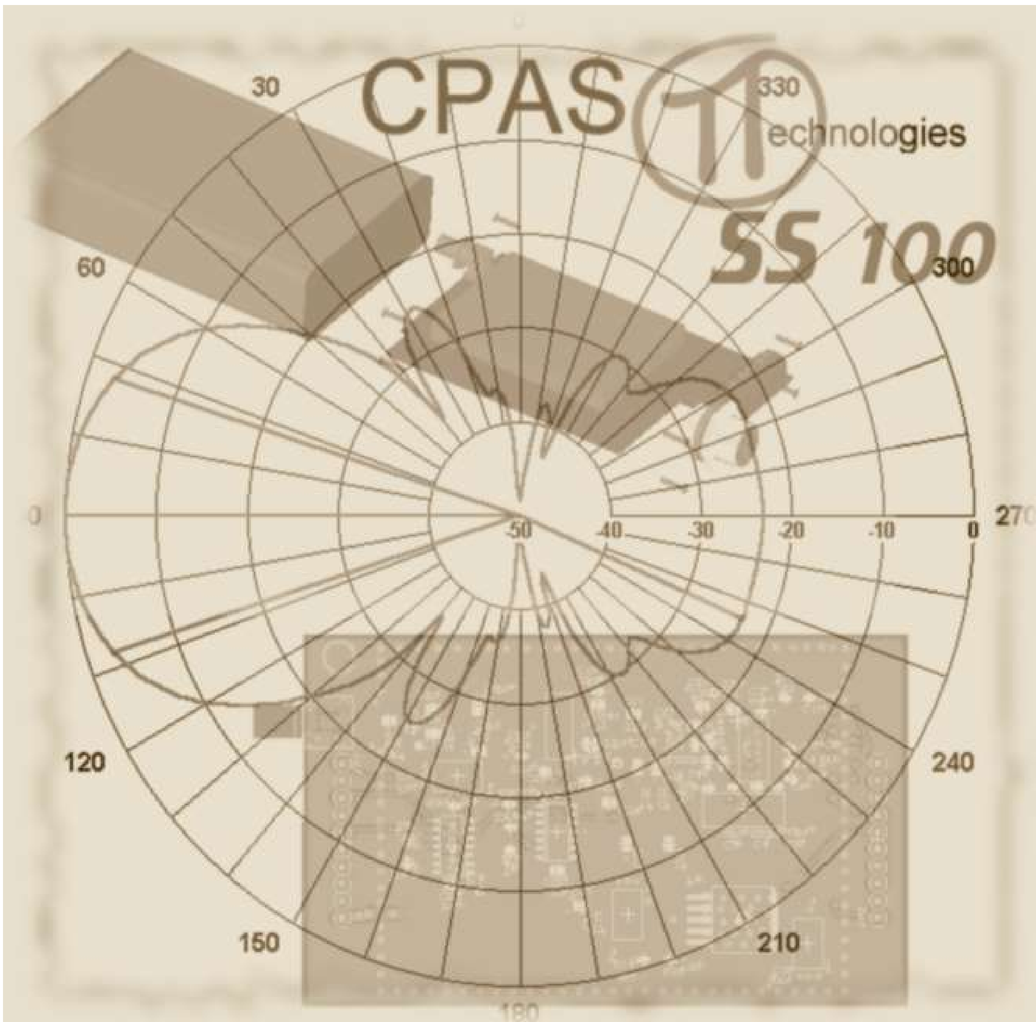


Operation Manual

Operation Manual

CPAS TTechnologies SS100

902-928 MHz Spread Spectrum
Data Acquisition System
01/26/04

WARNING In order to comply with Part 15.203 of the FCC regulations, this transmitter system will need to be installed professionally in accordance with Part 15.31 of the FCC regulations to ensure that the RF limits are not exceeded. Installation of all antennas must be performed in a manner that will provide at least 2 meters clearance from the front radiating aperture, to any user or member of the public. See the ***System Installation Manual*** for more details.

