OMNEX
CONTROL SYSTEMS INC

Model AP-1648
Spread Spectrum Data Transmitter

and

Model AP-1221
Interface Module

Specifications
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1. Introduction

The AP-1648 is a frequency hopped 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 such as cranes, concrete pumpers, loaders, etc. It will be used in conjunction with an existing OMNEX interface module that allows the connection of switches, potentiometers, joysticks etc. as required for a particular control application. The transmitter and interface module are housed in an ABS plastic enclosure with an internal antenna. Power is provided by a standard Makita power tool (Ni-Cad) battery pack.

2. Specifications

Operating Frequency Range: 902-928 MHz

Number of Radio Channels: 256

RF Output Power: 100 Milliwatts

Frequency Stability: 2.5PPM from -30C to +70C. (Synthesized with TCXO reference osc.)

Type of Emission: Frequency Hopped Spread Spectrum

Power Supply: 9.6 volt power tool battery. (Makita)

3. Technical Description

3.1 General

The AP-1648 is a frequency hopped spread spectrum transmitter designed to be compatible with U.S. (FCC Part 15.247) and Canadian (RSS-210) regulations for license free use in the 902-928 MHz band. The major elements include a frequency agile, narrow band transmitter and frequency hopping software for sequence generation and acquisition/tracking. The AP-1648 transmitter sends packets of telemetry and control data to compatible receivers (OMNEX REX-900). One data packet is sent on each frequency in the hop sequence. A data packet contains a transmit start flag, a transmit address, 11 bytes of user data and a CRC -16 error detection check sum. A data packet is formed (in a 68HC11E9 microprocessor), then digitally filtered (in a PIC processor), before FM modulation onto the transmit VCO. The transmitter generates a Reed-Solomon pseudo random frequency hop sequence of length 64 based on a pre-programmed seed. The full 902 to 928MHz band is utilized in equally spaced 30KHz channels. The hop dwell time is 20 milliseconds for a total sequence repetition time of 1.26 seconds.

The transmitter system includes a AP-1648 RF transmitter module and a 1221 interface module enclosed in an ABS enclosure. The enclosure may contain control switches and/or potentiometers (dials or joysticks) as required for a particular application. The following diagram depicts the transmitter system in block diagram form.

