302230
System Theory Of Operation & Block Diagram

By: Romer Johnson Date: 11-18-02

Purpose:

Using a unique Intra AP (Access point) routing scheme, Modular Mining is able to provide complete coverage of a mine site with an 802.11 wireless network. While the heavy equipment and AP's are custom designed based on proprietary hardware and software, several customers have also asked for a standard ruggedized Windows based PC in order run some of their own applications.

Description:

In order to provide a solution to the customers, a foreman's truck system has been designed using mostly off-the-shelf components. The ruggedized PC from TNAC contains a standard Cisco AIR LMC352 PCMCIA 802.11b wireless Card. Due to the significant losses of LMR-195 Cable, and the routing distances required in some pickups, a ½ Watt 2.4GHz RF bi-directional Amplifier was selected in order to counter these losses. This way, around ¼ Watt may be delivered to the 2.5dBi omni antenna. The Omni has been extended 5 feet above the roof of the automobile by using a fiberglass tube that has LMR-195 cable running down the center. This 5-foot extension is needed in a mine in order for the pickup to have LOS (Line-of-sight) RF coverage over the top of the high berms that line the haul roads. Mines are required to build high berms next to the haul roads in order to minimize the likelihood of a mine vehicle driving off the edge and falling into the pit. The extra gain from the RF amplifier is needed not only to counter the cabling losses inside the truck, but to provide the little extra range required to reach all of the scattered AP's located throughout the mine property. Without the Amp and with 26 Feet of LMR-195 cabling losses there would only be 15.2dBm at the antenna, which would only provide for roughly 1 mile of coverage (Versus 3-4 miles with the amp).

RF Operation Theory.

The RF Block Diagram (302230) attached, illustrates all of the expected power levels and losses in the system. The TX path originates with the Cisco PCMCIA card which measured at exactly 100mW (20dBm) using an Agilent E4416A power meter (matches the datasheet perfectly). Six feet of LMR-195 Cable yields 1.1dB of loss at 2.4GHz. Combined with a 10dB pad at the input of the RF Amplifier, results in an input power of 8.9dBm (7.8mW) to the amp. This input power level was determined via testing in the lab to be optimal. At 8.9dBm the output power level is only 0.8dB less than the ½ Watt maximum and the output compression level is less than 0.1dB. This means that there is almost no rise in the side-bands due to the RF amplifier and the output power from the amp is 26.2dBm (417mW). Unfortunately, 20 more feet of LMR-195 cable is typically needed to route to the roof and up the 5-foot extension tube to reach the antenna. This

results in an additional loss of 3.7dB, which means that at the antenna there is only 22.5dBm (178mW) of power remaining. If the amplifier enclosure is placed up high against the rear of the cab or just under the roof, the final cable run may be reduced to 10 feet. This would reduce cabling losses to 1.86dB resulting in 24.34dBm (272mW) at the antenna. Using the 2.5dBi omni antenna results in an estimated range of 3 miles (for 178mW) or 4 miles (for 272mW).

Power Protection.

The only other items in the 302230 enclosure are two power protection devices. The 20 Amp Automotive DC Filter and the 12V "ChargeGuard" help eliminate transient surges that could cause the ruggedized PC to reset. The ChargeGuard also incorporates over/under voltage protection and a power down timer. The power down timer is set to 15 minutes and will automatically power down the system after the vehicle has been turned off in order to prevent accidental discharging of the vehicles battery.

Tuning / Calibration

No tuning or calibration is required for this system. In fact, all of the Cisco radios that have been purchased for prototyping have been already calibrated to exactly 100mW. The RF amps are also within a very tight tolerance. The numbers discussed in the RF sections above should be accurate to within a dB for each installation.