Operation of this equipment in a residential area may cause radio interference, in which case the user, at his own expense, will be required to take whatever measures necessary to correct the interference.

FCC Declaration of Conformity

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received including interference that may cause undesired operation.

FCC Class B Instructions to users

This equipment has been tested and found to comply with the limits for a class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer on an experienced radio/TV technician for help.

This equipment has been certified to comply with the limits for a class B computing device, pursuant to FCC Rules. In order to maintain compliance with FCC regulations, shielded cables must be used with this equipment. Operation with non-approved equipment or unshielded cables is likely to result in interference to radio and TV reception. The user is cautioned that changes and modifications made to the equipment without the approval of manufacturer could void the user's authority to operate this equipment.

1.0 Product Overview

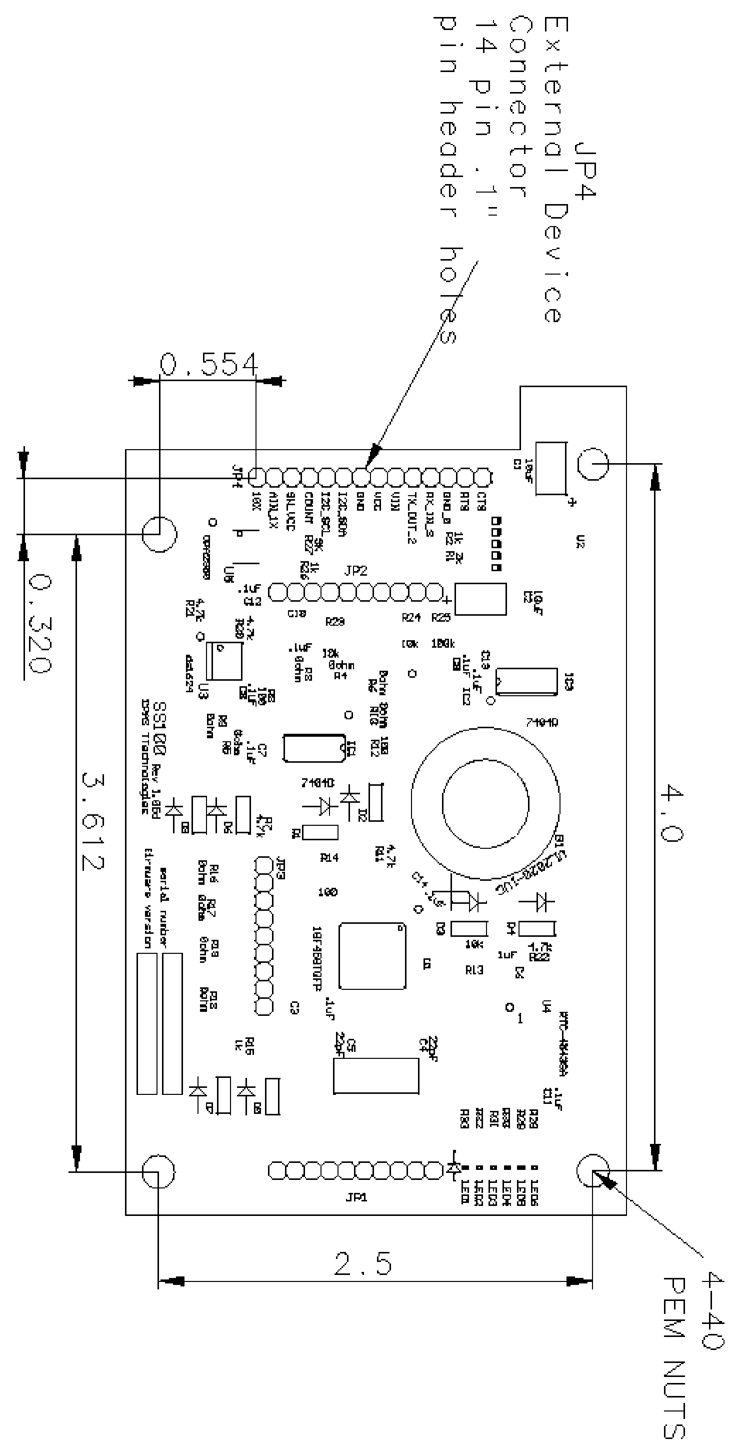
The CPAS TTechnologies SS100 is a modular, high performance, low-cost,point-to-multi-point wireless data acquisition system. It operates in the 902-928MHz ISM frequency band for license-free operation in North America. Its frequency hopping mode of operation offers high reliability due to the inherent tolerance of interfering signals. The RF output power is configurable with 8 levels ranging from 28mW to 500mW. High output power, excellent receiver sensitivity, and frequency hopping all help ensure that remote measurements can be made in environments considered to be difficult for typical UHF systems.

