8) 250kbps / 1000kbps.

4.2 Reference schematics

Attached reference schematics give an example how to have TRW-24G module to work with micro-controller, it might be 8051, chips of microchip or any embedded SOC, to communicate with host through RS-232 interface. U4 is RS-232 transceiver chip which converts signals level.



5 Configuration and Operation Modes

TRW-24G 2.4Ghz module has three modes, Active, Configuration and Stand by; which depends on the setting of signal CE and CS. The following Table details the setting.

Mode	CE	CS
Active (RX/TX)	1	0
Configuration	0	1
Stand by	0	0

Device allows user to have two communication models in Active mode – Direct Mode and ShockBurst to transmit and receive data from remote parties. It depends on the content of configuration to set up the working models.

Configuration Mode allows user to setup the following settings:

1. Communication Mode : Direct Mode
ShockBurst Mode
2. Transmit power
3. Frequency selection for Channel 1 & 2
4. Data Rate
5. One / Two receiving simultaneously

Stand-by mode is used to minimize average current consumption while maintaining short start up times. The configuration word content is maintained during stand by.

The following introduction shall commence from configuration setting

5.1 Configuration Mode

All configuration of the TRW-24G is done via 3-wire interface to a single configuration register. The configuration word can be up to 15 bytes long for ShockBurst™.

5.1.1 Configuration of ShockBurst™ operation:

The configuration word in ShockBurst™ enables the TRW-24G to handle the RF protocol. Once the protocol is completed and loaded into TRW-24G only one byte, bit [7:0], needs to be updated during actual operation.

The configuration blocks dedicated to ShockBurst™ is as follows:

1. **Payload section width:** Specifies the number of payload bits in a RF package. This enables the TRW-24G to distinguish between payload data and the CRC bytes in a received package.
2. **Address width:** Sets the number of bits used for address in the RF package. This enables the TRW-24G to distinguish between address and payload data.
3. **Address** (RX Channel 1 and 2): Destination address for received data.
4. **CRC:** Enables TRW-24G on-chip CRC generation and de-coding.

NOTE

These configuration blocks, with the exception of the CRC, are dedicated for the packages that a TRW-24G is to receive. In TX mode, the MCU must generate an address and a payload section that fits the configuration of the TRW-24G that is to receive the data. When using the TRW-24G on-chip CRC feature ensure that CRC is enabled and uses the same length for both the TX and RX devices.

PRE-AMBLE	ADDRESS	PAYLOAD	CRC
-----------	---------	---------	-----

Figure 1 Data packet set-up

5.1.2 Configuration for Direct Mode operation

For direct mode operation only the two first bytes (bit[15:0]) of the configuring word are relevant.

Configuration word overview

	Bit Position	Number of bits	Name	Function
ShockBurst™ configuration	143:120	24	TEST	Reserved for testing
	119:112	8	DATA2_W	Length of data payload section RX channel 2
	111:104	8	DATA1_W	Length of data payload section RX channel 1
	103:64	40	ADDR2	Up to 5 byte address for RX channel 2
	63:24	40	ADDR1	Up to 5 byte address for RX channel 1
	23:18	6	ADDR_W	Number of address bits (both RX channels).
	17	1	CRC_L	8 or 16 bit CRC
	16	1	CRC_EN	Enable on-chip CRC generation/checking.

ADDR_W						Default
D23	D22	D21	D20	D19	D18	
Address width in # of bits (both channels)						
0	0	1	0	0	0	

CRC		Default
D17	D16	
CRC Mode 1 = 16bit, 0 = 8bit		
0	CRC 1 = enable; 0 = disable	
0	1	

RF-Programming															LSB	Default
D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	
Two Ch	BUF	OD	XO Frequency		RF Power		Channel selection								RX/RN	
0	0	0	0	1	1	1	1	0	0	0	0	0	1	0	0	

Table 2 Configuration data word

The MSB bit should be loaded first into the configuration register.

Default configuration word: h8E08.1C20.2000.0000.00E7.0000.0000.E721.0F04.

5.2 ShockBurst™ configuration

The section B[119:16] contains the segments of the configuration register dedicated to ShockBurst™ operational protocol. After VDD is turned on ShockBurst™ configuration is done once and remains set whilst VDD is present, during operation only the first byte for frequency channel and RX/TX switching need to be changed.

PLL_CTRL

PLL_CTRL		
D121	D120	PLL
0	0	Open Tx / Closed Rx
0	1	Open Tx / Open Rx
1	0	Closed Tx / Closed Rx
1	1	Closed Tx / Open Rx

Table 3 PLL setting

Bit 121-120:

PLL_CTRL: Controls the setting of the PLL for test purposes. With closed PLL in TX no deviation will be present. For normal operational mode these two bits must both be low.

DATAx_W

DATA2_W							
119	118	117	116	115	114	113	112
DATA1_W							
111	110	109	108	107	106	105	104

Table 4 Number of bits in payload

Bit 119-112:

DATA2_W: Length of RF package payload section for receive-channel 2.

Bit 111-104:

DATA1_W: Length of RF package payload section for receive-channel 1.

NOTE

The total number of bits in a ShockBurst™ RF package may not exceed 256!
Maximum length of payload section is hence given by:

$$\text{DATAx_W(bits)} = 256 - \text{ADDR_W} - \text{CRC}$$

Where:

ADDR_W: length of RX address set in configuration word B[23:18]

CRC: check sum, 8 or 16 bits set in configuration word B[17]

PRE: preamble, 4 or 8 bits are automatically included

Shorter address and CRC leaves more room for payload data in each package.

ADDRx

ADDR2											
103	102	101		71	70	69	68	67	66	65	64
ADDR1											
63	62	61		31	30	29	28	27	26	25	24

Table 5 Address of receiver #2 and receiver #1

Bit 103-64:

ADDR2: Receiver address channel 2, up to 40 bit.

Bit 63-24:

ADDR1: Receiver address channel 1, up to 40 bit.

NOTE

Bits in ADDRx exceeding the address width set in ADDR_W are redundant and can be set to logic 0.

ADDR_W & CRC

ADDR_W						CRC_L	CRC_EN
23	22	21	20	19	18	17	16

Table 6 Number of bits reserved for RX address + CRC setting

Bit 23-18:

ADDR_W: Number of bits reserved for RX address in ShockBurst™ packages.

NOTE

Maximum number of address bits is 40 (5 bytes). Values over 40 in ADDR_W are not valid.

Bit 17:

CRC_L: CRC length to be calculated by TRW-24G in shockBurst.

Logic 0: 8 bit CRC

Logic 1: 16 bit CRC

Bit 16:

CRC_EN: Enables on-chip CRC generation (TX) and verification (RX).

Logic 0: On-chip CRC generation/checking disabled

Logic 1: On-chip CRC generation/checking enabled

NOTE

An 8 bit CRC will increase the number of payload bits possible in each ShockBurst™ data packet, but will also reduce the system integrity.

5.3 General device configuration

This section of the configuration word handles RF and device related parameters modes:

RX2_EN	CM	RFDR_SB	XO_F			RF_PWR	
15	14	13	12	11	10	9	8

Table 7 RF operational settings

Bit 15:

RX2_EN:

Logic 0: One channel receive

Logic 1: Two channels receive

NOTE

In two channels receive, the TRW-24G receives on two, separate frequency channels simultaneously. The frequency of receive channel 1 is set in the configuration word B[7-1], receive channel 2 is always 8 channels (8 MHz) above receive channel 1.

Bit 14:

Communication Mode:

Logic 1: operates in ShockBurst™ mode

Bit 13:

RF Data Rate:

Logic 0: 250 kbps

Logic 1: 1 Mbps

NOTE

Utilizing 250 kbps instead of 1 Mbps will improve the receiver sensitivity by 10 dB. 1 Mbps requires 16MHz crystal.

Bit 12-10:

XO_F: Selects the crystal frequency to be used. Default to be 16MHz.

XO FREQUENCY SELECTION			
D12	D11	D10	MHz
0	0	0	4
0	0	1	8
0	1	0	12
0	1	1	16
1	0	0	20

Table 8 Crystal frequency setting

Bit 9-8:

RF_PWR: Sets TRW-24G RF output power in transmit mode:

RF OUTPUT POWER		
D9	D8	P[dBm]
0	0	-20
0	1	-10
1	0	-5
1	1	0

Table 9 RF output power setting

RF channel & direction

RF CH#							RXEN
7	6	5	4	3	2	1	0

Table 10 Frequency channel + RX/TX setting

Bit 7-1:

RF_CH#: Sets the frequency channel the nRF2401 operates on.

The channel frequency in **transmit** is given by:

$$Channel_{RF} = 2400 \text{ MHz} + RF_CH\# \cdot 1.0 \text{ MHz}$$

RF_CH # : between 2400MHz and 2527MHz may be set.

The channel frequency in **data channel 1** is given by:

$$Channel_{RF} = 2400 \text{ MHz} + RF_CH\# \cdot 1.0 \text{ MHz} \text{ (Receive at PIN\#8)}$$

RF_CH # : between 2400MHz and 2524MHz may be set.

NOTE

The channels above 83 can only be utilized in certain territories (ex: Japan)

The channel frequency in **data channel 2** is given by:

$$Channel_{RF} = 2400 \text{ MHz} + RF_CH\# \cdot 1.0 \text{ MHz} + 8\text{MHz}$$

(Receive at PIN#4)

RF_CH # : between 2408MHz and 2524MHz may be set.

Bit 0:

Set active mode:

Logic 0: transmit mode

Logic 1: receive mode

5.4 Data Package Description

The data packet for both ShockBurst™ mode and direct mode communication is divided into 4 sections. These are:

PRE-AMBLE	ADDRESS	PAYLOAD	CRC
-----------	---------	---------	-----

Figure 2 Data Package Diagram

Hereby is the information in detail about these 4 sections.

1. PREAMBLE	● The preamble field is required in ShockBurst and Direct Mode ● Preamble is 8 bits in length and is dependent of the first data bit in direct mode. <table><tr><td>PREAMBLE</td><td>1st ADDR-BIT</td></tr><tr><td>01010101</td><td>0</td></tr><tr><td>10101010</td><td>1</td></tr></table>	PREAMBLE	1st ADDR-BIT	01010101	0	10101010	1
PREAMBLE	1st ADDR-BIT						
01010101	0						
10101010	1						
2. ADDRESS	● The address field is required in ShockBurst mode. ● 8 to 40 bits length. ● Address automatically removed from received packet in shockBurst mode. In Direct Mode MCU must handle address						
3. PAYLOAD	● The data to be transmitted ● In Shock-Burst mode payload size is 256 bits minus the following: (Address: 8 to 40 bits. + CRC 8 or 16 bits).						
4. CRC	● The CRC is optional in ShockBurst™ mode, and is not used in Direct mode ● 8 or 16 bits length ● The CRC is removed from the received output data in ShockBurst™ RX.						

