STD-402

SYNTHESIZED TRANSCEIVER
UHF FM-NARROW BAND
RADIO DATA MODULE

[Direct Mode Operation Guide]

Version1.2a (April, 2000)

CIRCUIT DESIGN,INC.

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CIRCUIT DESIGN,INC.

Contents

General description

The STD-402 is a short range device stipulated by CEPT/ERC recommendation 70-03 and is a radio module complying with ETSI standard EN300-220-1 with a transceiver built into its compact case.
The built-in PLL synthesizer circuit enables both transmission and receipt through 64 pre-set channel frequencies between the 433 to 434MHz bands.
The transmit mode/receive mode settings and the frequency channel settings can be made easily with dip switches or jumpers without the use of an external microcomputer.
As the system operates on low voltage and low current consumption in consideration of mobile communications, battery operation is also possible.
The FSK modulation enables transmission at a maximum of 9,600bps. Also, when multiple channels are to be used simultaneous or if high communication standards are required, the MSK modulation enables transmission at a maximum of 2,400bps. However, it is necessary to install an MSK modem IC externally for this purpose.
The radio module has been designed with high levels of reliability cultivated through long-term results, and this provides excellent levels of selectivity receiving sensitivity and radio interference capabilities.

Features

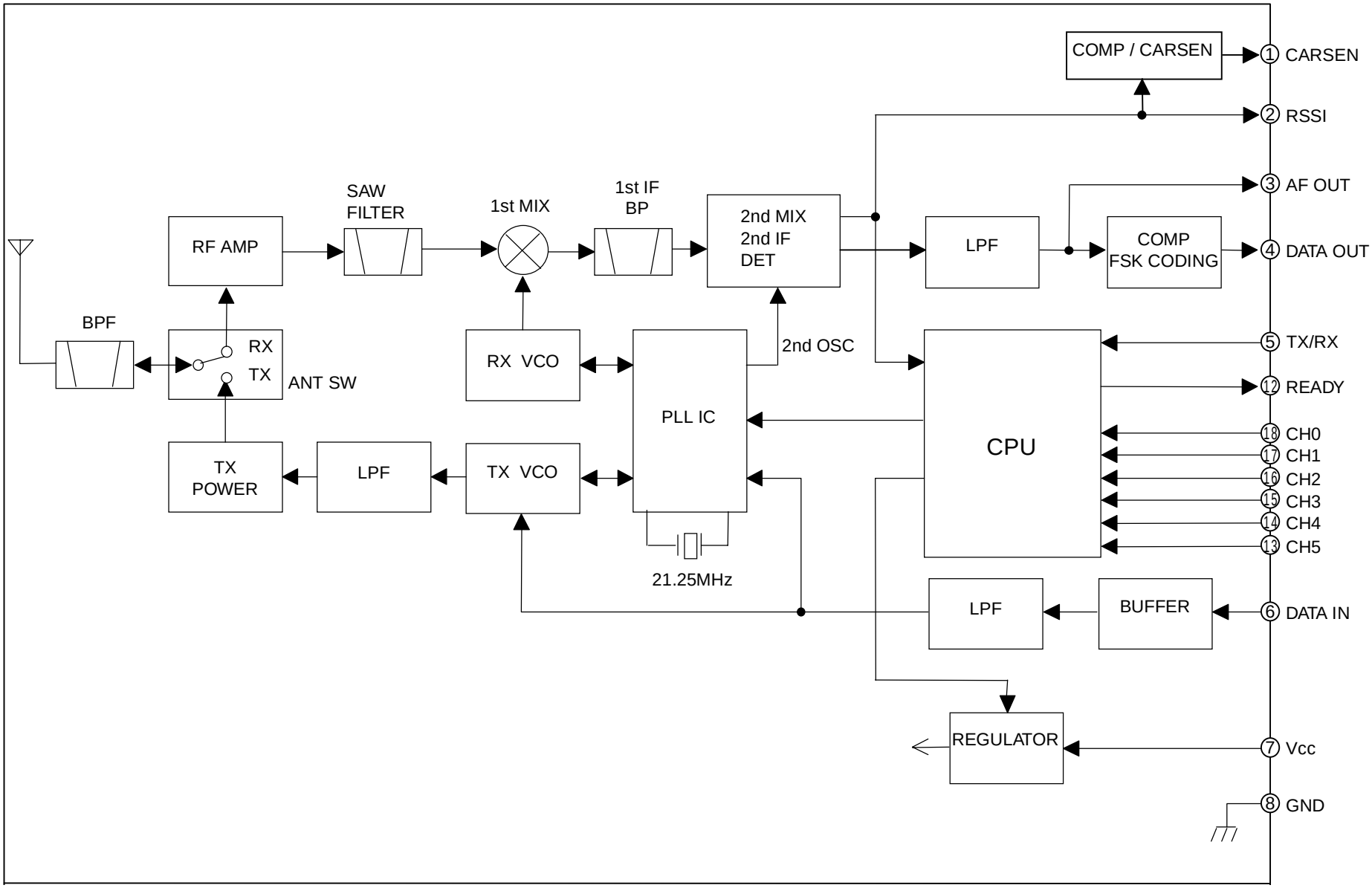
- Comply with EN 300 220
- Compact size (53mm x 35mm x 12mm) with built-in transcieving functions (STD-402)
- Baud rate of maximum 9,600bps
- Simple channel setting with switches
- Continual "0" or "1" data transmission for a maximum of 20msec.
- High-level endurance capabilities against the effects of antenna reflection and surrounding equipment
- Low-voltage operations: 3.6V to 12V
- Low current consumption: 36mA (transmit mode), 26mA (receive mode)

