A Novel Base Station Antenna Monitoring System

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The bat. The only mammal capable of true flight. This furry and mouse li on echo location to navigate.

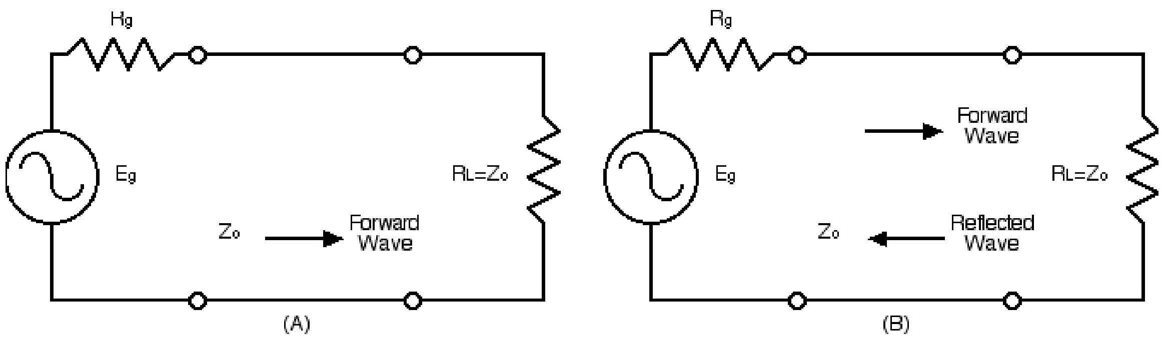
Until now, it has been difficult to monitor and measure performance of a base station's receive antenna because it requires disruption of service. A new method of monitoring a base station's receive antenna has been invented1. This approach provides uninterrupted service for systems operators and constant unattended monitoring of antennas.

Conventional Antenna Monitoring

For technical, environmental and economic reasons base stations are located in high and often remote places. Lately, there has been a trend to "lease back" antenna sites from providers who share costs by concentrating as many carriers on the same tower as possible to minimize antenna clutter and centralize maintenance. The classic method used for monitoring the quality of an antenna has been to measure the amount of power injected into an antenna and compare the amount of signal that is reflected back. This calculation is known as the Standing Wave Ratio (SWR). Without disrupting service, antenna monitoring has been limited to transmit antennas, where the signal is relatively high, and any reflected energy is still enough to measure as energy reflected. The magnitude of reflections are proportional to the quality of "impedance match" of the antenna, transmission line and source of RF power; a good indication of the system's efficiency or integrity. The greater the reflected energy, the greater the SWR mismatch or antenna damage2.

Base Station Application

The principal quantities to be measured on transmission lines or antenna are line current or voltage, and standing-wave ratio (SWR). Measurements of current or voltage are made for the purpose of determining the power input to the line. During operation of base station transmitters, high energy radiated on a single channel is fed to a transmit antenna, and if significant energy returns, the SWR may be defined as excessive. With the high power applied to a transmitter antenna, it is easy to detect (with a directive coupler and diode detector) mismatched loads. The rectified DC voltage will be proportional to the reflected signals. When using conventional detectors this level would be far too weak to detect without injecting high level, narrow bandwidth stimulus signals which could interfere with received signals.



At A the coaxial transmission line is terminated with resistance equal to its Zo. All power is absorbed in the load. At B, coaxial line is shown terminated in an impedance consisting of a resistance and a capacitive reactance. this is a mismatched line, and a reflected wave will be returned back down the line toward the generator. The reflected wave reacts with the forward wave on the line. the amount of reflection depends on the difference between the load impedance and the characteristic impedence of the transmission line.

FIGURE 2

Circuit description of the BAT™ receive antenna SWR monitor

The Base station Antenna Tester (**BAT™**)3 automatically monitors ***receive antennas*** for proper operation. The system uses principles embodied in direct sequence Wideband-CDMA, and integrates this signal over long intervals (called time spreading). The instrument uses a very low-power PN (pseudo-random) transmitter (source), a dual correlation PN receiver (detector) and a two-port directional coupler connected in series with the transmission line of the receive antenna. Each directional coupler provides at least -30 dB directivity to prevent the PN energy transmitted from entering directly into the reverse coupler, masking the reflected PN signal.

