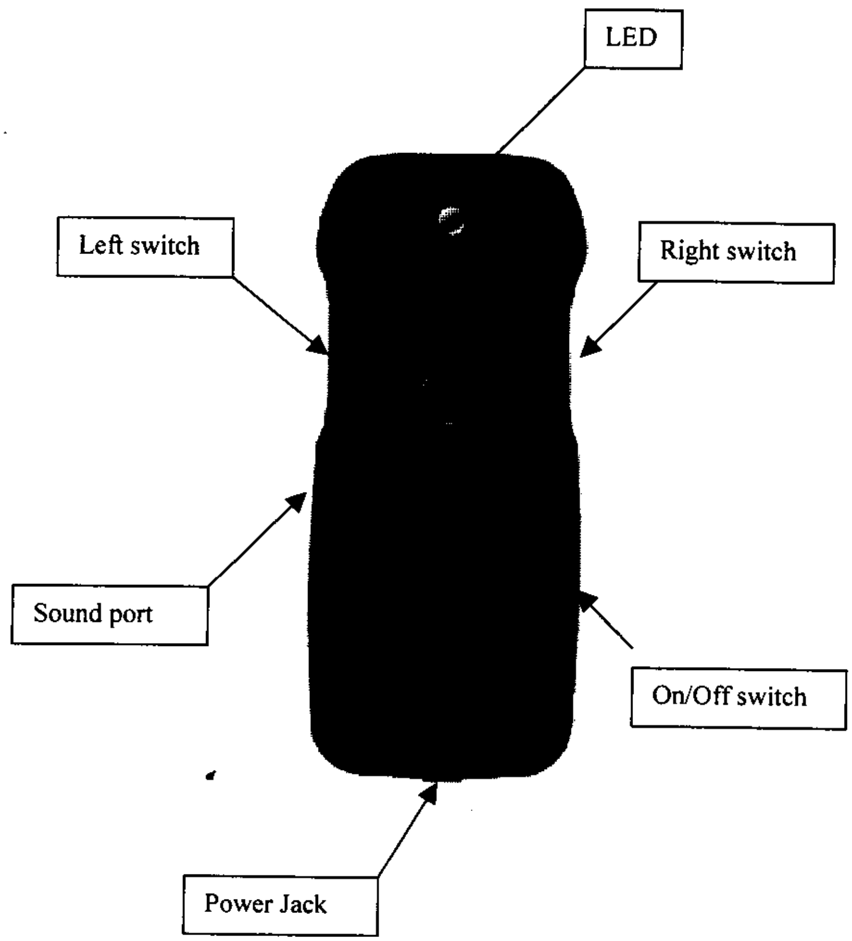
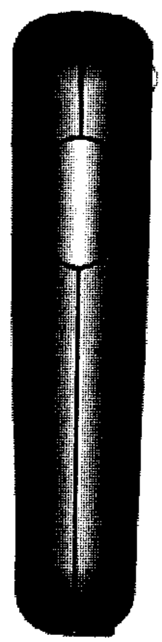
Specifications

RF	
Transmit frequency	915.2 MHz
Transmit power	1 watt ERP
Modulation	Direct Sequence Spread Spectrum
Battery	
Battery type	Lithium Ion
Unit life (normal mode)	12 hours
Recharge time	3 hours
Battery charge cycles	500
Low battery indication	visual
Charge complete indication	visual
User interface	
Audio transducer	3100 Hz
Light emitting diode	red, green, yellow
ON/OFF	one momentary, delayed action switch
Function selection	two momentary delayed action switches
Battery charging input	2.5-mm jack – 6 volt DC

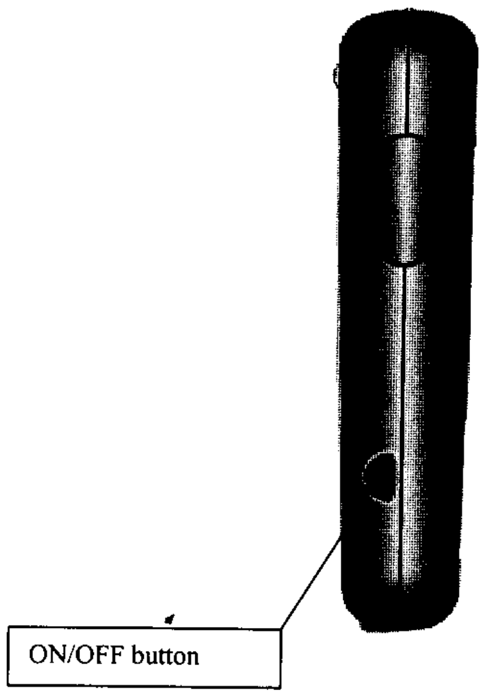
Professional transmitter – Front View



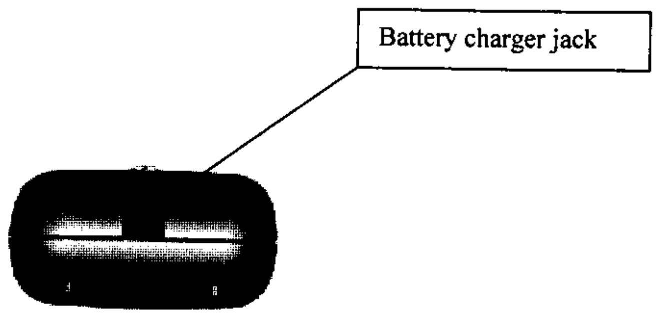
Professional Transmitter - Left Side View



Professional Transmitter – Right Side View



Professional Transmitter – Bottom View



Operational Modes

Power on

Power up the transmitter by pressing the ON/OFF button on the side of the unit. The button must be held in for .6 seconds to be recognized (see button delay section). When the unit begins its powering up sequence it will emit three beeps and light the green Light Emitting Diode (LED) in unison. Once the beep is heard the button can be released. If the button remains pressed past the three beeps the unit will begin the power OFF sequence.

Power off

Turn the transmitter OFF by pressing the ON/OFF button. The button must stay depressed for the .6 seconds. When the unit begins to shut down it will emit a long audio tone and turn on the red LED. Once the tone is heard then button can be released. The audio tone and the LED will stay active for up to 2.3 seconds or until the button is released which ever occurs first. The unit will recycle through a power ON sequence if the button remains pressed.

Battery Charging

The transmitter will immediately go into a charging mode if a charger is plugged into the transmitter. All other functions, buttons, and transmission modes will be deactivated when a charger is detected. It is assumed that if a charger is plugged in no other unit operation will be needed are provided.

The transmitter will respond to the charger by flashing the LED. The LED will continue to flash the entire time a charger is plugged in. The LED will flash yellow if the battery has been sufficiently depleted to cause the unit to go into a full charge mode. The LED will turn into flashing green when the battery gets fully charged and the charger circuitry is switching over to a trickle charge mode.

If the LED immediately goes to a green LED flash when the charger is plugged in to the transmitter then the battery was not depleted. The unit has determined the battery does not need a full charge and will go directly into a trickle charge mode.

Normal operation

After a power up sequence the transmitter will enter a normal mode of operation. This consist of sending out a period transmit burst once every 18 seconds for a period of .5 seconds.

The unit will indicate that it is in normal operation by flashing the LED for .1 seconds every 3 seconds. The LED will be a green flash when the battery is good. The flashing will change to yellow when a low battery is detected warning the user of a limited amount of remaining unit functionality.

The process of flashing the LED and sending the periodic transmission burst will continue the entire time the unit is on or until one of the other modes is activated.

Transmitter test

The transmitter can be placed in a test mode by pressing either the right or left buttons for the .6 seconds. The transmitter test consist of changing the transmission mode from a .5 second transmission burst to a 9 second transmission burst. This mode can be used to increase the probability of being acquired by a receiver and is intended to be used as a test aid in initial roll out of the system.

The transmitter will indicate that it is in test mode by beeping and flashing the yellow LED for .15 seconds every 4 seconds. This test mode will last about 30 seconds. When the test mode is completed the unit will revert back to a normal transmission mode.

Emergency Transmission

Emergency mode is invoked by pressing both the right and left function keys simultaneously and holding them in for the minimum period of .6 seconds. The emergency mode will send out a transmission burst that last 9 seconds, turn off for 9 seconds, then repeat the sequence. This process will continue until the unit is turned off.

The transmitter will indicate it is in the emergency mode by turning on the red LED and producing an audio beep that last for 3 seconds. This process will repeat twice then the LED will switch to a fast pulsing red color.

When in the emergency mode the test mode will no longer be available. Only the Man Down function or a power cycle will terminate this mode.

Man Down Transmission

The Man Down function is started when the unit detects that it has been placed in a near horizontal position. This is a function that is not initiated or stopped by a user action with a button. It can only be activated or deactivated by changing the transmitters' orientation.

Upon detecting that it is in a horizontal position the unit will emit a warning signal to warn the user that a man down transmission is eminent unless the unit is up righted. The warning will last for 15 seconds and consist of 5 1-second beeps along with a red LED flash. During this time the unit continues to transmit in the normal mode.

If the unit is placed back in a semi-vertical position the warning will cease immediately. The unit will return to a normal transmission with the normal LED indication. If the unit is again placed in a horizontal position the warning will restart and the delay time will start again at the beginning.

If the unit is not upright by the end of the warning sequence then the unit starts an emergency Man Down transmission. This transmission is a 9-second on, 9 second off sequence. The transmission will continue until the unit is powered off. Neither the test mode nor the emergency mode is recognized by the unit once it has entered into the Man Down mode. The LED will change to a fast flashing red indicator when in the man down transmission mode.

Programming options

Button delays

All buttons are sampled several times before the action requested is recognized. This is to prevent the accidental change in transmitter modes by the momentary pressing a switch. All switches use the same delay. The delay can be set in 73 millisecond increments and can be programmed to go from .073 seconds to 18.615 seconds. The delay is currently set for .657 seconds. If the button is released any time during the delay period the button processing is stopped. If the button is pressed again then the delay will start from zero and complete the entire delay period before initiating the response.

Indicator selection

There are three indicators used to provide feed back to the user. These are the buzzer, the red Light emitting Diode (LED), and the green LED. In addition to he red and green light colors the red and green LED's can be combine to produce a yellow light.

Each of these devices can be selected in any combination to produce a response to the user. The only restriction is that the devices selected have to be on simultaneously and off simultaneously. The unit can not be programmed to alternate between red light and green light flashes.

Indicator repetitions

Each of the indicator commands consists of an on time and an off time, making an event cycle. The event can be programmed to repeat itself a number of times before terminating the indication activity. The range of repetitions is one to seven, and 'always'. The 'always' causes the cycle to repeat itself indefinitely or until another event, such as a button press, terminates the process.

Indicator ON Time

The amount of time an indicator is ON can be set in .073 second increments. This is value is valid from 0 to 18.615 seconds. The length of time an indicator is ON is independent of its OFF time and its repetition number.

Indicator OFF Time

The amount of time an indicator is OFF can be set in .073 second increments. This is value is valid from 0 to 18.615 seconds. The length of time an indicator is OFF is independent of its ON time and its repetition number.

Buzzer Tone

The buzzer tone can be programmed in 54.5 Hz increments. It can be set form 0 to 6.921 kHz. The buzzer tone is the same for all functions at this time but could be change in the future. The current frequency is 3106 Hz. And was selected to obtain the maximum volume for the resonance of the installed buzzer.

Multiple Responses

In some cases the unit is capable of performing two successive response indications. The completion of the first response must be the beginning of the second response. There can not be a delay between the two responses.

Current Indicators Settings

The following chart shows the current reporting configurations for the transmitter.

Mode	First Response						Second Response					
	Green	*red*	*buzzer*	*On (1)*	*Off (1)*	*Rep(2)*	*Green*	*red*	*buzzer*	*On (1)*	*Off(1)*	*Rep(2)*
Charging	X	X		0.5	2.0	(3)						
Charged	X			0.5	2.0	(3)						
Power on	X		X	0.3	0.36	3						
Power off		X	X	2.3	0	1						
Normal (4)	X			0.1	3.0	(3)						
Normal (5)	X	X		0.1	3.0	(3)						
Test	X	X	X	0.14	4.1	7						
Emergency		X	X	1.75	.51	2		X		0.1	0.1	(3)
Man down		X	X	1.0	1.0	5		X		0.1	0.1	(3)

(1) seconds
(2) repetitions, number of time the event repeats before exiting
(3) loop forever or until an outside stimulus causes a branch in the software
(4) Normal unit operation, periodic transmit with good battery
(5) Normal unit operation, periodic transmit with low battery

Exhibit No. 2

ABSTRACT

The "processing gain" for the PSSI PS911 system is computed.

BACKGROUND

The PSSI system occupies the 902-928 ISM band and as such must meet federal regulations for this band. Operation under CFR Title 47 Part 15.247 requires that transmitters use either a frequency hop or direct sequence spread spectrum (DSPN) modulation. Further, a DSPN modulation must exhibit at least 10 dB of 'processing gain'.

The PSSI PS911 system uses a DSPN sequence. Our system has a fundamental chipping rate of 7.15 MegaChips/sec. That is, a new binary 'chip' [1] is presented about once every 140 nSec. The sequence we use has a total of 255 chips. After 255 chips, the sequence repeats. 32 repetitions of this sequence are used to form a data bit. More specifically, we XOR (exclusive or) the 32 repetitions of the sequence with the data bit we wish to transmit. If the data bit is a logic '0', we send the sequence as is. If the data bit is a logic '1', then the sequence is inverted prior to transmission.

PROCESSING GAIN COMPUTATION

The processing gain of the PS911 system is a function both of the waveform we have chosen and the type of jamming (interference) we assume.

In CFR Title 47 part 15.247(e)(1), the processing gain is defined to be the improvement in signal-to-noise ratio (S/N) seen when the code is turned off compared to that seen when the code is turned on. Implicitly, the regulations assume that we have filtered to the spreading bandwidth when the code is on, and that we have filtered to the modulation bandwidth when the code is off. Further, the definition assumes white noise as the 'interference'. In the PSSI system, 7,150,000 Hz is the (single-sided) bandwidth when the code is on, and 7,150,000/(32*255) = 836.2 Hz is the bandwidth when the code is off. Stated another way, our chipping rate is 7,150,000 cps and the data rate is (approximately) 836 bits/sec. The ratio is 7,150,000/836 = 8160, which is the number of chips per bit. Stated in dB, the apparent processing gain is 10 * log(8160) = 39 dB.

Though correct, the 39 dB processing gain alluded to in the previous paragraph is misleading. It would be realized only against white noise. Anything other than white noise will reduce this figure. Accordingly, it should be taken as an upper bound. Furthermore, this 'processing gain' is due only to straight-forward filtering. A pseudo

[1] Traditionally, a pn code 'bit' is called a 'chip' by communication system engineers. The word 'bit' is reserved for true information. A pseudo noise code has no information content.

noise (PN) code is useless against white noise or a very broad band jammer in the sense that one should have bypassed the PN code and simply broadcast the data bits by themselves. The PN code would be needless sophistication.

In 15.247(e)(2), though, a different definition is presented. In this definition, a CW (continuous wave, or a simple sinusoidal carrier only) interferer is stepped in 50 KHz increments across the band. This interfering signal is added to the desired signal, and the combination is presented to the receiver. At each step, we adjust the power level of the interferer until the observed bit error rate (BER) is reduced to the "recommended" BER.[2] At that point, we measure the jammer power and compute the jammer to signal ratio (J/S). The processing gain is then defined as in the regulations as

$$G_p = S / N + Mj + Lsys$$

where

Gp is the processing gain;
S/N i s the signal to noise ratio required to obtain the given BER[3]
Mj is the poorest J/S ratio seen during the sweep;[4] and
Lsys are system losses, assumed by the regs to be less than 2 dB.

The benefit of this definition is that it conducts a real test against the worst case interferer, namely a sinusoid. The pass fail criterion for this test is simple: At the required BER, the J/S ratio Mj must be larger than 10 – 7.2 – 2, or 0.8 dB.

We pass this test easily. Our processing gain against a CW signal is determined entirely by the capabilities of our 255 chip PN code.. If the code we used were ideal, the processing gain would be 10 * log(255) = 24 dB. In practice, because our code is a real world code that is less than ideal, we see about a 22 dB worst-case gain. The fact that we repeat this code 32 times per bit does not improve the situation. This is because the PN code repeats at a 7,150,000/255 = 28 KHz rate. If the jammer is at a frequency 'close' to 915.2 MHz +/- n * 28KHz, then it is correlated to our signal. Whatever 'noise' comes out of the correlator is repeated over and over again. As such, it is not filterable and is indistinguishable from desired signal. More importantly, this 'noise' grows with accumulation at exactly the same rate as the signal grows, and thus the S/N stays constant no matter how much you accumulate (filter).

This, though, should be taken as a worst case bound. As noted, our signal looks like a series of sinusoids each separated by a frequency span of 28 KHz. The accumulation we do in both the DSP and the software form an effective low pass filter (LPF) with 3 dB bandwidth 876/2 = 438 Hz. Thus, any CW waveform which is not approximately phase locked and is farther than 438 Hz away from one of our spectral components will see extra attenuation due to our LPF operation. If we step in 50 KHz steps, only occasionally will the interferer be this close to one of the waveform's spectral components. Thus, we exhibit processing gain much larger than 24 dB on most of the tests, and no worse than 22 dB in all cases.

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[2] In the PS911 system, that would be about one error in every 100 bits. We can conceivably sustain lower, but not happily.

[3] For a bit error rate of 0 01, the required Eb/No is approximately 4.2 dB. The S/N value is precisely 3 dB higher, that is, 7.2 dB.

[4] Actually, you are allowed to discard the bottom 20%. Mj is the J/S which remains <u>after</u> this discard.