Enhancing Embedded Copper Plant for Improved Voice and DSL Performance

BACKGROUND

In 1877, the first significant deployment of public telephone lines occurred between Boston and Salem, Massachusetts. In the one hundred and thirty years since that original installation, millions of miles of copper twisted pairs have been buried and strung across the nation. Copper plant remains a valuable asset to the telecommunications providers of today. Despite its limitations, copper is often the fastest, easiest and most economical way to deliver voice and data services to subscribers. This white paper will explore the ways in which three technologies from Charles Industries (Smart Coil™, AdrenaLine™ and HVDL) are adding value to embedded copper and helping service providers optimize their outside plant for extended-reach DSL delivery.

SMART COIL

Target Application: ADSL and POTS transmission on a single copper pair

Charles Industries has a long history of providing innovative technologies that enhance the performance of copper. The company introduced the telecommunications industry to the modular encapsulated torrodial coil (load coil), a simple device that added inductance to copper pairs in order to improve quality of service on copper pairs delivering plain old telephone service (POTS). Charles load coils have been a staple of the outside plant for over 40 years, deployed by virtually every telecommunications provider. While load coils are very good at improving quality of service (QoS) on POTS lines, they are a roadblock when it comes to delivering ADSL signals over copper. Common load coils limit the high frequency spectrum used by ADSL, and therefore must be removed from a copper pair before it can be conditioned for ADSL deployment.

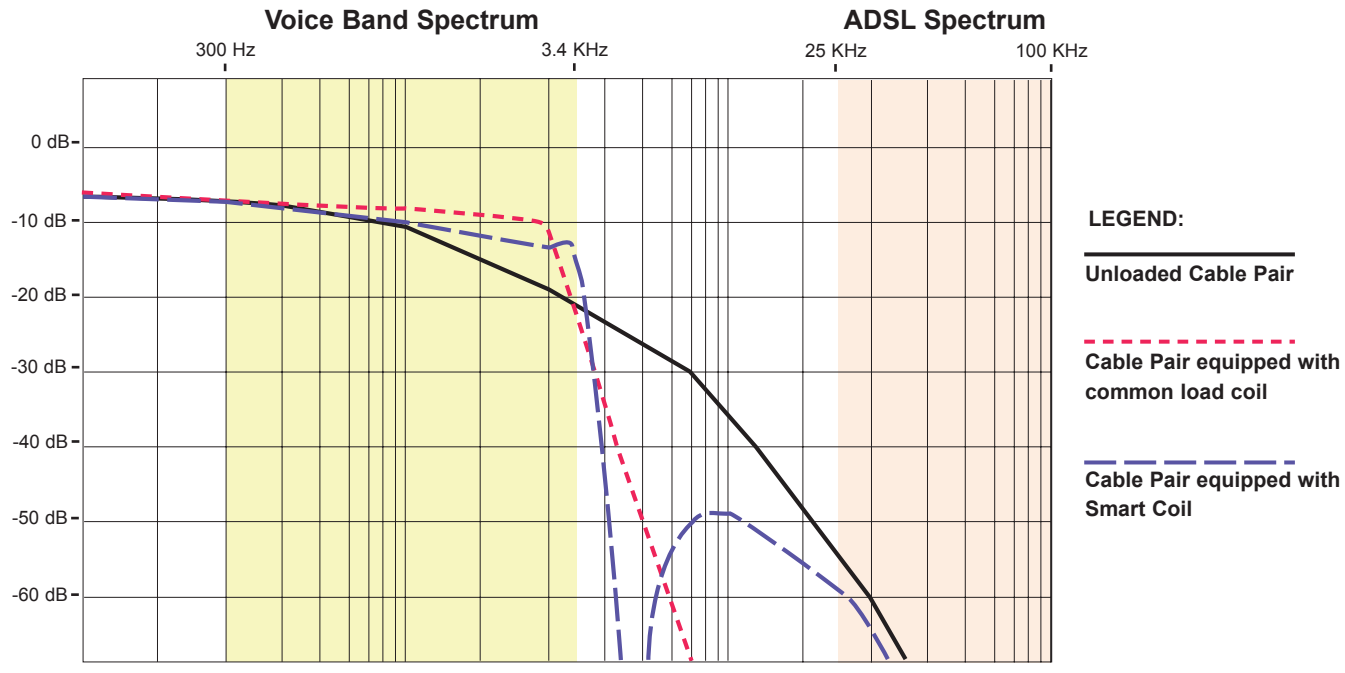
In 2002, Charles introduced an innovative solution to this problem. The Smart Coil solved the dilemma of line conditioning a copper pair for both POTS and ADSL signals. Smart Coil provides the line conditioning benefit of a common load coil for POTS traffic while allowing an ADSL signal to pass through. With Smart Coil, a loop that was providing either POTS or ADSL exclusively can instead handle both services on a single copper pair.