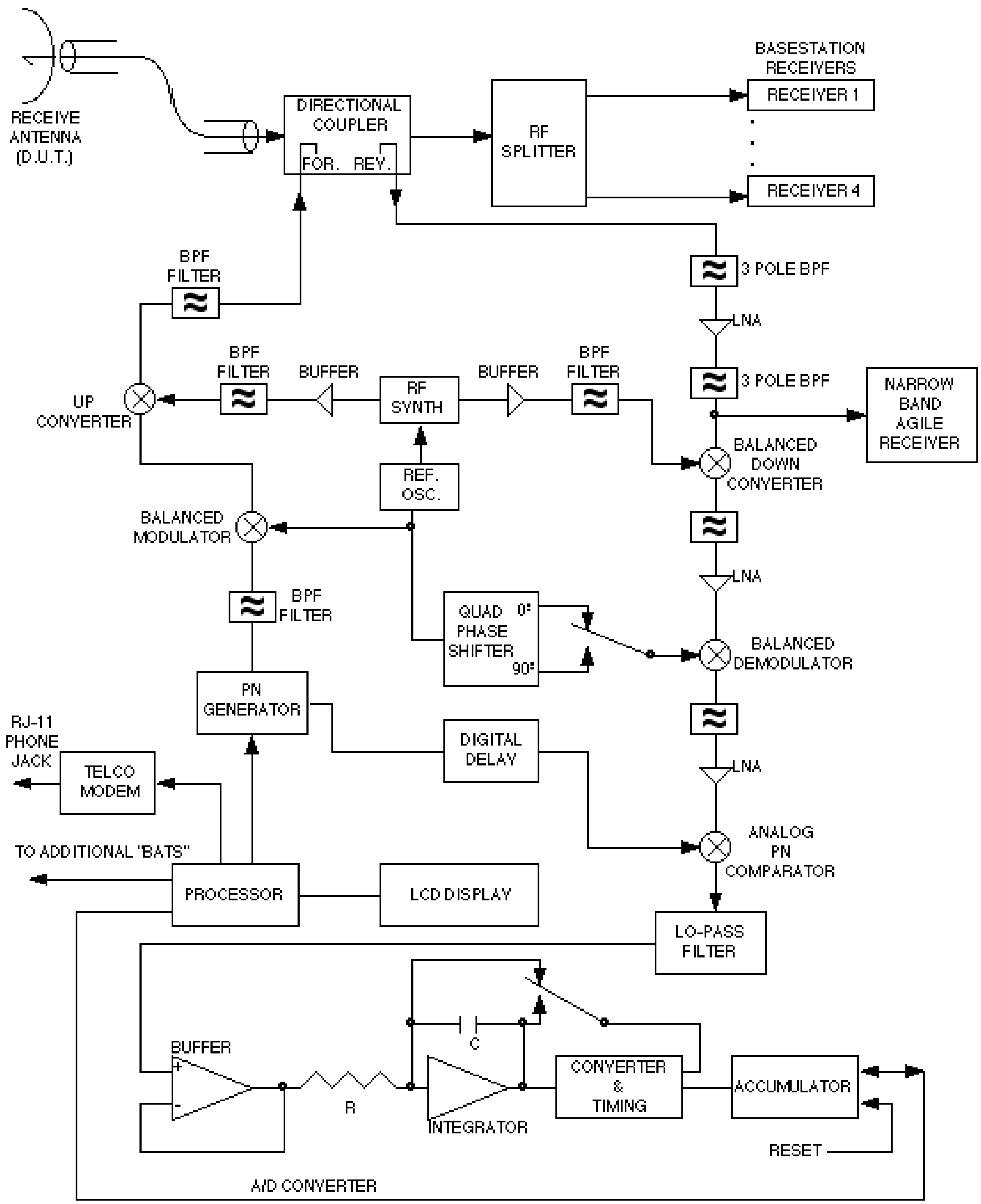


FIGURE 2
SIMPLIFIED DIAGRAM OF THE BAT™ AUTOMATIC ANTENNA MONITORING SYSTEM

On the transmit side of the system, a reference oscillator is modulated (encoded) with a high data rate, long Pseudo Random (PN) sequence (much like noise) which spreads out the signal's bandwidth (and energy level) to cover several megahertz. This wide-band modulated RF is then filtered, up-converted through the forward port of the directional coupler and applied to the base station's antenna to be monitored. The energy presented to the receive antenna is at least -60 dB below the strongest expected receive signal, and hence presents no significant interference to the weak mobile narrow-band traffic signals. In the simplest form, the CDMA modulation may be BPSK; simply a series of "ones" and "zeros". The phase of the modulated waveform is shifted by 180° for a "1" or 0° for a "0". The block diagram shows a QPSK modulation technique being used for the antenna monitor system.

On the receive side of the system, reflected energy from the receive antenna (including noise and other RF signals) is received through the reverse port of the directional coupler, filtered, down-converted and fed to a 2-step (analog and digital) correlation system. First, the output of the down-convertor feeds an analog PN correlator which attempts to match (bit by bit) the sense of the energy reflected with the original PN code transmitted. During this process, the correlator behaves like a matched filter, eliminating noise and unwanted signals; leaving only the reflected stimulus signal. Then, over several seconds the circuit measures the magnitude of this integrated (PN) voltage to determine if it exceeds a predetermined threshold, such as a high VSWR. Most amazingly, the PN receiver has a processing gain greater than +80 dB, allowing it to detect very weak signals in the presence of much stronger traffic and noise signals; well below the noise floor!

Referring again to Figure 2, compensation (clock timing) for the round-trip delay through the coaxial transmission line is provided to the receive correlator. The PN code is digitally delayed approximately 2 nanoseconds for each foot the antenna is located away from the antenna tester. The output of the analog PN comparator produces a voltage which is fed to a low pass filter for integration. This voltage is buffered and then fed to a A/D convertor which accurately translates the magnitude of the correlated waveform to a binary number for storage in the digital (memory) accumulator. This eliminates the nasty "droop problem" often associated with integrate and dump circuits allowing for relatively long integration periods, and thus very high processing gains.

<u>BAT™ Technical and Operational Advantages</u>

This low energy injection technique coupled with very high processing gain using analog and digital correlation of the reflected energy allows monitoring from antenna systems without shutting off receive signals. The instrument operates in the presence of high (as high as -20 dB) interference levels; . The PN stimulus is only -80 dBm which permits the monitor to operate within recommended conducted spurious emissions for a base station. The antenna monitor operates continuously, providing quick response in the event of antenna or feed line damage. In the event that the VSWR exceeds a prescribed threshold, the monitoring system dials-out via a data modem to immediately report this anomaly. Each **BAT**™ can monitor 3 antennas and up to 16 **BATS**™ can be interconnected via a simple 4-wire telephone cable to its built-in network for measuring multi-sector antenna arrays while sharing a single telephone line for the modem. The BAT™ can be rack mounted and operating from 24 to 48 volts DC and includes a large LCD for real-time status monitoring of band, VSWR, emergency telephone numbers and data relating to antenna performance history.