Fermi National Accelerator Laboratory

TM-1644

An Inexpensive Tunnel Antenna System for Remote Control of Robots

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From time to time there is a need to get voice and/or video signals in and out of the accelerator tunnels. Typical voice propagation in the Main Ring tunnel is about 600 feet with five watt NBFM at 410MHz. Getting the signal in and out of the tunnels is much more difficult.

In the course of developement of a Remote Accelerator Television System (RATS), a lossy antenna was installed in the PBAR tunnel extending from AP10 to AP30 then going upstairs to racks in the AP30 service building.

The antenna was approximately 500 feet of common 300 ohm twinlead purchased at 6 cents per foot. The twinlead ran to the service building through one of the four inch access pipes. One inch square fiberglass supports slotted to take the flat twinlead were hot glued to the tunnel ceiling every two feet or so. The twin lead was in general not twisted. The antenna was supported 0.75 inches below the ceiling.

Two tests were conducted. First a toy RC car at AP10 was controled by an operator upstairs at AP30. We used 180 micro watts at 49 MHz. Second a CCD video camera at AP10 modulated a one watt carrier on 58 MHz. The transmitter antenna was ten feet of hook-up wire supported about eight inches above the floor. An acceptable TV signal was recieved upstairs at AP30. No attempt was made to match impedances.

Signal propagation was measured. An HP8590A spectrum analyzer was used at the AP30 service building. Meanwhile an HP8620 sweep generator was used as a transmitter at the foot of the stairs in the tunnel at AP10. The generator level was 0.0 dBm and coupled to the antenna with .5 to 6 turns of hookup wire.

Signal levels at 50 MHz were 45 dB down with most of the attenuation occuring over the path from the AP30 racks and through the tunnel access port. 10 dB was lost in coupling coax. Signal propagation continued to fall off to zero at 600 MHz. The range 600 to 1300 MHz demonstrated no propagation. See figure 1.

