High Power DTV Monitoring

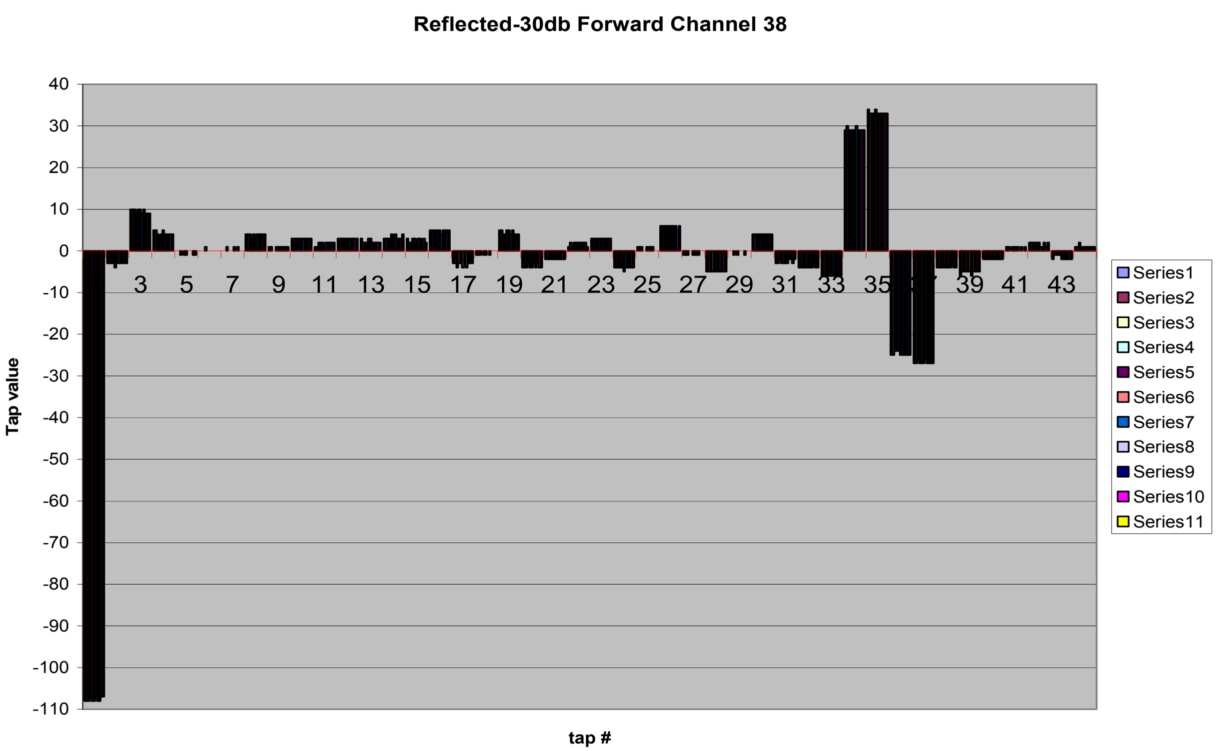
ANDRE SKALINA
WILLIAM A. DECORMIER
Dielectric Communications
Raymond, Maine
GUY LEWIS
Z Technology
Beaverton, Oregon

BACKGROUND

Dielectric is developing a new high power DTV real time TDR-like transmission line monitoring system. The methodology described in this paper is being currently patented. The currently available systems for transmission line monitoring are frequency domain VSWR based systems. A reported increase in VSWR for such a system is open to wide interpretation and numerous errors. When monitoring the frequency domain VSWR in existing systems and the normal VSWR rises from 1.10:1 to 1.20:1, how can it be determined if the problem is in the transmission line or the antenna or filters in the transmitter building? It cannot be narrowed to one or the other much less the elbows, gas barriers, channel splitters, channel combiners, elbow complexes or the antenna. The station operators are left to guess based on history and previously known problems. But in times of fast turn-around in personnel how much history does the operator know about? The alternative is to bring a technician with a network analyzer and go off the air to check the system. However, many times the fault is occurring only at higher transmitter powers thus transparent to network analyzer measurements.

