UHF Narrow band radio transceiver
STD-302 429MHz

Operation Guide

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GENERAL DESCRIPTION & FEATURES

General Description

The UHF FM narrow band semi-duplex radio data module STD-302 is an STD-T67 compliant, high performance transceiver designed for use in industrial applications requiring long range, high performance and reliability.

All high frequency circuits are enclosed inside a robust housing to provide superior resistance against shock and vibration. A narrow band technique enables high interference rejection and concurrent operation with multiple modules.

STD-302 429MHz, a narrowband module with 12.5 kHz channel steps, achieves high TX/RX switching speed, making it an ideal RF unit for inclusion in feedback systems.

This product is designed to meet the basic specifications of the standard, however it has not been certified for conformity with the technical regulations. Users are required to perform the procedures for certification with their final products after installing this product in their systems.

Features

- 10 mW RF power, 3.0 V operation
- Programmable RF channel
- Fast TX/RX switching time (5 ms)
- High sensitivity -119 dBm
- Excellent mechanical durability, high vibration & shock resistance
- STD-T67 compliant

Applications

- Telemetry
  Water level monitor for rivers, dams, etc.
  Monitoring systems for environmental data such as temperature, humidity, etc.
  Transmission of measurement data (pressure, revolution, current, etc) to PC
  Security alarm monitoring
- Telecontrol
  Industrial remote control systems
  Remote control systems for factory automation machines
  Control of various driving motors
- Data transmission
  RS232/RS485 serial data transmission

SPECIFICATIONS

STD-302 429 MHz

All ratings at 25°C unless otherwise noted

Parameter	Rating	Conditions
General characteristics		
Communication method	Semi-duplex	
Oscillation type	PLL Controlled VCO	
Operating frequency range	429.175 – 429.7375 MHz	
Channel step	Programmable	
Frequency stability	+/- 4 ppm	-10 to +55 °C
	+/- 8 ppm	-20 to +65 °C
Data rate	4800 bps max.	Input data pulse width: Min208μs, Max 5 ms
PLL reference frequency	21.25 MHz	
Operating temperature range	- 10 to + 55 °C	
	- 20 to + 65 °C	*A
Operating voltage range	3 - 5.5 V	
Dimensions	30 x 50 x 9 mm	
Transmitter part		
RF output power	9.0 mW +/- 1mW	AT 429.5MHz / Antenna impedance 50 Ω
Deviation	1.8 kHz +/-0.3 kHz	PN9, 4800 bps, LPF 20 kHz
Deviation frequency characteristics	+/- 3 dB	50 - 2400 Hz
Residual FM noise	0.17 kHz	LPF 20 kHz
TX S/N	-30 dB	1 kHz, Dev.= +/-2.0 kHz CCITT filter
Spurious emission	-60 dBm	< 1 GHz
	-43 dBm	≥ 1 GHz
Adjacent channel leakage power	-40 dB	CH 12.5 kHz, BW 8.5 kHz, PN9, 4800 bps
Total distortion and noise	30 dB	1 kHz, Dev.+/-2.0 kHz, CCITT filter
Consumption current	40 mA	
Switching time RX to TX	5 - 10 ms	RX -> TX [*1]
Lock time	30 - 40 ms	Free Run -> TX [*2]
	10 - 20 ms	25 kHz channel shift [*3]
Receiver part		
Reception method	Double superheterodyne	
Sensitivity	-119 dBm (AF OUT)	1 kHz, Dev.+/-2.0 kHz, CCITT filter
Bit error rate	-111 dBm (Data Out)	4800 bps, PN9 (1/2556 bit error), internal synchronous
AF output	130+/-35 mVrms	fmod.+/- 2.0 kHz, fm+/-1.2 kHz (RF level -30 dBm)
	125+/-35 mVrms	fmod.+/- 2.0 kHz, fm+/-2.4 kHz (RF level -30 dBm)
RX S/N	35 dB	1 kHz, Dev.+/-2.0 kHz, CCITT filter (RF level -30 dBm)
Distortion	-30 dB	1 kHz, Dev.+/-2.0 kHz, CCITT filter (RF level -30 dBm)
Spurious emission	-60 dBm	
Spurious sensitivity	45 dB	Two signal method, Jamming signal = FM
Intermodulation	45 dB	Two signal method
Next adjacent channel selectivity	45 dB	Two signal method, CH 25 kHz, Jamming signal = FM
Consumption current	26 mA	
Switching time TX to RX	5 - 10 ms	TX -> RX [*1]
Lock Time	30 - 40 ms	Free Run -> RX [*2]
	10 - 20 ms	25 kHz channel shift [*3]