The SS100 can be interfaced with several different types of sensors for remote measurement of various parameters such as:

- Air temperature
- Leafwetness
- Relative humidity
- Precipitation
- Wind speed
- Soil moisture
- As well as many others.

1.1 **Product Features**

- License-free operation – no cellular airtime costs
- Low cost – allows users to install more measurement sites
- Reliability – frequency hopping reduces problems with communication due to interference
- Speed – can collect data from up to 255 remote sites at a rate up to 25 stations per second
- 8 user selectable output power levels from 28mW to 500mW
- 2 channel groups of 50 channels each for a total of 100 RF channels
- 256 user selectable hopping patterns for co-existence of multiple networks
- 32 bit encryption key for privacy and non-interference between networks
- 16-bit CRC error detection for error-free data collection
- Collection systems shut down radio circuitry when not in use for battery conservation.
- Designed for extended temperature range
- Easy configuration and deployment
- Low-drift real time clock
- Link range of 15 miles or more is possible depending on environment, antenna placement, and gain.


JP4
External Device
Connector
14 pin .1"
pin header holes
0.554
0.320
3.612
4.0
2.5
4-40
PEM NUTS
JP2
JP1
JP3
SS100

JP4 Buffered Pin assignments

PIN	NAME	DESCRIPTION
1	CTS	RS232 CLEAR TO SEND OUTPUT FROM SS100
2	RTS	RS232 REQUEST TO SEND INPUT TO SS100
3	GND_5	RS232 SIGNAL GROUND
4	RX_IN_3	RS232 RXD INPUT TO SS100
5	TX_OUT_2	RS232 TXD OUTPUT FROM SS100
6	VIN	POWER SUPPLY FOR SS100 4-20V DC
7	VCC	3.6V OUTPUT
8	GND	POWER SUPPLY GROUND FOR SS100
9	I2C_SDA	Data signal for I2C bus. I/O
10	I2C_SCL	Clock signal for I2C bus. I/O
11	COUNT	External Digital Pulse Counter INPUT
12	SW_VCC	SWITCHABLE 3.6V OUTPUT FROM SS100
13	AIN_1x	ANALOG INPUT 1x GAIN TO SS100
14	AIN_10x	ANALOG INPUT 10x GAIN TO SS100

1.3 SS100 Operational Description

Spread spectrum systems come mainly in two varieties: Direct sequence and frequency hopping. The SS100 is the latter. Frequency hopping spread spectrum systems are similar to a standard narrow-band fixed-frequency system in the way that communications take place. The main difference is that frequency hoppers are constantly changing RF channels within a given range of the RF spectrum. So how do they stay synchronized?

First, a little background in some of the basic regulations for 902-928 MHz FHSS systems operated in North America. 1) The order in which the device changes channels must be pseudo-random. 2) For a 900 MHz ISM device to operate at the maximum 1 watt RF power level, it must use at least 50 channels in its hopping pattern. The SS100 has 256 such hopping patterns consisting of 50 channels each. 3) Each channel must be used equally to comply with the rules for non-stop communications. The SS100 changes RF channels approximately every 20 ms with default settings. This means it takes about 1 second for it to use all 50 channels in a given hopping pattern.

