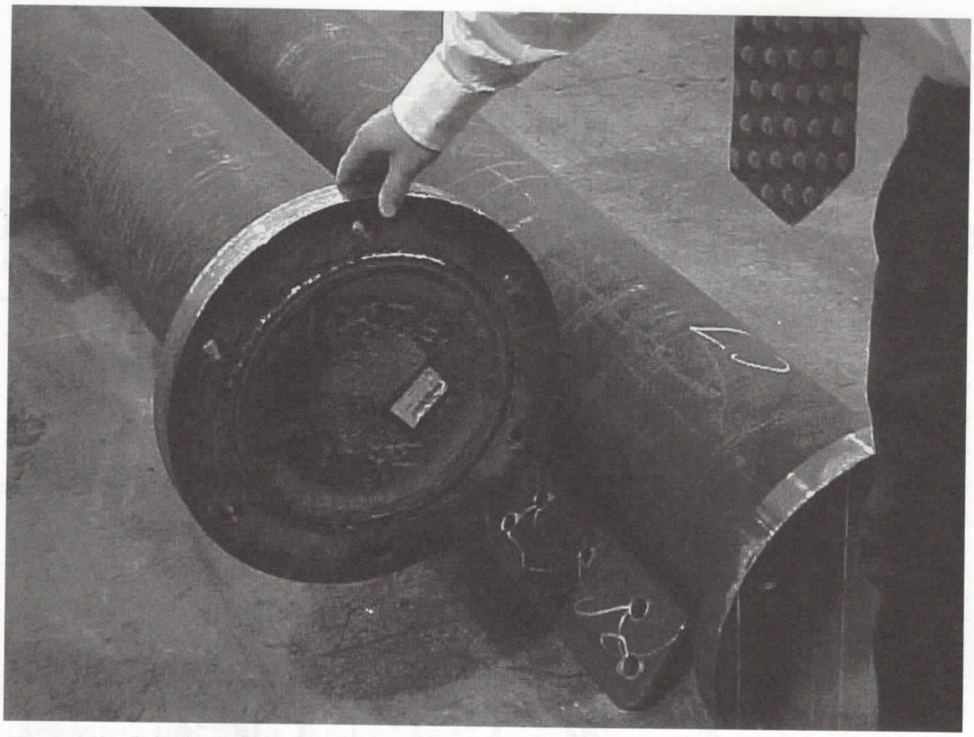

Figure 13.27 Solid leg for tower.

personal auto liability. Major causes of tower failures are weather and human error (such as replacement of tower members and top-mounted antennas).

13.4 DTV Reception

To many, DTV reception might be the Achilles heel of the whole DTV scheme. At least to begin with reception will be via antenna, either set-top or roof-top. Cable systems will initially not carry DTV signals. Much of what will make the DTV transmission scheme a viable replacement for NTSC is the processing that will take place in the receiver. Massive DSP activities surround channel equalization, and multipath elimination at the receiver end kills a lot of the demons in the transmit path.

Many facilities will need to conduct DTV reception testing. To understand the protocol and what a DTV reception test indicates, the methodology used by the Model Station Group is described here.

13.4.1 Test vehicles

The objective of a test vehicle is to detect and measure signals that range from over 100 dBμV/m down to what the FCC considers the edge of a UHF DTV