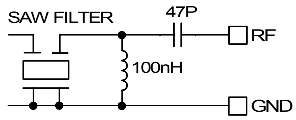
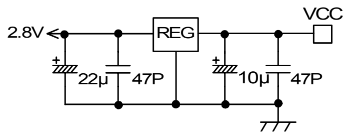
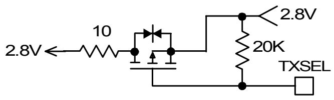
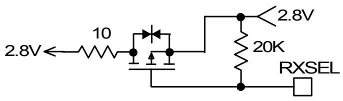
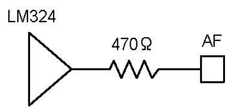
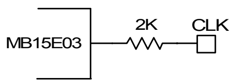
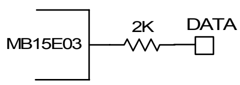
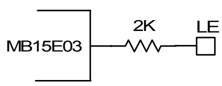
[*A] Under -10°C, the time required till effective data is output from DO is longer than that at normal temperature. It is recommended to use a preamble which is twice the length of the usual preamble. Please refer to page 13.

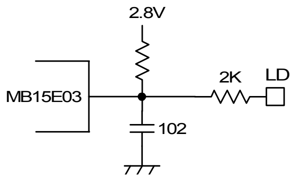
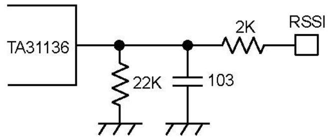
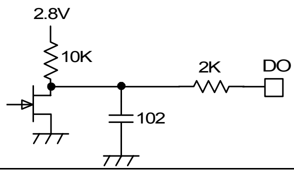
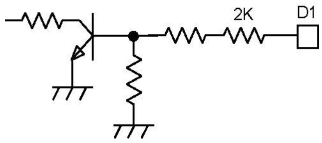
[*1] Time required for the TX frequency or 1st local frequency to reach within +/-1.5 ppm of a stable frequency.

[*2] Time required for the TX frequency or 1st local frequency to reach within +/-1.5 ppm of a stable frequency after PLL setting data is output.

[*3] Time required for the TX frequency or 1st local frequency to reach within +/-1.5 ppm of a stable frequency after PLL setting data for 25kHz shift is output.

PIN DESCRIPTION

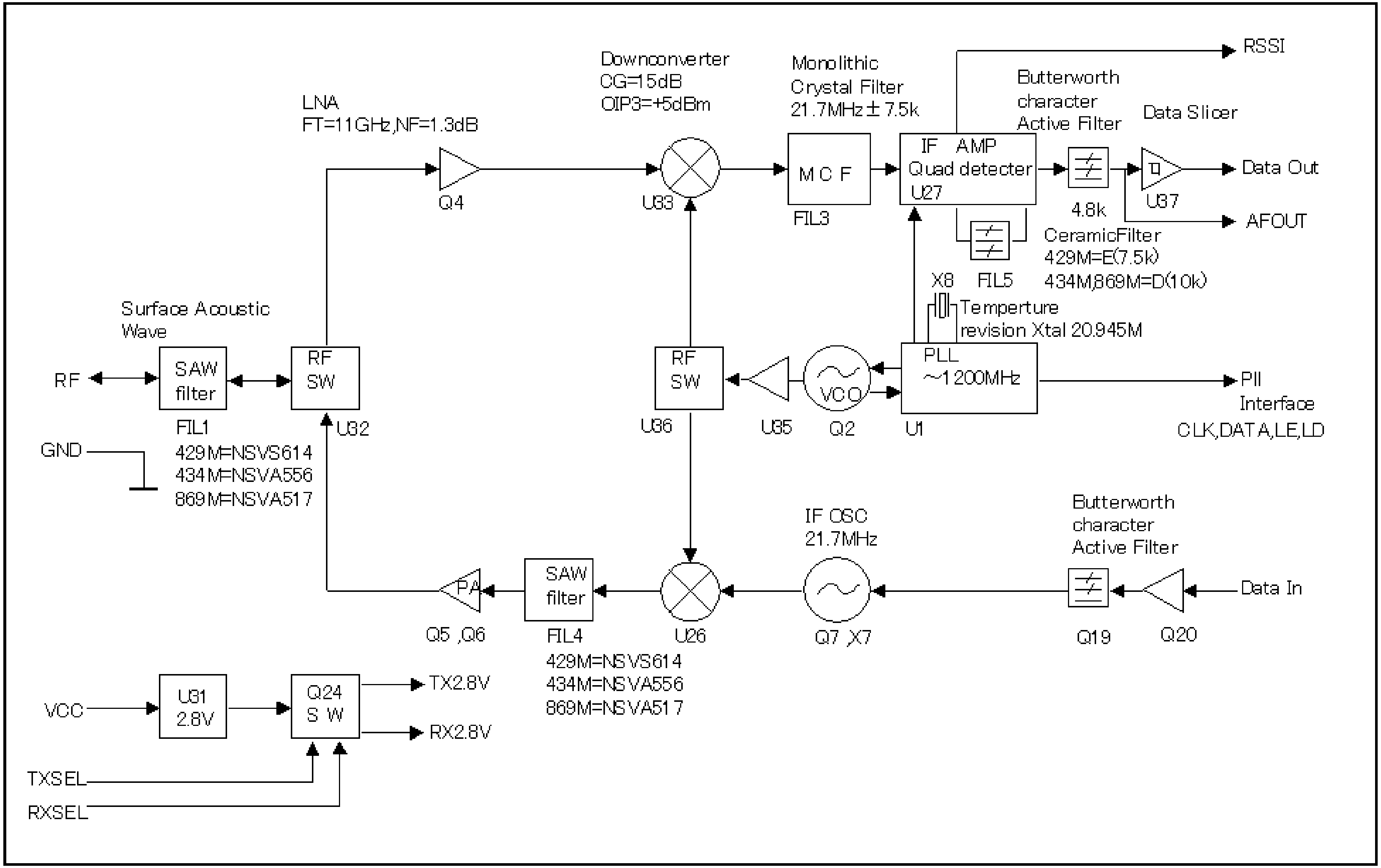
Pin name	I/O	Description	Equivalent circuit
RF	I/O	RF input terminal Antenna impedance nominal 50 Ω	
GND	I	GROUND terminal The GND pins and the feet of the shield case shoud be connected to the wide GND pattern.	
VCC	I	Power supply terminal DC 3.0 to 5.5 V	
TXSEL	I	TX select terminal GND = TXSEL active To enable the transmitter circuits, connect TXSEL to GND and RXSEL to OPEN or 2.8 V.	
RXSEL	I	RX select terminal GND= RXSEL active To enable the receiver circuits, connect RXSEL to GND and TXSEL to OPEN or 2.8 V.	
AF	I	Analogue output terminal There is DC offset of approx. 1 V. Refer to the specification table for amplitude level.	
CLK	I	PLL data setting input terminal Interface voltage H = 2.8 V, L = 0 V	
DATA	I	PLL data setting input terminal Interface voltage H = 2.8 V, L = 0 V	
LE	I	PLL data setting input terminal Interface voltage H = 2.8 V, L = 0 V	