5.5 ShockBurst™

The ShockBurst™ technology uses on-chip FIFO to clock in data at a low data rate and transmit at a very high rate thus enabling extremely power reduction.

When operation the TRW-24G in ShockBurst™, you gain access to the high data rates (1 Mbps) offered by the 2.4GHz band without the need of a costly, high-speed micro controller (MCU) for data processing.

By putting all high speed signal processing related to RF protocol on-chip, the TRW-24G offers the following benefits:

1. Highly reduced current consumption.
2. Lower system cost (facilitates use of less expensive micro controller).
3. Greatly reduced risk of 'on-air' collisions due to short transmission time.

The TRW-24G can be programmed using a simple 3-wire interface where the data rate is decided by the speed of the micro controller.

By allowing the digital part of the application to run at low speed while maximizing the data rate on the RF link, the nRF ShockBurst™ mode reduces the average current consumption in applications considerably.

5.5.1 ShockBurst™ principle

When the TRW-24G is configured in ShockBurst™, TX or RX operation is conducted in the following way (10 kbps for the example only).

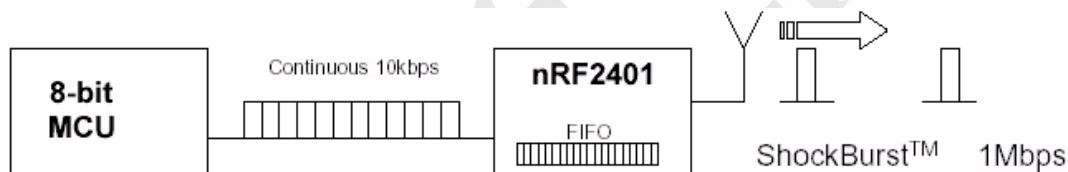


Figure 3 Clocking in data with MCU and sending with ShockBurst™ technology

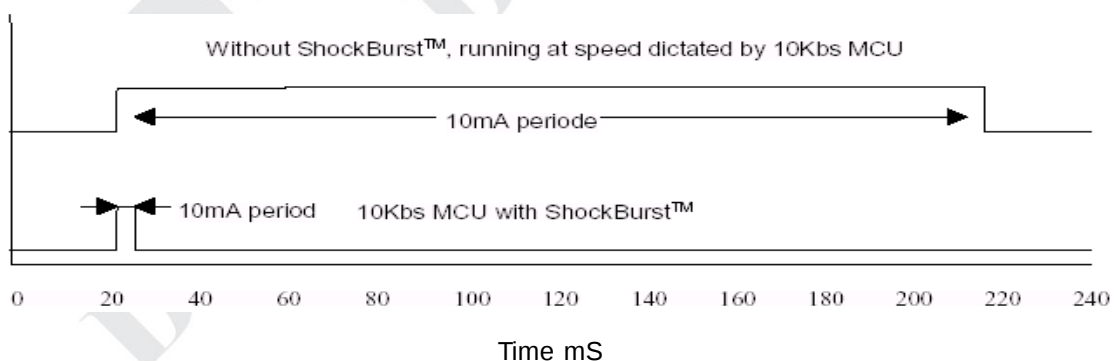


Figure 4 Current consumption with & without ShockBurst™ technology

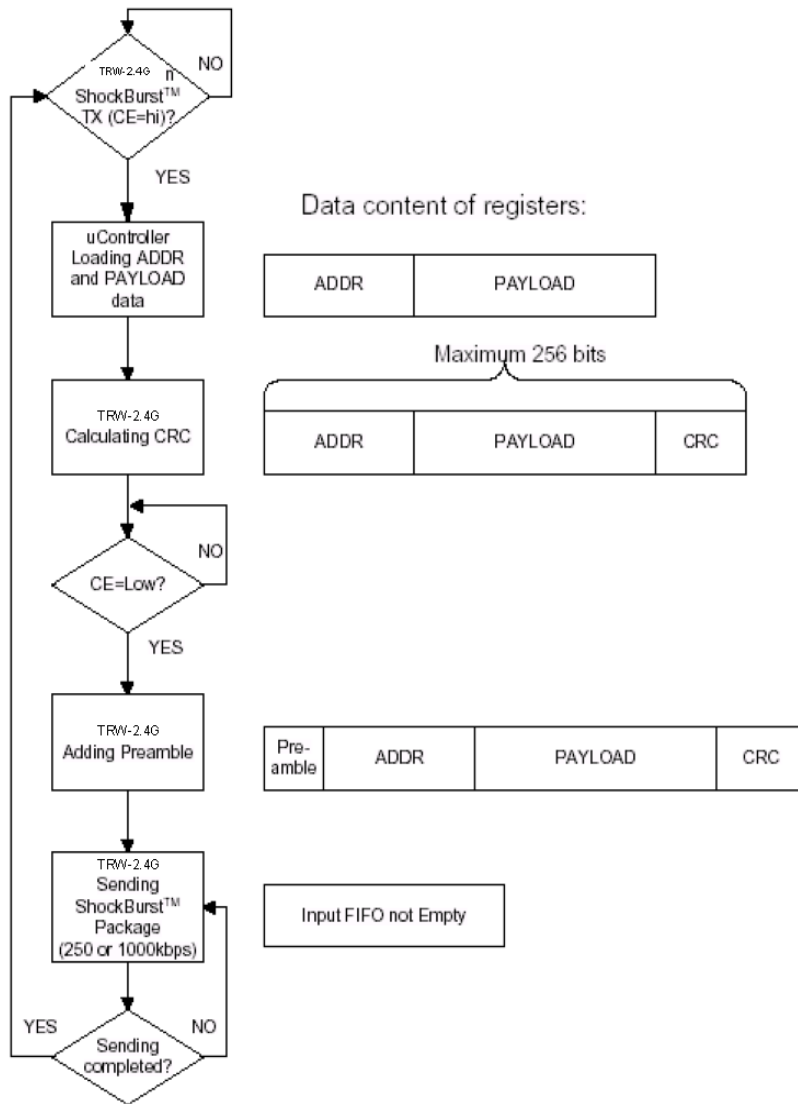


Figure 5 Flow Chart shockBurst™ Transmit of TRW-24G

5.5.2 TRW-24G ShockBurst™ Transmit

MCU interface pins:CE,CLK1,DATA

1. When the application MCU has data to send, set CE high. This activates TRW-24G on-board data processing.
2. The address of the receiving node(RX address) and payload data is clocked into the TRW-24G. The application protocol or MCU sets the speed <1Mbps(ex:10kbps)>.
3. MCU sets CE low, this activates a TRW-24G ShockBurst™ transmission.
4. TRW-24G ShockBurst™:
 - RF front end is powered up.
 - RF package is completed (preamble added, CRC calculated).
 - Data is transmitted at high speed (250kbps or 1 Mbps configured by user).
 - TRW-24G returns to stand-by when finished.

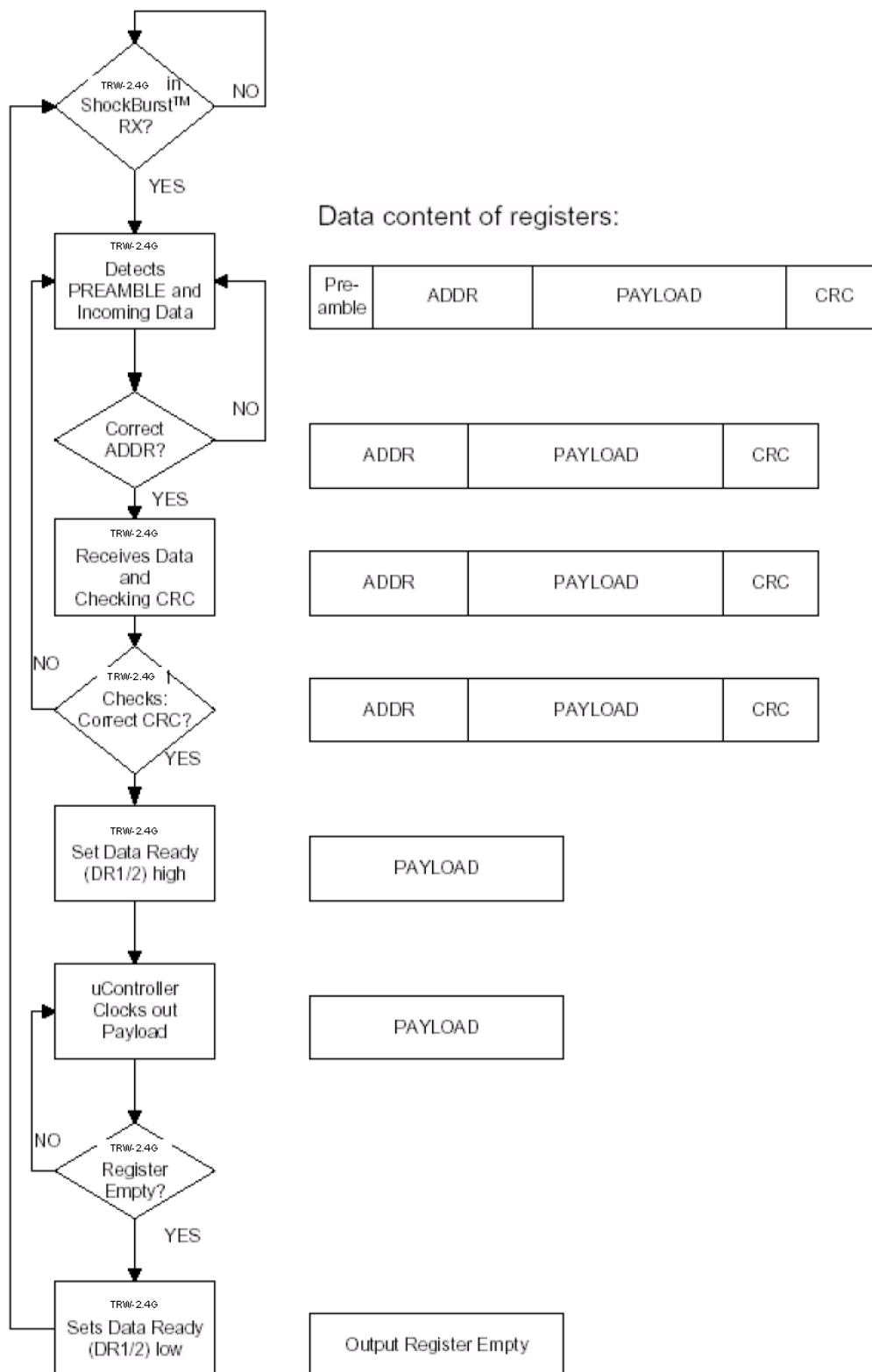


Figure 6 Flow Chart ShockBurst™ Receive of TRW-24G.

