60351

INVENTION DISCLOSURE

1. **Invention Title.**

Method to Measure Distortion and Noise At Terminal Equipment

2. **Invention Summary.**

A method to discover non-linear distortion in downstream cable plant by capturing a first downstream signal at a hub site, a second downstream signal at a terminal device and processing them together to determine non-linear distortion. A trigger is provided by a downstream sync signal to insure that the downstream signal capture occurs at a same relative time.

3. **Invention Description**.

a. Describe the invention in detail.

Cable systems typically have downstream signals in the 54-860 MHz region. Because the signals are passed by a laser link and a number of amplifiers, there will be additional random noise and non-linear distortion in the received signals. Also, because of reflections and group delay in the cable plant, there may also be linear distortions present. By capturing a sample of a full-spectrum downstream signal at the hub site and processing it with a downstream signal received at a subscriber's terminal, a level of non-linear distortion can be calculated in a vacant channel. Comparison of captured signal traces is done using DSP (digital signal processing). This processing can be more accurate if the data captured is in a spectral "hole", which may be just above the top frequency utilized, or in an unused 6 MHz channel. Any random energy level in the spectral hole can also be computed. Thus, a full-spectrum capture is done at the hub site, but a capture done by the terminal may be only the spectral hole. This can be done because the terminal has limited memory storage, and because of the amount of bandwith required to relay a long duration full-spectrum captured trace using SNMP.

To simplify the capture of the downstream signal at the relative exact time, a trigger circuit is provided that takes its timing reference from a downstream sync signal. The downstream sync signal could, for example, be provided by a DOCSIS carrier or a particular video carrier the terminal may be using. The signal traces captured at the terminal and at the hub site are relayed using TCP/IP (e.g. SNMP) to a processing station where the DSP processing is done. Processing is done by mathematically distorting the clean signal captured at the hub until the distortion matches the signal captured at the terminal. Any signal that can't be accounted for by distortion is random noise.

The Taylor series expansion is used to empirically determine the levels of a, b, and c coefficients (first, second and third order distortion terms).
2nd order distortion will most likely occur in a fiber optic link, while 3rd order distortion will more likely occur in the amplifiers as a result of common triple beat (CTB). Linear distortion

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will not fill a vacant channel, so all energy found in a vacant channel (or in the roll-off) will be non-linear distortion or random noise.

Linear distortion can also be computed by this system. In this case full spectrum captures are done at the hub and the terminal. Frequency domain division will allow complex frequency response to be calculated. Ripples in the frequency response indicate the presence of echoes and non-linear phase response indicates there is group delay distortion present.
Ingressing carriers can also be revealed by this system. The clean signal captured at the hub site is subtracted by the signal captured at the terminal.

The terminal device can be a cable modem, set top box, or a gateway device.

This system solves the problem of being unable to measure CTB in the field when a system converts from analog NTSC carriers to predominately digital downstream carriers.

By inspecting distortion levels at terminal devices connected to different amplifiers in a cascade, a determination can be made of which amplifier in a cascade contributed an excessive level of distortion. This reduces truck-rolls and time to repair.

b. Why was the invention developed? What problem(s) does the invention solve? How is it better?

When downstream signals converted to digital from analog, conventional methods of measuring CTB became impossible. This allows distortion to be measured without a truck roll. This also allows CTB to be distinguished from random noise.

c. Briefly outline the potential commercial value and customers of the invention.

Big, for reasons less time to repair and less truck rolls for troubleshooting/proofing a system.

4. **HOW is your invention different from existing products, processes, systems?**

See patents by Arcom and Trilithic. Arcom patent has different purpose, which is locating common path distortion on the upstream. Trilithic patent (Reitman) is for upstream burst testing.