Application

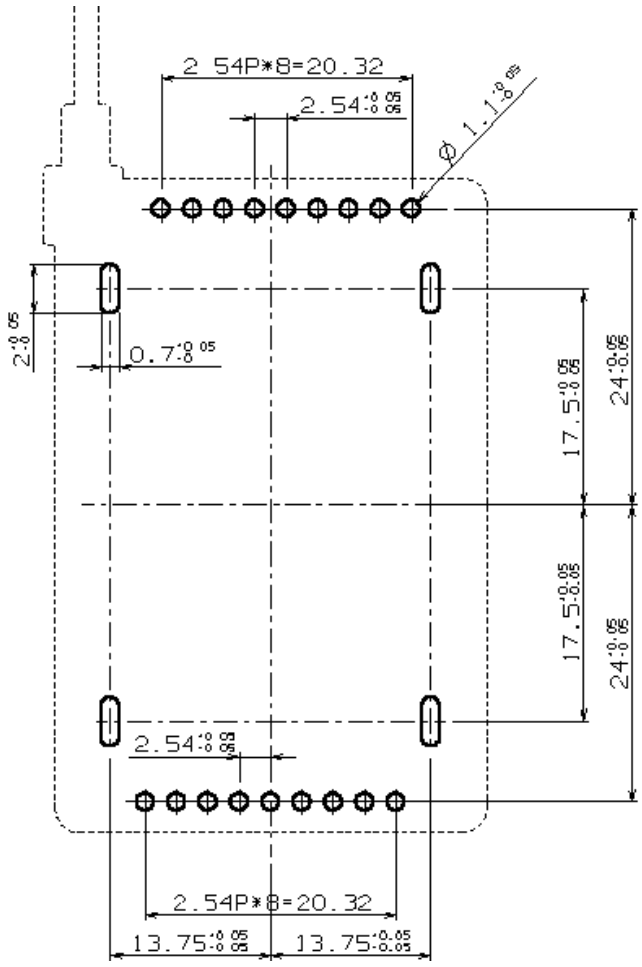
Industrial/commercial

- Telecommand and Telecontrol
- Telemetry
- Alarms
- Data terminals

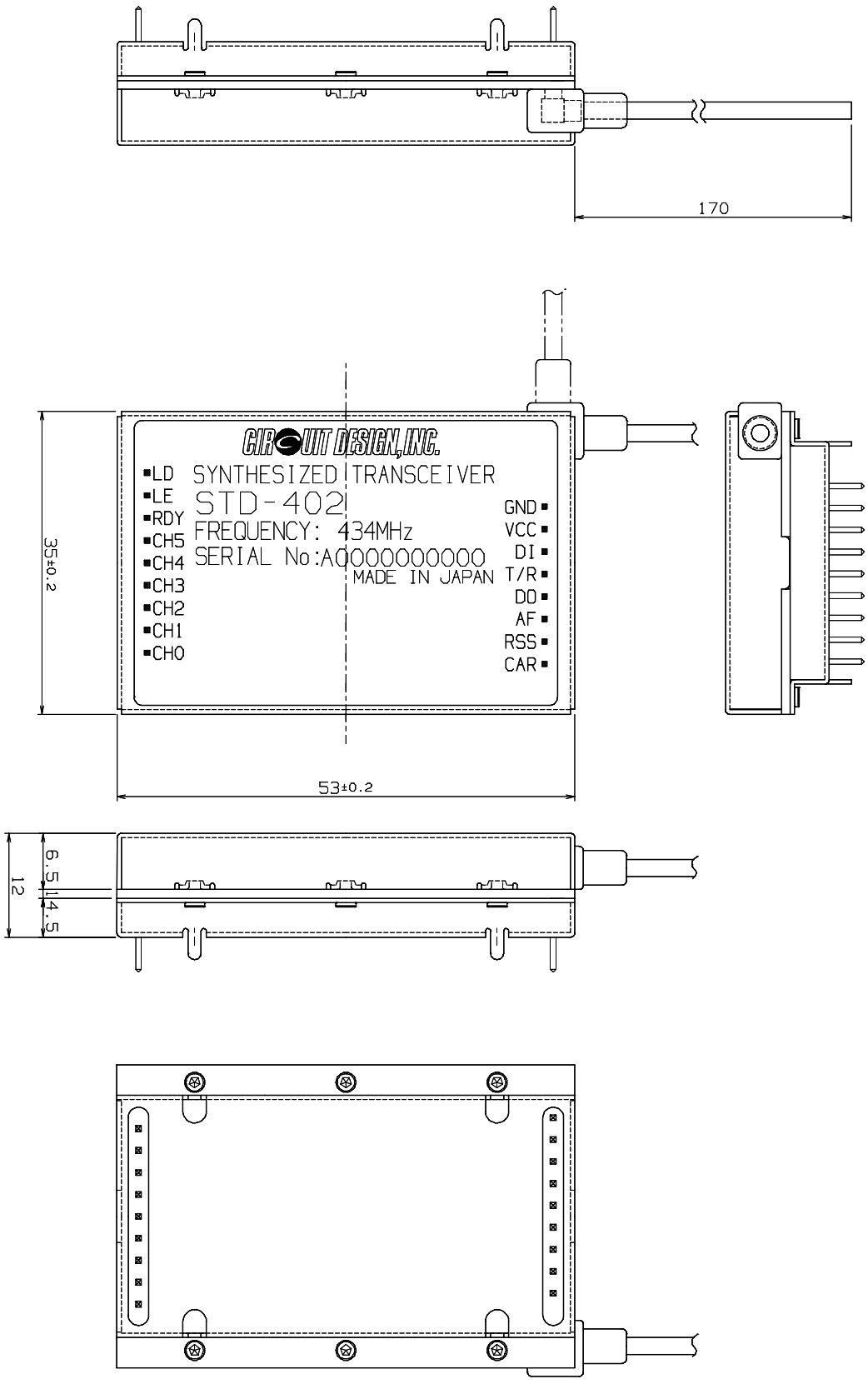
Block diagram



PIN Dimension

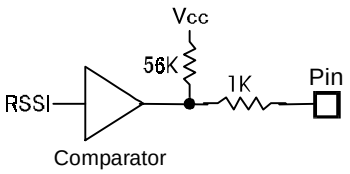
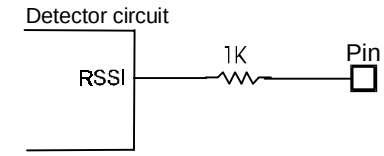
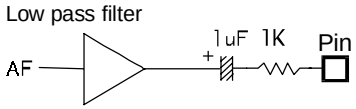
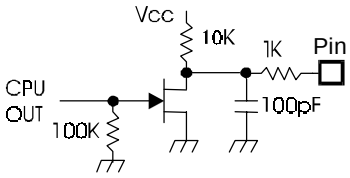
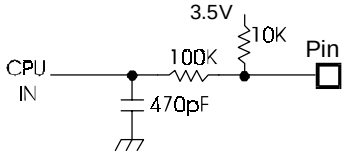
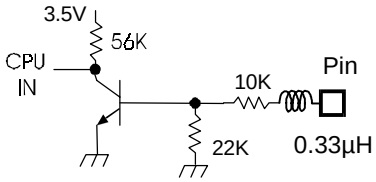


Dimension

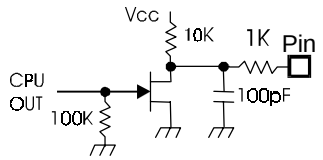
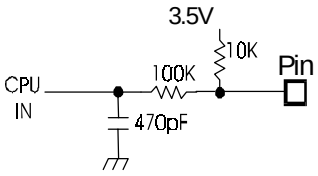

170
CIRCUIT DESIGN,INC.
■LD SYNTHESIZED TRANSCEIVER
■LE STD-402
■RDY FREQUENCY: 434MHz
■CH5 SERIAL No:A0000000000
■CH4 MADE IN JAPAN
■CH3
■CH2
■CH1
■CH0
GND■
VCC■
DI■
T/R■
DO■
AF■
RSS■
CAR■
35±0.2
53±0.2
12
6.5
4.5

Pin description 1

As the built-in STD-402 circuit operations on 3.5V, the interface circuit operates on Vcc.

Number	Pin name	I/O	Description	Equivalent internal circuit
1	CAR	O	Carrier sense output of the receiver. The RSSI signal (receiving level) will become "H" when the signal exceed the threshold. The threshold level is -107dBm (2uV).	
2	RSS	O	The receiving level output of the receiver. The strength of the RF level is converted to the direct current voltage.	
3	AF	O	The AF output of the receiving section. Connect the unit to an external MSK decoder when the MSK modulation mode is to be used. The output level is -14dBm (100K ohm terminal.)	
4	DO	O	The data output for the receiving section. As this is an FET buffer output, the 'H' level is the Vcc voltage.	
5	T/R	I	TX (transmit mode) / RX (receive mode) setting. The port is pulled up with resister. L (GND): TX mode. H (OPEN): RX mode.	
6	DI	I	Data input for the transmission section. The port uses transistor input, the digital "H" level is Vcc and the digital "L" is GND. Refer to [Example of an MSM6882 Connection] if the MSK modulation mode is to be used.	
7	VCC	-	The power supply terminal. Operates on 3.5V to 12V, but the same Vcc level as the surrounding circuits must be used.	
8	GND	-	The ground. Extend the pattern over the widest area possible on the printed circuit board.	

Pin description 2

Number	Pin name	I/O	Description	Equivalent internal circuit
11	RDY	O	The READY signal output. RDY is active when at "L". The following conditions apply when RDY is "H": (1) Initial status. (2) CAR is "H". (3) Call name being transmitted.	
12 13 14 15 16 17	CH5 CH4 CH3 CH2 CH1 CH0	I	Select the transceiving channel with CH0 to CH5. The port is pulled up with resister. Refer to Channel Table for details on channels and frequencies.	

Electrical characteristics

- Common characteristics

Item	Rating	Conditions/remarks
Communication form	Semi-duplex	
Modulation	F1D	FSK
	F2D	MSK
Oscillation system	PLL controlled VCO	
Frequency range	433.200-434.775MHz	
Channel step	25KHz	
Number of RF channel	64 channels	
Baud rate	Maximum 9,600bps	FSK
Modulation polarity	Positive	
Demodulation polarity	Positive	
Antenna impedance	50Ω	
1st IF	21.7MHz	
2nd IF	450KHz	
Range	200 m or more	F1D 9,600bps
Operation temperature	-10 to 55°C	
Operating power voltage	3.6-12V	
Supply current	36mA	TX mode
	26mA	RX mode
Dimensions	53x35x12mm	
Weight	34g	

- Transmission section characteristics

Item	Rating	Conditions
Transmitter type	PLL synthesizer	
RF output power	9.0mW±1.0mW	10mW
Frequency stability	±4ppm	-10 to +55°C
Spurious emission	<-60dBm	<1GHz
	<-50dBm	>1GHz
Deviation	±1.9 to 2.1KHz	*1
S/N ratio	>25dB	*1
Adjacent channel power	>40dB	Spectrum analyzer act, *1
Transmitter start-up time	<30msec	PLL data setting
Channel switching time	<15msec	25KHz
	<25msec	100KHz

*1: 4,800bps, 511bit (Pseudo Noise)

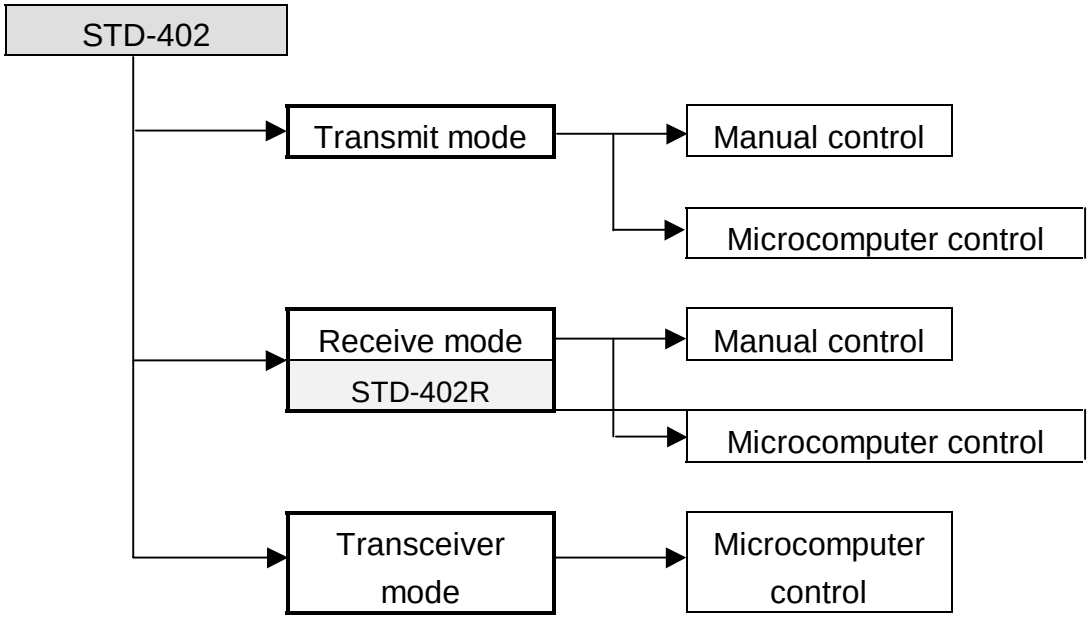
- Receiving section characteristics

Item	Rating	Conditions
Receiver mode	Double super heterodyne	
Sensitivity	<-117dBm	25°C, *2
Spurious response	>45dB	*3
Selectivity	>45dB	*3
Local frequency stability	±4ppm	-10 to +55°C
Radiation from local oscillator	<-65dBm	<1GHz
	<-60dBm	>1GHz
Carrier sense response time	<30msec	PLL data setting
Channel switching time	<15msec	25KHz
	<25msec	100KHz
Carrier sense level	-107dBm (0 to -2dB)	fixed
Bit error rate	1×10^{-2}	Less than –110 dBm
	1×10^{-4}	Less than –107 dBm

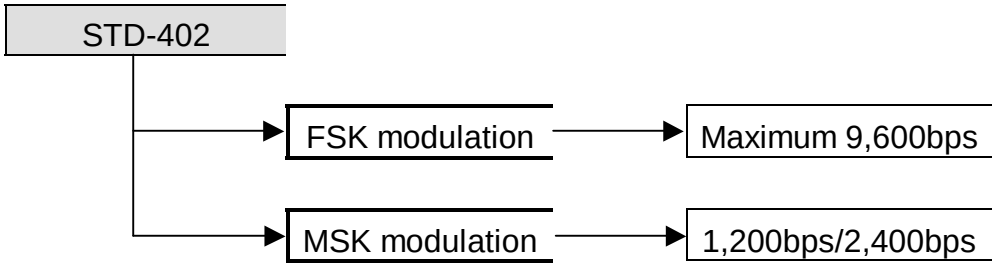
*2: AF=1kHz, fmod=2kHz, CCITT filter ON
*3: Jamming waves AF=400Hz, fmod=40%
*4: 2556bit/4800bps

Function outline

- Models and modes
  - The STD-402 comprises of two different models; model STD-402 with a built-in transmitter and receiver, and the STD-402R module for receiving only. The explanations covered in this manual are for the STD-402. Unless otherwise specified, STD-402 will stand for STD-402 when used in this manual.
  - The STD-402 is equipped with a transmitter and a receiver, and the T/R port enables to set the module in TX or RX. However, simultaneous transmission and receiving is not possible with a single module.
  - The STD-402 can be controlled manually with a simple set of external switches and jumpers, or with a microcomputer controller.