5.5.3 TRW-24G ShockBurst™ Receive

MCU interface pins: CE, DR1, CLK1 and DATA (one RX channel receive)

1. Correct address and size of payload of incoming RF packages are set when TRW-24G is configured to ShockBurst™ RX.
2. To activate RX, set CE high.
3. After 200us settling, TRW-24G is monitoring the air for incoming communication.
4. When a valid package has been received (correct address and CRC found), TRW-24G removes the preamble, address and CRC bits.
5. TRW-24G then notifies (interrupts) the MCU by setting the DR1 pin high.
6. MCU may (or may not) set the CE low to disable the RF front end (low current mode).
7. The MCU will clock out just the payload data at a suitable rate (ex, 10 kbps).
8. When all payload data is retrieved TRW-24G sets DR1 low again, and is ready for new incoming data package if CE is kept high during data download. If the CE was set low, a new start up sequence can begin, see Figure 12.

5.5.4 Duoceiver™ Simultaneous Two Channel Receive Mode

In ShockBurst™ mode the TRW-24G can facilitate simultaneous reception of two parallel independent frequency channels at the maximum data rate. This means:

1. TRW-24G can receive data from two 1Mbps transmitters (ex: TRW-24G or TRW-24G) 8MHz (8 frequency channels) apart through one antenna interface.
2. The output from the two data channels is fed to two separate MCU interfaces.
3. Data channel 1: CLK1, DATA, and DR1
4. Data channel 2: CLK2, DOUT2, and DR2
5. DR1 and DR2 are available only in ShockBurst™.

The TRW-24G DuoCeiver™ technology provides 2 separate dedicated data channels for RX and replaces the need for two, stand alone receiver systems.

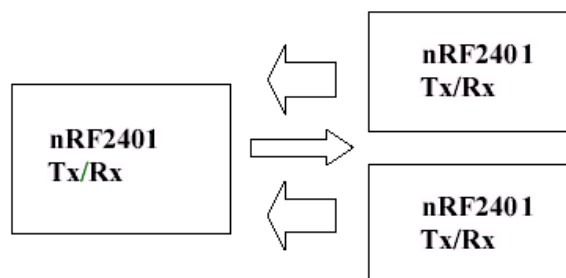


Figure 7 Simultaneous 2 channel receive on TRW-24G

There is one absolute requirement for using the second data channel. For the TRW-24G to be able to receive at the second data channel the frequency channel must be 8MHz higher than the frequency of data channel 1. The TRW-24G must be programmed to receive at the frequency of data channel 1. No time multiplexing is used in TRW-24G to fulfil this function. In direct mode the MCU must be able to handle two simultaneously incoming data packets if it is not multiplexing between the two data channels. In ShockBurst™ it is possible for the MCU to clock out one data channel at a time while data on the other data channel waits for MCU availability, without any lost data packets, and by doing so reduce the needed performance of the MCU.

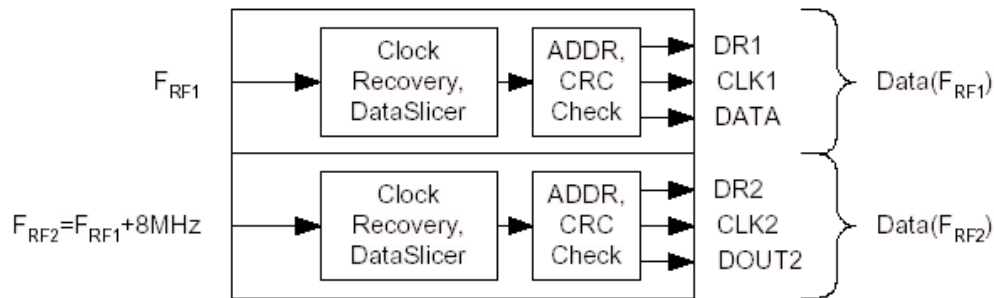


Figure 8 DuoCeiver™ with two simultaneously independent receive channels

5.6 DirectMode

In direct mode the nRF2401 works like a traditional RF device. Data must be at 1Mbps ± 200 ppm, or 250kbps ± 200 ppm at low data rate setting, for the receiver to detect the signals.

5.6.1 Direct Mode Transmit

MCU interface pins: CE, DATA

1. When application MCU has data to send, set CE high
2. The nRF2401 RF front end is now immediately activated, and after 200 ms settling time, data will modulate the carrier directly.
3. All RF protocol parts must hence be implemented in MCU firmware (preamble, address and CRC).

5.6.2 Direct Mode Receive

MCU interface pins: CE, CLK1, and DATA

1. Once the nRF2401 is configured and powered up (CE high) in direct RX mode, DATA will start to toggle due to noise present on the air.
2. CLK1 will also start to toggle as nRF2401 is trying to lock on to the incoming data stream.
3. Once a valid preamble arrives, CLK1 and DATA will lock on to the incoming signal and the RF package will appear at the DATA pin with the same speed as it is transmitted.
4. To enable the demodulator to re-generate the clock, the preamble must be 8 bits toggling hi-low, starting with low if the first data bit is low.
5. In this mode no data ready (DR) signals is available. Address and checksum verification must also be done in the receiving MCU.

5.6.3 DuoCeiver™ Simultaneous Two Channel Receive Mode

In direct mode, it can facilitate simultaneous reception of two parallel independent frequency channels as ShockBurst™ mode. Please refer to section 5.5.4.

TRW-24G ShockBurst Mode configuration data starts from MSB.

Example 1 : ShockBurst Transmitting mode

Channel Freq: 2410MHz, Data Rate : 1 Mbps

Bit143	Bit142	Bit141	Bit140	Bit139	Bit138	Bit137	Bit136
1	0	0	0	1	1	1	0
Bit135	Bit134	Bit133	Bit132	Bit131	Bit130	Bit129	Bit128
0	0	0	0	1	0	0	0
Bit127	Bit126	Bit125	Bit124	Bit123	Bit122	Bit121	Bit120
0	0	0	1	1	1	0	0
Bit119	Bit118	Bit117	Bit116	Bit115	Bit114	Bit113	Bit112
1	1	0	0	1	0	0	0
Bit111	Bit110	Bit109	Bit108	Bit107	Bit106	Bit105	Bit104
1	1	0	0	1	0	0	0
Bit103	Bit102	Bit101	Bit100	Bit99	Bit98	Bit97	Bit96
1	1	0	0	0	0	0	0
Bit95	Bit94	Bit93	Bit92	Bit91	Bit90	Bit89	Bit88
1	0	1	0	1	0	1	0
Bit87	Bit86	Bit85	Bit84	Bit83	Bit82	Bit81	Bit80
0	1	0	1	0	1	0	1
Bit79	Bit78	Bit77	Bit76	Bit75	Bit74	Bit73	Bit72
1	0	1	0	1	0	1	0
Bit71	Bit70	Bit69	Bit68	Bit67	Bit66	Bit65	Bit64
0	1	0	1	0	1	0	1
Bit63	Bit62	Bit61	Bit60	Bit59	Bit58	Bit57	Bit56
1	0	1	0	1	0	1	0
Bit55	Bit54	Bit53	Bit52	Bit51	Bit50	Bit49	Bit48
0	1	0	1	0	1	0	1
Bit47	Bit46	Bit45	Bit44	Bit43	Bit42	Bit41	Bit40
1	0	1	0	1	0	1	0
Bit39	Bit38	Bit37	Bit36	Bit35	Bit34	Bit33	Bit32
0	1	0	1	0	1	0	1
Bit31	Bit30	Bit29	Bit28	Bit27	Bit26	Bit25	Bit24
1	0	1	0	1	0	1	0
Bit23	Bit22	Bit21	Bit20	Bit19	Bit18	Bit17	Bit16
1	0	1	0	0	0	1	1
Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8
0	1	1	0	1	1	1	1
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0	0	0	1	0	1	0	0

Example 2 : ShockBurst Receiving mode

Channel Freq: 2410MHz, Data Rate : 1 Mbps

Bit143	Bit142	Bit141	Bit140	Bit139	Bit138	Bit137	Bit136
1	0	0	0	1	1	1	0
Bit135	Bit134	Bit133	Bit132	Bit131	Bit130	Bit129	Bit128
0	0	0	0	1	0	0	0
Bit127	Bit126	Bit125	Bit124	Bit123	Bit122	Bit121	Bit120
0	0	0	1	1	1	0	0
Bit119	Bit118	Bit117	Bit116	Bit115	Bit114	Bit113	Bit112
1	1	0	0	1	0	0	0
Bit111	Bit110	Bit109	Bit108	Bit107	Bit106	Bit105	Bit104
1	1	0	0	1	0	0	0
Bit103	Bit102	Bit101	Bit100	Bit99	Bit98	Bit97	Bit96
1	1	0	0	0	0	0	0
Bit95	Bit94	Bit93	Bit92	Bit91	Bit90	Bit89	Bit88
1	0	1	0	1	0	1	0
Bit87	Bit86	Bit85	Bit84	Bit83	Bit82	Bit81	Bit80
0	1	0	1	0	1	0	1
Bit79	Bit78	Bit77	Bit76	Bit75	Bit74	Bit73	Bit72
1	0	1	0	1	0	1	0
Bit71	Bit70	Bit69	Bit68	Bit67	Bit66	Bit65	Bit64
0	1	0	1	0	1	0	1
Bit63	Bit62	Bit61	Bit60	Bit59	Bit58	Bit57	Bit56
1	0	1	0	1	0	1	0
Bit55	Bit54	Bit53	Bit52	Bit51	Bit50	Bit49	Bit48
0	1	0	1	0	1	0	1
Bit47	Bit46	Bit45	Bit44	Bit43	Bit42	Bit41	Bit40
1	0	1	0	1	0	1	0
Bit39	Bit38	Bit37	Bit36	Bit35	Bit34	Bit33	Bit32
0	1	0	1	0	1	0	1
Bit31	Bit30	Bit29	Bit28	Bit27	Bit26	Bit25	Bit24
1	0	1	0	1	0	1	0
Bit23	Bit22	Bit21	Bit20	Bit19	Bit18	Bit17	Bit16
1	0	1	0	0	0	1	1
Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8
0	1	1	0	1	1	1	1
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0	0	0	1	0	1	0	1