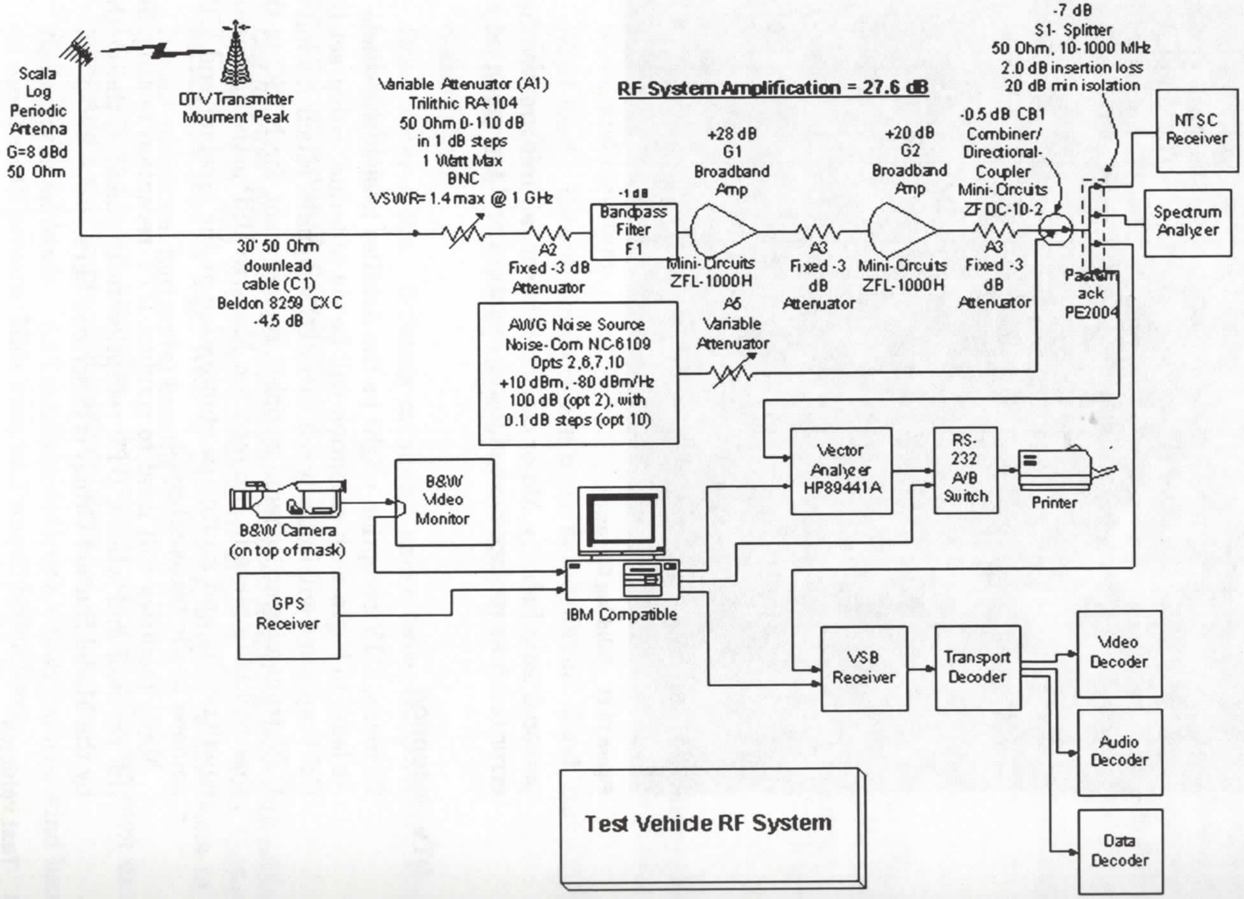

Figure 13.28 Test vehicle block diagram based on model station specifications.

service area (41 dBμV/m plus the FCC's dipole factor, which for channel 52 is around 43.5; Fig. 13.28). To be able to measure and recover signals at fringe locations, the test truck's design is based on parameters found there.

Therefore, the truck's receive signal path must be such that the signal fed to the VSB receiver must be at least 15 dB above the noise floor (value for the edge of error-free operation) at fringe locations. The amplification must be high enough to boost the received signal so that it is not only higher than the vector analyzer's noise floor (~−80 dBm/6 MHz), which is needed as part of the test, but enough that the signal into the VSB receiver is higher than the noise floor by at least 15 dBm. This must be the case even as the field strength of the signal falls to under 45 dBμV/m.