- Modulation mode
  - The maximum baud rate is 9,600bps with FSK. The data format may be decided by the user.
  - The MSK modulation is recommended when stable operations are required during the use of multiple channels within the same area. However, the MSK mode requires an external MSK modem IC (MSM6882 manufactured by OKI or an equivalent model.) Restrictions in the performance of this IC mean that the maximum baud rate is 2,400bps.



Channel Table

- Channels

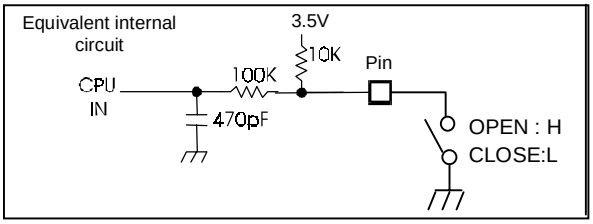
  The STD-402 can be set up with the following 64 channels in the 433MHz ISM band with 25KHz steps within 433.050 to 434.790MHz.

- Channel setting with dip switches
  - Channel setting is possible even when dip switches are connected to each port between CH0 and CH5.
  - The following table lists the port settings and the channel frequencies.

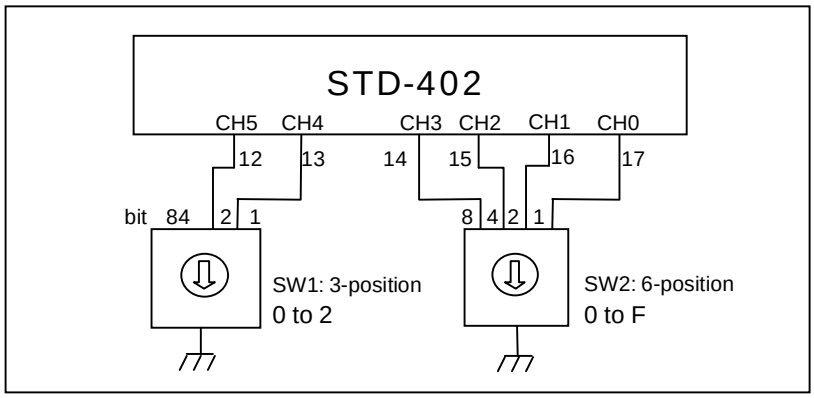
CH	CH5	CH4	CH3	CH2	CH1	CH0	Frequency
0	OPEN	OPEN	OPEN	OPEN	OPEN	OPEN	433.200MHz
1	OPEN	OPEN	OPEN	OPEN	OPEN	GND	433.225MHz
2	OPEN	OPEN	OPEN	OPEN	GND	OPEN	433.250MHz
3	OPEN	OPEN	OPEN	OPEN	GND	GND	433.275MHz
4	OPEN	OPEN	OPEN	GND	OPEN	OPEN	433.300MHz
5	OPEN	OPEN	OPEN	GND	OPEN	GND	433.325MHz
6	OPEN	OPEN	OPEN	GND	GND	OPEN	433.350MHz
7	OPEN	OPEN	OPEN	GND	GND	GND	433.375MHz
8	OPEN	OPEN	GND	OPEN	OPEN	OPEN	433.400MHz
9	OPEN	OPEN	GND	OPEN	OPEN	GND	433.425MHz
10	OPEN	OPEN	GND	OPEN	GND	OPEN	433.450MHz
11	OPEN	OPEN	GND	OPEN	GND	GND	433.475MHz
12	OPEN	OPEN	GND	GND	OPEN	OPEN	433.500MHz
13	OPEN	OPEN	GND	GND	OPEN	GND	433.525MHz
14	OPEN	OPEN	GND	GND	GND	OPEN	433.550MHz
15	OPEN	OPEN	GND	GND	GND	GND	433.575MHz
16	OPEN	GND	OPEN	OPEN	OPEN	OPEN	433.600MHz
17	OPEN	GND	OPEN	OPEN	OPEN	GND	433.625MHz
18	OPEN	GND	OPEN	OPEN	GND	OPEN	433.650MHz
19	OPEN	GND	OPEN	OPEN	GND	GND	433.675MHz
20	OPEN	GND	OPEN	GND	OPEN	OPEN	433.700MHz
21	OPEN	GND	OPEN	GND	OPEN	GND	433.725MHz
22	OPEN	GND	OPEN	GND	GND	OPEN	433.750MHz
23	OPEN	GND	OPEN	GND	GND	GND	433.775MHz
24	OPEN	GND	GND	OPEN	OPEN	OPEN	433.800MHz
25	OPEN	GND	GND	OPEN	OPEN	GND	433.825MHz
26	OPEN	GND	GND	OPEN	GND	OPEN	433.850MHz
27	OPEN	GND	GND	OPEN	GND	GND	433.875MHz
28	OPEN	GND	GND	GND	OPEN	OPEN	433.900MHz
29	OPEN	GND	GND	GND	OPEN	GND	433.925MHz
30	OPEN	GND	GND	GND	GND	OPEN	433.950MHz
31	OPEN	GND	GND	GND	GND	GND	433.975MHz
32	GND	OPEN	OPEN	OPEN	OPEN	OPEN	434.000MHz
33	GND	OPEN	OPEN	OPEN	OPEN	GND	434.025MHz
34	GND	OPEN	OPEN	OPEN	GND	OPEN	434.050MHz
35	GND	OPEN	OPEN	OPEN	GND	GND	434.075MHz
36	GND	OPEN	OPEN	GND	OPEN	OPEN	434.100MHz
37	GND	OPEN	OPEN	GND	OPEN	GND	434.125MHz
38	GND	OPEN	OPEN	GND	GND	OPEN	434.150MHz
39	GND	OPEN	OPEN	GND	GND	GND	434.175MHz
40	GND	OPEN	GND	OPEN	OPEN	OPEN	434.200MHz
41	GND	OPEN	GND	OPEN	OPEN	GND	434.225MHz
42	GND	OPEN	GND	OPEN	GND	OPEN	434.250MHz
43	GND	OPEN	GND	OPEN	GND	GND	434.275MHz
44	GND	OPEN	GND	GND	OPEN	OPEN	434.300MHz
45	GND	OPEN	GND	GND	OPEN	GND	434.325MHz

46	GND	OPEN	GND	GND	GND	OPEN	434.350MHz
47	GND	OPEN	GND	GND	GND	GND	434.375MHz
48	GND	GND	OPEN	OPEN	OPEN	OPEN	434.400MHz
49	GND	GND	OPEN	OPEN	OPEN	GND	434.425MHz
50	GND	GND	OPEN	OPEN	GND	OPEN	434.450MHz
51	GND	GND	OPEN	OPEN	GND	GND	434.475MHz
52	GND	GND	OPEN	GND	OPEN	OPEN	434.500MHz
53	GND	GND	OPEN	GND	OPEN	GND	434.525MHz
54	GND	GND	OPEN	GND	GND	OPEN	434.550MHz
55	GND	GND	OPEN	GND	GND	GND	434.575MHz
56	GND	GND	GND	OPEN	OPEN	OPEN	434.600MHz
57	GND	GND	GND	OPEN	OPEN	GND	434.625MHz
58	GND	GND	GND	OPEN	GND	OPEN	434.650MHz
59	GND	GND	GND	OPEN	GND	GND	434.675MHz
60	GND	GND	GND	GND	OPEN	OPEN	434.700MHz
61	GND	GND	GND	GND	OPEN	GND	434.725MHz
62	GND	GND	GND	GND	GND	OPEN	434.750MHz
63	GND	GND	GND	GND	GND	GND	434.775MHz

- Ports
  1. The channel settings switch the CH0 to CH5 6bit ports with external dip switches and rotary switches.
  2. An equivalent port circuit is shown below. As internal pull-up is performed, it is necessary to ground the switches.



- Channel setting with rotary switches
  1. Channel setting can be carried out simply with the use of real-type rotary switches.
  2. The method of connection is shown in the diagram below. As the switch requires 4bit inputs, connect the first two bits (bit2, bit1) of SW1 to CH4 and CH5 and leave the last two bits (bit8, bit4) open.

