TAG-IT UHF READER (RI-RU1-001A-00)
FUNCTIONAL DESCRIPTION

Purpose:

This device is intended for applications in the areas of identification, verification, and inventory control. The system consists of two main parts, a reader and ID tags. The reader is operated by the user to interrogate the tags, which are attached to objects in the field. Tags are small in size and have read/write capability.

Theory of Operation:

The ID tags derive their power from the RF energy of the reader signal, and are not internally powered.

Signaling from reader to tag is accomplished by momentarily switching off the RF transmitter in a predetermined pattern. Signaling from tag to reader is accomplished though antenna backscatter. The tag momentarily shorts its antenna terminals together, which causes the transmitted power that was being absorbed into the tag to reflect back off its antenna. This reflected signal sensed by the receiver.

Transmitter:

The transmitter produces a phase locked CW signal, which is modulated by momentarily switching off the output power. In the transmitter, the phase locked loop output is amplified and then modulated by an RF switch, which is also controlled by the microprocessor. It then passes through the final amplifier, low pass filter, SP9T switch, and ultimately is transmitted from the antenna.

Receiver:

The received signal from the antenna comes through the SP9T switch, through a circulator, to a power divider. The two signals from the power divider are quadrature down converted (to base band) using an LO derived from the transmitter. The two baseband signals are amplified and filtered, the absolute values are taken, and the two resultant signals are summed. This composite baseband signal goes to a comparator circuit, which provides an input signal to the microprocessor.

Antenna:

Tag-it UHF Reader (RI-RU1-001A-00) can use up to 9 transmit/receive antennas.

Power:

Antenna port power is less than 28.5 dBm. With an antenna gain of 7.5 dBi, the effective radiated output power is rated at less than 36 dBm (4 Watts).

Modulated Signal Bandwidth:

The 20 dB bandwidth of the modulated signal power is less than 500 KHz.

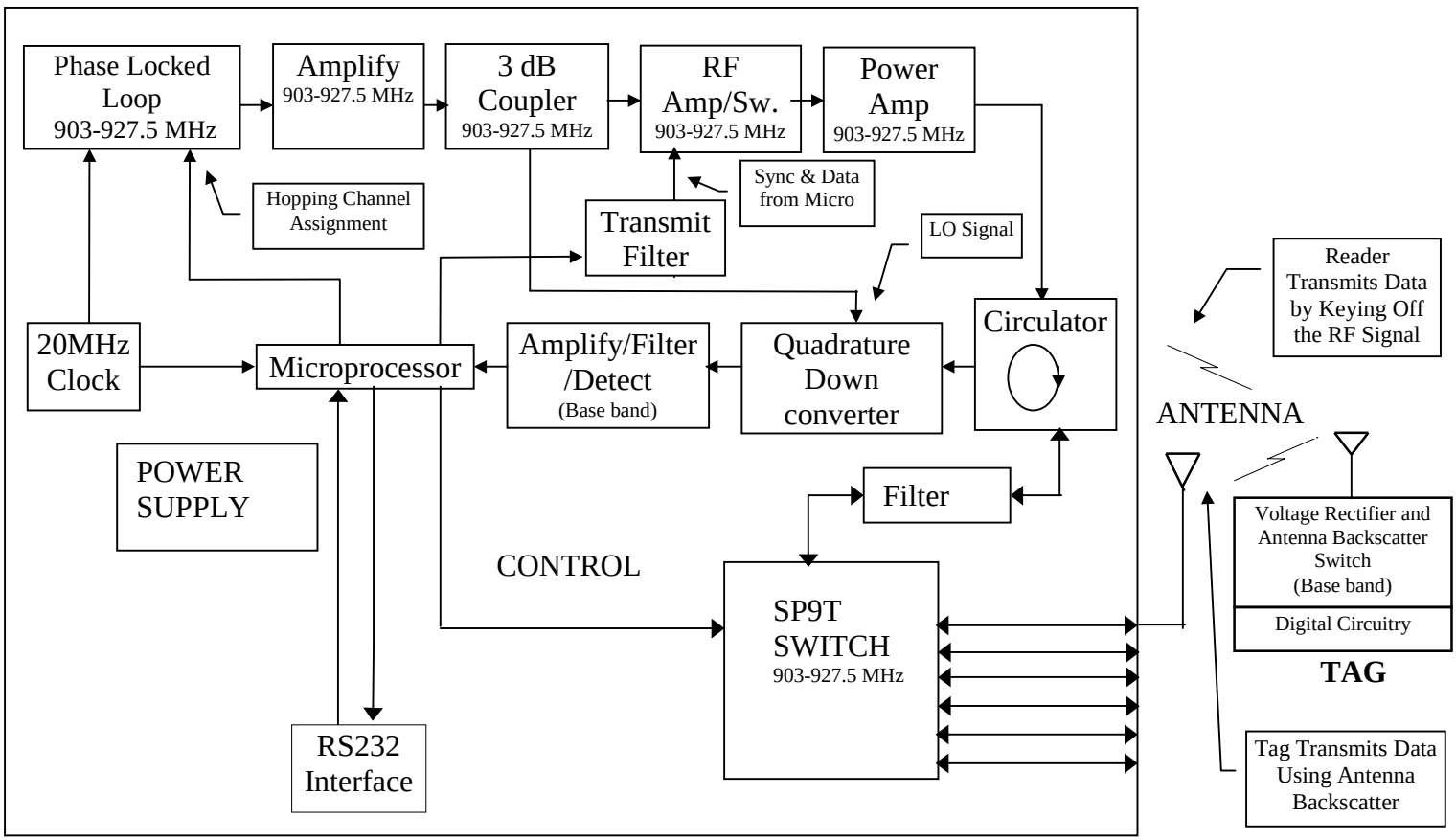
Frequency Hopping Configuration:

There are 50 hopping channels with center frequencies located at 0.5 MHz intervals starting at 903 MHz and continuing to 927.5 MHz. The hopping dwell time is 300msec. The frequencies - numbered 1 through 50 - are chosen pseudorandomly. The frequency number is modulo 50 of the contents of a 7-bit maximum length feedback shift register.

Equal use of all channels §15.247 (a)(1):

The linear feedback shift register (counter) operates continuously as soon as power is switched on. However, power is not applied to the final amplifier (to begin transmitting) until a command is received by the scanner from the operator via the host computer. The starting frequency (time) at which the transmit command occurs will generally be uniformly distributed across the 50 channels. The shift register (counter) continues to operate which should guarantee a uniform distribution of restart frequencies.

Tag-it UHF Reader (RI-RU1-001A-00) Functional Block Diagram



TAG-IT UHF READER (RI-RU1-001A-00) FREQUENCY HOPPING AND MODULATION

The Tag-it UHF Reader (RI-RU1-001A-00) uses frequency hopping as a method of meeting the FCC requirement for spread spectrum operation. The frequency hopping is completely independent of the modulation used to communicate with the RF ID labels. Both functions are described below.

Frequency Hopping

The RF frequency is generated using a phase locked loop (PLL) and a voltage controlled oscillator (VCO). At power up the microprocessor begins sending the PLL integrated circuit (National Semiconductor's LMX2325TM) the serial information to the set frequency. The PLL uses a 20 MHz crystal oscillator as a reference frequency. The PLL generates a voltage for the voltage-controlled oscillator (VCO). The VCO generates the RF signal, which is then fed back to the PLL. The PLL divides this signal down, and compares it to the 20 MHz reference. In the closed control loop, the PLL's output voltage is adjusted to precisely maintain the set frequency.

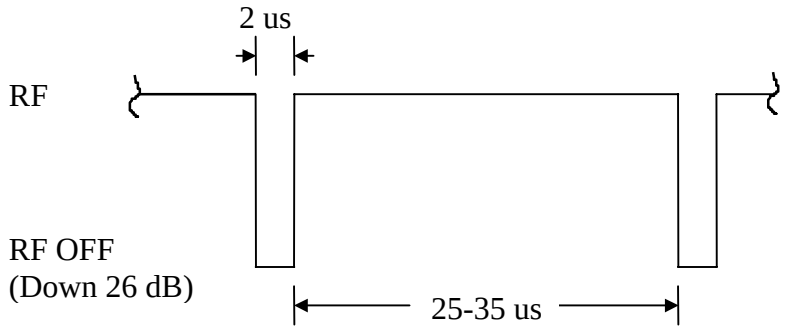
The frequency hopping timing is maintained by the microprocessor in the Tag-it UHF Reader (RI-RU1-001A-00). When it is time to hop, the microprocessor sends serial data to the PLL to change the frequency. There are 50 hopping channels with center frequencies located at 0.5 MHz intervals starting at 903 MHz and continuing to 927.5 MHz. The hopping dwell time is 300msec. The frequencies - numbered 1 through 50 - are chosen pseudorandomly. The frequency number is modulo 50 of the contents of a 7-bit maximum length feedback shift register. The linear feedback shift register (counter) operates continuously as soon as power is switched on. However, power is not applied to the final amplifier (to begin transmitting) until a command is received by the scanner from the operator via the host computer. The time at which the transmit command occurs will generally be uniformly distributed across the 50 channels. The shift register (counter) continues to operate which should guarantee a uniform distribution of restart frequencies.