LD	O	PLL lock/unlock monitor terminal Lock = H (2.8 V), Unlock = L (0 V)	
RSSI	O	Received Signal Strength Indicator terminal	
DO	O	Data output terminal Interface voltage: H=2.8V, L=0V	
DI	I	Data input terminal Interface voltage: H=Vcc, L=0V Input data pulse width Min.208 μs Max.5 ms	

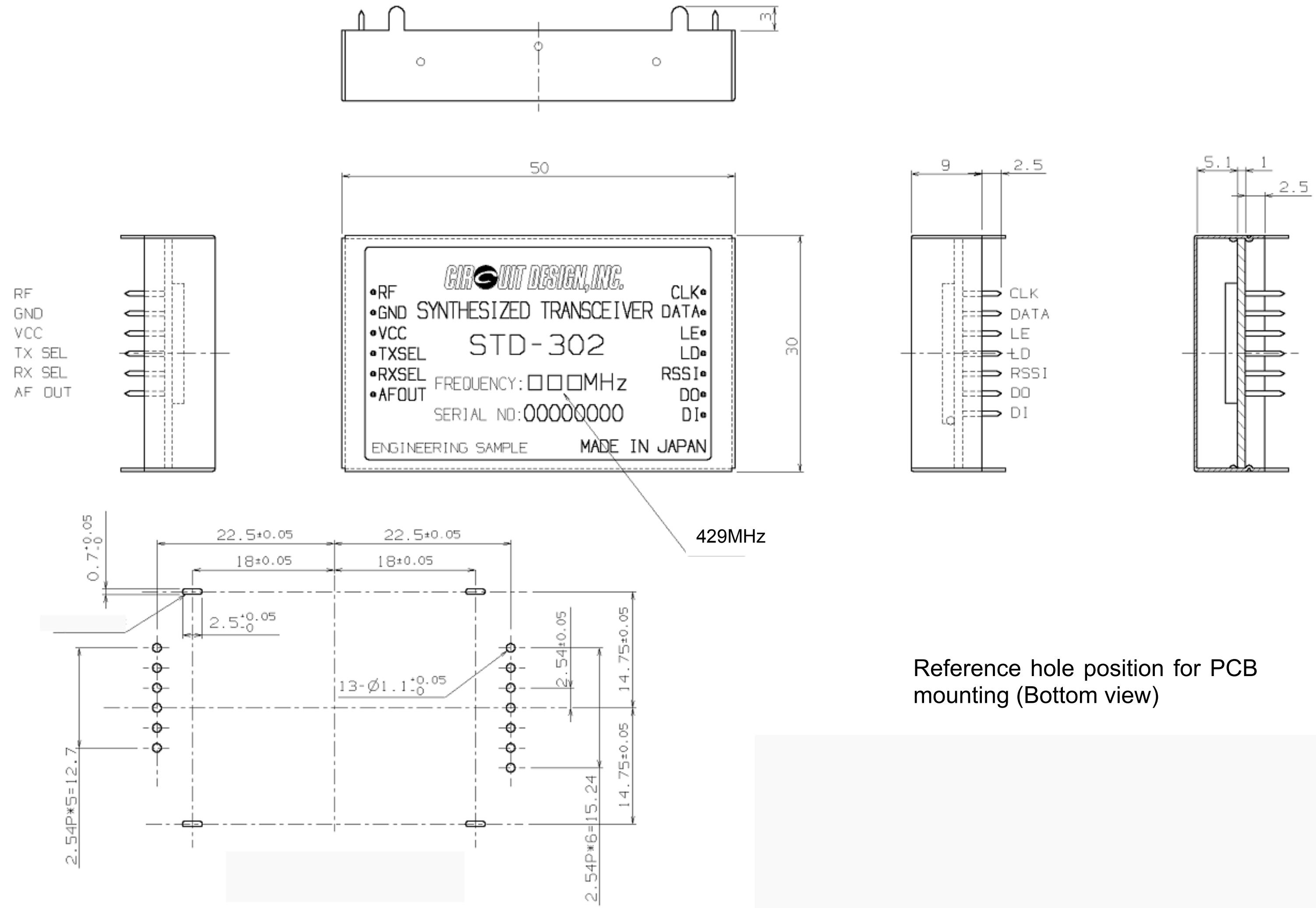
Frequency table (STD-T67)