The need for a new product like the demodulator/monitor is also greater for DTV than it was for NTSC applications. With NTSC applications the power levels used to specify a transmission system included both the ratio of Peak to Average as well as the black picture to normal picture.

Figure #1 Reflected -30 dB Forward channel 38 tap values for 11 sets of data

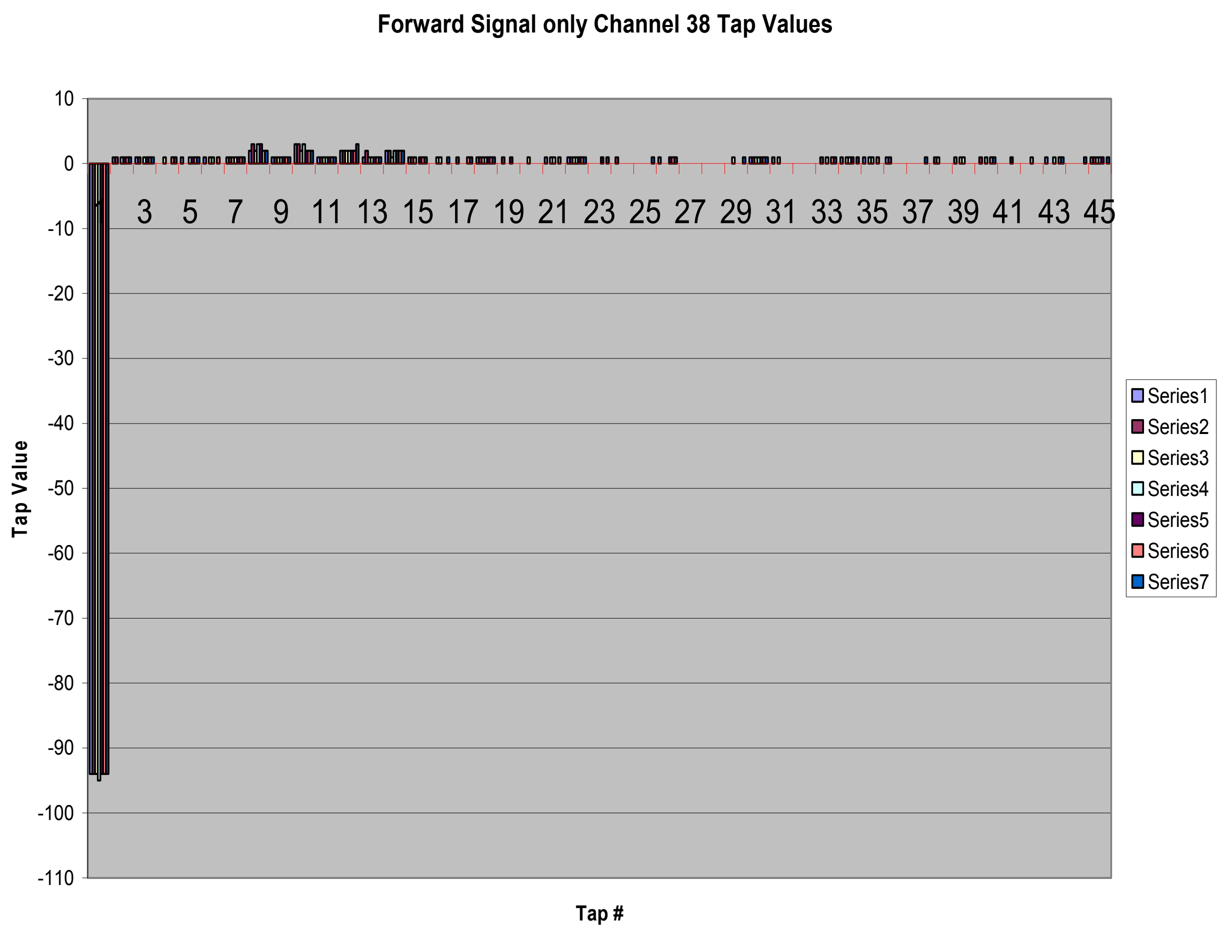


Most transmission line systems were supplied with a margin of safety of 10% above the inherent margins already built into the above ratios. DTV applications rely solely on the margin of safety specifically provided. No additional margins of safety are inherent.

In addition as the income stream shifts from NTSC to DTV the need for preemptive maintenance will become very important to avoid costly shut downs. The new high power DTV real time TDR-like transmission monitoring system will provide the station with the ability to monitor flange joints, elbows, gas barriers and the antenna and respond preemptively to the first signs of a problem. The new monitor will provide a change in a TDR like value at the first sign of a problem before destructive burn-up has started or progressed to completion. It will allow visual analysis when an operator wants to know how far to turn the power down. Is 50% power going to be sufficient to stop the burning or will 70% power be sufficient to maintain status-quo until someone can do a visual inspection of the line, the elbow, the splitter, the combiner or the antenna? When the riggers and the field service technician arrive, they will not be guessing where the problem is. The output of the monitoring system will point them to the spot where the problem is located.

The uniquely capable system can detect some previously undetected burn up situations. In recent years at least two sites experienced burn-ups in the middle of a vertical run, and no alarms sounded until a length of line was destroyed. It's been theorized that in these situations frequency domain VSWR was not observed in large magnitude because much of the missing reflected energy was absorbed as heat at the point of failure. The charred remains acted as a sort of a load. The newly developed system is capable of detecting these types of failures due to the proprietary algorithm capabilities built into the Visual Basic program.

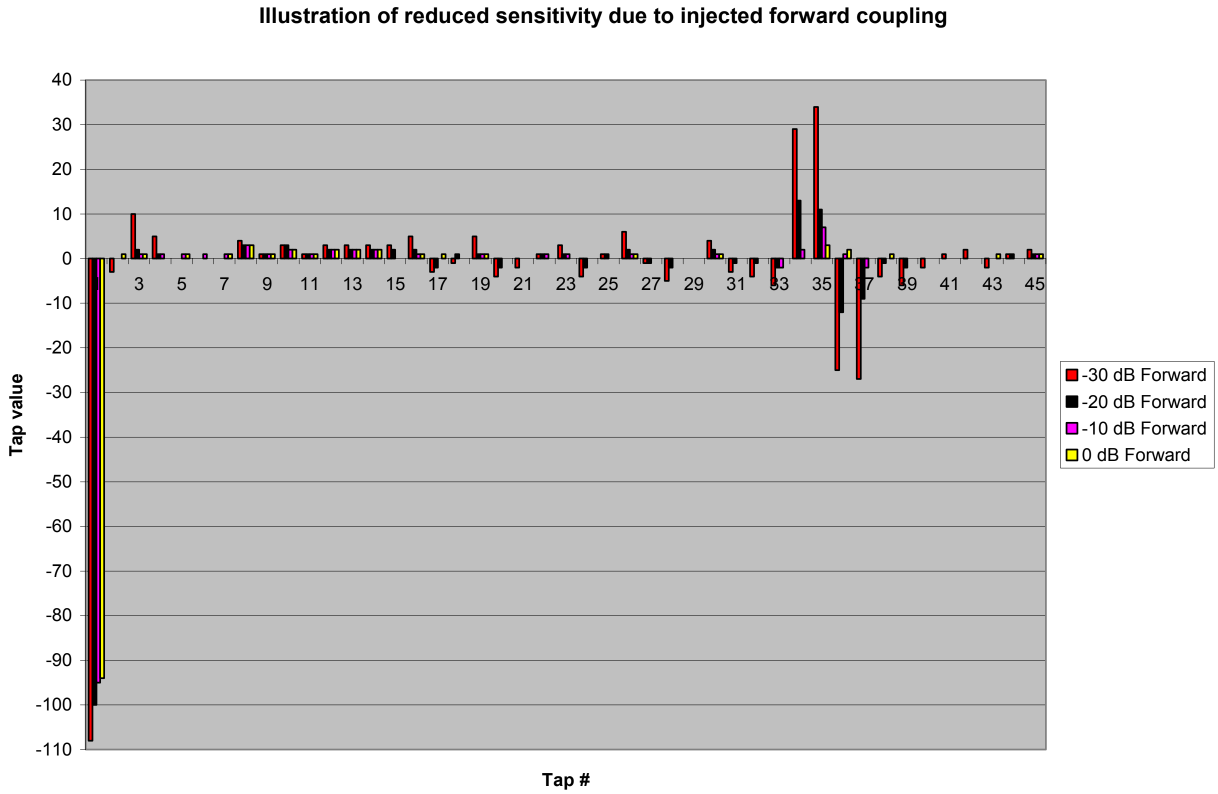
Figure #2 Forward signal only tap values channel 38 for 7 data sets