Modulation

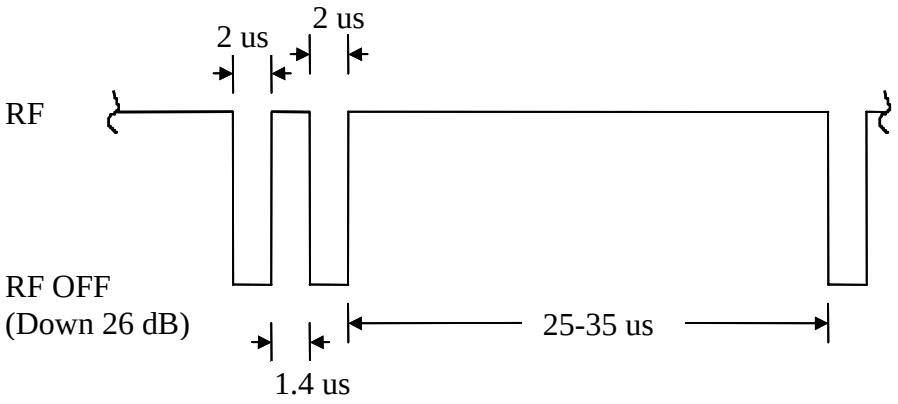
The RI-RU1-001A-00 Transceiver uses an RF on/off modulation scheme. The RF signal powers the ID tag in the field, and then communicates with the tag by briefly turning off the RF power at the proper time. The waveform timing and duty cycle depend on the transmitted symbol. There are 3 transmitter waveforms. The transceiver is either sending just a clock, sending a logic "0", or sending a logic "1". Figure 1 shows the timing for each of these waveforms. The range of time for the next frame of data or clock varies as a function of the interrupt latency of the microprocessor. The modulation either has the RF at full strength in the "on" state, or attenuated by at least 20 dB in the "off" state. Any time the scanner is normally operating, the RF signal is continuously being modulated. The commands being sent and the frequency of these commands is user dependant. The system is operating unmodulated only when the transceiver is instructed to operate as such, via operator command. Even when not modulated, the scanner is still frequency hopping at 300 ms intervals. The sequence of clock, logic "0" and logic "1" information being transmitted is completely dependent on the commands issued by the processor, and by the tag responses.

The modulation of the signal is controlled with a digital pulse sequence from the FPGA. This signal is RC filtered to limit the transmission bandwidth, and then is sent to the analog gain control of an RF amplifier. The RF amplifier attenuates the RF signal by a minimum of 20 dB when in the "off" state.

CLOCK ONLY



LOGIC "0" TRANSMITTED



LOGIC "1" TRANSMITTED

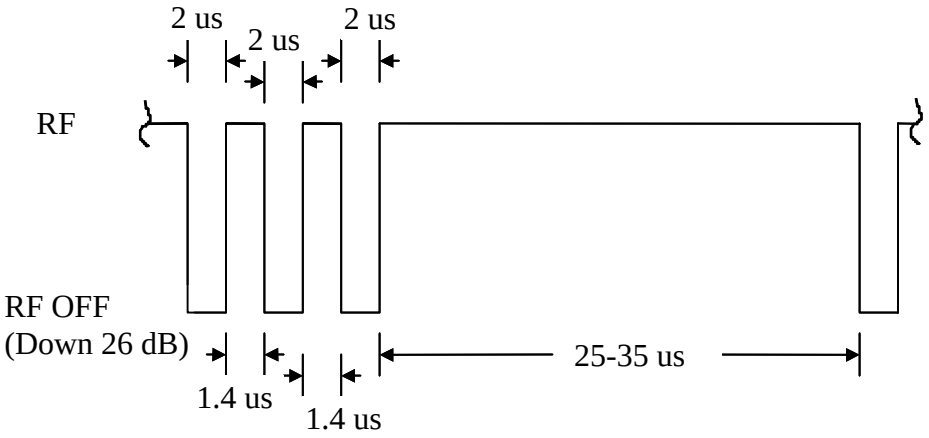


Figure 1. Modulation Modes of the **RI-RU1-001A-00** Transceiver

Texas Instruments

Tag-it UHF Reader

Table 1 of CFR 1.1310 states the MPE for Uncontrolled Exposure is f/1500 mW/cm^2 in the 300-1500 MHz range.

MPE=	f/1500	mW/cm^2	where f=902 MHz minimum
	=902/1500	mW/cm^2	
	=0.601	mW/cm^2	
	=6.01	W/m^2	

In order to calculate the range at which the power density (Pd) is 0.601 mW/cm^2, the following equation is used.

Pd= (Pt*Gt)/(4*PI*R^2) where: Pt= transmitted power= 0.708 Watt
Gt= gain of transmitting antenna= 5.62
PI= 3.14
R= Distance from antenna

Solving for R yields:

R=	[(Pt*Gt)/(4*PI*Pd)]^0.5	
	=[(.708*5.62)/(4*3.14*6.01)]^0.5	
	=[(3.98)/(75.49)]^0.5	
	=[0.05273]^0.5	
	=0.230	meters
	=9.041	inches

In conclusion, the range at which the power density of the Tag-it UHF Reader (RI-RU1-001A-00) is 0.6 mW is 9.04 inches (23 cm). This information will be placed in the RI-RU1-001A-00 operation manual.