Channel number	Operating frequency (MHz)	Transmission time restriction
1	429.1750	Transmission for 40 sec, pause for 2 sec
2	429.1875	
3	429.2000	
4	429.2125	
5	429.2250	
6	429.2375	
7	429.2500	Continuous transmission (Intermittent communication possible)
8	429.2625	
9	429.2750	
10	429.2875	
11	429.3000	
12	429.3125	
13	429.3250	
14	429.3750	
15	429.3875	
16	429.3625	
17	429.3750	
18	429.3875	
19	429.4000	
20	429.4125	
21	429.4250	
22	429.4375	
23	429.4500	
24	429.4625	
25	429.4750	
26	429.4875	
27	429.5000	
28	429.5125	
29	429.5250	
30	429.5375	
31	429.5500	
32	429.5625	
33	429.5750	
34	429.5875	
35	429.6000	
36	429.6125	
37	429.6250	
38	429.6375	
39	429.6500	
40	429.6625	
41	429.6750	
42	429.6875	
43	429.7000	
44	429.7125	
45	429.7250	
46	429.7375	

BLOCK DIAGRAM <STD-302 429 MHz>



DIMENSIONS

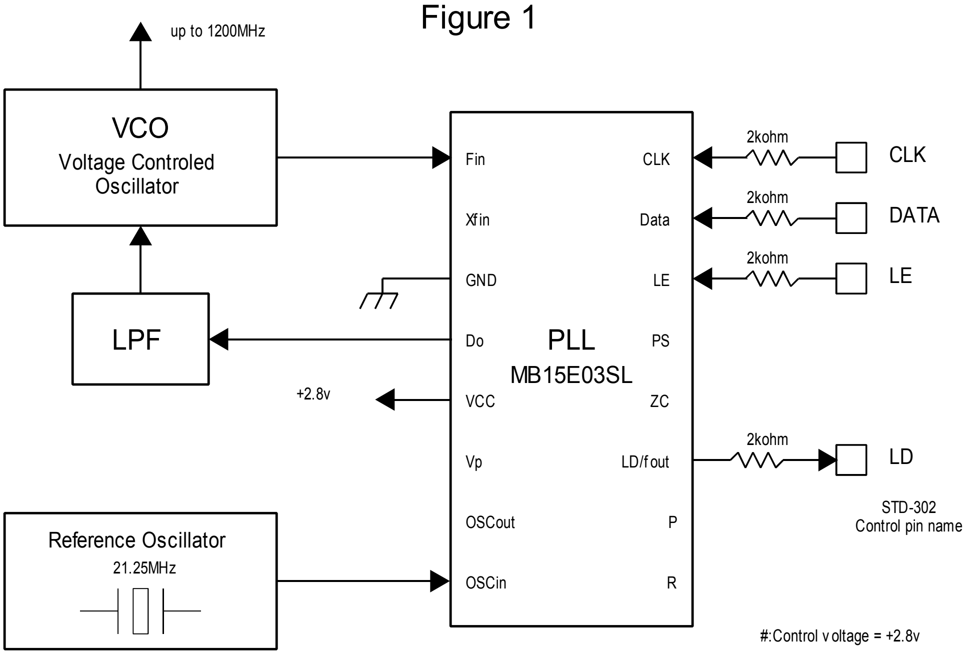


Reference hole position for PCB mounting (Bottom view)

PLL IC CONTROL

- **PLL IC control**

Figure 1



STD-302 is equipped with an internal PLL frequency synthesizer as shown in Figure 1. The operation of the PLL circuit enables the VCO to oscillate at a stable frequency. Transmission frequency is set externally by the controlling IC. STD-302 has control terminals (CLK, LE, DATA) for the PLL IC and the setting data is sent to the internal register serially via the data line. Also STD-302 has a Lock Detect (LD) terminal that shows the lock status of the frequency. These signal lines are connected directly to the PLL IC through a 2 kΩ resistor.