THE MONITORING SYSTEM

The monitoring system consists of a Z-Technology DM1010W Professional ATSC/8VSB Demodulator which provides a graph of dynamic equalizer tap energy. The tap energy is proportional to TDR like discontinuities in the RF system from the directional coupler sample point to the antenna inclusive. The customer interface is a menu driven Visual Basic PC based program that interrogates the tap data provided

Figure #3 Effects of introducing Forward measured signal into Reflected measurement



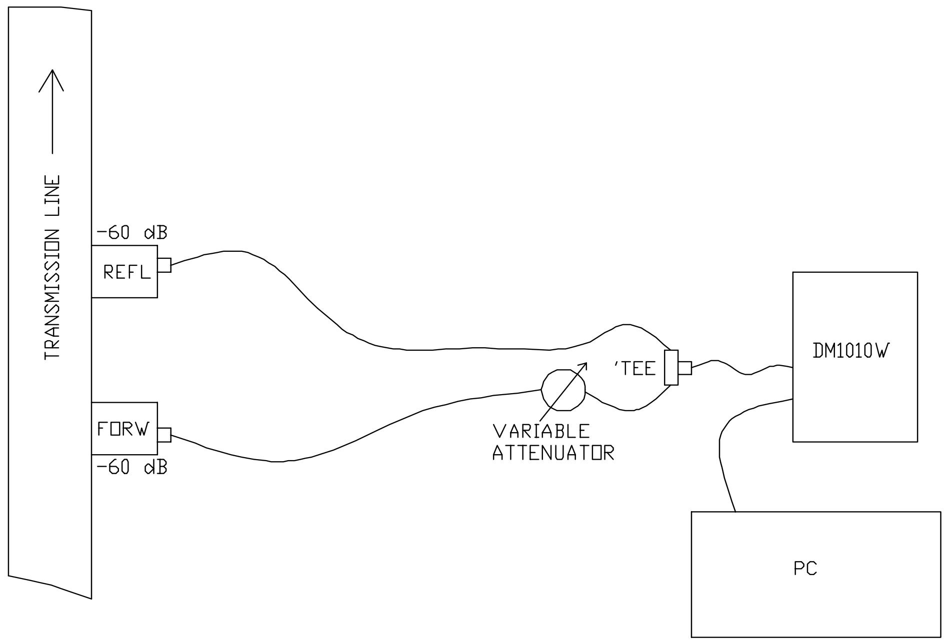
by the demodulator software and compares the measured values to a site specific set of warning and shutdown alarms. Different alarm levels are assigned to elbows, transmission line flanges, channel combiners, channel splitters, elbow complex and the antenna. The reason for the differentiation in alarm levels is that a small change of VSWR at the antenna can be a normal change due to temperature or weather conditions at antenna. As long as the VSWR returns to normal no alarm will sound. However, even a small change in the enclosed transmission line components might indicate a problem and will be closely monitored. A specific tap point of the demodulator will be assigned to each component of a site for unique 1 tap to 1 component site specific layout. Any site-specific component between the directional coupler monitor point and the antenna may be targeted. Alarm levels for warnings and trips can be programmatically set and adjusted. As site specific responses are observed the proper alarm limits can be adjusted to allow for anomalies. Outputs can be connected to transmitter trip functions, remote monitoring, or any other intranet compatible device via local intranet. When any of the alarms are triggered, the PC program will alert the station, the manufacturer and any site specific contact personnel via modems or via intranet. Alarm or warning conditions can be e-mailed to the necessary personnel's cell phone. Additional I/O for local control is available for transmitter interface if required. The new monitoring can be used as an option to many existing monitoring systems.

DEMODULATOR SPECIFICATIONS

The ATSC/8VSB demodulator was chosen for the transmission line monitoring system because of its measurement quality front-end design, data provided by the WinDM™ integrated demodulator software application, and its ability to communicate with the PC system software. This demodulator's excellent RF performance and traceable calibration over a full range of signal levels, operating frequencies, and operating temperatures, allows an accurate, location-specific evaluation of signal reflections in the antenna system beyond the directional coupler.

The demodulator design incorporates automatically ranged attenuators in the RF front-end to maintain an optimum gain distribution through the demodulator, and provides a comprehensive set of RF and Data Figures-of-Merit. The demodulator program application displays these values and places the measurements periodically into a history file for future analysis. Examples of parameters available for evaluation when the demodulator software is active are: RF Input Level, Signal-to-Noise Ratio, Segment Error Rate, Sync Lock, Equalizer Lock, Total Tap Energy, and a graph of Dynamic Tap Energy. The demodulator also provides a quality 8VSB monitoring output on channels 7 or 8 for in-house monitoring at locations where strong multipath may exist on the station's broadcast channel.

Figure #4 layout of demodulator/monitor including couplers, attenuators, tee, DM1010W and a PC



SPECIFICATIONS OF PERIPHERALS

The connection between the transmission line and the demodulator is provided by two high directivity directional couplers. The primary RF feed to the demodulator is provided by the coupler sampling the reflected RF signal. See Figure #4 for layout of components. For normal faultless transmission line operation the reflected signal is the only RF signal required. To maintain resolution and avoid losing the reference signal equalizer lock, a second RF source from the forward coupler is coupled into the reflected sample signal at a reduced level. For the data provided as examples in this paper, the couplers were set at -50 dB with -44 dB directivity in a DTV transmission line with 4250 Watts TPO at Channel D38. At the levels provided by these couplers the demodulator operated at an AGC level of 40 dB in a range of 0 to 60 dB. A signal level 10 dB lower would fall in the 30 dB range of the AGC on the demodulator. The lower level would provide maximum margin of safety. The demodulator will not fail due to excessive or inadequate signal level. For DTV TPO's higher than listed above, attenuators will be necessary for optimum performance.

Figure #1 illustrates a typical dynamic response of the tap values for 11 sets of data when only the reflected signal is monitored. Each of the 1/8 inch wide vertical bars in Figure #1 represent 11 data sets for that tap. A variation of one unit in magnitude can be noted on many of the taps. This is due to the resolution in the magnitude. The demodulator has 8 bit resolution for a range of plus and minus 128. Therefore if a measured value oscillates above and below a unitary boundary by a fractional value less than one, the reported answer will report a higher or lower value by an increment of one. This is not a significant error in magnitude for this application.