A noise floor increase by the system's amplification above −80 dBm is desired so that the HP vector analyzer can display the actual system noise floor, and not its own. This is critical if the received signal's S/N ratio is to be accurately measured. The noise floor in our vehicle turned out to be approximately −65 dB. This is also a needed control, so that we can judge receive system health as the test proceeds. The preamps must have a gain large enough to ensure that the receive test system's overall noise value is determined by the amps, and not any of the test equipment (Fig. 13.29).

The truck's rf system should be robust enough to handle large NTSC and DTV interfering signals and have a large dynamic range. To simplify testing of the entire coverage area, it is necessary to leave the rf system intact throughout the testing period. It is not desirable to have to switch out the preamps at strong signal level sights. This will cause calibrated gain changes and also affect the truck's noise floor. As a control, it is necessary to have a known measurable noise floor which is eternal to the VSB receiver on which to evaluate system performance. If the limiting noise floor is within the VSB receiver, which is determined internally by its tuner, there is no simple way to determine the noise floor other than to use a noise figure meter, which is not practical in the field.

A practical way to handle a large dynamic range of received signal strengths over the entire testing area is to use a manually set attenuator to prevent preamp overloading. The attenuator is adjusted so that the rf system output is at a predetermined level, such as −30 dBm, which is the value that was used for testing. The rf attenuator's value must be documented at every test site so that the site's field strength and site margin can be calculated.

To restate, the preamp's large gain ensures that the overall truck noise value is determined by the preamp, and not any downstream test equipment. The FCC's planing factor calls for a 10-dB noise value in the receiver. The truck's first preamp has almost the same noise value, so that the collected data closely correlate.