The interface voltage of STD-302 is 2.8 V, so the control voltage must be the same.
STD-302 comes equipped with a Fujitsu MB15E03SL PLL IC. Please refer to the manual of the PLL IC.

The following is a supplementary description related to operation with STD-302. In this description, the same names and terminology as in the PLL IC manual are used, so please read the manual beforehand.

- **How to calculate the setting values for the PLL register**

The PLL IC manual shows that the PLL frequency setting value is obtained with the following equation.
f_{vco} = [(M x N)+A] x f_{osc} / R -- Equation 1
f_{vco} : Output frequency of external VCO
M: Preset divide ratio of the prescaler (64 or 128)
N: Preset divide ratio of binary 11-bit programmable counter (3 to 2,047)
A: Preset divide ratio of binary 7-bit swallow counter ($0 \le A \le 127$ A<N))
f_{osc}: Output frequency of the reference frequency oscillator
R: Preset divide ratio of binary 14-bit programmable reference counter (3 to 16,383)

With STD-302, there is an offset frequency (f_{offset}) 21.7 MHz for the transmission RF channel frequency f_{ch}. Therefore the expected value of the frequency generated at VCO (f_{expect}) is as below.
$f_{vco} = f_{expect} = f_{ch} - f_{offset}$ ---- Equation 2

The PLL internal circuit compares the phase to the oscillation frequency $f_{vco.}$ This phase comparison frequency (f_{comp}) must be decided. f_{comp} is made by dividing the frequency input to the PLL from the reference frequency oscillator by reference counter R. STD-302 uses 21.25 MHz for the reference clock $f_{osc.}$ f_{comp} is one of 6.25 kHz, 12.5 kHz or 25 kHz.

The above equation 1 results in the following with n = M x N + A, where “n” is the number for division.
$f_{vco}=n*f_{comp}$ ---- Equation 3 $n = f_{vco}/f_{comp}$ ---- Equation 4 note: $f_{comp} = f_{osc}/R$

Also, this PLL IC operates with the following R, N, A and M relational expressions.
$R=f_{osc}/f_{comp}$ ---- Equation 5 N = INT (n / M) ---- Equation 6 A = n - (M x N) ---- Equation 7
INT: integer portion of a division.

As an example, the setting value of RF channel frequency f_{ch} 869.725 MHz can be calculated as below.
The constant values depend on the electronic circuits of STD-302.

Conditions:	Channel center frequency:	f_{ch} = 869.725 MHz
	Constant: Offset frequency:	f_{offset}=21.7 MHz
	Constant: Reference frequency:	f_{osc}=21.25 MHz
	Set 25 kHz for Phase comparison frequency and 64 for Prescaler value M	

The frequency of VCO will be
$f_{vco} = f_{expect} = f_{ch} - f_{offset}$ = 869.725 –21.7 = 848.025MHz
Dividing value “n” is derived from Equation 4
n = f_{vco} / f_{comp} = 848.025MHz/25kHz = 33921
Value “R” of the reference counter is derived from Equation 5.
R = f_{osc}/f_{comp} = 21.25MHz/25kHz = 850
Value “N” of the programmable counter is derived from Equation 6.
N = INT (n/M) = INT(33921/64) = 530
Value “A“ of the swallow counter is derived from Equation 7.
A = n – (M x N) = 33921 – 64 x 530 = 1

The frequency of STD-302 is locked at a center frequency f_{ch} by inputting the PLL setting values N, A and R obtained with the above equations as serial data. The above calculations are the same for the other frequencies.
Excel sheets that contain automatic calculations for the above equations can be found on our web site (www.circuitdesign.jp/eng/).