Voice quality commonly deteriorates on unloaded pairs at distances beyond 18Kft. Load coils have long been used to extend high quality voice service to customers beyond this distance. However, common load coils limit the high frequency spectrum used by ADSL, requiring an additional pair or refusal of ADSL service. Smart Coil removes the loop length limitations of ADSL and allows it to reach its maximum deployable distance, an impossibility with the use of common load coils.

With Smart Coils installed in place of common load coils on the copper pair, signal equalization is maintained throughout the voice band spectrum, while the ADSL signal is permitted to pass through (see **Figure 1** next page). Unlike a standard load coil, Smart Coil is essentially an LC notch filter, providing internal inductance and capacitance with a resonant point tuned to the dead space between the POTS and ADSL signals. A notch filter typically consists of an inductor and a capacitor that passes most frequencies unaltered, but attenuates those in a specific range to very low levels.

The design of the Smart Coil allows for flexible placement. Smart Coil actually senses the pair and adjusts automatically. This allows for ease of installation on almost any system. The Smart Coil may be deployed in either 66mH (4,500 ft.) or 88mH (6,000 ft.) standard spacing, with the first Smart Coil placed at half these distances. It is important that all bridge taps, build-out capacitors, lattice networks and common load coils be removed when using Smart Coil. Preparing the cable pair to be as close to an ideal non-loaded pair, as would be done for ADSL transmission, achieves Smart Coil's maximum benefit.

FIGURE 1: TYPICAL CABLE FREQUENCY RESPONSE



The great majority of FAX and dial-up modems work correctly with the Smart Coil, although Smart Coil typically caps the top data transmission speed attainable to 33 Kbps on these devices. This speed limitation is a function of the position of the Smart Coil and the cable type. Some loops have slower modem speeds while others have faster modem speeds. The slower speed is a result of the limited energy available for POTS gain. To obtain sufficient POTS gain without affecting ADSL transmission, the POTS bandwidth is reduced.

Most Voice Frequency Repeaters (VFRs) work with Smart Coil. However, a few VFRs are not compatible. Since there are several manufacturers of VFRs, the customer should test Smart Coils with their particular brand/model of VFR prior to a full scale Smart Coil deployment.

ADRENALINE

Target Application: Increase the rate and reach of ADSL and ADSL2+

AdrenaLine is a powerful tool for service providers looking to expand their DSL serving areas or improve service to existing customers. Easily deployable on existing copper pairs, AdrenaLine significantly boosts DSL transfer speeds and extends coverage to areas that can not be conveniently served with traditional deployment methods.