There are different ways to achieve synchronization of the radios. The method used by the SS100 is referred to as master/slave communications. A master radio is constantly sending out synchronization packets at the beginning of each channel change. If a slave radio is not yet synchronized with the master, it will start changing RF channels at a much slower rate than that of the master. It could completely stop changing channels and wait for the master to catch up to it, but changing channels occasionally helps prevent non-synchronization in cases where there is interference on some of the channels. In this manner, with good communications, synchronization should occur within a maximum of 1 second or the duration of the entire hopping pattern. Once the slave radio receives a synchronization packet and verifies that it came from its configured master, it then starts to change channels in tandem with the master. If the slave doesn't hear from the master on a particular channel, it starts counting. If this happens too many times in a row, it assumes it has lost synchronization and starts the process all over again.

One of the unique aspects of the SS100 system is its speed and reliability of data collection from the remote systems. The basic data collection algorithm is described as follows:

- Upon waking from a configured sleep time, the master builds a table with the number of configured retries for each of the remotes in a given network.
- The base embeds the ID of each slave in the network in the synchronization packet sent to each slave, starting with ID = 0 and ending with the highest configured remote ID in the network, at which time the loop starts back at ID = 0.
- After a synchronization packet is sent, the master switches to receive mode waiting for a response from the slave with the ID contained in the synchronization packet. Once the slave receives a synchronization packet with its configured embedded ID, it switches to transmit mode, reads its configured sensors, and transmits a 'sensor' packet to the master.
- By the time the receiver actually responds with the transmission, a channel change has taken place. This is why the master only sends synchronization packets every other channel change. If the master successfully receives the 'sensor' packet from the slave, it is transmitted out of the master's serial port to whatever device it is connected to (a PC or some other device). The master also records that this slave has responded. If the master does not receive a response from the remote slave, it continues to the next ID.
- If the current slave ID has already been called successfully for this collection cycle, the master sends this slave a 'sleep' packet containing the amount of time to the next collection cycle. Upon receiving the 'sleep' packet, the remote slave then turns its radio circuitry off for the specified time.
- This loop continues until the master has either successfully called all slaves or exhausted all retries for all remote slaves, at which time the master will shut down its radio circuitry for the remainder of the configured sleep time.

This algorithm allows for data collection at a rate of up to 25 stations per second, efficient battery usage, distributed retries, and small packet size / short hop interval for increased reliability.

1.4 Configuration Mode

The SS100 is configured using a standard terminal emulator configured for communications at 57,600 or 115,200 baud with no flow control. To enter the configuration menu, press the '+' character rapidly three times. A remote or base menu similar to the following should appear on the screen. The SS100 firmware uses “base” to refer to a master radio and “remote” to refer to a slave.

REMOTE MODE MENU

CPAS TTechnologies SS100 $Revision: 1.69 $

0 - Mode: REMOTE STATION
1 - Power: 500mW 27.0 dBm
2 - Channel Group: 01
3 - Unit ID: 00
4 - P Hop Pattern: 0F
5 - Encryption: 12345678
c - Sweep Spectrum
d - RSSI dBm: -~
e - Sensor 1 Config: Temp 1
f - Sensor 2 Config: Battery Voltage
g - DTE/DCE Baud Rate: 115200
ESC - Data Mode

S - Set Date/Time 2003-09-30,09:10:41
P - Show Radio PCB Temp
Temp/Freq correction: -.00 kHz
Battery Voltage: 7.43v

BASE STATION MODE MENU

CPAS TTechnologies SS100 $Revision: 1.69 $

0 - Mode: BASE STATION
1 - Power: 500mW 27.0 dBm
2 - Channel Group: 01
4 - P Hop Pattern: 0F
5 - Encryption: 12345678
7 - Highest Remote ID: 03
a - Remote Sleep Time: 78
b - Call Retries: 64
c - Sweep Spectrum
d - RSSI dBm: -~
g - DTE/DCE Baud Rate: 115200
ESC - Data Mode

S - Set Date/Time 2003-09-30,11:52:06
P - Show Radio PCB Temp
Temp/Freq correction: -.77 kHz
Battery Voltage: 7.43v

To change a particular parameter, press the character indicated. For example to change the mode of operation, press the '0' key. A description of each parameter follows.