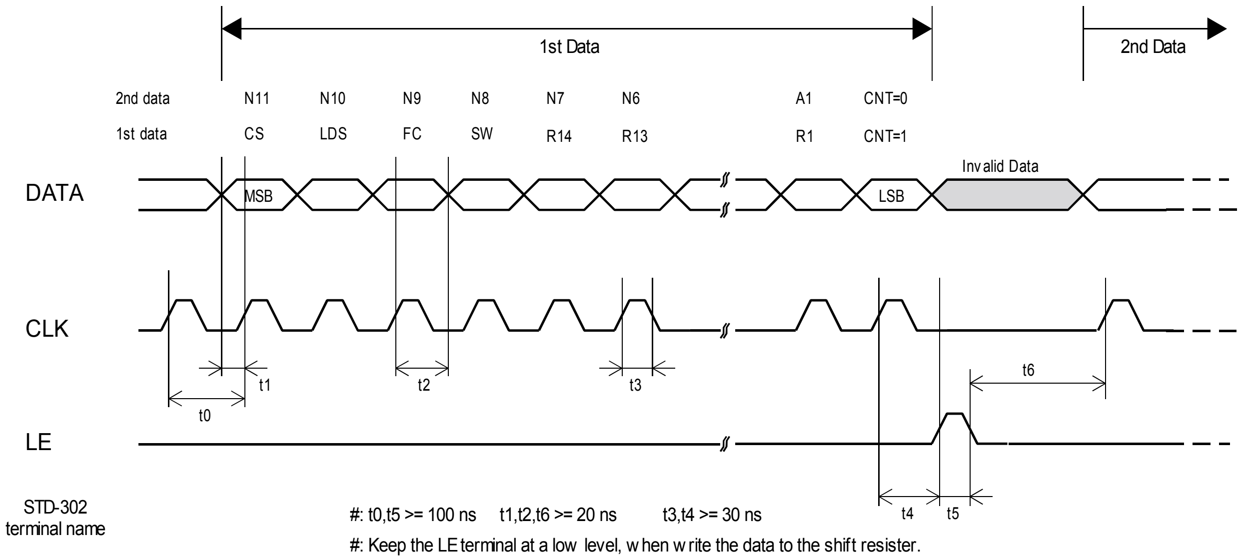
The result of the calculations is arranged as a table in the CPU ROM. The table is read by the channel change routine each time the channel is changed, and the data is sent to the PLL.

- **Method of serial data input to the PLL**

After the RF channel table plan is decided, the data needs to be allocated to the ROM table and read from there or calculated with the software.
Together with this setting data, operation bits that decide operation of the PLL must be sent to the PLL.
The operation bits for setting the PLL are as follows. These values are placed at the head of the reference counter value and are sent to the PLL.

1. CS: Charge pump current select bit
   CS = 0   +/-1.5 mA select   VCO is optimized to +/-1.5 mA
2. LDS: LD/fout output setting bit
   LDS = 0   LD select   Hardware is set to LD output
3. FC: Phase control bit for the phase comparator
   FC = 1   Hardware operates at this phase

Figure 2



The PLL IC, which operates as shown in the block diagram in the manual, shifts the data to the 19-bit shift register and then transfers it to the respective latch (counter, register) by judging the CNT control bit value input at the end.

1. CLK [Clock]: Data is shifted into the shift register on the rising edge of this clock.
2. LE [Load Enable]: Data in the 19-bit shift register is transferred to respective latches on the rising edge of the clock. The data is transferred to a latch according to the control bit CNT value.
3. Data [Serial Data]: You can perform either reference counter setup or programmable counter setup first.

TIMING CHART

Control timing in a typical application is shown in Figure 3.
Initial setting of the port connected to the radio module is performed when power is supplied by the CPU and reset is completed. MOS-FET for supply voltage control of the radio module, RXSEL and TXSEL are set to inactive to avoid unwanted emissions. The power supply of the radio module is then turned on. When the radio module is turned on, the PLL internal resistor is not yet set and the peripheral VCO circuit is unstable. Therefore data transmission and reception is possible 40 ms after the setting data is sent to the PLL at the first change of channel, however from the second change of channel, the circuit stabilizes within 20 ms and is able to handle the data.
Changing channels must be carried out in the receive mode. If switching is performed in transmission mode, unwanted emission occurs.