Example 3 : ShockBurst Transmitting mode

Channel Freq: 2410MHz, Data Rate : 250 Kbps

Bit143	Bit142	Bit141	Bit140	Bit139	Bit138	Bit137	Bit136
1	0	0	0	1	1	1	0
Bit135	Bit134	Bit133	Bit132	Bit131	Bit130	Bit129	Bit128
0	0	0	0	1	0	0	0
Bit127	Bit126	Bit125	Bit124	Bit123	Bit122	Bit121	Bit120
0	0	0	1	1	1	0	0
Bit119	Bit118	Bit117	Bit116	Bit115	Bit114	Bit113	Bit112
1	1	0	0	1	0	0	0
Bit111	Bit110	Bit109	Bit108	Bit107	Bit106	Bit105	Bit104
1	1	0	0	1	0	0	0
Bit103	Bit102	Bit101	Bit100	Bit99	Bit98	Bit97	Bit96
1	1	0	0	0	0	0	0
Bit95	Bit94	Bit93	Bit92	Bit91	Bit90	Bit89	Bit88
1	0	1	0	1	0	1	0
Bit87	Bit86	Bit85	Bit84	Bit83	Bit82	Bit81	Bit80
0	1	0	1	0	1	0	1
Bit79	Bit78	Bit77	Bit76	Bit75	Bit74	Bit73	Bit72
1	0	1	0	1	0	1	0
Bit71	Bit70	Bit69	Bit68	Bit67	Bit66	Bit65	Bit64
0	1	0	1	0	1	0	1
Bit63	Bit62	Bit61	Bit60	Bit59	Bit58	Bit57	Bit56
1	0	1	0	1	0	1	0
Bit55	Bit54	Bit53	Bit52	Bit51	Bit50	Bit49	Bit48
0	1	0	1	0	1	0	1
Bit47	Bit46	Bit45	Bit44	Bit43	Bit42	Bit41	Bit40
1	0	1	0	1	0	1	0
Bit39	Bit38	Bit37	Bit36	Bit35	Bit34	Bit33	Bit32
0	1	0	1	0	1	0	1
Bit31	Bit30	Bit29	Bit28	Bit27	Bit26	Bit25	Bit24
1	0	1	0	1	0	1	0
Bit23	Bit22	Bit21	Bit20	Bit19	Bit18	Bit17	Bit16
1	0	1	0	0	0	1	1
Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8
0	1	0	0	1	1	1	1
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0	0	0	1	0	1	0	0

Example 4: ShockBurst Receiving mode

Channel Freq: 2410MHz, Data Rate : 250 Kbps

Bit143	Bit142	Bit141	Bit140	Bit139	Bit138	Bit137	Bit136
1	0	0	0	1	1	1	0
Bit135	Bit134	Bit133	Bit132	Bit131	Bit130	Bit129	Bit128
0	0	0	0	1	0	0	0
Bit127	Bit126	Bit125	Bit124	Bit123	Bit122	Bit121	Bit120
0	0	0	1	1	1	0	0
Bit119	Bit118	Bit117	Bit116	Bit115	Bit114	Bit113	Bit112
1	1	0	0	1	0	0	0
Bit111	Bit110	Bit109	Bit108	Bit107	Bit106	Bit105	Bit104
1	1	0	0	1	0	0	0
Bit103	Bit102	Bit101	Bit100	Bit99	Bit98	Bit97	Bit96
1	1	0	0	0	0	0	0
Bit95	Bit94	Bit93	Bit92	Bit91	Bit90	Bit89	Bit88
1	0	1	0	1	0	1	0
Bit87	Bit86	Bit85	Bit84	Bit83	Bit82	Bit81	Bit80
0	1	0	1	0	1	0	1
Bit79	Bit78	Bit77	Bit76	Bit75	Bit74	Bit73	Bit72
1	0	1	0	1	0	1	0
Bit71	Bit70	Bit69	Bit68	Bit67	Bit66	Bit65	Bit64
0	1	0	1	0	1	0	1
Bit63	Bit62	Bit61	Bit60	Bit59	Bit58	Bit57	Bit56
1	0	1	0	1	0	1	0
Bit55	Bit54	Bit53	Bit52	Bit51	Bit50	Bit49	Bit48
0	1	0	1	0	1	0	1
Bit47	Bit46	Bit45	Bit44	Bit43	Bit42	Bit41	Bit40
1	0	1	0	1	0	1	0
Bit39	Bit38	Bit37	Bit36	Bit35	Bit34	Bit33	Bit32
0	1	0	1	0	1	0	1
Bit31	Bit30	Bit29	Bit28	Bit27	Bit26	Bit25	Bit24
1	0	1	0	1	0	1	0
Bit23	Bit22	Bit21	Bit20	Bit19	Bit18	Bit17	Bit16
1	0	1	0	0	0	1	1
Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8
0	1	0	0	1	1	1	1
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0	0	0	1	0	1	0	1

Example 5 : ShockBurst Due-Channel Transmitting mode

Channel Freq: 2410MHz, Data Rate : 250 Kbps

Bit143	Bit142	Bit141	Bit140	Bit139	Bit138	Bit137	Bit136
1	0	0	0	1	1	1	0
Bit135	Bit134	Bit133	Bit132	Bit131	Bit130	Bit129	Bit128
0	0	0	0	1	0	0	0
Bit127	Bit126	Bit125	Bit124	Bit123	Bit122	Bit121	Bit120
0	0	0	1	1	1	0	0
Bit119	Bit118	Bit117	Bit116	Bit115	Bit114	Bit113	Bit112
1	1	0	0	1	0	0	0
Bit111	Bit110	Bit109	Bit108	Bit107	Bit106	Bit105	Bit104
1	1	0	0	1	0	0	0
Bit103	Bit102	Bit101	Bit100	Bit99	Bit98	Bit97	Bit96
1	1	0	0	0	0	0	0
Bit95	Bit94	Bit93	Bit92	Bit91	Bit90	Bit89	Bit88
1	0	1	0	1	0	1	0
Bit87	Bit86	Bit85	Bit84	Bit83	Bit82	Bit81	Bit80
0	1	0	1	0	1	0	1
Bit79	Bit78	Bit77	Bit76	Bit75	Bit74	Bit73	Bit72
1	0	1	0	1	0	1	0
Bit71	Bit70	Bit69	Bit68	Bit67	Bit66	Bit65	Bit64
0	1	0	1	0	1	0	1
Bit63	Bit62	Bit61	Bit60	Bit59	Bit58	Bit57	Bit56
1	0	1	0	1	0	1	0
Bit55	Bit54	Bit53	Bit52	Bit51	Bit50	Bit49	Bit48
0	1	0	1	0	1	0	1
Bit47	Bit46	Bit45	Bit44	Bit43	Bit42	Bit41	Bit40
1	0	1	0	1	0	1	0
Bit39	Bit38	Bit37	Bit36	Bit35	Bit34	Bit33	Bit32
0	1	0	1	0	1	0	1
Bit31	Bit30	Bit29	Bit28	Bit27	Bit26	Bit25	Bit24
1	0	1	0	1	0	1	0
Bit23	Bit22	Bit21	Bit20	Bit19	Bit18	Bit17	Bit16
1	0	1	0	0	0	1	1
Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8
1	1	1	0	1	1	1	1
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0	0	0	1	0	1	0	1

Example 6: ShockBurst Due-Channel Receiving mode

Channel Freq: 2410MHz, Data Rate : 250 Kbps

Bit143	Bit142	Bit141	Bit140	Bit139	Bit138	Bit137	Bit136
1	0	0	0	1	1	1	0
Bit135	Bit134	Bit133	Bit132	Bit131	Bit130	Bit129	Bit128
0	0	0	0	1	0	0	0
Bit127	Bit126	Bit125	Bit124	Bit123	Bit122	Bit121	Bit120
0	0	0	1	1	1	0	0
Bit119	Bit118	Bit117	Bit116	Bit115	Bit114	Bit113	Bit112
1	1	0	0	1	0	0	0
Bit111	Bit110	Bit109	Bit108	Bit107	Bit106	Bit105	Bit104
1	1	0	0	1	0	0	0
Bit103	Bit102	Bit101	Bit100	Bit99	Bit98	Bit97	Bit96
1	1	0	0	0	0	0	0
Bit95	Bit94	Bit93	Bit92	Bit91	Bit90	Bit89	Bit88
1	0	1	0	1	0	1	0
Bit87	Bit86	Bit85	Bit84	Bit83	Bit82	Bit81	Bit80
0	1	0	1	0	1	0	1
Bit79	Bit78	Bit77	Bit76	Bit75	Bit74	Bit73	Bit72
1	0	1	0	1	0	1	0
Bit71	Bit70	Bit69	Bit68	Bit67	Bit66	Bit65	Bit64
0	1	0	1	0	1	0	1
Bit63	Bit62	Bit61	Bit60	Bit59	Bit58	Bit57	Bit56
1	0	1	0	1	0	1	0
Bit55	Bit54	Bit53	Bit52	Bit51	Bit50	Bit49	Bit48
0	1	0	1	0	1	0	1
Bit47	Bit46	Bit45	Bit44	Bit43	Bit42	Bit41	Bit40
1	0	1	0	1	0	1	0
Bit39	Bit38	Bit37	Bit36	Bit35	Bit34	Bit33	Bit32
0	1	0	1	0	1	0	1
Bit31	Bit30	Bit29	Bit28	Bit27	Bit26	Bit25	Bit24
1	0	1	0	1	0	1	0
Bit23	Bit22	Bit21	Bit20	Bit19	Bit18	Bit17	Bit16
1	0	1	0	0	0	1	1
Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8
1	1	0	0	1	1	1	1
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0	0	0	1	0	1	0	1

TRW-24G Direct Mode configuration data starts from MSB.

Example 7 : Direct Mode Transmitting mode

Channel Freq: 2410MHz, Data Rate : 250 Kbps

Bit143	Bit142	Bit141	Bit140	Bit139	Bit138	Bit137	Bit136
1	0	0	0	1	1	1	0
Bit135	Bit134	Bit133	Bit132	Bit131	Bit130	Bit129	Bit128
0	0	0	0	1	0	0	0
Bit127	Bit126	Bit125	Bit124	Bit123	Bit122	Bit121	Bit120
0	0	0	1	1	1	0	0
Bit119	Bit118	Bit117	Bit116	Bit115	Bit114	Bit113	Bit112
1	1	0	0	1	0	0	0
Bit111	Bit110	Bit109	Bit108	Bit107	Bit106	Bit105	Bit104
1	1	0	0	1	0	0	0
Bit103	Bit102	Bit101	Bit100	Bit99	Bit98	Bit97	Bit96
1	1	0	0	0	0	0	0
Bit95	Bit94	Bit93	Bit92	Bit91	Bit90	Bit89	Bit88
1	0	1	0	1	0	1	0
Bit87	Bit86	Bit85	Bit84	Bit83	Bit82	Bit81	Bit80
0	1	0	1	0	1	0	1
Bit79	Bit78	Bit77	Bit76	Bit75	Bit74	Bit73	Bit72
1	0	1	0	1	0	1	0
Bit71	Bit70	Bit69	Bit68	Bit67	Bit66	Bit65	Bit64
0	1	0	1	0	1	0	1
Bit63	Bit62	Bit61	Bit60	Bit59	Bit58	Bit57	Bit56
1	0	1	0	1	0	1	0
Bit55	Bit54	Bit53	Bit52	Bit51	Bit50	Bit49	Bit48
0	1	0	1	0	1	0	1
Bit47	Bit46	Bit45	Bit44	Bit43	Bit42	Bit41	Bit40
1	0	1	0	1	0	1	0
Bit39	Bit38	Bit37	Bit36	Bit35	Bit34	Bit33	Bit32
0	1	0	1	0	1	0	1
Bit31	Bit30	Bit29	Bit28	Bit27	Bit26	Bit25	Bit24
1	0	1	0	1	0	1	0
Bit23	Bit22	Bit21	Bit20	Bit19	Bit18	Bit17	Bit16
1	0	1	0	0	0	1	1
Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8
0	0	0	0	1	1	1	1
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0	0	0	1	0	1	0	0