Note the large signal at tap #1 that serves as an equalizer locking signal for the demodulator. The resolution in the horizontal axis of the demodulator system is 48 feet. The distance resolution is related to the tap time constant. Tap # 3 represents the elbow at the base of the tower. Taps # 4 through #33 represent normal transmission line with 2 or 3 flanges and 6 or 7 line insulators captured by the 48 foot tap interval. Those quantities of flanges and insulators will vary depending on whether the tap lines up with a flange or not. In this example taps #34 and #35 represent a shared line splitting tee that splits channel 13 from channel 38. The measured transmission path is the channel 38 path and therefore the #36 and #37 taps represent the channel 38 antenna. These transmission line discontinuities will be different on each site. There may be additional components and their associated discontinuities on other sites.

Figure #2 illustrates a sample taken from the forward coupler. In Figure #2 the tap #1 is the primary signal and all the remaining tap values are very low or non-existent. If an adjustable quantity of the tap #1 value in Figure #2 is added to the tap trace of Figure #1 the sensitivity of subsequent tap values #2 through #45 can all be reduced. If the tap value for the antenna in the reflected only trace rises to approach the value of tap #1, the demodulator would lose its equalizer lock. Consequently adding a value to the value tap #1 is a guard against losing lock during conditions like icing of the antenna. This addition of a buffer to the synchronization pulse is achieved by teeing the two coupled RF signals together with a -30 dB programmatically adjustable attenuator in the forward coupled line. As the tap value of any signal beyond the tap #1 rises to a point approximately 80 % of tap #1 that would jeopardize the lock of the equipment, the program will reduce the value of the -30 dB attenuator toward 0 dB to avoid losing the equalizer lock. This avoidance maneuver will increase the value of tap #1 only, towards its higher ratio to other taps limit as shown in Figure #2.

The PC based Visual Basic program will retrieve this data as shown in the charts above and convert all numbers to their absolute value and scale the graph to make the reference pulse 100 %. The program will also accept a series of warning and trip limits for numerous taps that identify special components and another set of warnings and trips to assign to all remaining transmission line components. The program will also perform proprietary calculations on tap values and do necessary analysis of the result in an effort to find less obvious sources of potential burn-up.

Data can be retrieved as frequently as every 3 seconds. Analysis can be completed on all sequential data, and appropriate responses generated. For periods of time where no anomalies are noted, limited sets of original data can be retained while discarding excessive quantities of repetitive data. Any anomalous event can generate more complete and continuous data. The retained data can be used for historical records and available for analysis and reports.

Two types of responses can be generated in the event of an alarm; E-mail and I/O alarms. E-mail type of notification can be generated to all addresses listed for notification and communicated by modem or local intranet. Two types of E-mail can also be available. One E-mail suitable for cell phone notification and another to PC's that includes more detailed data including copies of the plots depicting the alarm condition. In addition, for sites where this system is installed as a standalone system, a suitable number of I/O can be supplied through USB connection to provide sensors and control if automatic trips are required. For locations that also have existing conventional monitoring systems with integrated control, the I/O of the integrated PC in the Monitoring system can be used to interface the two systems in a seamless fashion so that only one of the systems can report alarms to the designated recipients.

For sites with multiple transmission lines, couplers can be installed on all lines and the multiple sample lines can converge on the demodulator. Since the front end of the demodulator is so robust there is reason to believe that simply tee-ing the multiple lines together will be allowed. In that case the demodulator can be programmatically switched between channels and provide the necessary isolation. If ongoing testing shows this approach to be deficient in any way, low power programmable RF switches will be used in conjunction with the programming of the demodulator to monitor multiple lines. The first approach is preferred since it can keep the component count and costs down.

SUMMARY

The major benefits of this monitoring system are:

1. The monitoring is real time
2. The monitoring is done at full power or at any operating power
3. It will indicate a change in transmission line status and report different fault levels
4. It will find problems in transmission line that do not show up with standard VSWR measurement
5. It is non-invasive
6. Does not require any additional signal to be inserted
7. Low cost

Discussions are proceeding at press time to improve the resolution to 24 feet.

Dielectric would like to thank the management and engineering staff at WGME, owned by Sinclair Communications, in Portland, Maine for the access to their site and the cooperation they have extended to us in providing a real test site.