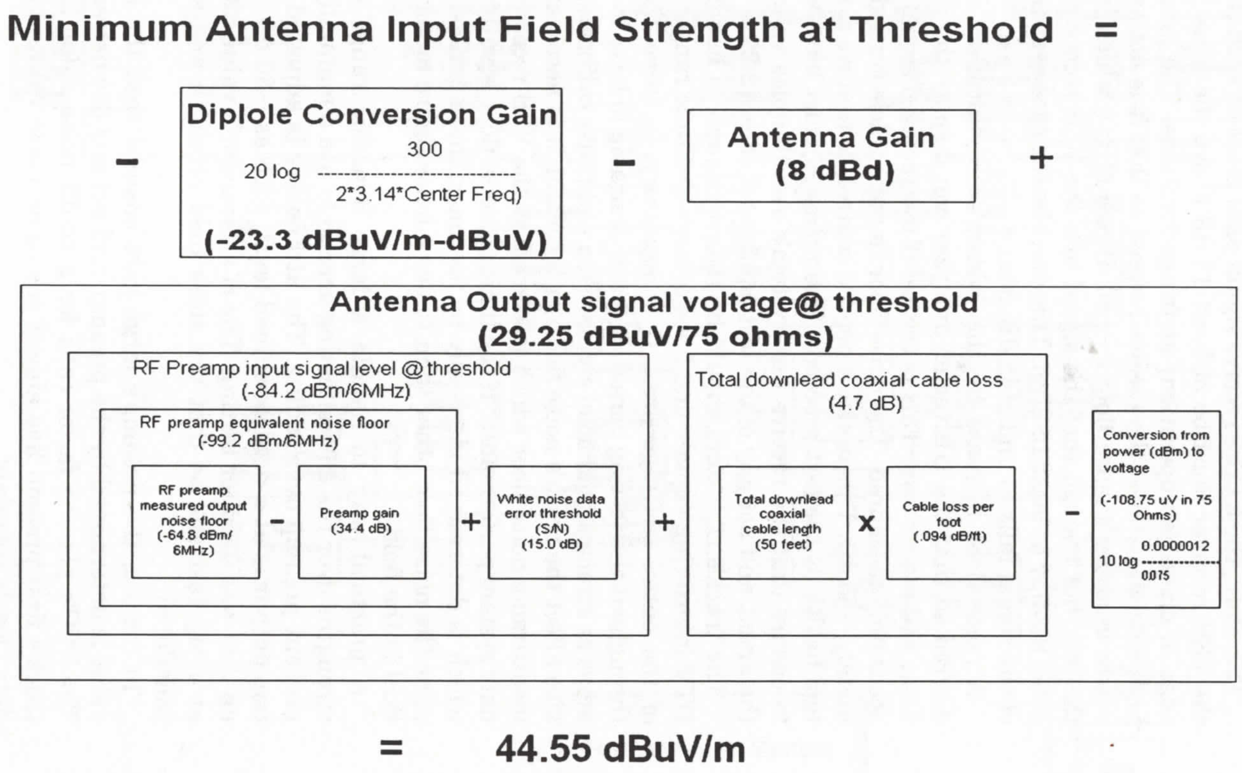

Figure 13.29 Algorithm for determining minimum received field strength for test vehicle.

13.4.2 Site tests

The following steps are performed at each site:

1. The time, date, geodetic location, distance and bearing from the transmitter, and weather are recorded.

2. Next, the rf system attenuation is set for −30 dBm on the vector signal analyzer. The attenuation is recorded. This attenuation value, along with the rf system gain measured during the AM calibration, is used to determine the DTV field strength at that site.

3. The rf feed is removed, and the 6-MHz noise floor is measured. This value is used in the DTV SNR calculations.

4. Next, the DTV pilot power is measured. It generally ranges between −11 and −13 dB below DTV channel power.

5. Next, plots are taken of the DTV channel passband and tilt using the VSA. Ripple and tilt are often caused by multipath. Extreme close-in ghosts (less than one symbol time) that are out of phase will boost frequencies at the high end. This creates positive passband tilt. Close-in ghosts that are in phase create negative passband tilt. NTSC video appears "enhanced" or peaked in the first case and "rolled off" in the second case. A single ghost that is not close-in will create ripple across the passband with a frequency separation equal to the inverse of its period in the time domain. As an example, a 1-μs ghost will create ripples across the channel with a spacing of (1/1E – 6) 1 MHz (Figs. 13.30 and 13.31).

6. Then a test receiver that can record tap energy is given a command to record the equalizer's input and output S/N ratio tap energy and all the individual coefficients along with a summation value of all the coefficients. The S/N ratio into and out of the receiver's equalizer system is also recorded. Many receivers use the 256 tap coefficients displayed here (Figs. 13.32 to 13.35) to cancel reflections to maximize reception. All DTV receivers must do this, but the test requires a demod that also displays these values as a measure of multipath at a given site. The magnitudes of all the coefficients, except the main one, are squared and then summed. Then the logarithmic ratio between the summed squares and the squared main tap is displayed in the upper left corner as tap energy.

At 0 dB, the energy in all coefficients is equal in magnitude to the main tap. Sites with no reflections will have tap energy values below −18 dB. Decoding may no longer be possible when the tap energy approaches −3 dB.

The signal-to-noise values reported by the test demod represent the 8-VSB constellation landing errors that result from noise and intersymbol interference. In other words, they indicate how far off from a valid sample level the vector has landed or deviated from its ideal value along the *I* axis. Intersymbol interference due to multipath can be thought of as noise since the data are random (noiselike). The equalizer input S/N can be less than 15 dB and still be decodable. The reason why the S/N value in the equalizer can be less than 15 dB and still be recovered is because this value may be partially comprised