0) ***MODE*** - Set the operating mode of the device, 0 for a **Base**, 1 for a **Remote**

Only one device should be configured as a **Base** per network since the **Base** is responsible for all data collection and provides synchronization for all remotes. The **Base** antenna should be within RF line-of-sight communications range of all remotes. Other settings that are unique to the **Base** mode include 'Highest Remote ID,' 'Remote Sleep Time,' and 'Call Retries' as described below.

If the device is configured for the **Remote** mode, the **Unit ID** should be unique from all other **Remotes** in a given network. Unit IDs should be set in consecutive order starting with ID = 0. For maximum efficiency of data collection, there should be no gaps in the ID sequence. Other settings that are unique to the **Remote** mode are 'Unit ID,' 'Sensor 1 Config,' and 'Sensor 2 Config' as described below.

1) ***Power*** – *Sets* RF power to the antenna. *Power should only be changed by a professional installer*. Refer to the ***System Installation Manual*** for details.

2) ***Channel Group*** – Selects one of two channel groups to use in a given network, either group 00 or group 01.

Each channel groups consist of 50 channels with a channel separation of 400 kHz across the spectrum range 902-928MHz. Each channel bandwidth is about 200 kHz, making it possible to offset the two groups by 200 kHz so that two networks can operate together without interference. All radios on a given network must use the same Channel Group. If two networks are in close proximity to each other, they should use different channel groups as well as different hopping patterns.

3) ***Unit ID*** – Assigns a unique ID to each **Remote** in a network.

Each **Remote** must have a unique ID starting with ID = 0 and increasing in a consecutive order with few or no gaps between IDs for maximum data collection efficiency. This number is entered in hexadecimal (Base 16) with a range from 00 to FE.

4) ***Primary Hop Pattern*** – Determines the pseudo-random order in which a radio changes channels.

All devices on a given network must have the same hopping pattern. Packets received from devices configured with a different hopping pattern will be ignored. The number is entered in hexadecimal (Base 16) with a range from 00 to FF.

5) ***Encryption*** – Sets a 32 bit number that provides privacy and prevents interference from other networks with otherwise similar settings. Setting this to FFFFFFFF will reset all settings to factory defaults.

This number must be the same for all devices on a given network for communications to succeed. The number is entered in Hexadecimal (Base 16) with a range from 00000000 to FFFFFFFE. This provides the user with 4,294,967,295 combinations. **Please set this to a unique, non-obvious number for your networks!**

7) ***Highest Remote ID*** **(Base only)** – Sets the highest numerical ID that a **Base** will try collecting data from during a data collection cycle.

This ID should be set one higher than the highest **Remote** ID in the network. This number is entered in Hexadecimal (Base 16) with a range from 00 to FE.

a) ***Remote Sleep Time*** (**Base** only) – Sets the amount of time (in seconds) between data collection cycles.

This parameter should be set high enough so that all remote stations can be reliably called during each data collection cycle with some time to spare. This number is entered in hexadecimal (Base 16) with a range from 00 to FF.

b) ***Call Retries*** (**Base** only) – Sets the number of times a station will be called during a data collection cycle without successfully establishing communications.

After a number of attempts, the Base Station will time-out and start sending 'sleep' packets to a **Remote**. The call retries should be set high enough to reliably retrieve data but not so high that the data collection cycle is longer than the configured sleep time. The number is input in Hexadecimal (Base 16) with a range from 00 to FF.

c) ***Sweep Spectrum*** – A read only option that provides a list of the signal strength of the channels in the 902-928MHz spectrum.

The sweep spectrum cycles through all 50 channels of the configured channel group in sequence. The output lists the received signal strength in dBm (decibels relative to a milliwatt) for each channel. A dBm level of -107 represents a very weak signal to the SS100, while -50 dBm is a very strong signal. Signals less than -107 dBm are shown as a '~' character indicating extremely low signal strength. Constant signals of -50 dBm across the entire spectrum indicates that **high-power** cellular phone or paging equipment is in close proximity and is overloading the SS100 receiver front-end. Power lines will not interfere with the SS100.

d) ***RSSI*** – A read only option that shows the last measured signal level.