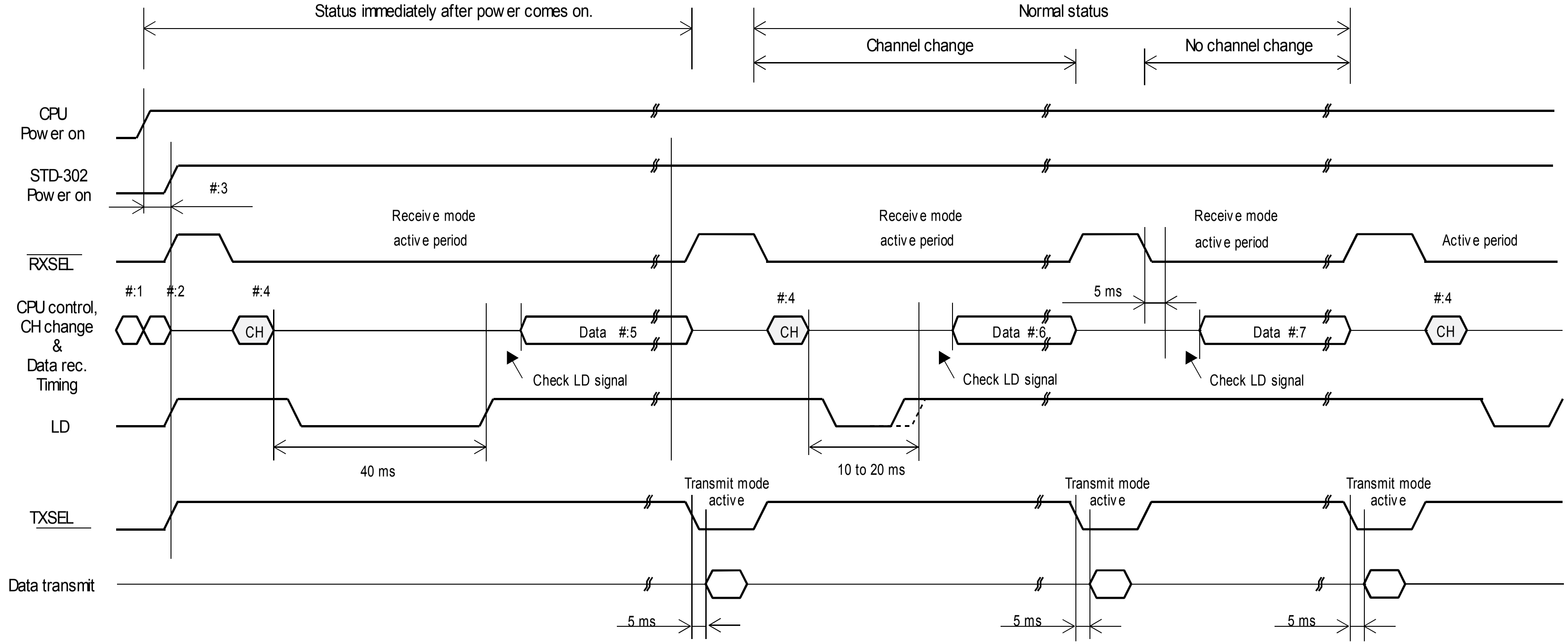
If the module is switched to the receive mode when operating in the same channel, (a new PLL setting is not necessary) it can receive data within 5 ms of switching[*1]. For data transmission, if the RF channel to be used for transmission is set while still in receiving mode, data can be sent at 5 ms after the radio module is switched from reception to transmission[*2].
Check that the Lock Detect signal is “high” 20 ms after the channel is changed. In some cases the Lock Detect signal becomes unstable before the lock is correctly detected, so it is necessary to note if processing of the signal is interrupted. It is recommended to observe the actual waveform before writing the process program.

[*1] DC offset may occur due to frequency drift caused by ambient temperature change. Under conditions below -10 °C, 10 to 20 ms delay of DO output is estimated. The customer is urged to verify operation at low temperature and optimize the timing.

[*2] Sending ‘10101…..’ preamble just after switching to transmission mode enables smoother operation of the binarization circuit of the receiver.
For 4800 bps, a preamble of ‘11001100’ is effective.
Recommended preamble length:
-10 °C - +55°C: 15 ms
-20 °C - +65 °C (for operation exceeding the above range): 30 ms

Remark
For details about PLL control and the sample programs, see our technical document ‘STD-302 interface method’

Figure 3: Timing diagram for STD-302



#:1 Reset control CPU
#:2 Initialize the port connected to the module.
#:3 Supply power to the module after initializing CPU.
#:4 RFchannel change must be performed in receiving mode.

#:5 40 ms later, the receiver can receive the data after changing the channel..
#:6 10 to 20 ms later, the receiver can receive the data after changing the channel.
#:7 5 ms later, the data can be received if the RF channel is not changed.

PLL FREQUENCY SETTING DATA REFERENCE

STD-302 PLL setting reference

429MHz band (429.1750 – 429.7375 MHz)

Parameter name	Value
Phase Comparing Frequency FCOMP [kHz]	12.5
Start Channel Frequency FCH [MHz]	429.1750
Channel Step Frequency [kHz]	12.5
Number of Channel	46
Prescaler M	64

Parameter name	Value
Reference Frequency FOSC [MHz]	21.25
Offset Frequency FOFFSET [MHz]	21.7

(green)	: For data input
(yellow)	: Result of calculation
(cyan)	: Fixed value

Parameter name	Value
Reference Counter R	850
Programmable Counter N Min. Value	254
Programmable Counter N Max. Value	255
Swallow Counter A Min. Value	0
Swallow Counter A Max. Value	63

