INVENTION DISCLOSURE

1. **Invention Title.**

   Non-Service Interrupting Time Domain Reflectometer (TDR) Using Bidirectional Injection

2. **Invention Summary.**
   A TDR is modified to allow it to work on cable plant that is in-service. This allows the diagnostic tests to be done without service interruption.

3. **Invention Description**.

   a. **Describe the invention in detail.**

Problem:
Cable operators are finding defects in their cable plant, frequently in hard line coax. The network monitoring tools being created by Cablelab's PNM (preventative network maintenance) group are locating approximate echo sites, based on affected cable modem locations. The next step for the technicians is to disconnect a suspect cable line and "shoot" it with a TDR to pinpoint the defect. This is usually done from both directions. Accurate defect location is important because digging is involved in a repair. However, disconnecting a cable line for testing is very disruptive to service, as hundreds of subscribers can be affected for a long period of time, perhaps an hour.

Solution:
Build a TDR that works by injecting a test signal into a passive device's unused KS port to propagate a test signal in both directions. The passive device can be a power inserter, directional coupler, or tap. The time to receive a reflection will accurately locate the defect. Generally, a direction a defect came from can be determined by distance information. For example, the test point may be up against an amplifier output. Alternately, the technician can go to another tap location and determine if he got closer to the defect, or further away from it.

See Fig. 1. KS port access allows a probe to touch the seizure screw. Passive device has two seizure screws, A and B that are accessible through the two KS ports. Either one may be used. Connection to a KS port will create a mismatch, so the mismatch will be created for only a brief test period. This is done with the optional electronic switch that closes while the test is being performed. Also illustrated is an optional low pass filter (LPF) that acts to block downstream energy from interfering with the TDR test. The TDR, which may be a modified off-the-shelf model, has a transmitter that generates a test signal, typically a pulse. Then electronic switch may close for the duration of the test. A high-impedance receiver senses both the transmitted signal, and the reflection. A display informs the technician the distance to the defect, taking into account round-trip travel time and velocity of propagation of the cable. Note that at point A the impedance will be half of 75 ohms, or 37.5 ohms. This can be taken into account when designing the test equipment, or the temporary mismatch can just be tolerated.

INVENTION DISCLOSURE

The low pass filter also acts to prevent interference to downstream services from test signals. It a modem transmission is occurring the instant of the test, the test can be repeated to fall into a transmission dead spot.

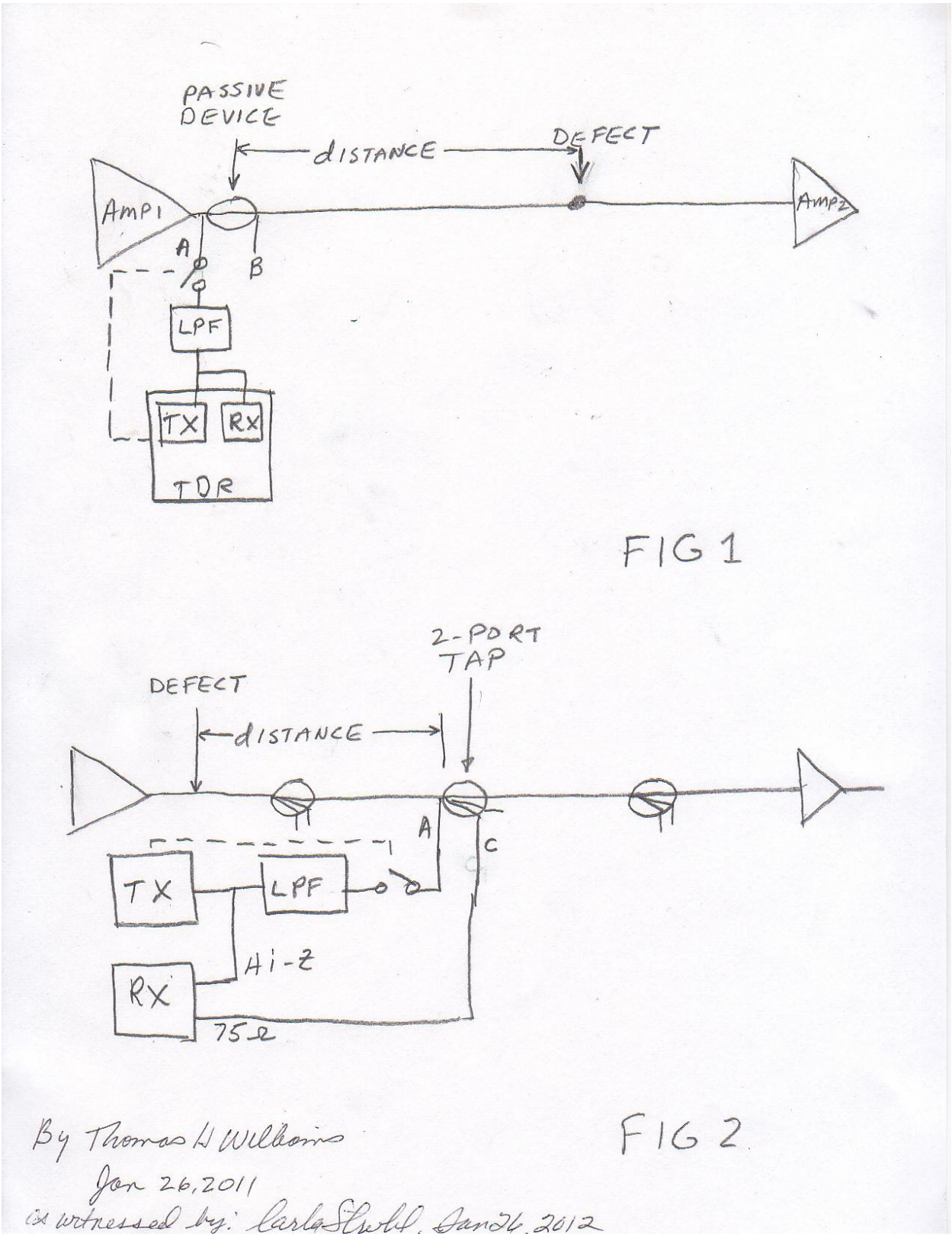
If the passive device is a tap of a directional coupler, the direction to a defect can easily be determined. See Fig. 2. Assume the TDR test is performed on a second tap in a string of 3 taps. The test signal is injected on point A and received on point A. The test signal is also received on point C. If the defect is upstream, a return signal will be generated, if the defect is downstream, a return signal will not be generated.

Another variant of this idea is to generate a test signal that is tolerant to additive ‘noise’, such a signals being transported on the plant. The test signal in this case should carry more energy than a single pulse. For example a PN-sequence, a Zadoff-Chu signal, or a chirp could be used. Any of these high-energy signals could be processed with digital signal processing for distance determination with spurious energy reduction. This would allow testing at higher frequencies where distance resolution would be better.

Note that since plant may be powered, an AC blocking capacitor should be employed.

Also note that PNM ranging resolution is about 1 tap without interpolation. If DOCSIS is using a 6.4 MHz channel with a 5.12 MSymbol/sec. symbol rate, and this invention’s test signal uses a 50MHz wide test signal, it should have approximately ten times more distance resolution accuracy.

INVENTION DISCLOSURE



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

INVENTION DISCLOSURE

Some MSO field crews are finding defects with PNM tools, but before digging starts, the lines must be disconnected to very accurately locate the distance to the reflection using a conventional TDR. Accuracy must be high for digging. These outages affect numerous subscribers for long periods of time.

c. Briefly outline the potential commercial value and customers of the invention.
Large. Many thousands of miles of cable plant have many defects, and vital services, such as 911 calls can't be disconnected.

4. **HOW is this invention different from existing products, processes, systems?**
See attached Trilithic I-Stop product data sheet. Used for sniffing, not injection.

"**Track reverse ingress down to the nearest tap**

The I-Stop Reverse Test Probe is a test accessory that you can use with most signal level meters to take bi-directional signal measurements with no risk of power damage.

Just screw the probe into a distribution tap's unused KS port and a spring-loaded "stinger" connects a 20 dB resistive test point circuit to the hardline. The bi-directional connection lets a meter or analyzer measure forward and reverse signals, as well as reverse ingress. A built-in AC/DC blocking circuit protects the meter or analyzer from damage from online power up to 90 volts. The I-Stop Probe also works with Trilithic's 860 DSPi and 9581 SST to let you track reverse ingress sources down to the nearest tap – without removing reverse modules or diplexers and without disrupting forward or reverse service."