3.2 System Block Diagram

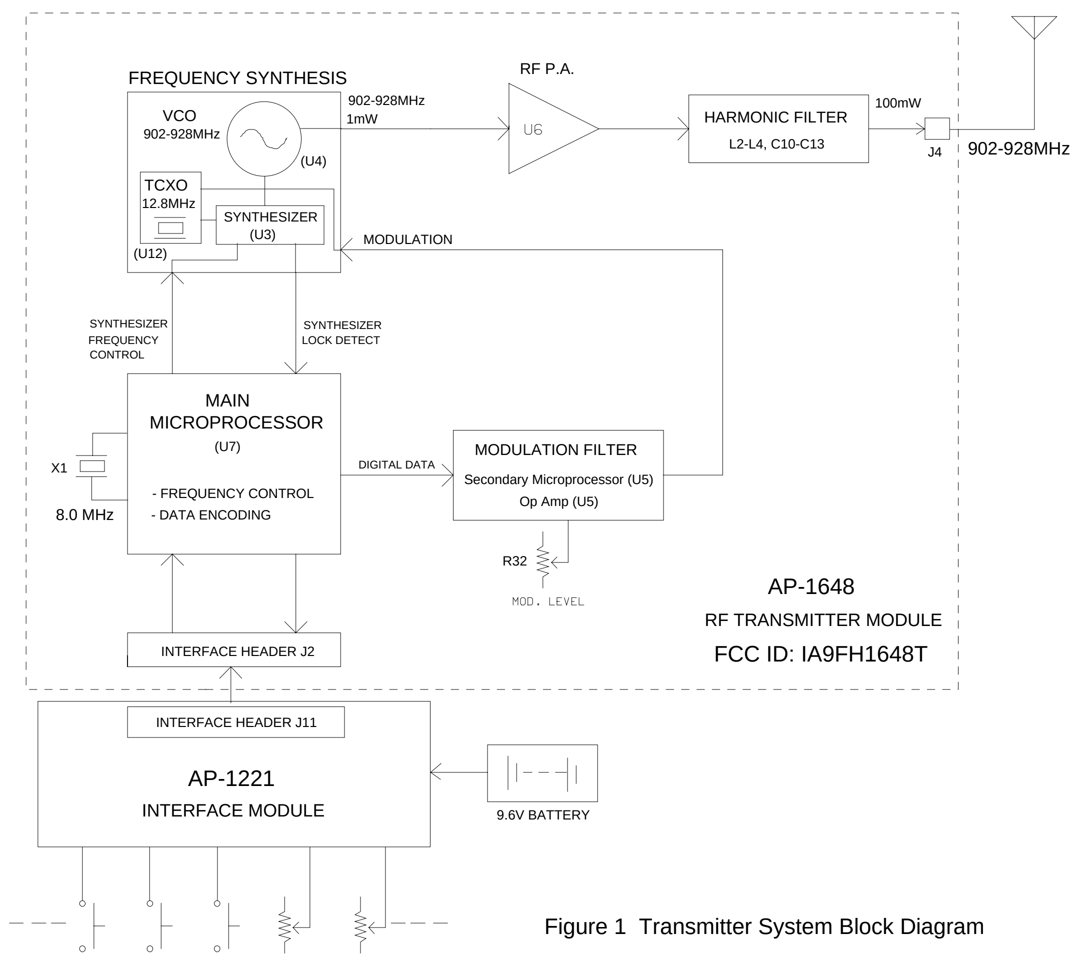


Figure 1 Transmitter System Block Diagram

3.3 Power Supply

See schematic diagram DSCH-1648-01 sheets 2 & 3.

The transmitter is powered by standard 9.6 volt power tool battery (Makita). Power enters at J1 on the 1221 interface module and is applied, through the header connector (J2), to the 1648 transmitter module. DC power is applied to switching regulator, U8 on the 1648 module, through Q3 and Q4. The 3.3VDC regulated output of the switching regulator supplies all circuits except the VCO. The VCO circuitry is supplied by a separate 3.3 volt linear regulator (U1).

3.4 Microprocessor

See schematic diagram DSCH-1648-01 sheet 3.

A Motorola 68HC11E9 microprocessor (U7) is employed to handle loading the synthesizer counter, packet formatting and interface functions. Crystal X1 provides an 8.00MHz clock while voltage comparator U11 holds the microprocessor in reset if the supply voltage is not within acceptable limits. A "lock" detect signal, supplied by the synthesizer, is also monitored by U7 which will shut down the transmitter in the event of a synthesizer malfunction.

Connector J2 is used to attach an interface module which allows the microprocessor to be interfaced to external switches or potentiometers as required in the control of industrial machinery. All connector pins are bypassed with capacitors (C60-C83) to reduce noise, EMI etc.

3.5 VCO/Frequency Synthesizer

See schematic diagram DSCH-1648-01 sheet 2.

The frequency synthesizer is the heart of the transmitter hardware. The RF oscillator is provided by a Maxim 2620 VCO IC, (U4). The resonant tank circuit is comprised of L8, C27,C18 and Varactor diode D1. D1 provides the necessary frequency pulling capability. U4 contains separate output buffers for the RF and synthesizer drive. The frequency synthesizer is a Philips SA7025 (U3), which is programmed by the microprocessor with the frequency hopping sequence. The synthesizer loop filter consists of R23-R25 and C37-C39. A 12.8MHz TCXO (U12) provides a stable reference oscillator.

3.6 Modulator

See schematic diagram DSCH-1648-01 sheet 2.

The transmitter employs a filtered FSK modulation scheme. Data from the main microprocessor is converted to a digitally encoded analog signal by a second microprocessor (U5) and a resistor combiner consisting of R28, R30, R35, R38, R40. Op amp. U5 shares the 8.00MHz clock used by the main processor. U6 filters the data further before it is injected into the synthesizer loop. FM modulation is achieved by applying the output of U6 to a voltage controlled tuning pin on the reference oscillator (U12).

3.7 R.F. Amplifier / Harmonic Filter

See schematic diagram DSCH-1648-01 sheet 2.

All R.F. amplifier circuitry is contained in a single Maxim 2439 IC (U2). This component is designed to be used as a linear amplifier in this frequency band and is biased to produce 100 milliwatts into a 50 ohm load. The amplifier output is followed by a low pass harmonic filter consisting of C10-C13 and L2-L4.