Example 8 : Direct Mode Receiving mode**Channel Freq: 2410MHz, Data Rate: 250 Kbps**

Bit143	Bit142	Bit141	Bit140	Bit139	Bit138	Bit137	Bit136
1	0	0	0	1	1	1	0
Bit135	Bit134	Bit133	Bit132	Bit131	Bit130	Bit129	Bit128
0	0	0	0	1	0	0	0
Bit127	Bit126	Bit125	Bit124	Bit123	Bit122	Bit121	Bit120
0	0	0	1	1	1	0	0
Bit119	Bit118	Bit117	Bit116	Bit115	Bit114	Bit113	Bit112
1	1	0	0	1	0	0	0
Bit111	Bit110	Bit109	Bit108	Bit107	Bit106	Bit105	Bit104
1	1	0	0	1	0	0	0
Bit103	Bit102	Bit101	Bit100	Bit99	Bit98	Bit97	Bit96
1	1	0	0	0	0	0	0
Bit95	Bit94	Bit93	Bit92	Bit91	Bit90	Bit89	Bit88
1	0	1	0	1	0	1	0
Bit87	Bit86	Bit85	Bit84	Bit83	Bit82	Bit81	Bit80
0	1	0	1	0	1	0	1
Bit79	Bit78	Bit77	Bit76	Bit75	Bit74	Bit73	Bit72
1	0	1	0	1	0	1	0
Bit71	Bit70	Bit69	Bit68	Bit67	Bit66	Bit65	Bit64
0	1	0	1	0	1	0	1
Bit63	Bit62	Bit61	Bit60	Bit59	Bit58	Bit57	Bit56
1	0	1	0	1	0	1	0
Bit55	Bit54	Bit53	Bit52	Bit51	Bit50	Bit49	Bit48
0	1	0	1	0	1	0	1
Bit47	Bit46	Bit45	Bit44	Bit43	Bit42	Bit41	Bit40
1	0	1	0	1	0	1	0
Bit39	Bit38	Bit37	Bit36	Bit35	Bit34	Bit33	Bit32
0	1	0	1	0	1	0	1
Bit31	Bit30	Bit29	Bit28	Bit27	Bit26	Bit25	Bit24
1	0	1	0	1	0	1	0
Bit23	Bit22	Bit21	Bit20	Bit19	Bit18	Bit17	Bit16
1	0	1	0	0	0	1	1
Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8
0	0	0	0	1	1	1	1
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0	0	0	1	0	1	0	1

Example 9 : Direct Mode Due-Channel Transmitting mode

Channel Freq: 2410MHz, Data Rate : 250 Kbps

Bit143	Bit142	Bit141	Bit140	Bit139	Bit138	Bit137	Bit136
1	0	0	0	1	1	1	0
Bit135	Bit134	Bit133	Bit132	Bit131	Bit130	Bit129	Bit128
0	0	0	0	1	0	0	0
Bit127	Bit126	Bit125	Bit124	Bit123	Bit122	Bit121	Bit120
0	0	0	1	1	1	0	0
Bit119	Bit118	Bit117	Bit116	Bit115	Bit114	Bit113	Bit112
1	1	0	0	1	0	0	0
Bit111	Bit110	Bit109	Bit108	Bit107	Bit106	Bit105	Bit104
1	1	0	0	1	0	0	0
Bit103	Bit102	Bit101	Bit100	Bit99	Bit98	Bit97	Bit96
1	1	0	0	0	0	0	0
Bit95	Bit94	Bit93	Bit92	Bit91	Bit90	Bit89	Bit88
1	0	1	0	1	0	1	0
Bit87	Bit86	Bit85	Bit84	Bit83	Bit82	Bit81	Bit80
0	1	0	1	0	1	0	1
Bit79	Bit78	Bit77	Bit76	Bit75	Bit74	Bit73	Bit72
1	0	1	0	1	0	1	0
Bit71	Bit70	Bit69	Bit68	Bit67	Bit66	Bit65	Bit64
0	1	0	1	0	1	0	1
Bit63	Bit62	Bit61	Bit60	Bit59	Bit58	Bit57	Bit56
1	0	1	0	1	0	1	0
Bit55	Bit54	Bit53	Bit52	Bit51	Bit50	Bit49	Bit48
0	1	0	1	0	1	0	1
Bit47	Bit46	Bit45	Bit44	Bit43	Bit42	Bit41	Bit40
1	0	1	0	1	0	1	0
Bit39	Bit38	Bit37	Bit36	Bit35	Bit34	Bit33	Bit32
0	1	0	1	0	1	0	1
Bit31	Bit30	Bit29	Bit28	Bit27	Bit26	Bit25	Bit24
1	0	1	0	1	0	1	0
Bit23	Bit22	Bit21	Bit20	Bit19	Bit18	Bit17	Bit16
1	0	1	0	0	0	1	1
Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8
1	0	0	0	1	1	1	1
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0	0	0	1	0	1	0	1

Example 10 : Direct Mode Due-Channel Receiving mode

Channel Freq: 2410MHz, Data Rate : 250 Kbps

Bit143	Bit142	Bit141	Bit140	Bit139	Bit138	Bit137	Bit136
1	0	0	0	1	1	1	0
Bit135	Bit134	Bit133	Bit132	Bit131	Bit130	Bit129	Bit128
0	0	0	0	1	0	0	0
Bit127	Bit126	Bit125	Bit124	Bit123	Bit122	Bit121	Bit120
0	0	0	1	1	1	0	0
Bit119	Bit118	Bit117	Bit116	Bit115	Bit114	Bit113	Bit112
1	1	0	0	1	0	0	0
Bit111	Bit110	Bit109	Bit108	Bit107	Bit106	Bit105	Bit104
1	1	0	0	1	0	0	0
Bit103	Bit102	Bit101	Bit100	Bit99	Bit98	Bit97	Bit96
1	1	0	0	0	0	0	0
Bit95	Bit94	Bit93	Bit92	Bit91	Bit90	Bit89	Bit88
1	0	1	0	1	0	1	0
Bit87	Bit86	Bit85	Bit84	Bit83	Bit82	Bit81	Bit80
0	1	0	1	0	1	0	1
Bit79	Bit78	Bit77	Bit76	Bit75	Bit74	Bit73	Bit72
1	0	1	0	1	0	1	0
Bit71	Bit70	Bit69	Bit68	Bit67	Bit66	Bit65	Bit64
0	1	0	1	0	1	0	1
Bit63	Bit62	Bit61	Bit60	Bit59	Bit58	Bit57	Bit56
1	0	1	0	1	0	1	0
Bit55	Bit54	Bit53	Bit52	Bit51	Bit50	Bit49	Bit48
0	1	0	1	0	1	0	1
Bit47	Bit46	Bit45	Bit44	Bit43	Bit42	Bit41	Bit40
1	0	1	0	1	0	1	0
Bit39	Bit38	Bit37	Bit36	Bit35	Bit34	Bit33	Bit32
0	1	0	1	0	1	0	1
Bit31	Bit30	Bit29	Bit28	Bit27	Bit26	Bit25	Bit24
1	0	1	0	1	0	1	0
Bit23	Bit22	Bit21	Bit20	Bit19	Bit18	Bit17	Bit16
1	0	1	0	0	0	1	1
Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8
1	0	1	0	1	1	1	1
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0	0	0	1	0	1	0	1

6 Important Timing Data

The following timing applies for operation of TRW-24G module

TRW-24G Timing Information:

nRF2401 timing	Max.	Min.	Name
PWR_DWN → ST_BY mode	3ms		Tpd2sby
PWR_DWN → Active mode (RX/TX)	3ms		Tpd2a
ST_BY → TX ShockBurst™	195μs		Tsby2txSB
ST_BY → TX Direct Mode	202μs		Tsby2txDM
ST_BY → RX mode	202μs		Tsby2rx
Minimum delay from CS to data.		5μs	Tcs2data
Minimum delay from CE to data.		5μs	Tce2data
Minimum delay from DRI/2 to clk.		50ns	Tdr2clk
Maximum delay from clk to data.	50ns		Tclk2data
Delay between edges		50ns	Td
Setup time		500ns	Ts
Hold time		500ns	Th
Delay to finish internal GFSK data		1/data rate	Tfd
Minimum input clock high		500ns	Thmin
Set-up of data in Direct Mode	50ns		Tsdm
Minimum clock high in Direct Mode		300ns	Thdm
Minimum clock low in Direct Mode		230ns	Tldm

Table 11 Switching times for TRW-24G

When the TRW-24G is in power down it must always settle in stand-by(Tpd2sby) before it can enter configuration or one of the active modes.

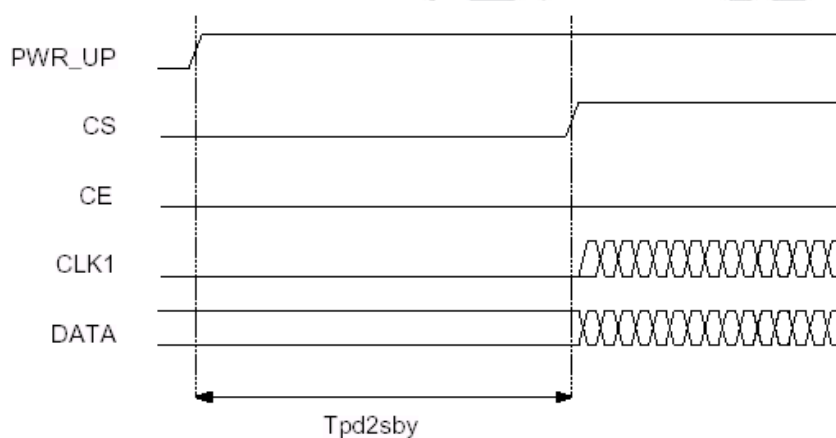


Figure 9 Timing diagram for TRW-24G (or VDD off) to stand by mode.

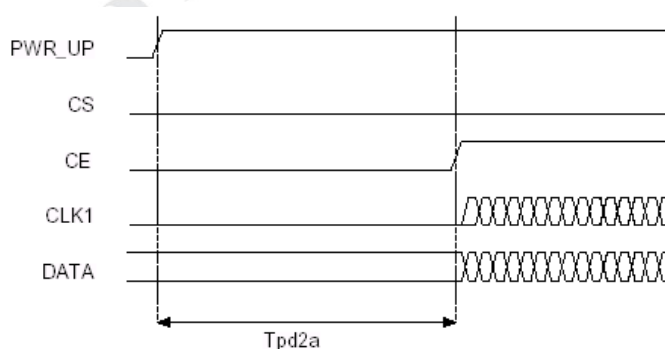


Figure10 VDD off to active mode

Note that the configuration word will be lost when VDD is turned off and that the device then must be configured before going to one of the active modes. If the device is configured one can go directly from power down to the wanted active mode.