Assuming that a **Remote** is synchronized to a **Base**, RSSI gives a good indication of the link margin between the two radios. A level of -107 or '~' is marginal, while -95 and higher is very good. -80 to -50 is excellent. This is useful in the field to test signal strength for best placement of the **Remote**.

e) ***Sensor 1 Config*** – Sets the sensor type installed at sensor position 1. The current choices are:
0 – PCB Temp
1 - Temp 1
2 - Temp 2
3 - Battery Voltage
9 - Not Connected

f) ***Sensor Config 2*** – Sets the sensor type installed at sensor position 2 as given for Sensor 1.

g) ***DTE/DCE Baud Rate*** – Sets the baud rate at which the SS100 communicates on its RS232 port.

The choices are 57,600 and 115,200 baud, with preference given to the higher baud rate. Note that any software used to communicate with a **Base** or **Remote** through the RS232 connection must match the selected baud rate for communications to take place.

ESC – Returns Station to Data Mode

Pressing escape while in the configuration mode exits the configuration mode and shifts to data mode. Note that the SS100 will revert back to data mode automatically after several seconds of no activity in the configuration mode.

S – Sets Date and Time

Use the following format to change data and time:
YYMMDDHHMMSS where YY=Year, MM=Month, DD=Day, HH=Hour, MM=Minute, and SS=Second

P – Shows the Radio PCB Temperature

A temperature sensor is located on the internal pc-board. This temperature is used to correct the frequency of the radio due to crystal oscillator temperature dependence every time the radio changes channels. At 77 °F, the correction will be 0 kHz. The pc-board temperature (°F) will be displayed when P is pressed.

1.5 DATA MODE

Data mode is the default mode for the SS100 at start-up. When configured as a **Base**, the data mode output during a data collection cycle looks similar to the following:

```
$2003-09-30,17:24:50
*00,01,03,77.06,7.31,-50
*01,01,03,77.15,6.52,-50
*02,01,03,76.94,6.34,-50
*03,01,03,77.15,7.43,-50
*04,01,03,77.06,6.35,-50
```

At the start of a data collection cycle the date and time is output preceded by a '$' character and followed by a carriage feed/line return. Output from each **Remote** is preceded by a '*' character and followed by a carriage return / line feed. The format is

*, Unit ID, Sensor 1 Type, Sensor 2 Type, Sensor 1 Value, Sensor 2 Value, RSSI value

When configured as a **Remote,** the data mode output during a data collection cycle looks similar to the following:

```
RSSI -50
RSSI -50
RSSI -50
ACK
RSSI -50
```

The RSSI values are the signal strength levels for each received packet coming from the **Base**. The ACK indicates that the **Remote** received a synchronization packet addressed to it and responded back to the **Base**. Being able to view the RSSI levels helps an installer know whether an antenna is placed in a good position and if signal strength will provide good communication.

Channel Frequencies

Channel Group 00 Freqencies

0	905.018 Mhz	25	915.018 Mhz
1	905.418 Mhz	26	915.418 Mhz
2	905.818 Mhz	27	915.818 Mhz
3	906.218 Mhz	28	916.218 Mhz
4	906.618 Mhz	29	916.618 Mhz
5	907.018 Mhz	30	917.018 Mhz
6	907.418 Mhz	31	917.418 Mhz
7	907.818 Mhz	32	917.818 Mhz
8	908.218 Mhz	33	918.218 Mhz
9	908.618 Mhz	34	918.618 Mhz
10	909.018 Mhz	35	919.018 Mhz
11	909.418 Mhz	36	919.418 Mhz
12	909.818 Mhz	37	919.818 Mhz
13	910.218 Mhz	38	920.218 Mhz
14	910.618 Mhz	39	920.618 Mhz
15	911.018 Mhz	40	921.018 Mhz
16	911.418 Mhz	41	921.418 Mhz
17	911.818 Mhz	42	921.818 Mhz
18	912.218 Mhz	43	922.218 Mhz
19	912.618 Mhz	44	922.618 Mhz
20	913.018 Mhz	45	923.018 Mhz
21	913.418 Mhz	46	923.418 Mhz
22	913.818 Mhz	47	923.818 Mhz
23	914.218 Mhz	48	924.218 Mhz
24	914.618 Mhz	49	924.618 Mhz

