Spectrum Testing Of Coaxial Cable Plants - Part 2

By Orrin Charm ■ *InfiniSys, Inc.*

In the previous article, we discussed the need for a new standard for performance of coaxial cable video distribution architecture, independent of the actual signal that would be provided by the video service provider.

This is because much of the construction of residential coaxial cable drops and distribution is being done or commissioned by the property owners, in many cases even prior to the selection of a service provider or the signing of service contracts.

The existing standards and regulations are all directed at equipment manufacturers or service providers – there are no specifications that isolate the distribution system, which is the portion that property owners are now responsible for.

The lack of a recognized standard for system performance measurement has prevented test equipment manufacturers from designing and building test instruments comparable to the TIA-568 Certification Testers used in data communications.

For this project, we used a Broadband Noise Source to simulate a CATV system. Noise Generators will produce a reasonably flat level of white noise across the desired spectrum, but do not generate any of the video or audio carriers, so some of the tests may not provide meaningful results. However, this type of testing will provide a much more reasonable measurement of broadband response than audio tone or single-channel testing.

A better test setup would include a signal generator that more accurately mimics a real-world CATV signal. Such a system can be built, using modular headend modulator units, such as the Blonder-Tongue Modular Headend products, plus a DVD player or other video source and a suitable distribution amplifier. However, such a system is quite bulky and expensive, and typically is limited to the 5-860MHz spectrum.

Another type of system measurement would be to use a Time-Delay Reflectometer, or TDR, to measure the cable in the time domain, rather than the frequency domain. A TDR looks very much like a spectrum analyzer, except that the screen is calibrated in time units rather than frequency units.

Instead of a broadband white noise source at the other end of the cable, a TDR sends a short high-frequency pulse from one end of the cable, and looks at echoes and reflections returning to the same cable end. The result is similar to an "x-ray" of the cable, since the time delay from the initial pulse to the reflections are proportional to the distance they have traveled. A TDR can also be used to measure the length of a cable, or to detect any anomalies along its length, such as shorts, opens, and cable damage. It can determine the distance of those anomalies from the source. It does not, however, provide a measurement of performance at any range of frequencies.

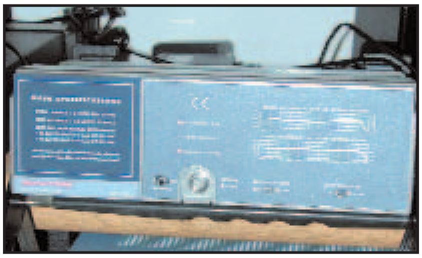
Due to time and equipment constraints, we did not evaluate TDR products for this article, although it became apparent that a combination of spectrum and time analysis would be much more insightful than either one alone.

Category 5 testers actually use a combination of static, frequency domain, and time domain tests to check cabling system quality.

Absolute measurements are of little value using broadband noise as a test signal- the actual measurement may vary greatly, depending on the measurement parameter of the test instrument. We got readings from +20dBmV to -20dBmV for the same signal, depending on the meter used and measurement parameters that were set. This is because the actual power level is dependent on the measurement bandwidth, and because testers "weight" the measured results because they are looking for carrier signals.

Nevertheless, it is the relative loss from one end of the network to the other that is significant, and these tests permit the observation of loss characteristics over the spectrum.

We tested two Broadband Noise Sources that could be used to simulate a "live" CATV signal. The first was the Sencore NG 1502 Noise Generator.

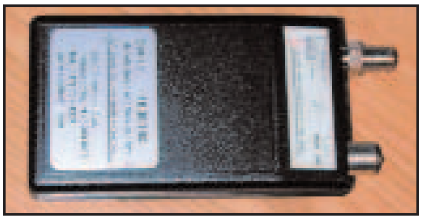


Sencore NG 1502 Noise Generator

The unit is specified to have an output of about +15dBmV with the 20dB attenuator off. The NG 1502 is battery powered, and has a list price of $895.00

The other unit tested was the Applied Instruments NS-1 Noise Generator. This is a much smaller handheld unit powered by a 9v battery, and has an output of around 0dBmV from

1-2000 MHz. It has a list price of $395.00.



Applied Instruments NS-1 Noise Generator

For measuring the signal, we used a variety of devices. On the high end was the Leader Instruments LF 983 Signal Level Meter. This compact instrument can provide measurements from 50 – 2150MHz (though not continuously-it can measure either 50-870MHz, or 950-1450MHz directly, or 1550-2150MHz with some effort). Its most distinctive feature is that it can store measurement results on a Compact Flash Card, like the kind used in digital cameras. The card can be removed from the instrument and the files transferred to a computer for archiving or analysis. A printer is also available that connects directly to the LF 983. The LF 983 has a list price of $3,295.00. Its cousin, the LF 982, omits some capability for measuring digital and cable-modem signals, and lists for $2,495.00. Both units run on internal rechargeable batteries.

Leader LF 983 Signal Level Meter

For field applications where extensive storage of test results is not required, the Sencore SLM 1453 Signal Level Meter is a good choice. This unit measures from 5-870MHz only, and can store up to 32 readings.

We also used the Sencore Model SA1501 Spectrum Analyzer.

This allows real-time analysis of signals up to 1GHz, but does not provide numeric results or store test data.

Sencore SA 1501 Spectrum Analyzer

None of these devices offered the comprehensive test capability or simplicity of most Category 5+ Cable Analyzers, but all provided far more information about cable and distribution system performance than a CATV toner-and-probe system (such as the Greenlee/Progressive Instruments 402K CATV Test Kit).

The most serious issues were that none of the instruments provided the ability to specify "PASS-FAIL" measurement ranges, and the fact that neither the noise sources nor the cable or distribution system being tested were linear as a function of frequency.

This non-linearity is pervasive in RF system design, and in fact, most systems are designed (and components specified) at one reference frequency, although performance may differ considerably at other frequencies. Fortunately, most TV sets have a very wide range of acceptable input signal levels, so they are able to provide an acceptable picture under a wide range of conditions. Nevertheless, in a large CATV distribution plant, such as in an MDU complex, there will be so much variation across the bandwidth that great care must be taken to avoid marginal signal levels, and to balance the system carefully. This is why a proper grade of coaxial cable and high-quality passive components are critical, and why distance limits are tightly controlled.

We first tested both Noise Generators, using the Leader LF 983 Signal Level Meter.

The Sencore NG1502 Noise Generator showed an output level of about +14dBmV ±2dB (See Figure 5). It is rated from 5 – 2150MHz, but the SA1501 only measures to 1000MHz. The NG1502 has a 20dB built in pad. It can be operated on battery power, or with an included AC adaptor.

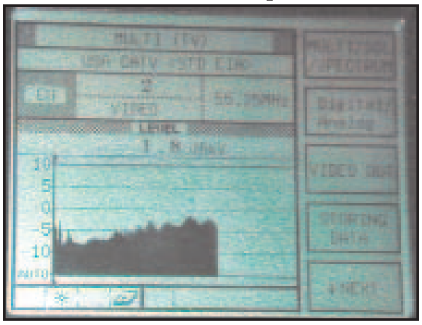


Figure 5 – NG 1502 Frequency Response

The Applied Instruments NS-1 showed an output level of about -5dBmV, about the same as the MG1502 with the pad in, It is not as flat as the NG1502 (see Figure 6), but its small size and lower price make it an attractive choice. It measured about ±3dB over the range of the Spectrum Analyzer.

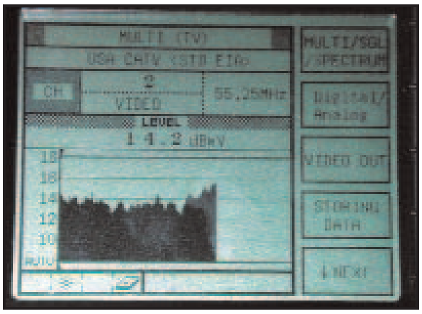


Figure 6 – NS-1 Frequency Response

The screens show a 1000MHz span, with 3dB/division from a +20dBmV from the reference line (top of the screen). The tests were made with a 24" RG-59 cable supplied by Sencore.

For reference purposes, we used the Sencore NG1502 Noise Generator because of its flatter frequency response, although the NS-1 showed similar characteristics. Results are shown without the -20dB pad, so the reference level is about +14dBmV at the source. Real-world CATV systems may be 6-9dB higher.

Figure 7 shows the response through 13' of RG-6 coax (Comm Scope F6SSVX).

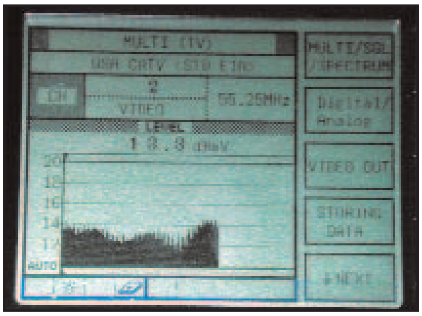


Figure 7 – 13' RG-6 Response

Figure 8 shows the response through 150' of RG-6 (Genesis/OnQ RG-6 Quad Shield).

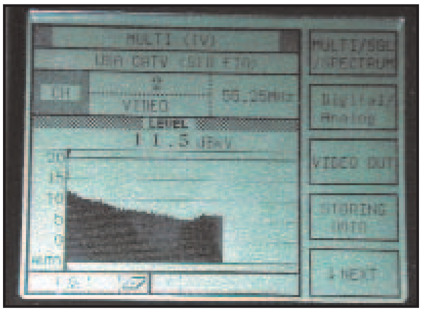


Figure 8 – 150' RG-6 Response

Figure 9 shows the response through both cables, with an F-81 barrel connector. The response is down -6dBmV at 50MHz, and down -12dBmV at 860MHz.

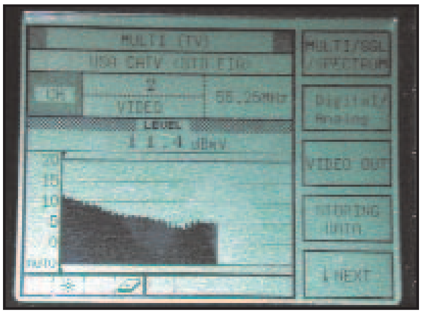


Figure 9 – 163' RG-6 Response

Figure 10 shows response through 150' of RG-6, a 4-way 2000MHz splitter, and another 13' of RG-6. The response is down to +4dBmV at 50MHz, and about -2dBmV at 860MHz.

This represents typical performance in an average MDU environment. With real-world signal levels- about +21dBmV – the level at Channel 2 would be about +10dBmV, and the level at the highest CATV band would be about +5dBmV. The service provider might provide tilt compensation at the site- attenuating the lower frequencies to provide flatter signal levels over long distances.

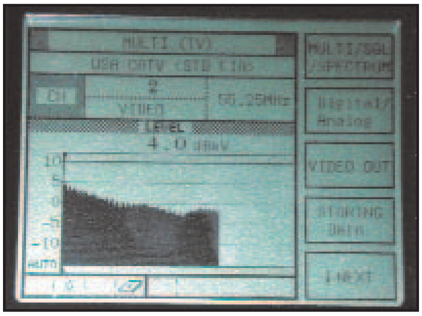


Figure 10 – with 4-Way 2050 MHz Splitter

Figure 11 shows response with a 6-way 1000MHz OnQ splitter.

If the system is designed to be able to transport "stacked" DBS satellite signals, response needs to extend to 2150MHz, although satellite receivers are able to handle even lower signal levels- around -2 to -10dBmV. Losses in the cable are greater at higher frequencies, and splitter losses can be even greater, especially if the splitters are not designed to offer higher bandwidth.

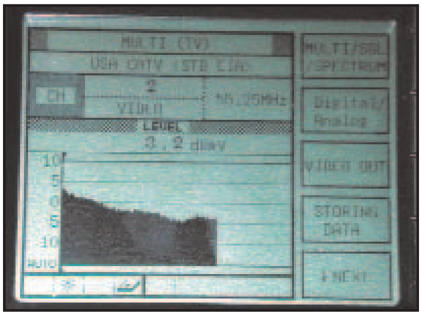


Figure 11 – with 6-Way 1000MHz Splitter

Figure 12 shows the response of the Noise Generator with a short cable attached.

With a longer cable connected, the signal loss at the higher frequencies is greater than at the lower ones (Figure 13).

With the 4-way splitter attached, the response is still adequate for a satellite system (Figure 14).

With the 6-way 1000MHz splitter,

the response falls off below an adequate level (Figure 15).

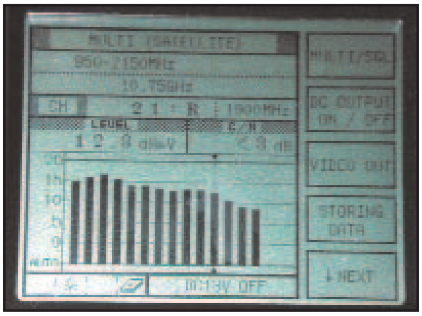


Figure 12 – 950-2150MHz Response- 2' Cable

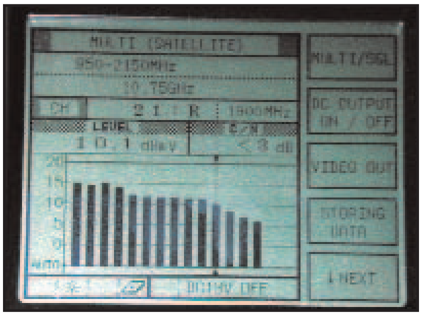


Figure 13 – 950-2150MHz Response – 150'

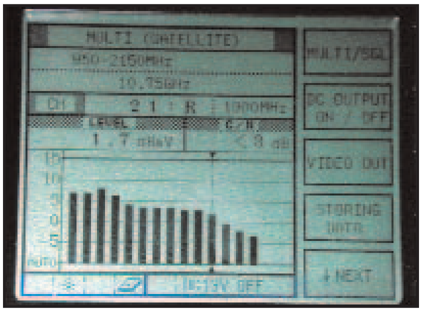


Figure 14 – 950-2150MHz – with 4-Way Splitter

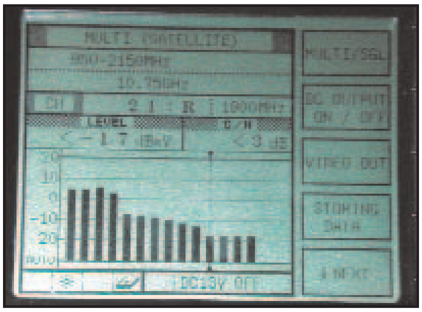


Figure 15 – 950-2150MHz with 6-Way Splitter

For this reason, 2050MHz splitters should always be installed, even in lower-bandwidth systems, so that they will not have to be replaced if the system is converted to DBS or other high-bandwidth program distribution in the future.

An interesting observation is that the test results for the 950-2150MHz band are actually much higher than the results at lower frequencies! This is mainly because the satellite signals have a much wider bandwidth than broadcast or CATV channels, so the overall power delivered is greater, even though the signal levels are lower, due to higher losses at higher frequencies.

Figures 16-21 show similar tests made with the Sencore SA 1501 Spectrum Analyzer. The relative curves are very similar, but the absolute numbers were very different.

The SA 1501 only reads to 1000MHz, and does not have any means of storing test results.

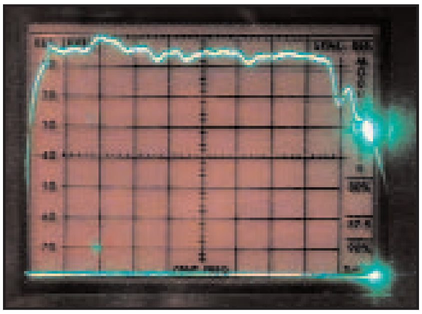


Figure 16 – NG 1502 Frequency Response

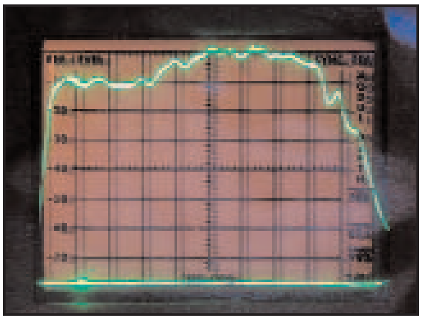


Figure 17 – SA-1 Frequency Response

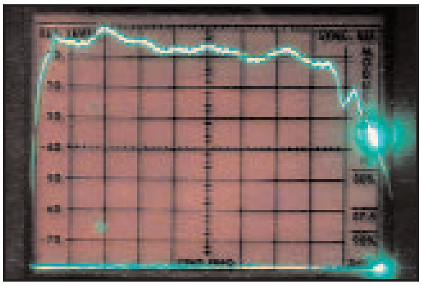


Figure 18 – 13' RG-6 Response

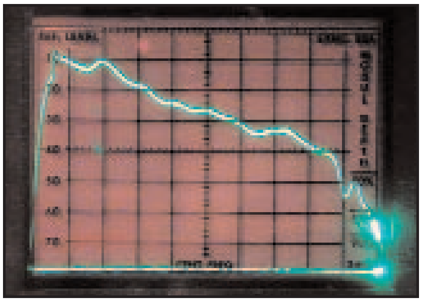


Figure 19 - 150' RG-6 Response

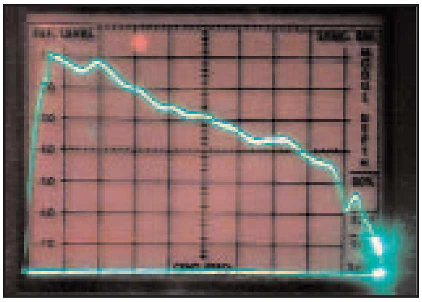


Figure 20 – with 4-Way 2050 MHz Splitter

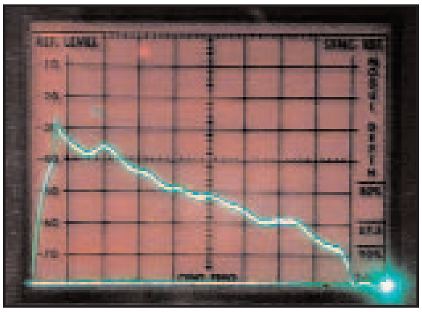


Figure 21 – with 6-Way 1000MHz Splitter

Conclusions:

Our primary conclusion was that a new breed of test equipment is needed to address the issues raised in this article. It also became obvious that such equipment could not be developed until recognized Standards were developed that specified exactly how the measurements should be taken, and what constitutes an acceptable or unacceptable result.

As a result, I have submitted proposals to both the TIA and SCTE to study these issues, and create a task force to develop a standard. The concept was well received by both Standards bodies, although the process will take some time.

If circumstances permit, the video service provider should get the outside plant installed and operating as early as possible, to allow testing of the distribution system under real-world circumstances. This is easier to do if the services are provided on a bulk basis to the property, assuming that contractual issues can be worked out early.

We have often tried to get service providers to agree to a "pre-connection" policy, where cable is "live" when a resident moves in, and the resident has a short trial period to either subscribe to the service, or have it disconnected. Although this appears to be a very reasonable policy, and would almost certainly boost the penetration rates, very few MSO's have been willing to consider it.

Also, the installation contract should stipulate that the installation is not deemed complete until a reasonable time after service is connected, although this is often impossible to enforce if residents are only connected after moving in and placing a service order.

In the meanwhile, the best prescription is to closely monitor the quality of any coaxial cable system installation, particularly paying attention to shielding construction, connector quality, potential cable damage during and after installation, and proximity of the cable to noise sources, such as AC power wiring.

Check also for any ground impedance between the coaxial cable shields and the adjacent electrical outlet grounds.

The devices we tested can be of significant value in spot-testing the cabling after installation, but the results need to be carefully interpreted. Several fresh samples of the cable being installed, of varying lengths, should be tested as a reference, and compared to the field test results. ■

About the Author

Orrin Charm is a Systems Architect with InfiniSys, Inc. InfiniSys, Inc. is the leader in creating broadband communications and low-voltage designs for MDU properties, from student housing to luxury apartments and condominiums. The author can be reached with questions or comments via email at orrinc@electronicarchitect.com.

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Applied Instruments, Inc.
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Indianapolis, IN 46203
Phone: (317) 782-4331
Fax: (317) 786-9665
www.appliedin.com

Leader Instruments Corporation
6484 Commerce Drive
Cypress, CA 90630
Toll Free: 1 (800) 645-5104
Phone: (714) 527-9300
Fax: (714) 527-7490
www.leaderusa.com

Sencore, Inc
3200 Sencore Drive
Sioux Falls, SD 57108
Toll Free: 1 (800) 736-2673 ext.216
Phone: (605) 339-0100 ext.216
Fax: (605) 339-0317
www.sencore.com

Sidebar to Spectrum Testing - Part 2

Test Procedures:

The best overall instrument for system testing was the Leader LF983 (or the LF982, at $700.00 less, if you do not want to test the 5-50MHz band used for Cable Modems).

This instrument can be programmed with specific test parameters, and both the test parameters and the results can be stored on a Compact Flash card and transferred to a PC for archiving or analysis, or to another LF983 to duplicate the test conditions.

The features of the unit are not perfect- in particular, the storage format is difficult to work with. Each test result can be named after it is measured, but the name is included in the text file that is created, not the name of the actual file. Thus, a test result can be named "Unit 103 Master Bedroom", but the filename on the Compact Flash card will be: "[driveletter]\DAT\BNK0000\00000001.DAT" The contents of that file (which must be renamed to a .txt file to read it) looks like this:

```
COM 4 SPLIT
IN1
IN2
CTN 209
NP1
NP2
DCV
DUA
M/S 0
CHN 013
SFQ 4.5
UNT 2
SCL 1, 15, 5
CHD   1,  5M:v,  5.00,  2.9
CHD   2, 25M:v, 25.00,  3.8
CHD   3, 50M:v, 50.00,  5.1
CHD   4,100M:v,100.00,  3.7
CHD   5,200M:v,200.00,  2.4
CHD   6,300M:v,300.00,  0.7
CHD   7,400M:v,400.00, -0.2
CHD   8,500M:v,500.00,  0.1
CHD   9,600M:v,600.00, -1.5
CHD  10,700M:v,700.00, -1.7
CHD  11,800M:v,800.00, -0.5
CHD  12,850M:v,850.00, -1.4
CHD  13,870M:v,870.00, -1.9
```

The first line contains the name you give the file, after COM (Comments).

The next lines show the test parameters- Channel Plan, number of channels, units, etc.:

COM 4 SPLIT	(File name refers to the "4-Wat Splitter" Test)
IN1	(for future use)
IN2	(for future use)
CTN 209	Channel Table Number (Channel Plan)
NP1	Noise Point Frequency 1 (Satellite LNB tests)
NP2	Noise Point Frequency 2"
DCV	DC Output Voltage (for connection to LNB's)
DUA	Satellite Selection
M/S 0	Multi, Single or Spectrum Display Option
CHN 013	Cursor Channel Number
SFQ 4.5	Sound Frequency
UNT 2	Units- dBmV, dBµV, dBmW
SCL 1, 15, 5	Scale- Manual/Auto, Reference Level, Range

The last lines are the actual results, showing Channel Number, Channel Name, Video or Audio settings, Frequency, and Level.

If you are making many tests, the management of all of the .DAT files can become tedious. I tried to name the files on the CF card before putting it into the tester. The tester was able to read the pre-written names, but overwrote them as soon as new file data was stored! In order to use the test results effectively, a program would have to be written to open each of the .DAT files, extract the relevant data, and export it into a database or spreadsheet, or create a graph (the instrument will display or print the graphs, but only stores the numbers).

The measurement parameters can also be stored on the card, and recalled each time the instrument is used. This makes it easy to set or create channels, and to preset all of the measurement specifications for consistency in test results.

A similar file is created that shows the overall test parameters stored in the Unit. It is in the PRG directory, and has a .PRG suffix, which must also be renamed to .TXT in order to read it. Its format is as follows:

```
COM 5MHz – 870MHz Test Range
IN1
IN2
CTN 209
NP1
NP2
DCV
DUA
M/S 0
CHN 013
SFQ 4.5
SCL 0,-14, 2
CHD   1,  5M:v,  5.00
CHD   2, 25M:v, 25.00
CHD   3, 50M:v, 50.00
CHD   4,100M:v,100.00
CHD   5,200M:v,200.00
CHD   6,300M:v,300.00
CHD   7,400M:v,400.00
CHD   8,500M:v,500.00
CHD   9,600M:v,600.00
CHD  10,700M:v,700.00
CHD  11,800M:v,800.00
CHD  12,850M:v,850.00
CHD  13,870M:v,870.00
```

This is identical to the DATA display, except that there are no values following the CHD (Channel Data) parameters.

The LF983 can measure at frequencies from 5-870MHz, and from 950-2150MHz, but these measurements must be performed separately.

I found it useful to set up a Custom Channel Plan with a limited number of measurement channels spaced evenly along the spectrum, rather than using actual broadcast channels. For testing with a Noise source, this is adequate. If a modular headend were used, the Channel Plan would have to include the channels programmed in the Modulators. This limits the size of the data files, and speeds up the tests.

Obviously, the signal levels will vary significantly, depending on the cable length and number of splits in the signal. The important thing is to make sure that the levels at the wall outlets do not exceed the loss budgets at any frequencies.