NOTE

CE and CS may not be high at the same time. Setting one or the other decides whether configuration or active mode is entered.

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6.1 Configuration mode timing

When one or more of the bits in the configuration word needs to be changed the following timing apply.

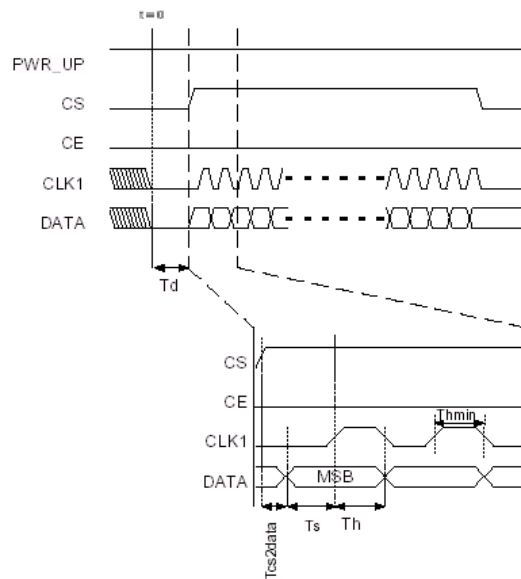


Figure11 Timing diagram for configuration of TRW-24G

If configuration mode is entered from power down, CS can be set high after T_{pd2sby} as shown in Figure 8

6.1.1 ShockBurst™ Mode timing

6.1.1.1 ShockBurst™ TX

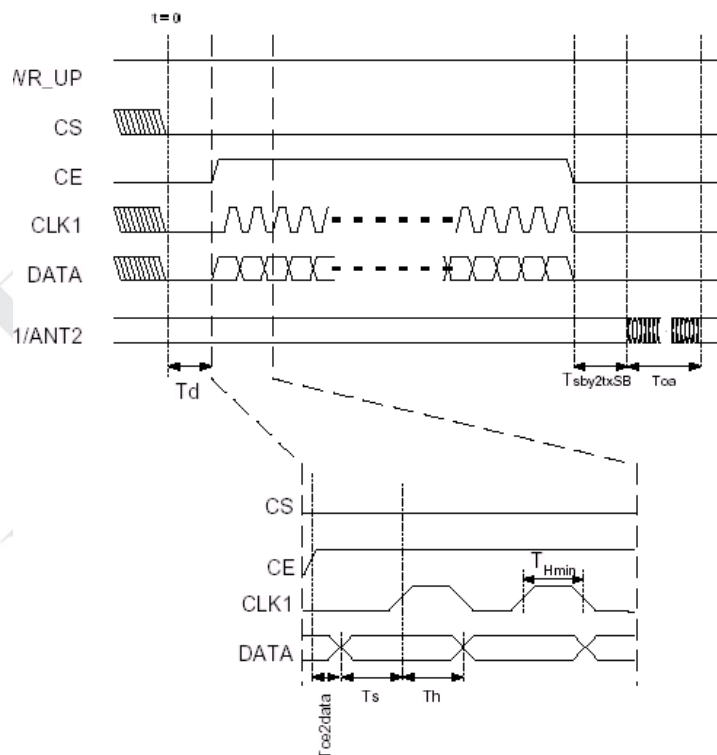


Figure12 Timing of ShockBurst™ in TX

The package length and the data rate give the delay T_{OA} (time on air), as shown in the equation.

$$T_{OA} = 1/\text{datarate} \cdot (\#\text{databits} + 1)$$

6.1.1.2 ShockBurst™ RX

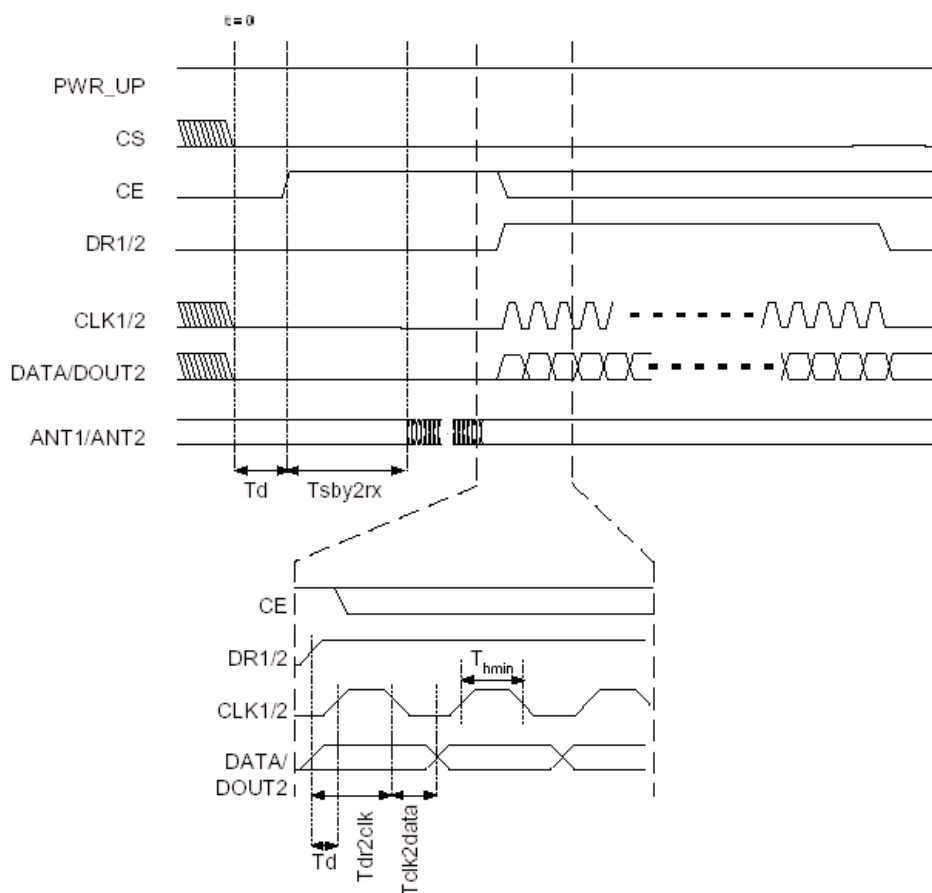


Figure13 Timing of ShockBurst™ in RX

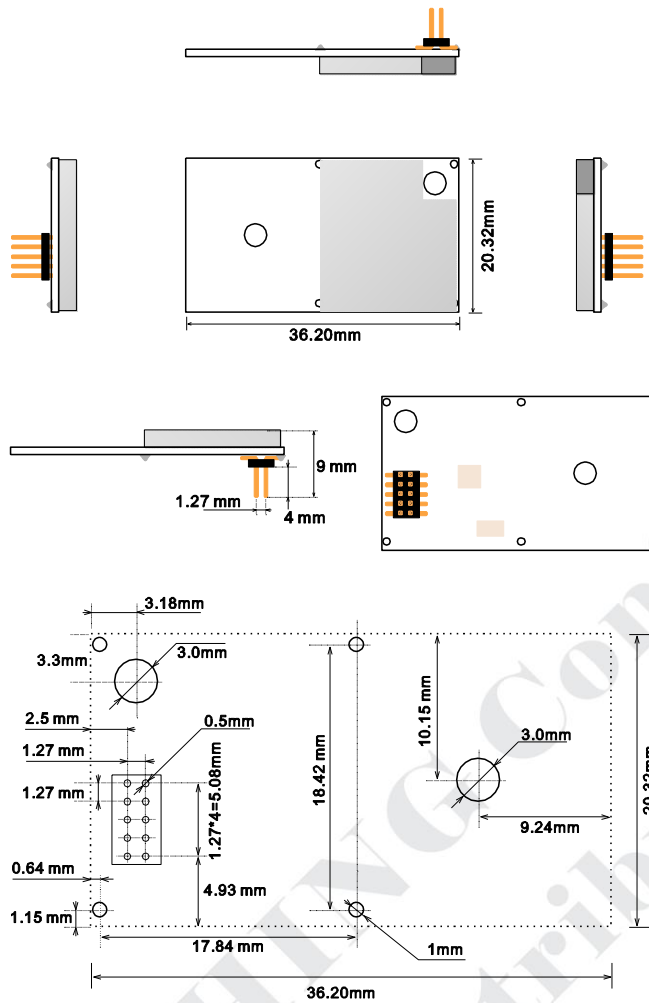
The CE may be kept high during downloading of data, but the cost is higher current consumption (18mA) and the benefit is no start-up time(200μs) after the DR1 goes low.

6.2 Output Power adjustment

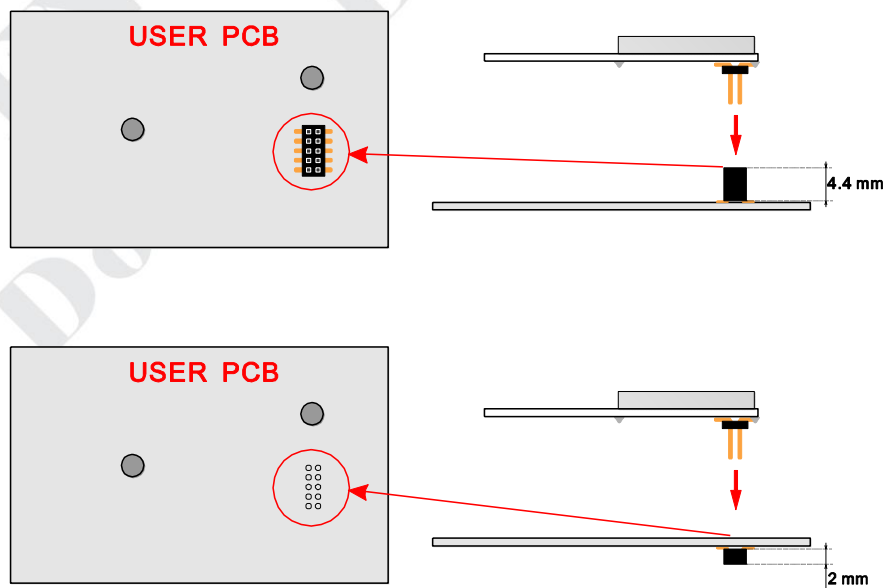
Conditions: VDD= 3.0V, VSS= 0V, T_A = 27°C , Load impedance =400Ω

Power setting bits of configuring word	RF output power	DC current consumption
11	0 dBm ±3dB	13.0 mA
10	-5 dBm ±3dB	10.5 mA
01	-10 dBm ±3dB	9.4 mA
00	-20 dBm ±3dB	8.8 mA

7 TRW-24G Mechanical Drawing



Reference hole position for PCB mounting(Bottom view)