Channel Group 01 Freqencies

0	904.818 Mhz	25	914.818 Mhz
1	905.218 Mhz	26	915.218 Mhz
2	905.618 Mhz	27	915.618 Mhz
3	906.018 Mhz	28	916.018 Mhz
4	906.418 Mhz	29	916.418 Mhz
5	906.818 Mhz	30	916.818 Mhz
6	907.218 Mhz	31	917.218 Mhz
7	907.618 Mhz	32	917.618 Mhz
8	908.018 Mhz	33	918.018 Mhz
9	908.418 Mhz	34	918.418 Mhz
10	908.818 Mhz	35	918.818 Mhz
11	909.218 Mhz	36	919.218 Mhz
12	909.618 Mhz	37	919.618 Mhz
13	910.018 Mhz	38	920.018 Mhz
14	910.418 Mhz	39	920.418 Mhz
15	910.818 Mhz	40	920.818 Mhz
16	911.218 Mhz	41	921.218 Mhz
17	911.618 Mhz	42	921.618 Mhz
18	912.018 Mhz	43	922.018 Mhz
19	912.418 Mhz	44	922.418 Mhz
20	912.818 Mhz	45	922.818 Mhz
21	913.218 Mhz	46	923.218 Mhz
22	913.618 Mhz	47	923.618 Mhz
23	914.018 Mhz	48	924.018 Mhz
24	914.418 Mhz	49	924.418 Mhz

1.7 Technical Specifications

Transmitter Specifications

Output Power	28-500mW with 8 levels
Phase Noise (specified typical)	-85 dBc/Hz @ 100 kHz from carrier
FSK Frequency Separation	133 kHz, 20 dB BW Approx. 175 kHz
Channel Spacing	400 kHz
Frequency Range	904.818 MHz to 924.618 MHz
Over-Air Data Rate	9600 bps – 38400 bps

Receiver Specifications

Sensitivity	-102 dBm BER=10^{-3} @ 9600 bps
IF Frequency	150 kHz
IF Bandwidth	175 kHz
RSSI Dynamic Range	-110 dBm to -48 dBm
RSSI Accuracy	+/- 6 dB
RSSI Linearity	+/- 2 dB
PLL Settling Time	200 microseconds

General Specifications

Temperature / Frequency Correction	+/- 7.5 kHz over temperature range
Temperature Operating Range	-40 C to +85 C by design
DTE/DCE Baud Rate	57,600 or 115,200 baud
Channel Dwell Time	Approx. 20 millseconds
Number Of Channels	100 (2 groups of 50)
Antenna Connector	SMA (reverse polarity)
Number of Hopping Patterns	256
Error Detection	CRC-16
Encryption	32 bit proprietary

Electrical Specifications

Voltage Input Range	4 to 15 volts (absolute max = 20 V)
Current Consumption Sleep Mode	11.8 mA
Current Consumption Receive Mode	29.6 mA
Current Transmit 28 mW	Average 90 mA Max 315 mA
Current Transmit 55 mW	Average 100 mA Max 324 mA
Current Transmit 78 mW	Average 105 mA Max 332 mA
Current Transmit 117 mW	Average 115 mA Max 358 mA
Current Transmit 182 mW	Average 127 mA Max 383 mA
Current Transmit 309 mW	Average 150 mA Max 445 mA
Current Transmit 489 mW	Average 166 mA Max 521 mA
Current Transmit 500 mW	Average 174 mA Max 530 mA