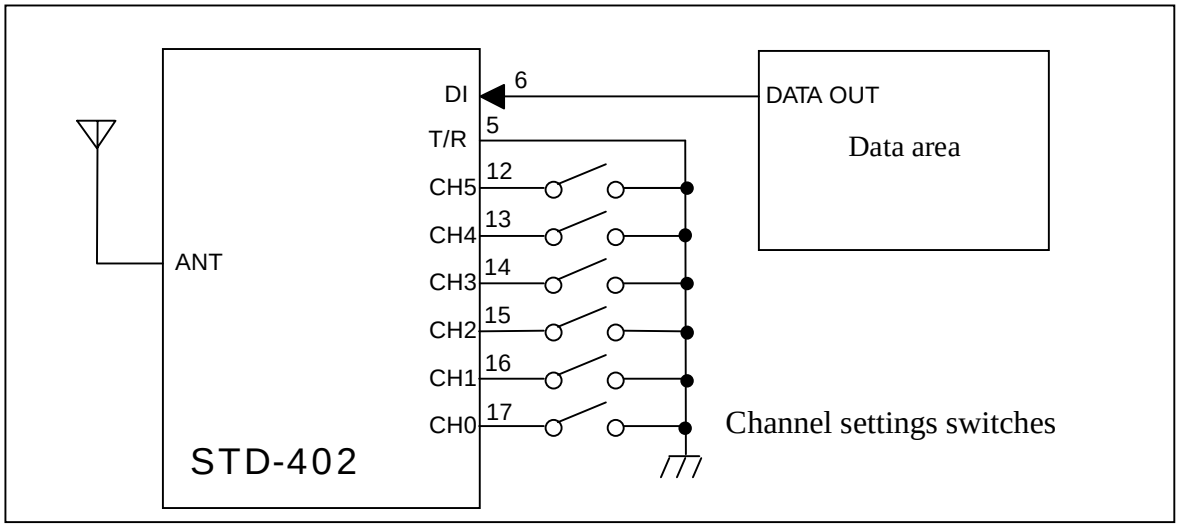


- A table of channel and switch positions is provided below.

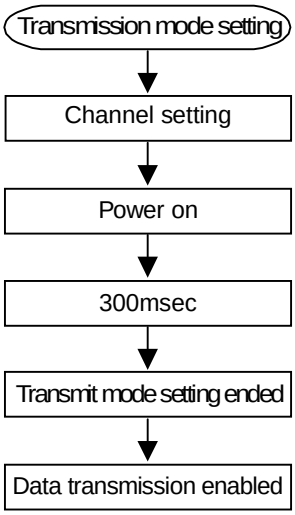
CH	SW1	SW2	CH	SW1	SW2	CH	SW1	SW2
0	0	0	22	1	6	44	2	C
1	0	1	23	1	7	45	2	D
2	0	2	24	1	8	46	2	E
3	0	3	25	1	9	47	2	F
4	0	4	26	1	A	48	2	0
5	0	5	27	1	B	49	2	1
6	0	6	28	1	C	50	2	2
7	0	7	29	1	D	51	2	3
8	0	8	30	1	E	52	2	4
9	0	9	31	1	F	53	2	5
10	0	A	32	2	0	54	2	6
11	0	B	33	2	1	55	2	7
12	0	C	34	2	2	56	2	8
13	0	D	35	2	3	57	2	9
14	0	E	36	2	4	58	2	A
15	0	F	37	2	5	59	2	B
16	1	0	38	2	6	60	2	C
17	1	1	39	2	7	61	2	D
18	1	2	40	2	8	62	2	E
19	1	3	41	2	9	63	2	F
20	1	4	42	2	A			
21	1	5	43	2	B			

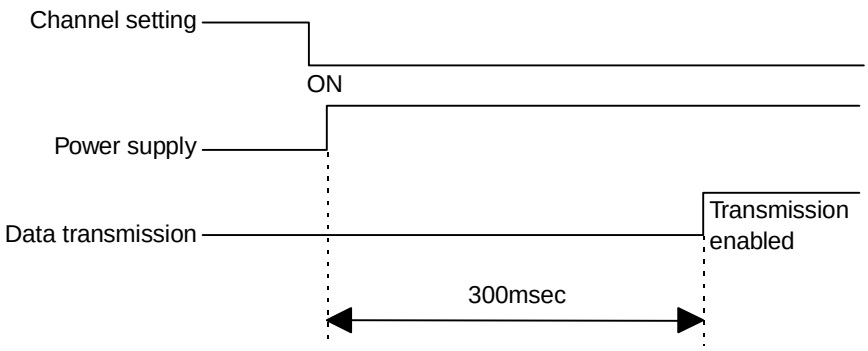
Manual transmit mode

- Connection method
  - A circuit diagram for the manual control transmission mode is provided below. Refer to [Transceiver mode with microcomputer] for details on microcomputer control.
  - Dip switches or rotary switches may be used as preferred for the channel setting switches.



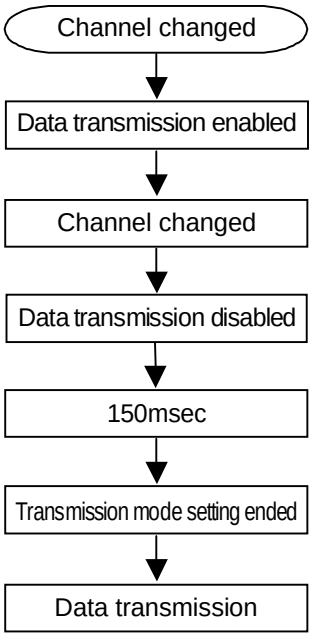
- Timing for switching the power on
  - STD-402 operations are shown in the flow chart and timing chart below.
  - Set the channel from 0ch. If pre-set channels are to be used, skip one channel and use alternative channels to avoid the effects of adjacent channels (0 --> 2 --> 4, etc.)
  - A period of 300msec is required to set up the module contents after the power has been switched on in the transmit mode. Data cannot be transmitted during this period.

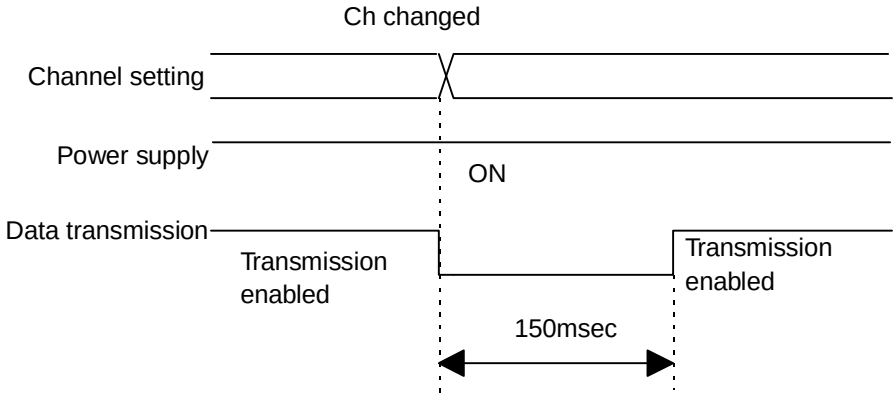




- Timing for channel changing

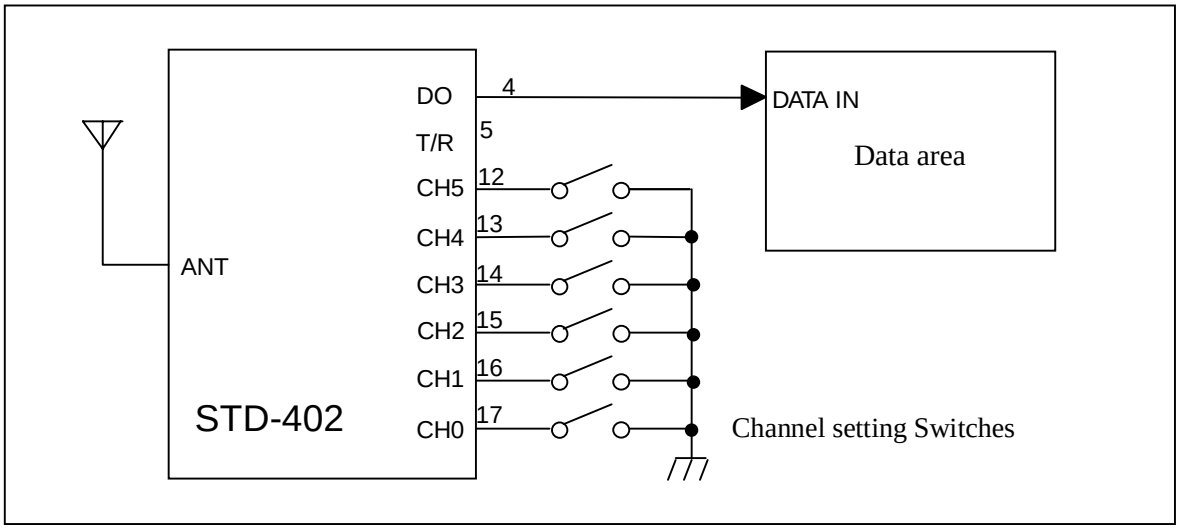
  The flow-chart and timing for switching between channels with the STD-402 are provided below. If the channel is changed when the power supply is on, a period of 150msecs is required while the parameters are reset.



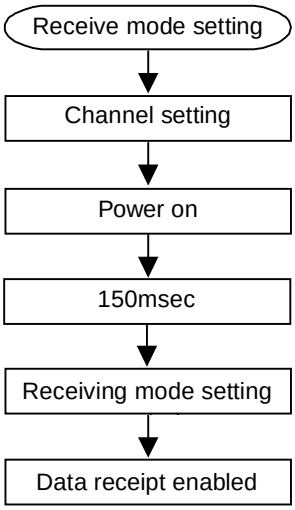


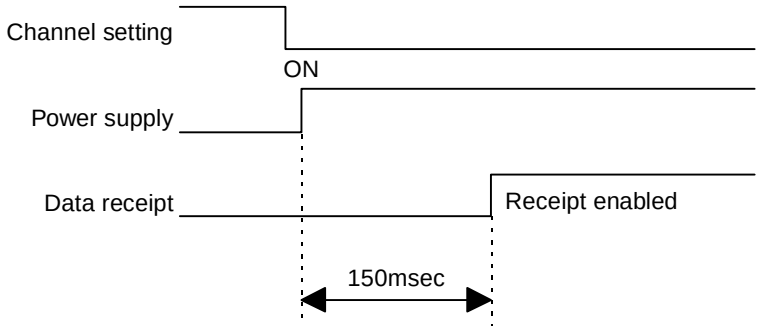
Manual receive mode

- Connection method
  - A circuit diagram for the manual control receiving mode is provided below. Refer to Transceiver mode with microcomputer for details on microcomputer control in the receiving mode.
  - Dip switches or rotary switches may be used as preferred for the channel setting switches.