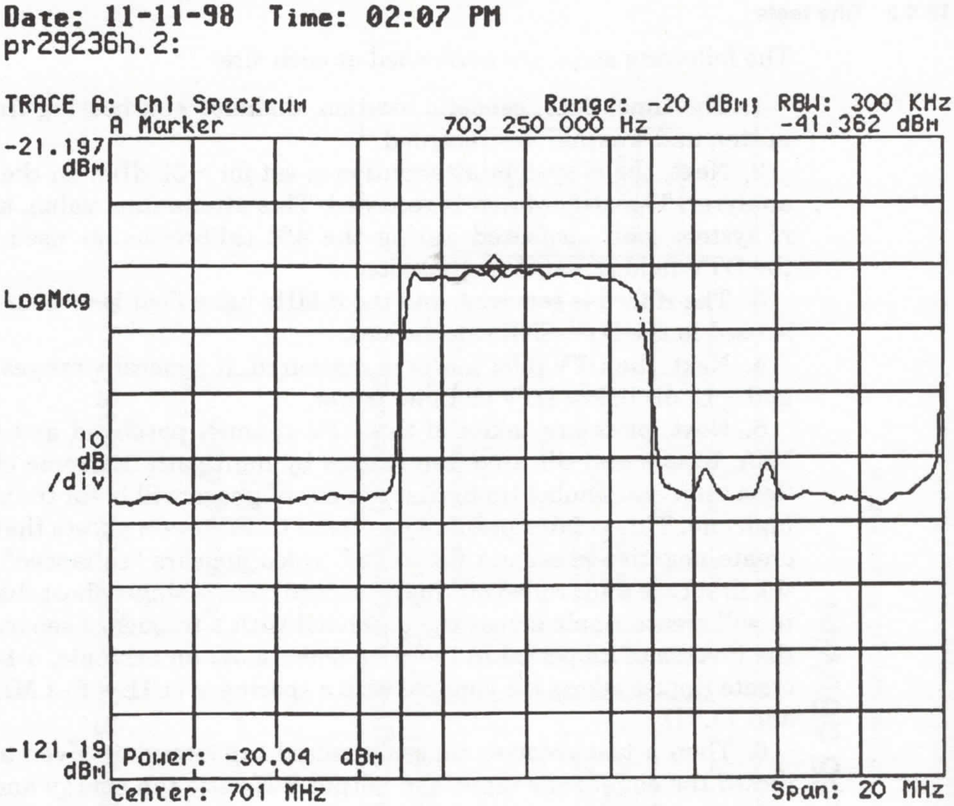

Figure 13.30 DTV passband.

of correlated reflections. If it is pure white noise, the value remains 15 dB, which means there is now an ambiguity as to the proper *I* value and errors will occur. The equalizer output S/N value in Fig. 13.32 illustrates multipath error improvement. However, it should also be noted that if many taps were on, in order to cancel the correlated ghost(s), the uncorrelated noise would increase as more taps are used. This is known as *white noise enhancement.* As tap energy approaches −5 dB, an additional 1.25 dB of noise will be introduced. This means that as multipath and hence tap energy increase, the 15-dB white noise threshold increases, decreasing headroom and pushing you closer to the error cliff. The difference between equalizer input S/N and equalizer output S/N is an indication of how much "work" the demodulator is doing to eliminate the effects of multipath. Phase output S/N is the S/N value due to uncorrelated noise after tuner phase noise has been corrected. A 511-symbol training string in the frame sync of the ATSC transmission data frame is used by the equalizer as a reference to create base tap coefficients that are applied to the data frame. It is interesting to note that if these time domain plots are taken to the