No.	Channel Frequency FCH (MHz)	Expect Frequency F EXPECT (MHz)	Lock Frequency FVCO (MHz)	Number of Division n	Programmable Counter N	Swallow Counter A
1	429.1750	407.4750	407.4750	32598	509	22
2	429.1875	407.4875	407.4875	32599	509	23
3	429.2000	407.5000	407.5000	32600	509	24
4	429.2125	407.5125	407.5125	32601	509	25
5	429.2250	407.5250	407.5250	32602	509	26
6	429.2375	407.5375	407.5375	32603	509	27
7	429.2500	407.5500	407.5500	32604	509	28
8	429.2625	407.5625	407.5625	32605	509	29
9	429.2750	407.5750	407.5750	32606	509	30
10	429.2875	407.5875	407.5875	32607	509	31
11	429.3000	407.6000	407.6000	32608	509	32
12	429.3125	407.6125	407.6125	32609	509	33
13	429.3250	407.6250	407.6250	32610	509	34
14	429.3375	407.6375	407.6375	32611	509	35
15	429.3500	407.6500	407.6500	32612	509	36
16	429.3625	407.6625	407.6625	32613	509	37
17	429.3750	407.6750	407.6750	32614	509	38
18	429.3875	407.6875	407.6875	32615	509	39
19	429.4000	407.7000	407.7000	32616	509	40
20	429.4125	407.7125	407.7125	32617	509	41
21	429.4250	407.7250	407.7250	32618	509	42
22	429.4375	407.7375	407.7375	32619	509	43
23	429.4500	407.7500	407.7500	32620	509	44
24	429.4625	407.7625	407.7625	32621	509	45
25	429.4750	407.7750	407.7750	32622	509	46
26	429.4875	407.7875	407.7875	32623	509	47
27	429.5000	407.8000	407.8000	32624	509	48
28	429.5125	407.8125	407.8125	32625	509	49
29	429.5250	407.8250	407.8250	32626	509	50
30	429.5375	407.8375	407.8375	32627	509	51
31	429.5500	407.8500	407.8500	32628	509	52
32	429.5625	407.8625	407.8625	32629	509	53
33	429.5750	407.8750	407.8750	32630	509	54
34	429.5875	407.8875	407.8875	32631	509	55
35	429.6000	407.9000	407.9000	32632	509	56
36	429.6125	407.9125	407.9125	32633	509	57
37	429.6250	407.9250	407.9250	32634	509	58
38	429.6375	407.9375	407.9375	32635	509	59
39	429.6500	407.9500	407.9500	32636	509	60
40	429.6625	407.9625	407.9625	32637	509	61
41	429.6750	407.9750	407.9750	32638	509	62
42	429.6875	407.9875	407.9875	32639	509	63
43	429.7000	408.0000	408.0000	32640	510	0
44	429.7125	408.0125	408.0125	32641	510	1
45	429.7250	408.0250	408.0250	32642	510	2
46	429.7375	408.0375	408.0375	32643	510	3

Cautions

- As the radio module communicates using electronic radio waves, there are cases where transmission will be temporarily cut off due to the surrounding environment and method of usage. The manufacturer is exempt from all responsibility relating to resulting harm to personnel or equipment and other secondary damage.
- Do not use the equipment within the vicinity of devices that may malfunction as a result of electronic radio waves from the radio module.
- The manufacturer is exempt from all responsibility relating to secondary damage resulting from the operation, performance and reliability of equipment connected to the radio module.
- Communication performance will be affected by the surrounding environment, so communication tests should be carried out before actual use.
- Ensure that the power supply for the radio module is within the specified rating. Short circuits and reverse connections may result in overheating and damage and must be avoided at all costs.
- Ensure that the power supply has been switched off before attempting any wiring work.
- The case is connected to the GND terminal of the internal circuit, so do not make contact between the '+' side of the power supply terminal and the case.
- When batteries are used as the power source, avoid short circuits, recharging, dismantling, and pressure. Failure to observe this caution may result in the outbreak of fire, overheating and damage to the equipment. Remove the batteries when the equipment is not to be used for a long period of time. Failure to observe this caution may result in battery leaks and damage to the equipment.
- Do not use this equipment in vehicles with the windows closed, in locations where it is subject to direct sunlight, or in locations with extremely high humidity.
- The radio module is neither waterproof nor splash proof. Ensure that it is not splashed with soot or water. Do not use the equipment if water or other foreign matter has entered the case.
- Do not drop the radio module or otherwise subject it to strong shocks.
- Do not subject the equipment to condensation (including moving it from cold locations to locations with a significant increase in temperature.)
- Do not use the equipment in locations where it is likely to be affected by acid, alkalis, organic agents or corrosive gas.
- Do not bend or break the antenna. Metallic objects placed in the vicinity of the antenna will have a great effect on communication performance. As far as possible, ensure that the equipment is placed well away from metallic objects.
- The GND for the radio module will also affect communication performance. If possible, ensure that the case GND and the circuit GND are connected to a large GND pattern.

Warnings

- Do not take a part or modify the equipment.
- Do not remove the product label (the label attached to the upper surface of the module.) Using a module from which the label has been removed is prohibited.