Appendix

1 Demo Program - EM78P156E MCU

```

;=====
;=====TRW-24G test program=====
;===== MCU: EM78P156E=====
;=====MCU CRYSTALL:6MHZ=====
;=====RF CRYSTALL:20MHZ=====
;=====
;
;
;
;
; PW --| P52      P51| -- T_LED1
;      --| P53      P50| -- R_LED1
;      --| TCC      OSCI| --
;      --| /RST      OSCO| --
;      --| VSS      VCC| --
; KEY_1--| P60      P67| --CS
; KEY_2--| P61      P66| --DR1
;      --| P62      P65| --CLK1
; CE --| P63      P64| --DATA
;      | _____ |
;      EM78P156E
;
;
;=====

```

```

TCC      EQU      0X1
P5        EQU      0X5
P6        EQU      0X6
FLAG      EQU      0X1F
BYTE      EQU      0X1E
R0        EQU      0X1D

```

```
DLY_REG EQU 0X1C  
  
KEY_REG EQU 0X1B  
  
TIMER_REG EQU 0X1A
```

```
; -----
```

```
ORG 0X0  
  
JMP RESET  
  
JMP INT_0
```

```
ORG 0X8  
  
JMP INT_1
```

RF_CONFIG_TABLE:

```
MOV A, R0  
ADD 0X2, A
```

```
RETL 0X8E ; TEST
```

```
RETL 0X08
```

```
RETL 0X1C
```

```
RETL 0X20 ; DATA2_W
```

```
RETL 0X0D0 ; DATA1_W
```

```
RETL 0X0BB ; ADDR2
```

```
RETL 0X0BB
```

```
RETL 0X0BB
```

```
RETL 0X0BB
```

```
RETL 0X0BB
```

```

RETL    0X12          ; ADDR1

RETL    0X34

RETL    0X56

RETL    0X78

RETL    0X9A

RETL    0X0A1         ; ADDR_W/CRC

```

```

RETL    0X53          ; RF-PROGRAMMING

RETL    0X02

```

```

;-----
ADDRESS_TABLE:  MOV    A, R0

```

```

    ADD    0X2, A

    RETL   0X12      ; ADDR1

    RETL   0X34

    RETL   0X56

    RETL   0X78

    RETL   0X9A

```

```

;-----
RESET:

```

```

    MOV    A, @0X0

    IOW    0XF

    IOW    0XE

    MOV    A, @0X0FF

    IOW    0XB

    MOV    A, @0X0F8

```

IOW 0XD

MOV A, @0X08 ; P5, 0- LED P5,1-LED P5,2-PW
P5,3-CRYSTALL_SELECT

IOW 0X5

MOV A, @0X47 ; P6, 0- KEY P6,1-KEY P6,2-KEY P6,3-CE

IOW 0X6 ; P6,4-DATA P6,5-CLK1 P6,6-DR1 P6,7-CS

BC P6, 3 ; CE

BC P6, 7 ; CS

MOV A, @0X0D ;WDT

CONTW

MOV A, @0X80

IOW 0XE ; WATCHDOG ENABLE

MOV A, @0X2F

MOV 0X3F, A

MOV A, @0X10

MOV 0X4, A

CLEAR_REG: CLR0X0

INC 0X4

DJZ 0X3F

JMP CLEAR_REG

MOV A, @0X3

MOV 0X10, A

S_LED_TEST:

MOV A, @0X0FF

MOV 0X11, A

S_LED_TEST1:

CALL DELAY1MS

CALL DELAY1MS

WDTC

JBS 0X11, 7

JMP S_LED_OFF

BS P5, 0 ; LED

BS P5, 1 ; LED

JMP S_SKIP

S_LED_OFF:

BC P5, 0 ; LED

BC P5, 1 ; LED

S_SKIP:

DJZ 0X11

JMP S_LED_TEST1

DJZ 0X10

JMP S_LED_TEST

; ENI

;=====

;===== MAIN PROGRAM =====

;=====

MAIN_LOOP:

BS P5, 2 ; PW

BC P5, 0 ; R_LED

BC P5, 1 ; T_LED

BC P6, 3 ; CE

```

CALL    DELAY1MS

MOV     A, P6

AND     A, @0X07

MOV     KEY_REG, A

JBC     P5, 3      ; CRYSTALL SELECT< 0-16M  1-20M>

BS      KEY_REG, 3

```

```

MOV     A, KEY_REG

AND     A, @0X03

XOR     A, @0X0

JBC     0X3, 2      ; Z

JMP     T_MODEL

```

```

MOV     A, KEY_REG

AND     A, @0X03

XOR     A, @0X1

JBC     0X3, 2      ; Z

JMP     R_MODEL

```

```

MOV     A, KEY_REG

AND     A, @0X03

XOR     A, @0X03

JBC     0X3, 2      ; Z

JMP     SLEEP_MODEL

```

```

JMP     MAIN_LOOP

```

```

;=====

```

```

T_MODEL:

```

```

BC      P5, 0      ; R_LED

```

T_LOOP:

<http://www.wenshing.com.tw> ; <http://www.rf.net.tw>

```

MOV     BYTE, A
JBC     P5, 3      ; KEY
BS      BYTE, 3
MOV     A, BYTE
XOR     A, KEY_REG
JBC     0X3, 2      ; Z
JMP     T_LOOP
BC      P5, 1      ; T_LED
JMP     MAIN_LOOP

```

;=====

R_MODEL:

```

BC      P5, 0      ; R_LED
BC      P5, 1      ; T_LED
CALL    DATA_PRO
MOV     A, @0X1F      ; TX_OFF RX_ON
MOV     0X22, A
MOV     A, @0X4F      ; 250K 0db
JBC     P6, 2      ; <0-250K 1-1000K>
MOV     A, @0X6F
MOV     0X30, A
MOV     A, @0X15      ; 2410
MOV     0X31, A
CALL    RF_CONFIG

```

```

MOV     A, @0X10
MOV     0X13, A
BS      P6, 3      ; CE
CLR     TCC

```

```

        BC      0XF, 0      ; TIMER FLAG

        MOV     A, @0X1

        IOW     0XF          ; TIMER INTERRUPT ENABLE

R_SP1:

        BC      P5, 0        ; R_LED

R_LOOP1:

        MOV     A, @0X060

        MOV     TIMER_REG, A

        BC      FLAG, 0      ; INTERRUPT FLAG

        DJZ     0X13

        JMP     R_LOOP

        JMP     R_MODEL

R_LOOP:

        WDTC

        JBC     FLAG, 0      ; INTERRUPT FLAG

        JMP     R_SP1

        MOV     A, P6

        AND     A, @0X7

        MOV     BYTE, A

        JBC     P5, 3        ; KEY

        BS      BYTE, 3

        MOV     A, BYTE

        XOR     A, KEY_REG

        JBS     0X3, 2        ; Z

        JMP     R_RET

        JBS     P6, 6        ; DR1

        JMP     R_LOOP

        BS      P5, 0        ; R_LED

        MOV     A, @0X10

```

```

MOV    0X13, A
CALL   RF_RECEIVE
CALL   DELAY1MS
JMP    R_LOOP1

```

R_RET:

```

BC     P6, 3    ; CE
BC     P5, 0
MOV    A, @0X0
IOW    0XF
JMP    MAIN_LOOP

```

;=====

SLEEP_MODEL:

```

CALL   DATA_PRO
BC     P5, 0    ; R_LED
BC     P5, 1    ; T_LED
CALL   DATA_PRO
MOV    A,@0X1E    ;TX_OFF RX_OFF
MOV    0X22, A
MOV    A, @0X4C    ;250K 0db
JBC    P6, 2    ;<0-250K 1-1000K>
MOV    A, @0X6C
MOV    0X30, A
MOV    A, @0X15    ;2410
MOV    0X31, A
CALL   RF_CONFIG
BC     P5, 2    ; PW

```

S_LOOP:

```

CALL   DELAY1MS

```

```

WDTC

MOV    A, P6

AND    A, @0X07

MOV    BYTE, A

JBC    P5, 3    ; KEY

BS     BYTE, 3

MOV    A, BYTE

XOR    A, KEY_REG

JBC    0X3, 2    ;Z

JMP    S_LOOP

JMP    MAIN_LOOP

```

```

;=====

```

```

DATA_PRO:

```

```

MOV    A, @0X20

MOV    0X4, A

CLR    R0

MOV    A, @0X12    ;18

MOV    0X10, A

```

```

DATA_LOOP:

```

```

CALL   RF_CONFIG_TABLE

MOV    0X0, A

INC    R0

INC    0X4

DJZ    0X10

JMP    DATA_LOOP

RET

```

```

;=====

```

```

;===== RF CONFIG SUBROUTINE =====

```

;=====

RF_CONFIG:

```
BC      P6, 3      ;CE
BS      P6,7       ;CS
CALL    DELAY200US
MOV     A, @0X12    ;18
MOV     0X10, A
MOV     A, @0X20
MOV     0X4, A
```

RF_CONF_BYTE_LP:

```
MOV     A, @0X8
MOV     0X11, A
MOV     A, 0X0
MOV     BYTE, A
```

RF_CONF_BIT_LP:

```
BC      P6, 5      ; CLK1
JBS     BYTE, 7
BC      P6, 4      ; DATA
JBC     BYTE, 7
BS      P6, 4      ; DATA
RLC     BYTE
BS      P6, 5      ; CLK1
DJZ     0X11
JMP     RF_CONF_BIT_LP
INC     0X4
DJZ     0X10
JMP     RF_CONF_BYTE_LP
CALL    DELAY5US
BC      P6, 5      ; CLK1
BC      P6, 7      ; CS
```

RET

;=====

;===== RF SEND SUBROUTINE =====

;=====

RF_SEND:

BC P6, 7 ; CS

BS P6, 3 ; CE

CALL DELAY5US

CALL DELAY5US

CLR R0

MOV A, @0X5 ; ADDRESS BIT 5*8=40 BIT

MOV 0X10, A

RF_S_ADD_BYTE:

CALL ADDRESS_TABLE

MOV BYTE, A

MOV A, @0X8

MOV 0X11, A

RF_S_ADD_BIT:

BC P6, 5 ; CLK1

JBS BYTE, 7

BC P6, 4 ; DATA

JBC BYTE, 7

BS P6, 4 ; DATA

RLC BYTE

BS P6, 5 ; CLK1

DJZ 0X11

JMP RF_S_ADD_BIT

INC R0

DJZ 0X10

JMP RF_S_ADD_BYTE

MOV A, @0X1A ; 208 BIT DATA

MOV 0X10, A

RF_S_D_BYTE:

MOV A, @0X8

MOV 0X11, A

MOV A, @0X037

MOV BYTE, A

RF_S_D_BIT:

BC P6, 5 ; CLK1

JBS BYTE, 7

BC P6, 4 ; DATA

JBC BYTE, 7

BS P6, 4 ; DATA

RLC BYTE

BS P6, 5 ; CLK1

DJZ 0X11

JMP RF_S_D_BIT

DJZ 0X10

JMP RF_S_D_BYTE

CALL DELAY5US

BC P6, 5 ; CLK1

BC P6, 3 ; CE

RET

;=====

;===== RF RECEIVE SUBROUTINE =====

;=====

RF_RECEIVE:

```

BC      P6, 7      ; CS
BC      P6, 3      ; CE

CALL    DELAY5US

CALL    DELAY5US

MOV     A, @0X20

MOV     0X4, A

MOV     A, @0X1A      ; 208 bit

MOV     0X10, A

CLR     BYTE

RF_BYTE_LP:

MOV     A, @0X8

MOV     0X11, A

RF_BIT_LP:

RLC     BYTE

BS      P6, 5      ; CLK1

JBS     P6, 4      ; DATA

BC      BYTE, 0

JBC     P6, 4      ; DATA

BS      BYTE, 0

BC      P6, 5      ; CLK1

DJZ     0X11

JMP     RF_BIT_LP

INC     0X4

DJZ     0X10

JMP     RF_BYTE_LP

CALL    DELAY5US

CALL    DELAY5US

BS      P6, 3      ; CE

RET

```

```

;=====
;===== DELAY1MS SUBROUTINE =====
;=====

```

DELAY1MS:

```

    MOV    A, @0X0FF
    JMP     DLY_SKIP

```

DELAY200US:

```

    MOV    A, @0X32
    JMP     DLY_SKIP

```

DELAY5US:

```

    MOV    A, @0X1

```

DLY_SKIP:

```

    MOV    DLY_REG,A

```

DLY_LOOP:

```

    NOP
    NOP
    NOP
    DJZ     DLY_REG
    JMP     DLY_LOOP
    RET

```

```

;=====
;===== INTERRUPT SUBROUTINE =====
;=====

```

INT_0:

INT_1:

```

    BC      0XF, 0      ;TIMER FLAG

```

DJZ	TIMER_REG	
JMP	INT_RET	
BS	FLAG, 0	;INTERRUPT FLAG

INT_RET:

RETI

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2 Demo Program - C8051F330 MCU

```
/* -----
```

Features: headers load area

```
-----*/
```

```
#include <C8051F330.H>
```

```
#include "Public_variable.h"
```

```
/* -----
```

Function: IO defined area

```
----- */
```

```
sbit TRW_24G_CLK = P1^1;
```

```
sbit TRW_24G_DATA = P1^6;
```

```
sbit TRW_24G_CS = P1^2;
```

```
sbit TRW_24G_CE = P1^3;
```

```
sbit TRW_24G_DR1 = P1^4;
```

```
/* -----
```

Features: TRW-24G is written a BYTE (includes write the word with configuration information sent a BYTE)

```
----- */
```

```
void Write_TRW_24G_BYTE(x)
```

```
{
```

```
    char i;
```

```
    for(i=0;i<8;i++)
```

```
    {
```

```
        TRW_24G_CLK = 0;
```

```
        if(x&0x80)
```

```
            TRW_24G_DATA= 1;
```

```
        else
```

```
            TRW_24G_DATA= 0;
```

```
        x<<=1;
```

```
        TRW_24G_CLK = 1;
```

```
        TRW_24G_CLK = 1;
```

```
        TRW_24G_CLK = 1;
```

```
    }
```

```
}
```

```
/* -----
```

Features: Reading a BYTE information from TRW-24G

```
-----*/
```

```
char Read_TRW_24G_BYTE(void)
```

```
{
```

```
    char i,x;
```

```
    for(i=0;i<8;i++)
```

```
    {
```

```
        TRW_24G_CLK = 0;
```

```
        TRW_24G_CLK = 0;
```

```
        TRW_24G_CLK = 0;
```

```
        TRW_24G_CLK = 1;
```

```
        x<<=1;
```

```

        if(TRW_24G_DATA)
            x|=0x01;
        else
            x|=0x00;
    }
    return(x);
}
/* -----
Features: TRW-24G configuration
----- */
void Config_TRW_24G(void)
{
    unsigned char i;
    P1MDOUT |= 0x4E;
    TRW_24G_CE = 0;
    TRW_24G_CS = 1;
    for(i=0;i<18;i++)
        Write_TRW_24G_BYTE(RF_Buffer[i]);
    TRW_24G_CS = 0;
    if(RF_Status[0]&&(RF_Status[6]==1))
    {

        P1MDOUT &= 0xBD;
        P1 |= 0x42;
        TRW_24G_CE = 1;

    }
}
/* -----

```

Function: The TRW-24G send a packet.

```

----- */
void Send_TRW_24G(char x)
{
    unsigned char i;
    TRW_24G_CS = 0;
    TRW_24G_CE = 1;
    Write_TRW_24G_BYTE(0xF0);
    Write_TRW_24G_BYTE(0xF0);
    for(i=0;i<28;i++)
        Write_TRW_24G_BYTE(x);
    TRW_24G_CE = 0;
}
/* -----

```

Function: TRW-24G read out a packet

```

----- */
char Receive_TRW_24G(void)
{
    unsigned char i=0,RF_Data[30];
    TRW_24G_CE = 1;
    P1MDOUT &= 0xBF;

```

```

P1      |= 0x40;
TRW_24G_CLK = 0;
if(TRW_24G_DR1)
{
    for(i=0;i<28;i++)
        RF_Data[i] = Read_TRW_24G_BYTE();
    i= RF_Data[4];
}
return(i);
}
/* -----

```

Features: Establish TRW-24G table

```

----- */
const unsigned char code TRW_24G_Table[18] =
{ 0x8E,0x08,0x1C,0xE0,0xE0,0x00,0x00,0x00,0xF0,
  0xF0,0x00,0x00,0x00,0xF0,0xF0,0x43,0x0F,0x00 };
/* -----

```

This program is Kit_10 to configure TRW_24G/TRW_24G part.

Which is used RF_Status [7] and RF_Buffer [110] array.

Here's RF_Status [7] array of detailed definitions:

RF_Status[0] = 0 , Modules work is in the state of launch

= 1 , Modules work is in the receiving state

RF_Status[1] = Neglected

RF_Status[2][3] = To retain frequencies via 16-band.

If its value = 0x0190, it express operating frequency now is 2400 M.

If its value = 0x01B0, it express operating frequency now is 2400 M.

RF_Status[4] = 0, Modules work is in the rate of 1 M

= 1 , Modules work in the 250 K rate.

RF_Status[5] = 0, Set up the transmitter power modules is for -20 dBm

= 1 , Set up the transmitter power modules is for -0 dBm

RF_Status[6] = 0, Modules work is in the direct model

= 1 , Modules work is in the ShockBurth model

.

```

-----
Void Control_TRW_24G(void)
{

```

```

    unsigned char i,Send_Value = 0x00,Receive_Time = 0,Receive_Value=0;
    unsigned int Freq_buffer;

```

```

    Freq_buffer = RF_Status[2]<<8;

```

```

    Freq_buffer += RF_Status[3];

```

```

    if((RF_Status[6]==1)&&(RF_Status[0]==0))

```

```

    {

```

```

        for(Freq_buffer=0;Freq_buffer<10000;Freq_buffer++)

```

```

        for(i=0;i<200;i++);

```

```

    }

```

```

else if((Freq_buffer>527)|| (Freq_buffer<400))

    show_Freq_Error();

else

{
    for(i=0;i<18;i++)
        RF_Buffer[i]=TRW_24G_Table[i];
    if(RF_Status[0])
    {

        RF_Buffer[2] = 0x1F;
        RF_Buffer[17] |= 0x01;
    }

    else
    {
        RF_Buffer[2] = 0x1C;
        RF_Buffer[17] &= 0x00;
    }

    Freq_buffer -= 400;
    Freq_buffer <=&1;
    i=Freq_buffer&0xFE;
    RF_Buffer[17] |= i;
    if(RF_Status[6]==0)
        RF_Buffer[16] |= 0x40;
    if(RF_Status[4]==0)
        RF_Buffer[16] |= 0x20;
    switch(RF_Status[5])
    {

        case 0:
            RF_Buffer[16] &= 0xFC; break;
        case 1:
            RF_Buffer[16] |= 0x01; break;
        default:
            RF_Buffer[16] |= 0x03; break;
    }
    Config_TRW_24N();

    if(RF_Status[0]&&(RF_Status[6]==1))
    {
        LCD_write_String(0x02,0x11,0xB2,"Direct output RF",0);
        LCD_write_String(0x02,0x11,0xB3," DATA from TP5 8",0);

        while((Key_Value&0x08)==0x00)

            Scan_Key();
    }
}

```

```

else
{
    Freq_buffer >>= 1;
    Show_24G_Image(Freq_buffer);

    while((Key_Value&0x08)!=0x00)
    {
        Scan_Key();
        if(RF_Status[0])
        {

            RF_Buffer[2] |= 0x1F;
            RF_Buffer[17] |= 0x01;
            Config_TRW_24G();
            for(Freq_buffer=0;Freq_buffer<500;Freq_buffer++);
            i =0;

            while(i==0)
            {
                i = Receive_TRW_24G();
                ++Receive_Time;
                if(Receive_Value>i)
                {
                    Receive_Time = 1;
                    Send_Value = 0;
                }
                Receive_Value = i;
                ++Send_Value;
                RF_Buffer[2] &= 0x1C;
                RF_Buffer[17] &= 0xFE;
                Config_TRW_24G();
                for(Freq_buffer=0;Freq_buffer<1000;Freq_buffer++);
                Send_TRW_24G(Send_Value);
                for(Freq_buffer=0;Freq_buffer<1500;Freq_buffer++);
            }
            else
            {
                if(Send_Value == 100)
                {

                    for(i=0;i<128;i++)
                    {
                        for(Freq_buffer=0;Freq_buffer<20000;Freq_buffer++)
                        {
                            Send_Value = 0;
                            Receive_Time = 0;
                        }
                        ++Send_Value;
                        RF_Buffer[17] &= 0xFE;
                        RF_Buffer[2] &= 0x1C;
                        Config_TRW_24G();
                        for(Freq_buffer=0;Freq_buffer<1000;Freq_buffer++);
                    }
                }
            }
        }
    }
}

```

```

Work_LED = 1;
Send_TRW_24G(Send_Value);
for(Freq_buffer=0;Freq_buffer<1500;Freq_buffer++);
Work_LED = 0;
RF_Buffer[17] |= 0x01;
RF_Buffer[2] |= 0x1F;
Config_TRW_24G();
for(Freq_buffer=0;Freq_buffer<500;Freq_buffer++);
for(Freq_buffer=0;Freq_buffer<30000;Freq_buffer++)
{ i = Receive_TRW_24G();
  if(i)
  {
    ++Receive_Time;
    break;
  }
}
for(;Freq_buffer<30000;Freq_buffer++);
}
SET_OLED_Adress(0x02,0x14,0xB3);
charDIV(Send_Value,0,0,0);
SET_OLED_Adress(0x02,0x14,0xB4);
charDIV(Receive_Time,0,0,0);
}
}
}
}
}

```