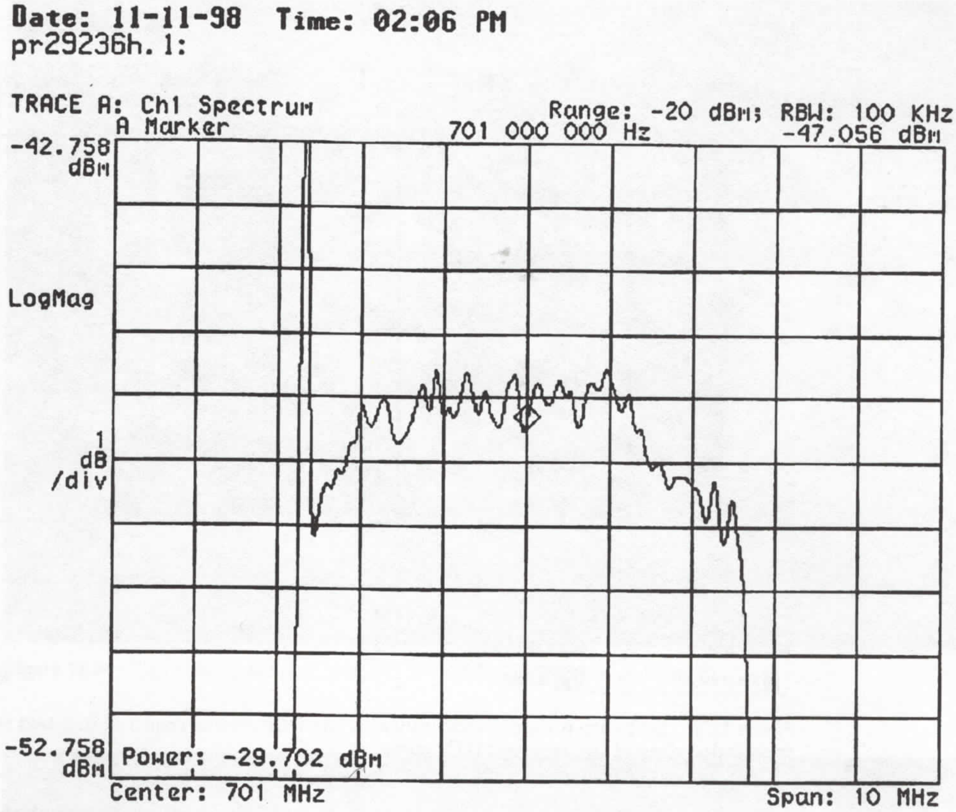

Figure 13.31 Channel tilt.

frequency domain, the result is a channel passband characteristic that cancels the errors in the actual passband.

7. Noise is then added to the system until the error threshold is reached. The DTV channel power and the noise power (rf input signal removed) are measured to determine the site margin and as a sanity check to confirm that the DTV signal is still recoverable with an S/N ratio of approximately 15 dB. Sure enough, when a power level of −30 dBm is input into the VSA, errors begin when the noise floor is brought up to −45 dBm.

There are two ways to determine the white noise margin of the received signal at a test site. The first way is to attenuate the receive signal until errors occur. However, any local EMI/RFI in the truck or test site can make this approach inaccurate. The preferred way is to add gaussian noise.

8. The test receiver is given the command to make the same equalizer and tap measurements again in this simulated near-threshold condition.

9. Peak sync power and C/N are measured for the NTSC channel as a basis for comparison. The CCIR impairment rating, a subjective five-point quality rating, is recorded for the NTSC signal.