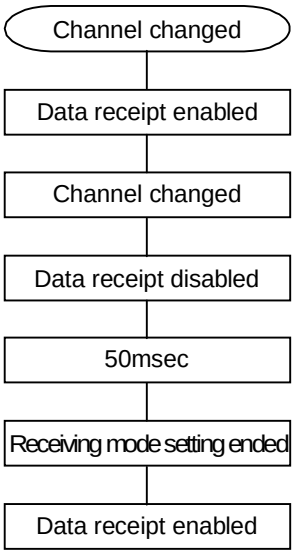
- Timing for switching the power on
  - STD-402 operations are shown in the flow chart and timing chart below.
  - Set the channel from 0ch. If pre-set channels are to be used, skip one channel and use alternative channels to avoid the effects of adjacent channels (0 --> 2 --> 4, etc.)
  - A period of 150msecs is required to set up the module contents after the power has been switched on in the receive mode. Data cannot be received during this period.

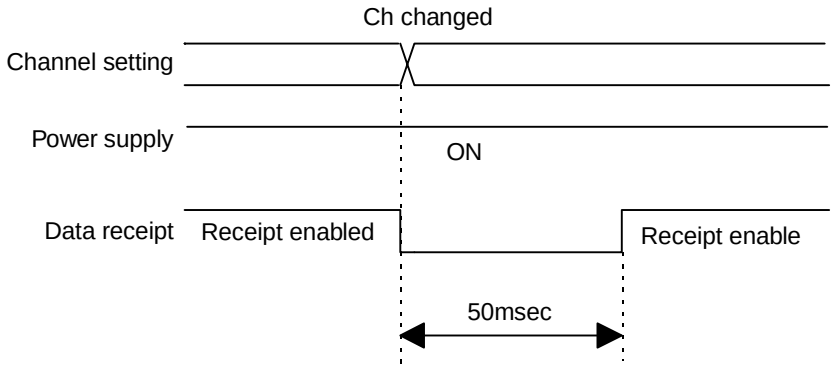




- Timing for channel changing

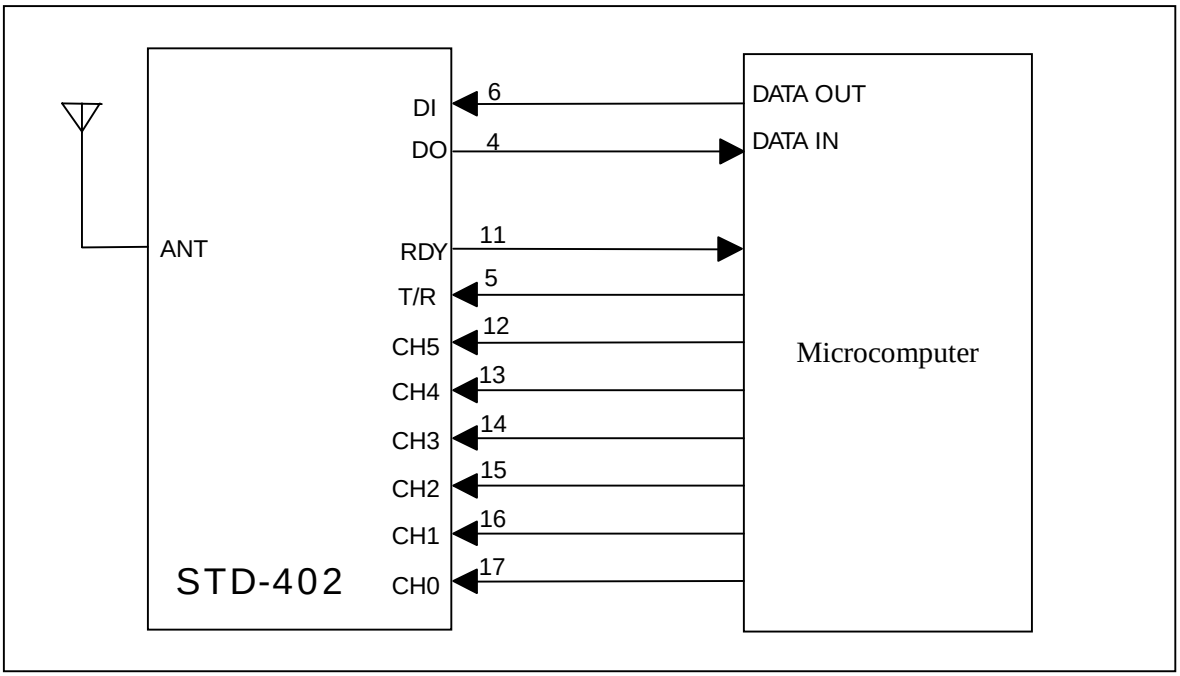
  The flow-chart and timing for switching between channels with the STD-402 are provided below. If the channel is changed when the power supply is on, a period of 50msecs is required while the parameters are reset.



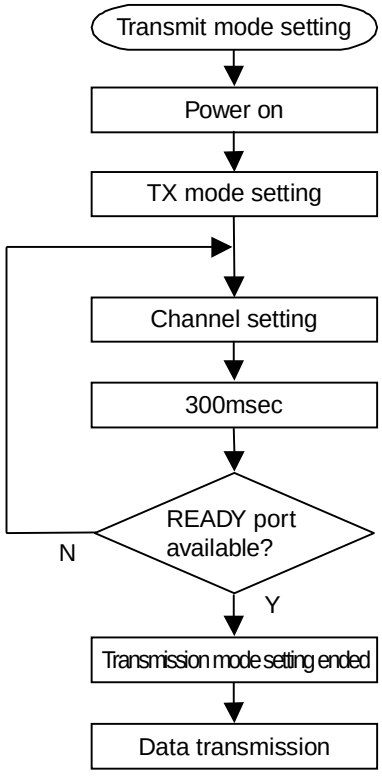


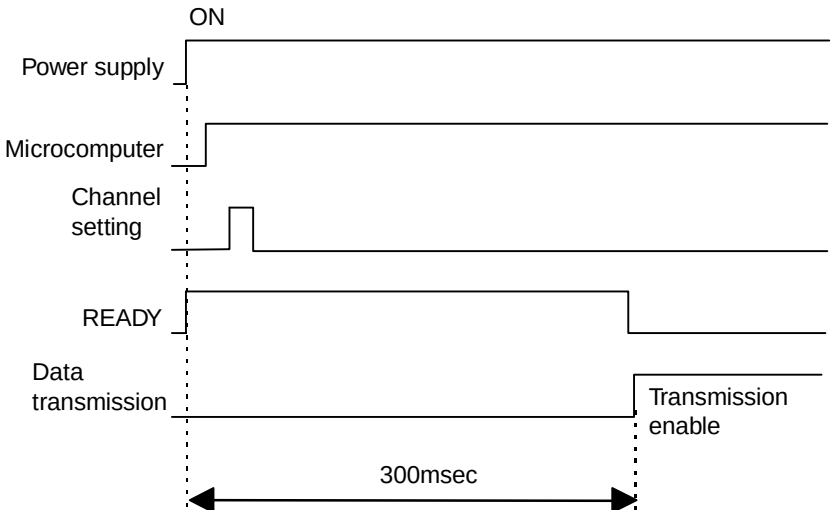
Transceiver mode with microcomputer

- Connection method
  - More complex settings are made available when the STD-402 modes and channels are controlled by microcomputer.
  - By developing microcomputer software that monitors the STD-402 READY ports, it is possible to avoid channels already occupied by other radios in the same way as MCA (Multi-Channel Access) and automatically set up empty channels.



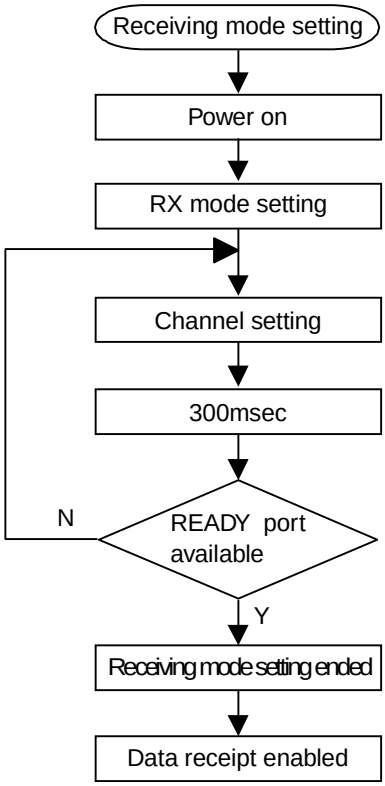
- Timing for transmit mode setting
  - The flow chart and timing chart for transmit mode setting when under microcomputer control are provided below.

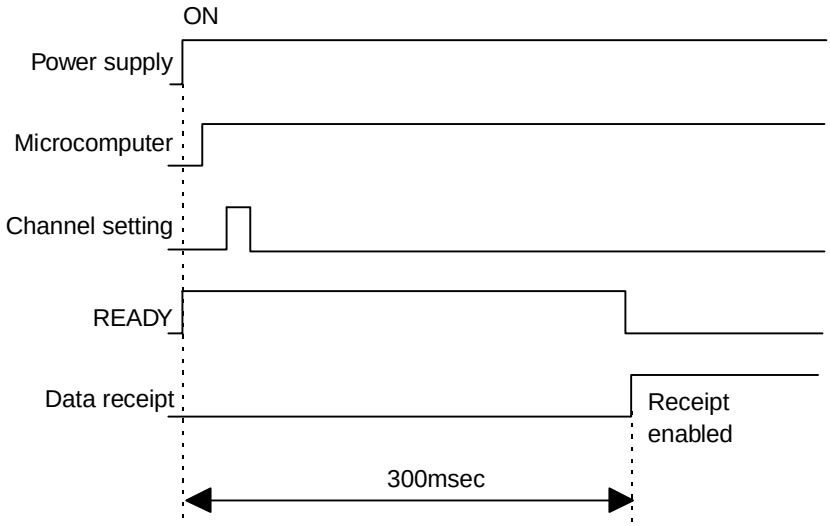




- READY becomes "L" when the set channel for the STD-402 is an empty channel.
- Change the channel after 300msec if READY is "H".
- A set-up time of 150msec is required after the channel has been changed.

