



Remtron Technical Note

THEORY OF OPERATION

The Remtron *Command Pro*® equipment operates in the range from 902 to 928 Megahertz (MHz). A wavelength at our frequency is 12.9 inches. The 400 MHz band used by most other manufacturers has a wavelength of 29 inches. Like light, 900 MHz radio signals will pass through glass and plastics, and will reflect off of walls, buildings, and metal structures. Unlike light, 900 MHz radio signals will penetrate all plastics, including those that you cannot see through, thin-gauge steel, dry wood, dry concrete, plasterboard, fog, and rain. Trees, earth, water, people, aluminum, copper, and some window tints will not pass our signals.

Antennas convert radio signals into radio waves and convert radio waves back into radio signals. They can send and receive in all directions or in a single direction, depending on their design. An omnidirectional antenna is like a light bulb, and a directional antenna is like a flashlight. Metal objects reflect radio waves, just as a mirror next to a light bulb will reflect light. Metal objects near an antenna alter the intended pattern of an antenna by either shading or reflecting signals.

Our standard antennas “see” equally well in all directions. We have other antennas that will “see” further in one direction for special applications. Our transmitters and receivers are designed to have more than a 2.5-mile operating range in “free space” (an unobstructed view). Our systems are range-tested to 600 feet, and we guarantee 300-foot performance. The extra signal strength provides a large margin, which allows for reliable operation in the presence of objects that can reflect or absorb radio signals.

The 902 to 928 MHz spectrum accommodates many license-free users and is set aside by the FCC as an ISM Band (Industrial, Scientific, and Medical). We have the ability to change frequencies in this band and have 85 different channels that we can assign to our transmitter and receiver. The actual frequency is coded into the receiver and transmitter at the factory but may be changed to one of the other 84 channels in the field. Other devices in this band include wireless phones, computer data links, and inventory equipment. As a condition of using this band, we must accept and handle interference from other users. The 900 MHz band has worked well for most users, and not being burdened with licensing regulations is always desirable. The FCC has allowed 50,000 microvolts per meter field strength on this band, which is 250 times higher than other unlicensed frequencies below this band. This allows our systems to operate very reliably in the presence of other signals.

We use Packet Mode Frequency Modulation to carry commands in a packet form from our transmitter to our receiver. To reduce battery drain, our transmitter transmits for a hundredth of a second, which is long enough to send one packet to our receiver at a repetition rate of 16 or 4 times a second. The rate varies: 16 times a second for three times when sending a command and four times a second when there is no change in commands and the transmitter is still on. Any time a lever or switch is activated, we send all control settings three times at the 16-per-second rate and then return to the slower rate of 4 times per second. Our receiver uses the slower rate for maintaining transmitter timing and provides for a maintained link where one is used. The only exception to this is the “ESTOP” switch, which transmits at 16 times per second as long as it is



depressed. In addition to lever and switch positions, each packet contains a unique address and CRC check sum (described in the next paragraph).

Safety and preventing loss of control are very important issues at Remtron. We use a unique identification code for each user. There are provisions in our system for 65,535 individual codes. Each transmission includes a CRC check sum, which is a polynomial created by factoring all of the previous bits transmitted. Once our receiver receives a valid start command from our transmitter, our receiver tracks the time of the transmitter and ignores all other transmissions that do not fall within the expected time frame of our transmitter. Maintained link systems must receive at least one valid transmission each second in order to allow the remote controlled equipment to function. Our receiver provides a loss-of-signal control output that safely shuts down the equipment if a loss of signal occurs. Our receiver will not allow restart of equipment under its control after a loss of signal until a valid system start command is received from our transmitter. This prevents an untended start-up from occurring if the transmitter returns within range of our receiver and is still operating. Our transmitters also check the position of all controls upon start-up. Our transmitter will not issue a start command if any of the controls are pressed at the time the start command is invoked. Exceptions for lights, horn, bell, or other user functions that do not place machinery in motion can be mapped into our control logic upon request.

The 900 MHz band has other users, but because we are only expecting a 300-foot range, we have experienced very little interference from other users. Spread-Spectrum and frequency-hopping devices are used in this band. They are allowed ten times the field strength that our transmitters are allowed. Spread spectrum transmitters are required to spread their power out over a large bandwidth (Spreading Code) and the maximum power they can radiate in our bandwidth is only a few percent of our allowed transmitter power. It would take several of these devices close to our receiving antenna to cause our equipment to go to the fail-safe mode. Frequency-hopping devices are required to use 50 or more channels, recognize other transmitters on frequency, and hop over them. A frequency-hopper may cause us to lose one command sequence from our transmitter, but because each command sequence is sent three times, our receiver will still receive each command sent. Radio waves diminish as the square of the distance, so a transmitter with ten times the power will be the same signal strength at 3.16 times the distance of our transmitter from our receiver. FM systems also have a capture effect, where the strongest signal will capture the receiver, which rejects the weaker signal. The operator is seldom more than 300 feet from the equipment he is operating. His transmitter is the strongest signal present unless other equipment on this band is allowed to operate within 1000 feet of the location of the receiver.

In summary, Remtron has developed a very robust proprietary digital communication protocol that will survive the harshest RF environment, including other signals present on the 900 MHz band.