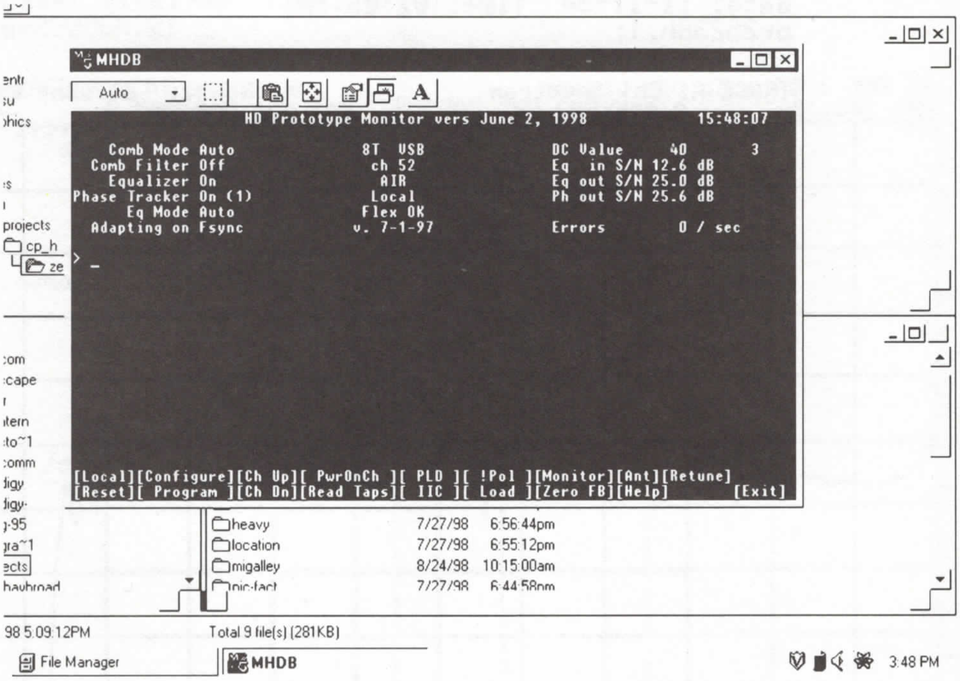

Figure 13.32 Software program that indicates the DSP efforts required in a test receiver to ensure proper decoding of the received DTV signal.

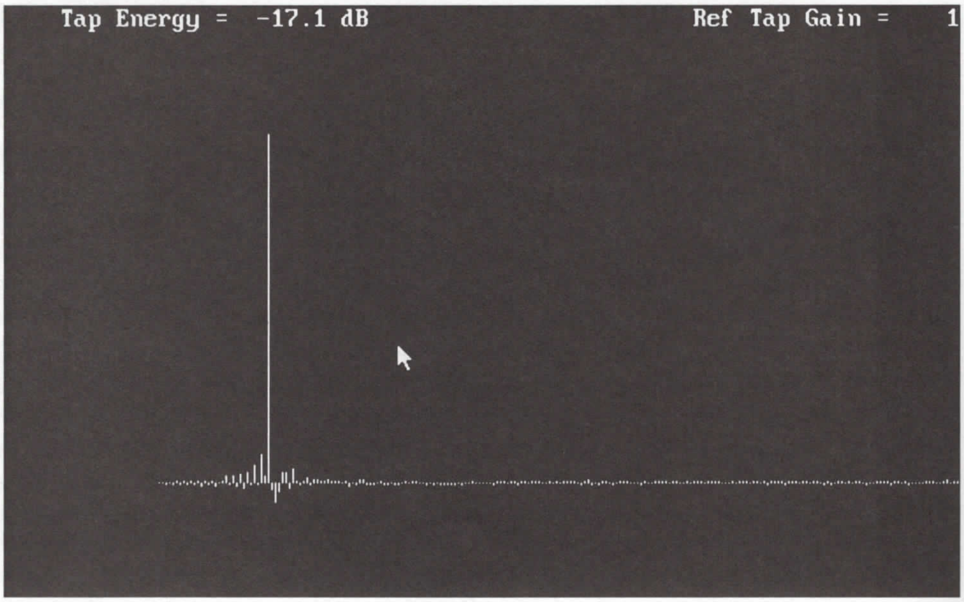

Figure 13.33 Tap energy plots displaying little multipath.