- Timing for receive mode setting
  - The flow chart and timing chart for receive mode setting when under microcomputer control are provided below.





- READY becomes "L" when the set channel for the STD-402 is an empty channel.
- Change the channel after 300msec if READY is "H".
- A set-up time of 150msec is required after the channel has been changed.

MSK modulation mode

- Modem IC
  - The MSM6882 MSK modem IC manufactured by OKI is recommended for the MSK (Minimum Shift Keying) modulation mode.
  - Modulation MSK waves are emitted by loading transmission data into the encoder.
  - The decoder converts MSK waves into receiving data.
  - Examples for the application of the MSM6882 terminal function, the transmission mode and the receiving mode are provided below.

- MSM6882 terminal function

❖ Encoder

PIN No.	NAME	I/O	DESCRIPTION	"0" setting	"1" setting
6	ST	O	Send Timing This timing signal is used to latch serial input data on the SD pin.		
5	SD	I	Send Data Serial data for transmission is input on this pin.		
8	PRE	I	Pre-amble or data transmission selection.	SD data	Pre-amble data
7	SIN	I	Modulation method selection.	Cosine	Sine
4	ME	I	Modulator Enable.	TI data	MSK modulator
12	TI	I	Voice signal input.		
21	FT	I	This pin contorls the internal connection of the AO pin.	Power down mode	Normal operation
13	AO	O	Analog signal output.		

❖ Decoder

PIN No.	NAME	I/O	DESCRIPTION	"0" setting	"1" setting
15	AI	I	Receiver Analog signal input		
20	RT	O	Receive Data Timing		
18	RD	O	Demodulated serial data output		
21	CF	I	Phase correcting speed of the digital PLL section		Phase correction
22	CT	I	The PLL's lock-in time selection	18bit	50bit

❖ Total

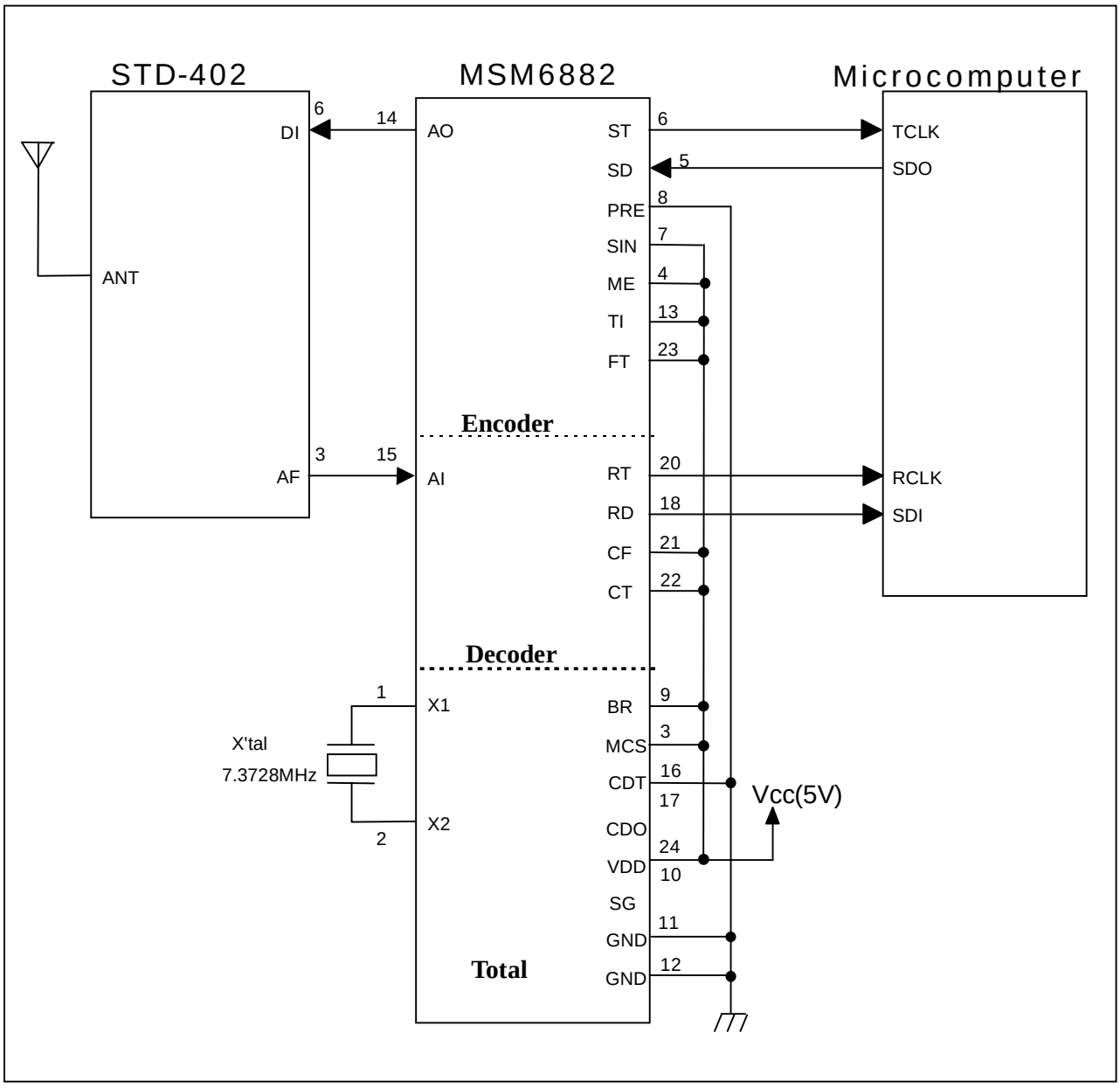
PIN No.	NAME	I/O	DESCRIPTION	"0" setting	"1" setting
9	BR	I	Baud Rate selection	1200	2400
3	MCS	I	Master Clock Selection	3.6864MHz	7.3728MHz
1	X1	O	Internal crystal oscillator I/O		
2	X2	I			
16	CDT	I	Test pin		
17	CDO	I	Test pin		
24	VDD	-	Power supply		
10	SG	-	Signal ground Built-in analogue signal ground		
11,12	GND	-	Ground (0V)		

The shaded areas represent the corresponding circuit settings on the next page

❖ Baud rate and carrier frequencies

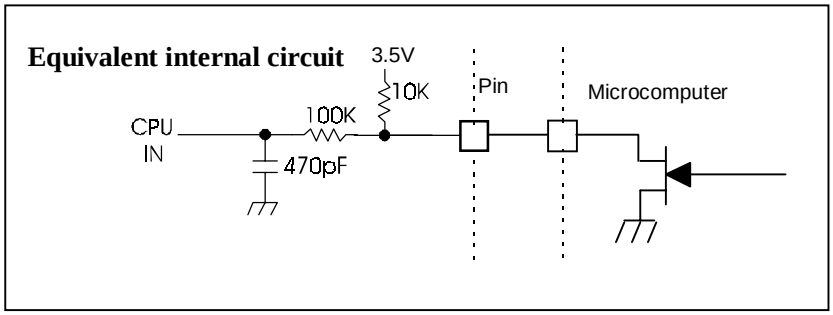
Master clock (MHz)	MCS	BR	Baud rate (bps)	Carrier frequency (Hz)	
				Mark	Space
7.3728	1	1	2400	1200	2400
	1	0	1200	1200	1800

- MSM6882 connection example
  - The diagram below is an example of the connections between the MSM6882, the STD-402 and the microcomputer.
  - The MSM6882 pin layout is for the SOP package.
  - The following diagram shows the transceiving mode. Connect the encoder with the peripheral circuits if only MSK transmission is required, and connect the decoder with the peripheral circuits if only receiving is required.
  - Refer to the MSM6882 manual for detailed information.
  - Refer to the settings on the following page for details on setting conditions.

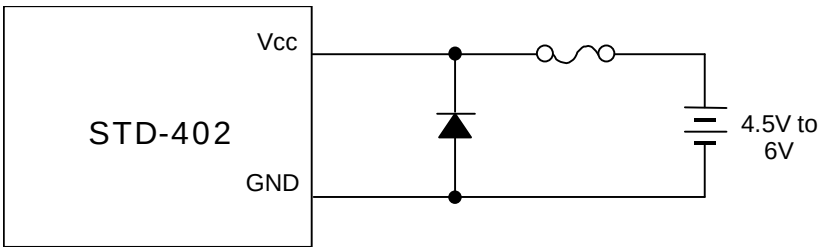


Cautions

- Power supply
  - The operating voltage range for the STD-402 is between 3.6V and 12.0V. A voltage exceeding the maximum of 12.0V will result in damage to the device, and must not be applied under any circumstances.
  - Ensure that an open drain or open collector port is connected when the TX/RX, CH0 to CH5 and external circuits are connected together.

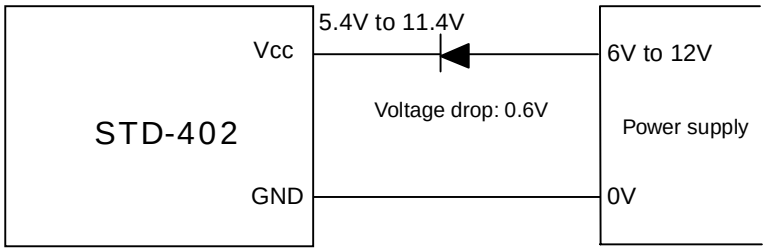


- Reverse connection protection circuit
  - ❖ When using low voltage with battery operations:



  - As the maximum battery supply current will flow into the diode when the battery is connected in the reverse position, much consideration must be given to the Pc (heat loss) in the diode.
  - Although this method is the simplest, long-term heat emission may result in the outbreak of fire. Take extreme caution when handling this.