3.8 Emission Types

The transmitter contains the following "fixed" frequency sources:

X1 - Main Microprocessor Clock **-** 8.00MHz crystal controlled.
U12 - 12.8MHz TCXO synthesizer reference oscillator.

The transmitter contains the following "variable" frequency source:

VCO - 902-928 MHz frequency synthesizer **-** Locked to the 12.8MHz TCXO.

3.9 Antenna

The antenna consists of a short length of RG174 coaxial cable with a 1/4 wave section stripped free of the outer shield braid. The antenna is contained inside the transmitter housing and is not user accessible.

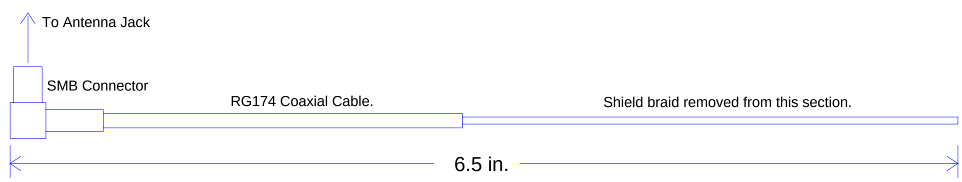
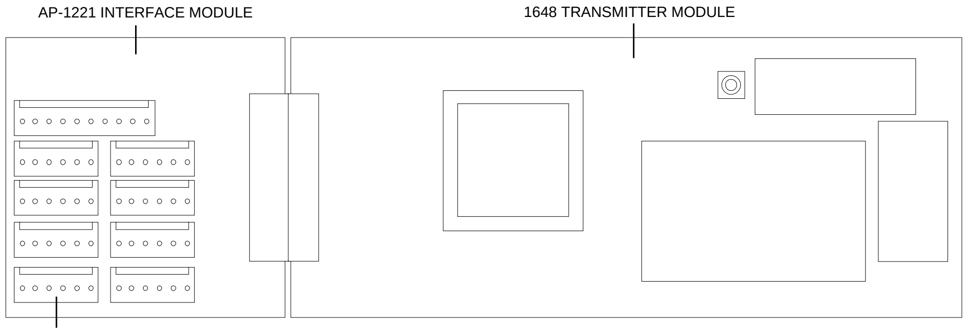


FIGURE 3 ANTENNA

4. AP-1221 Interface Module

(Refer to Fig. 1 block diagram and schematic diagram DSCH-1221-02)

The AP-1648 transmitter board does not function alone. It must be connected to an interface module that supplies power and also provides for the connection of control switches, potentiometers, etc. The interface module is a standard OMNEX product that is compatible with a number of existing transmitter boards. It allows transmitter assemblies to be completed, and stocked, less only the transmitter module. A transmitter module, suited to the particular control requirement, is installed just prior to shipment. The interface and transmitter modules are connected, via header plugs, as shown below:



Battery voltage is applied to J1, from which it is connected (via J2) to a power switch on the operator control panel. Voltage from the switch is then passed, through interface header J11, to the AP-1648 transmitter board. Switches that control on-off functions are connected to J4 inputs D1-D8. Joysticks or potentiometers to control analog functions are connected to headers J5-J10. Switch and analog control inputs are multiplexed U1 and U2 and processed by the main microprocessor (U7) on the AP-1648 board.

5. Sread Spectrum Operation

The frequency synthesized transmitter becomes a spread spectrum device via the software included in the unit. This section describes how the available frequency spectrum has been channelized, how data is transmitted on each channel, and how the hopping sequences are generated.

5.1 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 by the spread spectrum transmitter 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

5.2 Per Hop Activities

The transmitter operates on a different frequency every 20 ms. A full hop cycle takes 1.26 sec. The transmitter ON time is approximately 19 ms per frequency, and the remaining time is used to switch frequency and to key the transmit power amplifier on and off.

A data packet is constructed by a number of ASCII bytes assembled by the 68HX11E9 processor as follows:

FLAG (1 BYTE)	16 BIT ADDRESS (SW1 & 2)	11 USER DATA BYTES (MAX)	2 BYTE CRC-16 CHECK SUM

The data waveform is then encoded in the PIC processor to band limit the modulation. Four output bits from the PIC are used to form a simple D/A converter. Data is sent at a rate of 9600 bits per second.