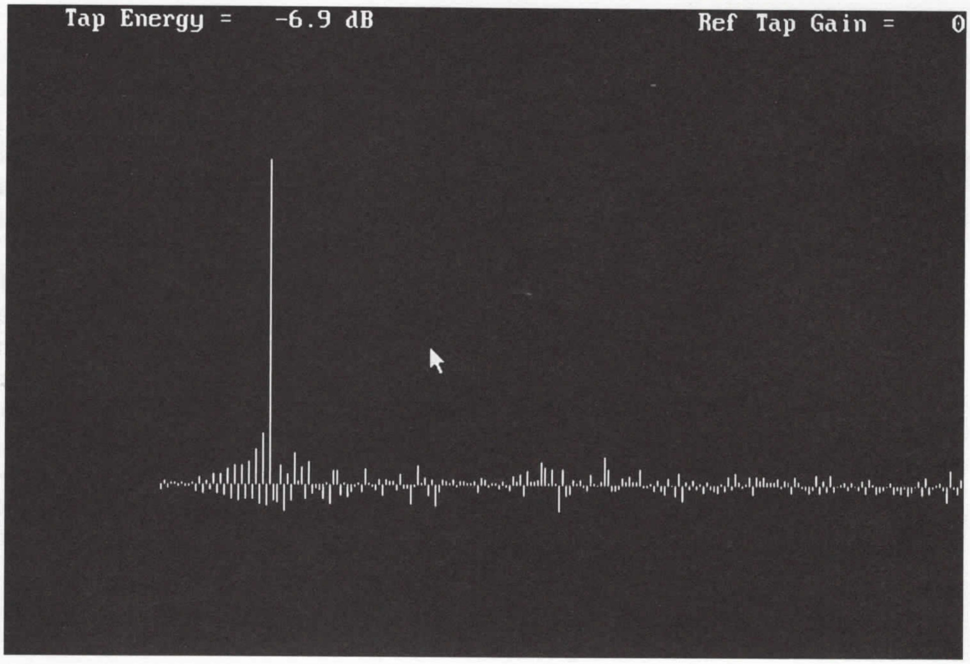

Figure 13.34 Tap energy plots displaying a medium amount of multipath.

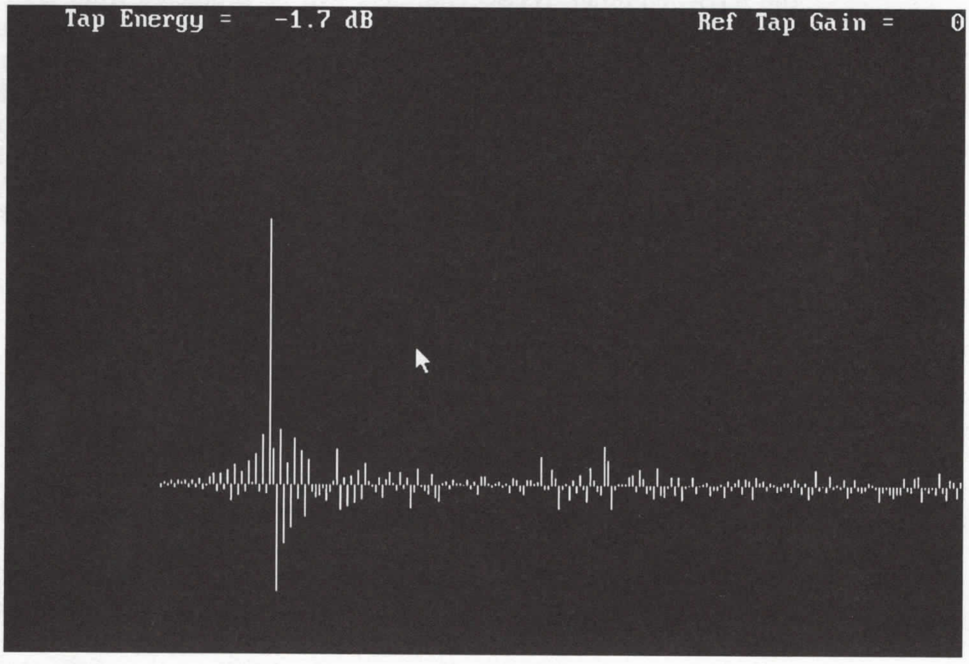

Figure 13.35 Tap energy plots displaying heavy multipath.