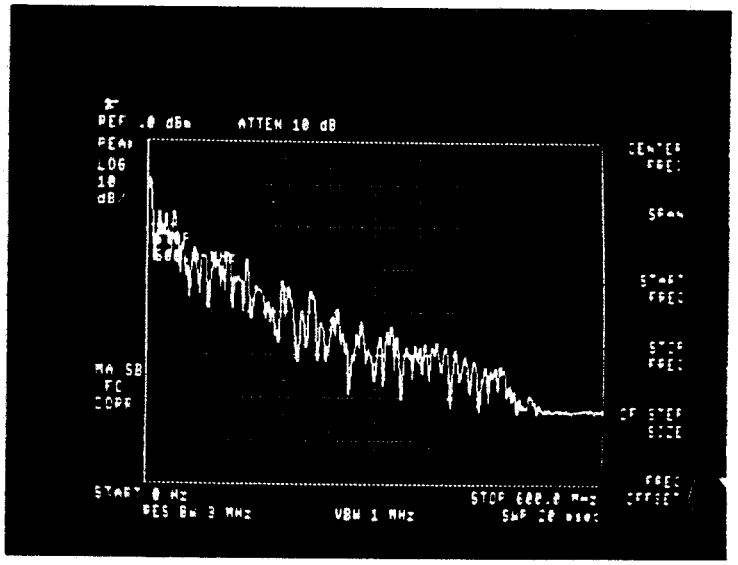
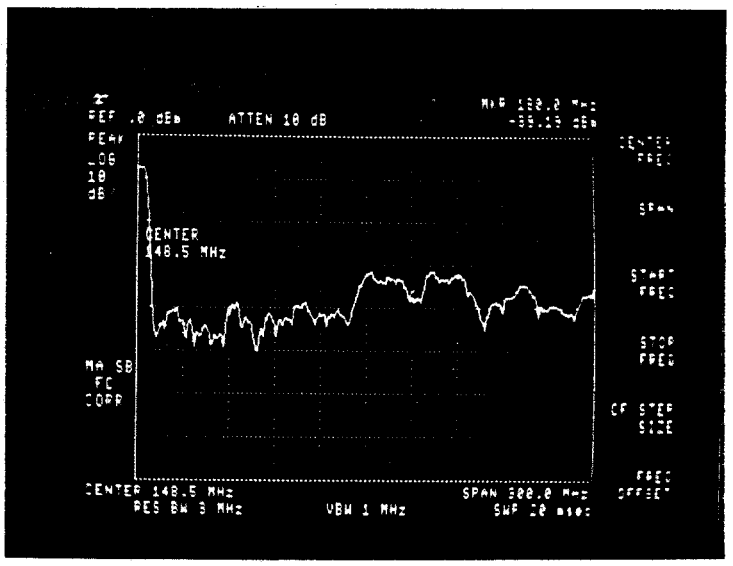
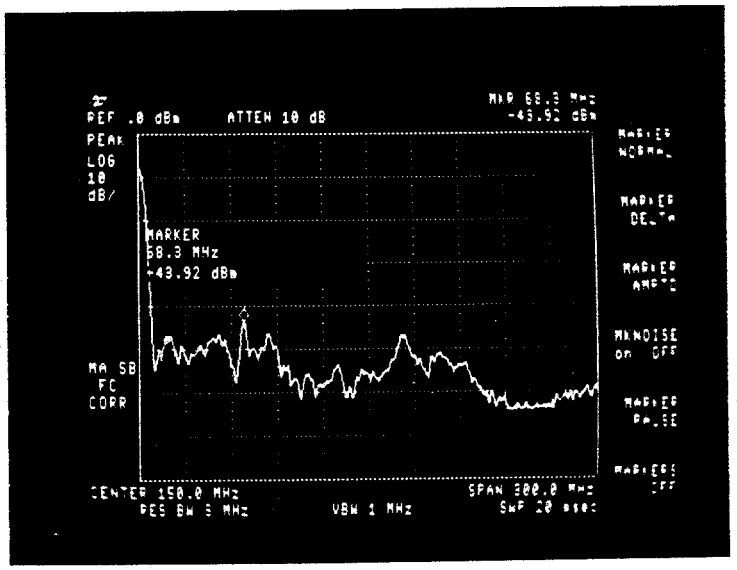


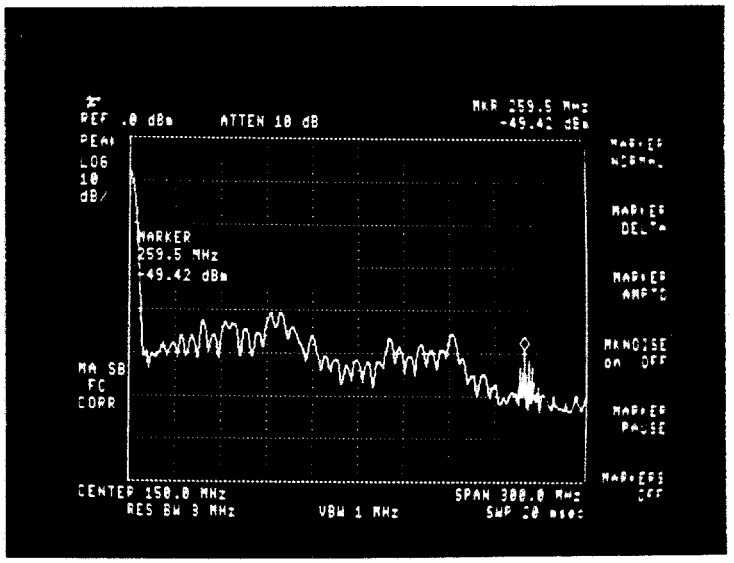
Figure 1



Response from 1 yard down the tunnel from the access port. 1 mw signal half turn coupling from RG-58 to twinlead.