6. Alignment Procedure: Model AP-1526 Transmitter

Equipment Required:

- Communications Service Monitor
- RF Watt meter (capable of accurate measurements below 100 milliwatts)
- Variable DC Power Supply
- Digital Voltmeter
- AP-1221-02 Test Fixture.

Procedure:

1. Install a 68HC11 microprocessor programmed with AFRM-1236-06 Iss. 3 software.

2. Connect the AP-1221 test fixture. Jumper pins 2 & 3 of CN1on the 1648 board. Set for single frequency operation on 914.4 MHz by setting the DIP switches on the test fixture as follows:

	SW1	SW2	SW3	SW4
902.2 MHz	Off	On	Off	Off
914.4 MHz	Off	Off	Off	Off
927.7 MHz	Off	Off	On	Off

3. Connect the watt meter to the antenna connector J1.

4. Set the DC power supply to 10VDC, and connect it to J1 on the interface module. Observe the polarity indicated on the connector! The watt meter should now indicate the output power (80-100 mW).

5. Set the communications monitor to receive on 914.4000MHz. Adjust the deviation control potentiometer (labeled MOD) counter-clockwise until no FM deviation is indicated.

6. Adjust the VCO reference oscillator (accessed through a hole on the synthesizer shield) until the frequency error is 0 (+/- 500Hz), as indicated on the communications monitor.

8. Adjust the deviation control potentiometer (labeled MOD) until the FM modulation is +/- 7KHz, as indicated on the communications monitor, then re-adjust the VCO reference oscillator, if required, for 0 frequency error. (There is some interaction between the MOD and VCO adjustments).

9. Check operation on 902.2 and 927.7 MHz by setting the dip switches as shown in the chart in step 2. The FM deviation should be 7KHz, +/- 500Hz. The frequency error should be +/- 500 Hz.

10. Adjust the DC power supply for exactly 9.60 volts. Next, using the digital voltmeter, adjust the battery warning potentiometer (labeled BAT) until the voltage measured at the test pad (beside the potentiometer) is exactly 3.2 volts.

11. Reduce the supply voltage to 9.4 volts. The led on the test fixture should now flash.

This completes the alignment procedure.

7. FCC, ISC Identification and Serial Number Labels

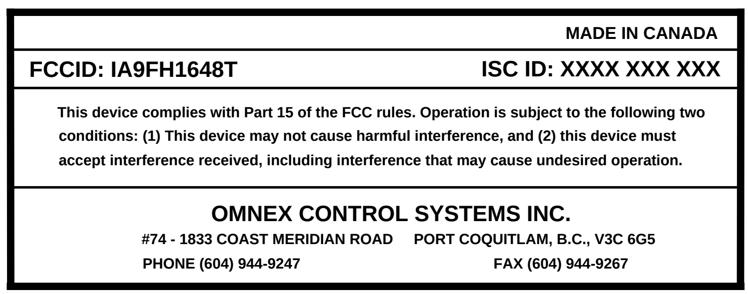
7.1 FCC and ISC Identifiation

A single label will be used for both FCC and ISC (Industry Canada) identification numbers. The label is shown below in actual size.

Material: Polycarbonate

Adhesive: SCOTCH - 3M 486MP High Performance Adhesive.

Color: The actual label will be white lettering on a black background. The diagram below shows the label in "negative" form.



SHOWN ACTUAL SIZE

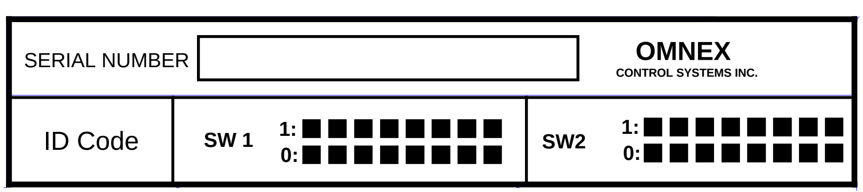
7.2 Serial Number Label:

Material: Polycarbonate

Adhesive: SCOTCH - 3M 486MP High Performance Adhesive.

Color: The actual label will be white lettering on a black background. The diagram below shows the label in "negative" form.

The Serial Number "window" is a clear, see through, panel. The serial number is applied to the back, adhesive side, of the label before it is applied to the product. The number cannot be altered without destroying the label.



SHOWN ACTUAL SIZE

7.3 FCC and ISC Identification Label Placement

Both identification and serial number labels are placed on the bottom of the transmitter enclosure as indicated in the picture below: