1.0 Introduction

The LPT-900 is a frequency hopping spread spectrum transmitter designed to be compatible with US (FCC Part 15.247) and Canadian (RSS-210) regulations for license free use in the 902-928 MHz band.

The transmitter will typically be used for the remote control of industrial equipment, pumps, valves, etc. The transmitter is designed to be built and tested as a stand alone unit and then installed in various remote control products. In all cases the LPT-900 will be installed on a main PC board via “half moon” connections around the perimeter of the module. An external antenna is required, generally just a quarter wave length trace on the main PC board. The module has onboard voltage regulation and is intended to be powered by 4 AA alkaline batteries .

2.0 Specifications

Parameter	MIN	TYP	MAX	UNITS
Frequency Range	902		928	MHz
DC Supply Voltage	4	6	10	VDC
Frequency Stability (synthesized with TCXO reference)		+/- 2.5		PPM
Operating Temperature	-40		+85	°C
Transmitter R.F. Power Output	9	10	12	mW.

Type of Emission: Frequency Hopping Spread Spectrum
Number of Radio Channels: 256

PCB Dimensions: 1.65 X 1.85 inches
Material: .031 inch thickness FR4
Number of layers: 4

3.0 System General Description:

The LPT-900 is a frequency hopping spread spectrum (FHSS) transmitter designed to be compatible with FCC Part 15.247 (US) and RSS-210 (Canada) regulations for license free operation in the 902-928 MHz frequency band. The major elements include a frequency agile, narrow band R.F. transmitter, and an embedded microprocessor for frequency hopping sequence generation and data generation. Packets of control data are transmitted to a mating receiver.

Packets are sent on selected frequencies in the hop sequence. A data packet consists of eight bytes. This includes a preamble, radio ID, data, and a CRC-16 word. The embedded microprocessor generates digital data, wave shaped using a digital to analog converter, which in turn frequency modulates the transmitter RF signal. The microprocessor also generates a Reed-Solomon pseudo random frequency hop sequence of length 64 based on a pre-programmed seed. The full 902 to 928 MHz band is utilized in equally spaced 100 kHz channels.

3.1 Power Supply:

Refer to schematic diagram DSCH-2238-02 sheet 1.

The transmitter requires an external 4-10VDC power supply connected to soldered connections on the board edge. The external voltage is regulated to 3.3VDC by switching regulator U7. After filtering by L4 and C39, the 3.3VDC output is again regulated by linear voltage regulator U6 , which provides the final 3.0VDC supply for the microprocessor and radio circuitry. Switching regulator U7 also contains the On/Off control for the module.

3.2 Microprocessor:

Refer to schematic diagram DSCH-2238-02 sheet 1.

An Atmel AT90LS8535 microprocessor, U9, is employed to handle frequency synthesis control, frequency hopping and data packet formatting. Crystal X2 provides the 3.686 MHz clock.

3.4 D to A converter:

Refer to schematic diagram DSCH-2238-02 sheet 1 & 2.

The transmitter employs a DAC circuit utilizing a summing operational amplifier, U4:B, for modulation. Four data outputs from the microprocessor are used to create an approximated or “stepped” sine wave pattern. The output of U4:B is amplified by op amp U4:A, and FM modulation is achieved by applying the signal to a voltage controlled tuning pin on the synthesizer TCXO reference oscillator, X1. Potentiometer R22 controls the FM deviation level, which is set to +/- 4KHz. To preserve battery life, this circuit is powered down when the module is not transmitting

3.5 VCO and Synthesizer:

Refer to schematic diagram DSCH-2238-02 sheet 2.

The frequency synthesizer is the heart of the transmitter hardware. The RF oscillation is provided by a Maxim 2623 VCO IC, U1. The VCO, resonant tank circuit and varactor diode are completely contained within the I.C. A tune pin is provided for frequency pulling. This circuit is also powered down when not transmitting to save power. The On/Off switching function is contained within the IC. The frequency synthesizer is a Philips SA8026, U3, which is programmed by the microprocessor with the frequency hopping sequence. The synthesizer loop filter consists of R12-R14 and C17-C21. A 12.8MHz TCXO, X1, provides a stable reference oscillator as well as a method of modulating the transmitter by means of a voltage controlled tuning pin.

3.6 R.F. Amplifier and Harmonic Filter:

Refer to schematic diagram DSCH-2238R02 sheet 2.

The output of the VCO is applied to the R.F output amplifier , U2 via resistor network R1-R5.The resistors provide approximately 2dB of attenuation for impedance matching on the main signal path as well as splitting off a sample of the RF signal to drive the synthesizer circuit. The final amplifier stage is enabled by the microprocessor only when the module is actually transmitting data. The R.F. output is routed to a soldered connection on the edge of the module, through a fifth order harmonic filter consisting of inductors L2-L3 and C10-C13. In typical usage, this will connect to a quarter wave length trace on the main board which functions as the antenna. Nominal R.F. output power is 10 milliwatts into 50 ohms.

3.7 Emission Types

The module contains the following "fixed" frequency sources:

X1 - 12.8MHz crystal controlled TCXO synthesizer reference oscillator.
X2 – 3.6864MHz Microprocessor clock crystal.

The module contains the following "variable" frequency source:

U1- 902-928 MHz Voltage controlled oscillator. Phase locked to reference TCXO.

3.8 Antenna

The antenna is defined by the particular application in which this module is installed. In most cases, the antenna will simply be a copper trace on the PC board to which the module is attached.

4.0 Spread Spectrum Operation

4.1 Frequency Plan

The transmitter can be set to operate on any one of 256 frequency channels in the 902-928MHz band. The frequencies are divided into four groups of 64 frequencies; each group using every fourth available frequency. 63 out of 64 frequencies in a group are then used equally in a pseudo random sequence. 63 different sequences are available for use in each frequency group. Each channel is 30KHz wide.

FREQUENCY PLAN

HOP FREQ. NUMBER	GROUP #1 (MHz)	GROUP #2 (MHz)	GROUP #3 (MHz)	GROUP #4 (MHz)
0	902.3	902.4	902.5	902.6
1	902.7	902.8	902.9	903.0
2	903.1	903.2	903.3	903.4
3	903.5	903.6	903.7	903.8
4	903.9	904.0	904.1	904.2
5	904.3	904.4	904.5	904.6
6	904.7	904.8	904.9	905.0
7	905.1	905.2	905.3	905.4
8	905.5	905.6	905.7	905.8
9	905.9	906.0	906.1	906.2
XX	**Add 400 kHz per Frequency Hop Number**			
54	923.8	923.9	924.0	924.1
55	924.2	924.3	924.4	924.5
56	924.6	924.7	924.8	924.9
57	925.0	925.1	925.2	925.3
58	925.4	925.5	925.6	925.7
59	925.8	925.9	926.0	926.1
60	926.2	926.3	926.4	926.5
61	926.6	927.7	926.8	926.9
62	927.0	927.1	927.2	927.3
63	927.4	927.5	927.6	927.7

4.2 Per Hop Activities

The transmitter operates on a different frequency every 25 ms. A full hop cycle takes 1.575 sec. To preserve battery life, the transmitter is only activated approximately every tenth hop. When there is a change of state in the application product the transmitter is activated for ten consecutive hops. Transmitter ON time is approximately 18.8 ms per active hop, and the remaining time is used to switch frequency and to key the various circuits on and off.

The system uses a nine bit data format. A data packet consists of eight bytes assembled by the microprocessor as follows:

9 bits **preamble**	**9 bits** **idle**	**36 bits** **user data**	**18 bits** **CRC**

Data is sent at a rate of 4800 bits per second.