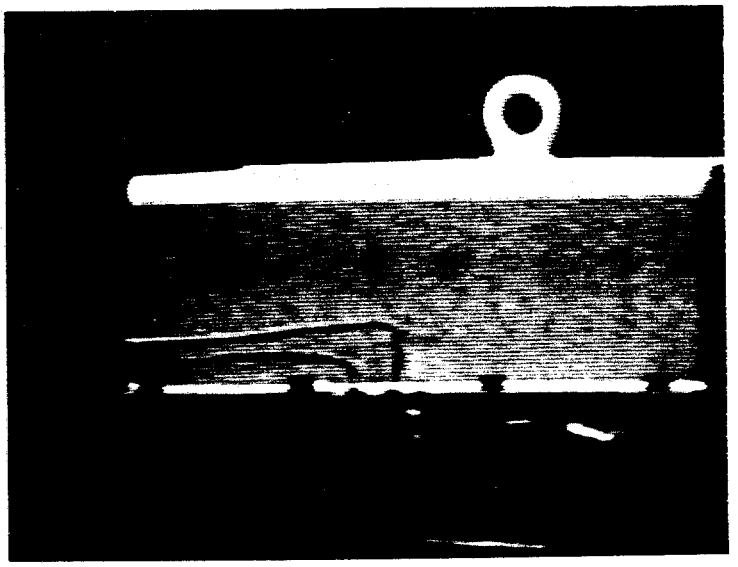


Response from AP20, 57 yards away.

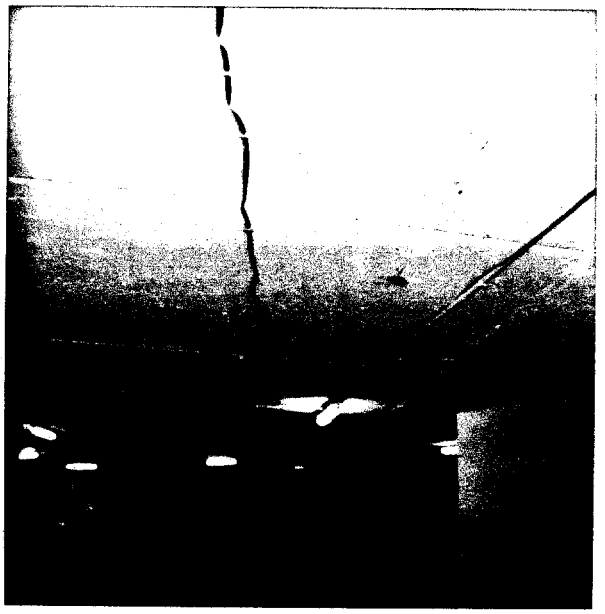


Response from AP10. 1 mw, 1/2 turn coupling to twinlead.

TV image of a Debuncher dipole at AP10 as seen upstairs at AP30.



The Antenna



Applications

It has been demonstrated that microwatt PWM signals can be used to control robots in RFI infested tunnels. It has also been shown that not much care need be taken to get pulsed data in and out of the tunnels. On the other hand, AM signals suffer from the noise. A medium scan television signal pulse modulating the carrier would probably work better. The usual AFSK could be recovered upstairs if need be. We did not have the opportunity to try it.

It appears that a 10 milliwatt PWM signal is easy to generate and is overkill for robot control. A two to ten watt AM signal seems best for getting the video out of the tunnel.

The same antenna has been demonstrated to work very well for two-way walkie-talkie work from upstairs to tunnel. We coordinated many of our tests on 410 MHz.

In noisey environments like E760, an inexpensive set of 49 MHz headsets and $10 worth of antenna could provide effective communications from counting room to tunnel. It would allow freedom of movement on both ends, cost less than $75, and install in one to two hours.

SSC vacuum leak detectors could use tunnel antennas to send their data long distances to a laptop PC serving as a data gatherer and chart recorder. Since they are stationary, they could be coupled tightly to the antenna normally used for an SSC tunnel inspection robot.