  - ❖ When using high-voltage mains power for stable operations

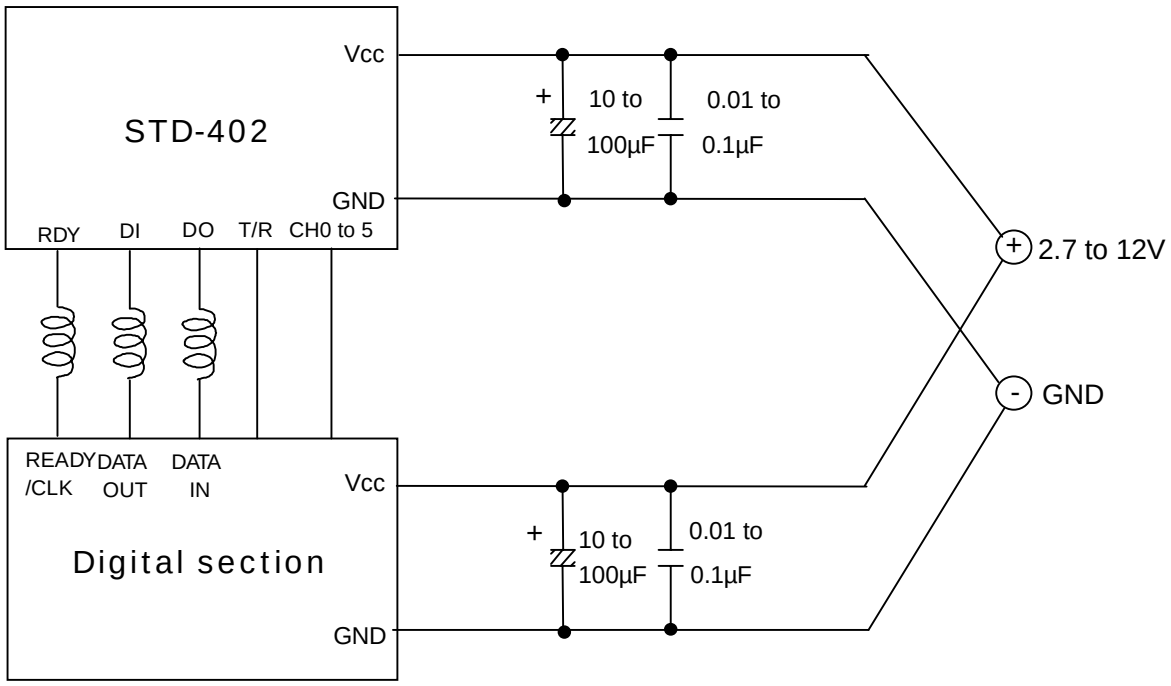


  - Although this method will not result in the buildup of heat in the diode, it will result in a lowering of the forward voltage in the diode and the efficiency rates of the mains power will be lower with batteries and other low voltages.
  - The forward voltage will differ depending on the type of the diode, but the general rectification is approximately 0.6 to 0.7V.

- Printed circuit boards and layouts

  - Pay attention to the following points when mounting the STD-402 on a printed circuit board.

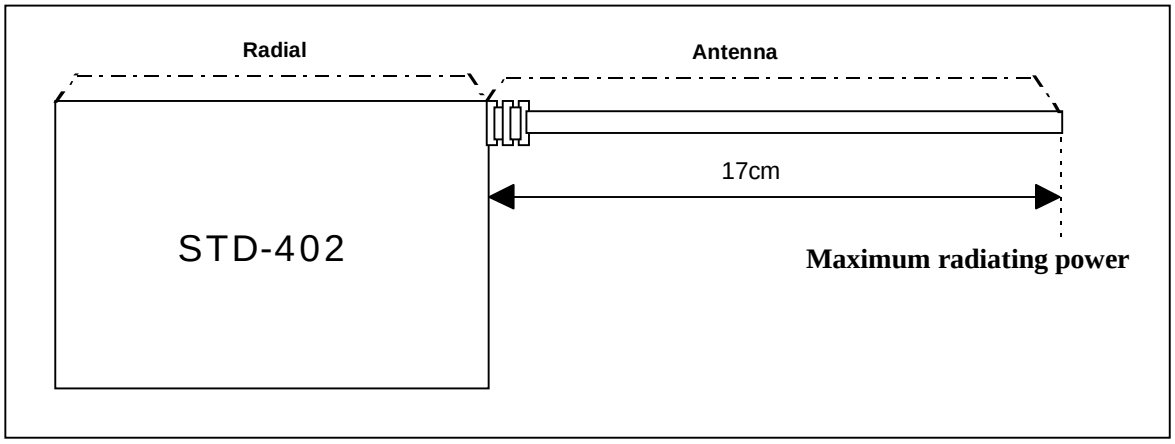
1) Separate the power supply lines into blocks and ensure that they do not interfere with each other.
2) Install the path controller adjacent to the module and IC terminal. Use the path controller in combination with a electrolytic condenser for low frequencies and a ceramic condenser for high frequencies.
3) Ensure that the power supply and the ground line do not have the same impedance, and run the supply from the same point.
4) Insert inductors to cut RF in the STD-402 and in the controller's digital section signal line.



- Antenna

❖ Antenna and radial

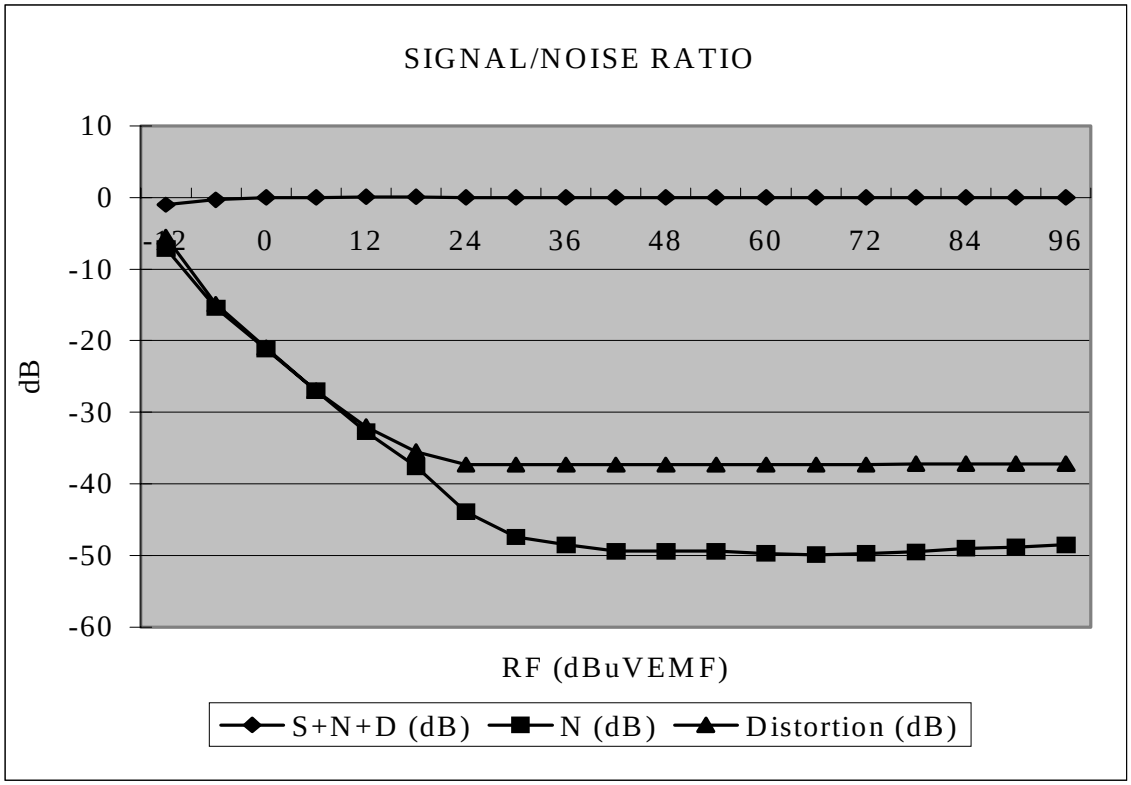
- The STD-402 antenna is approximately 17cm with a one quarter wavelength in the 434MHz band. The unit's metal case not only acts as the ground but is also known as the radial to radiate the electronic radio waves from the antenna and radial. The phase is inverted with the radial and antenna.
- Increase the module's ground pattern as much as possible. The electronic wave radiating power is strongest at the tip of the antenna, and when brought close to the unit's case, or radial, will work to cancel each other out, causing dramatic effect to the arrival distance.

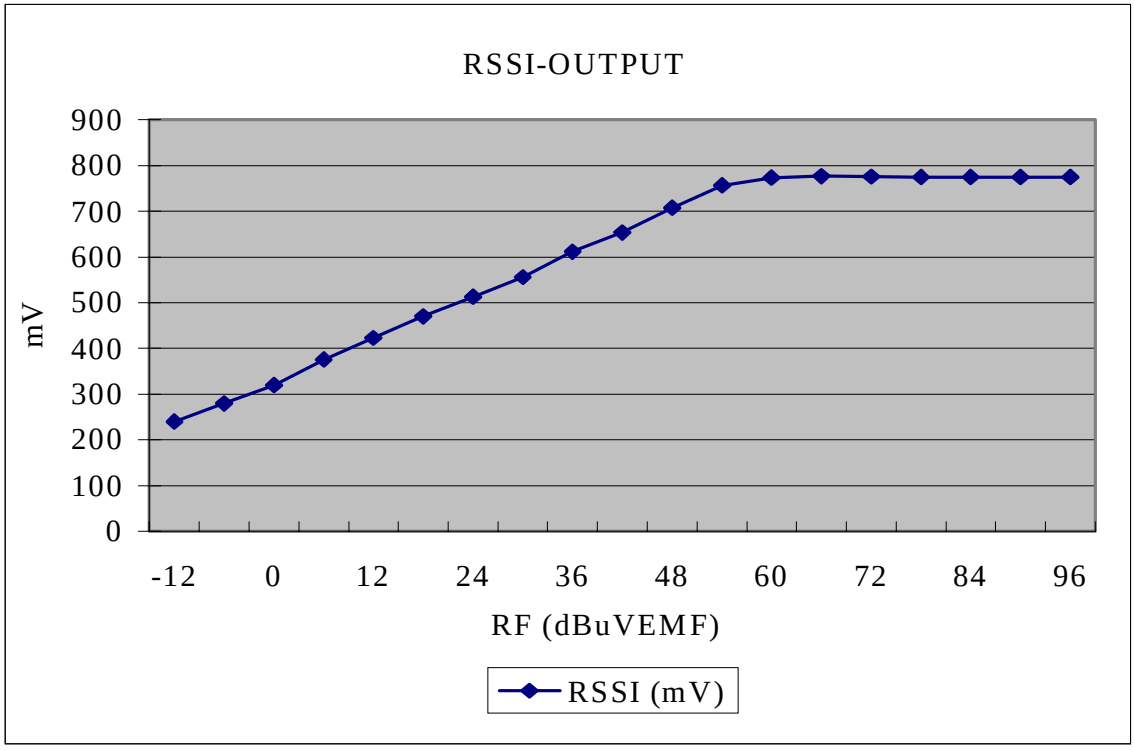


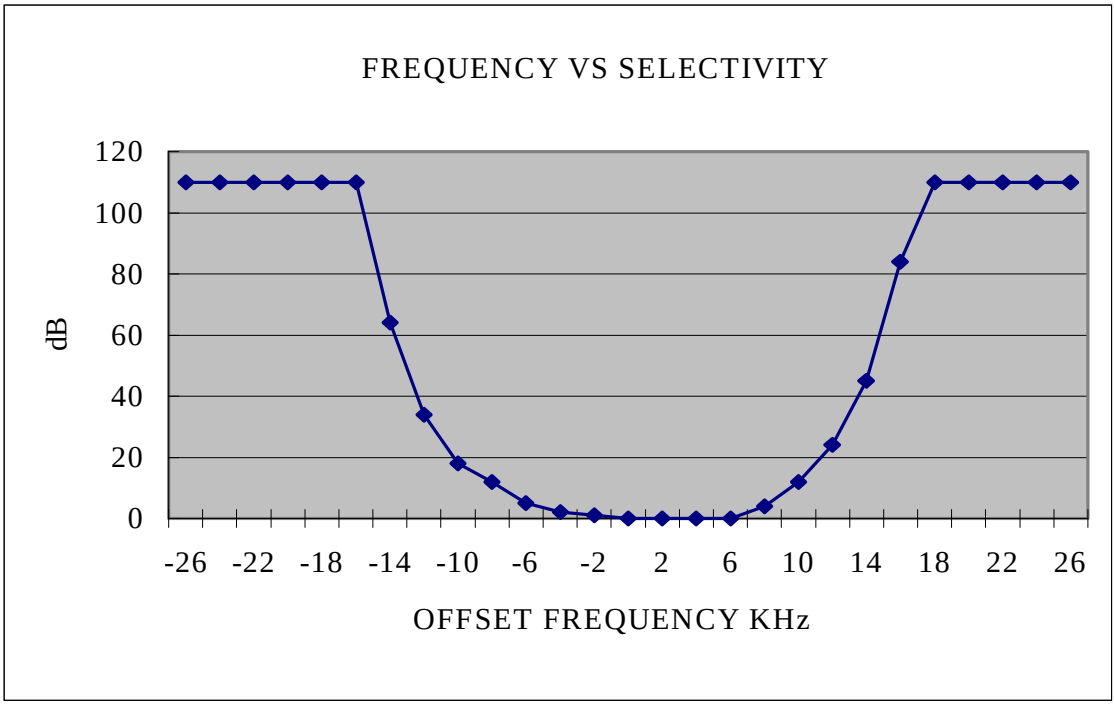
❖ Incorporating into equipment

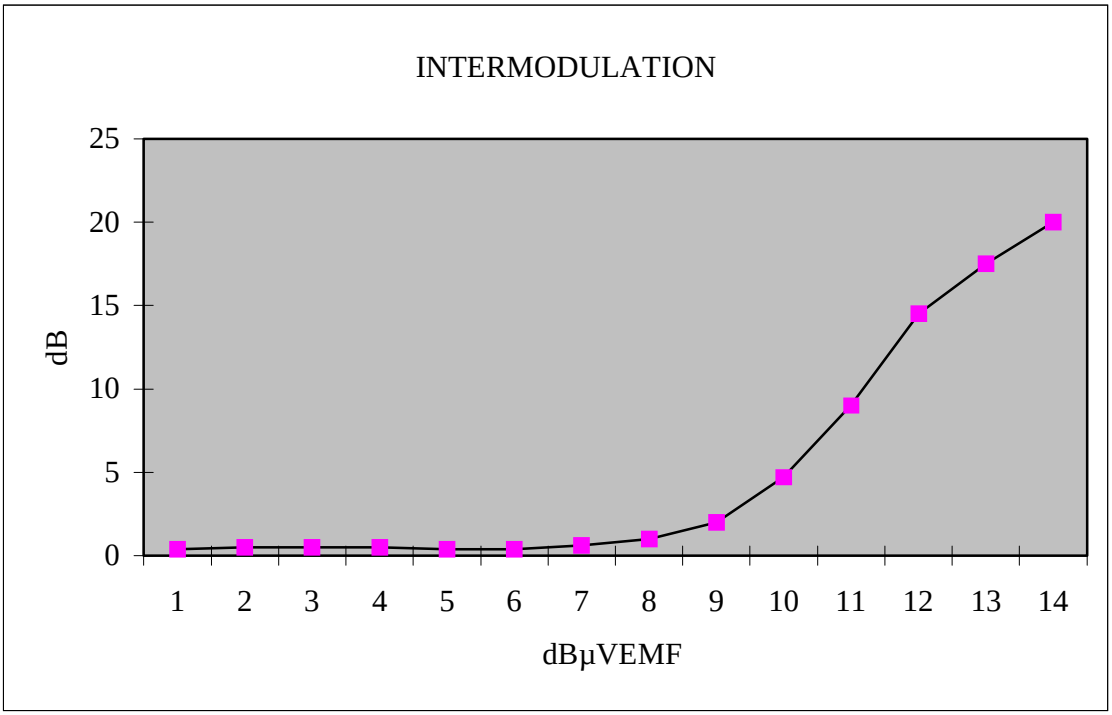
- A direct line is ideal for the antenna, but it should be separated from the case as much as possible when space for incorporating it into the equipment is limited.

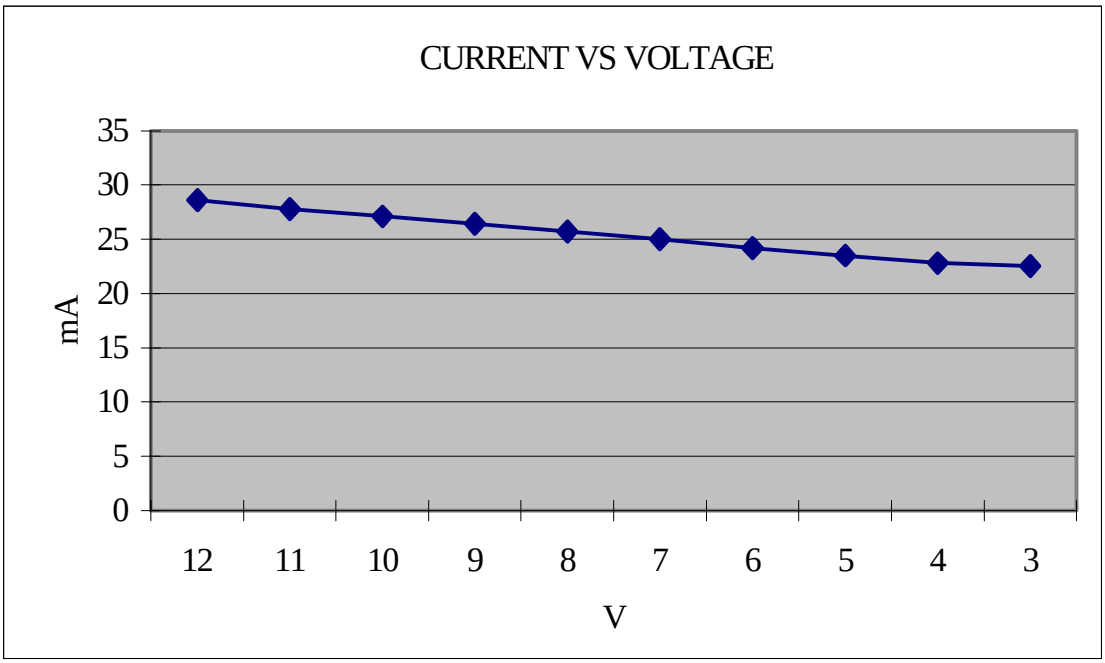
Measured data






FREQUENCY VS SELECTIVITY
120
100
80
60
40
20
0
dB
-26 -22 -18 -14 -10 -6 -2 2 6 10 14 18 22 26
OFFSET FREQUENCY KHz


INTERMODULATION
25
20
15
10
5
0
dB
1 2 3 4 5 6 7 8 9 10 11 12 13 14
dBµVEMF


CURRENT VS VOLTAGE
35
30
25
20
15
10
5
0
mA
12
11
10
9
8
7
6
5
4
3
V