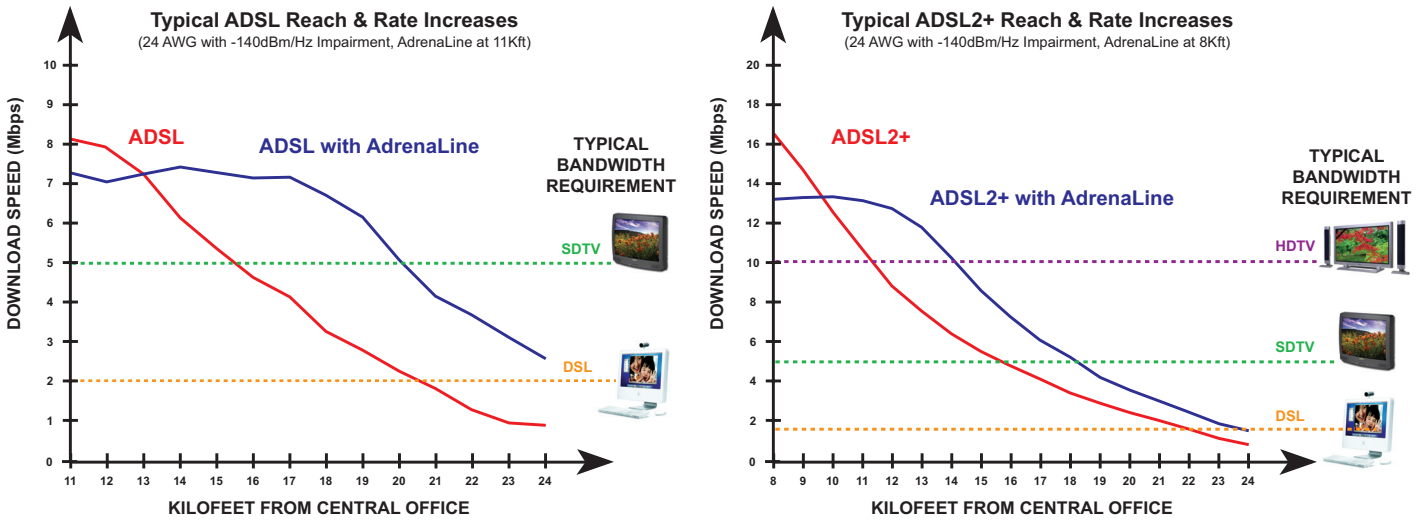
AdrenaLine is an analog device that improves available bandwidth through noise filtering and signal amplification. AdrenaLine tunes its internal circuitry to compensate for distance, wire gauge and other plant variables, and conditions the DSL line in both directions to maximize rate and reach. Noise filtering helps mitigate cross-talk effects, improve signal-to-noise-ratio (SNR), and minimize code violations. By placing AdrenaLine midway between the DSLAM and furthest CPE, minimal power is required, and negligible disturbance is imposed on adjacent pairs.

AdrenaLine conditioners are designed to install approximately midway between the DSLAM and the subscriber. A sheathed cable stub extends from the AdrenaLine case for splicing into existing copper twisted pair cable. AdrenaLine conditioners can be mounted in virtually all OSP applications, including pedestal or pole mounted, placed in grade level boxes, aerial strand mounted, or direct buried.

Deployment of AdrenaLine conditioners requires no changes at the central office, no equipment at the subscriber and no local power. A field technician can install AdrenaLine conditioners into existing copper cables in the same manner as other Telco-approved line conditioners

The data in the charts presented in **Figure 2** shows typical results based on multiple field observances of AdrenaLine installations. Actual performance may vary due to cable gauges, condition of the cable plant, and network hardware.

FIGURE 2: DSL RATE AND REACH GAINS WITH ADRENALINE



AdrenaLine is available in both line powered and express powered units. Both types of powering options have a short loop and long loop configuration available. Service providers are therefore able to choose the configuration that best supports their specific application in terms of bandwidth allocation.

Based upon studies of actual serving area plans, provisioning with AdrenaLine reduces the placement costs of traditional FTTN deployment architectures by approximately 25%. AdrenaLine eliminates or greatly reduces the number of expensive fiber node placements necessary to provide DSL to the typical distribution area. It is also less expensive to install and maintain than are fiber nodes. The majority of expenses associated with node placement are avoided; including right-of-way access permits, concrete pad placement, cabinet and hardware costs and local power.

An AdrenaLine Distribution Interface (ADI) is available to accommodate up to twenty-five (25) single line units in an environmentally-protected enclosure for multiple line deployments of AdrenaLine. The non-metallic ADI offers superior strength, outstanding environmental protection and ease of installation. It is available in both non-flame retardant and flame retardant models. Internally, the ADI features a two-tier rail system for mounting up to ten (10) AdrenaLine units on the top rail and up to fifteen (15) units on the lower rail. The ADI is available with terminal blocks for terminating AdrenaLine units and OSP cables in an orderly fashion.

USING SMARTCOILS WITH ADRENALINE

The combination of Smart Coils and AdrenaLine on a copper pair yields a line to the subscriber that is capable of delivering both clear POTS and DSL up to 28Kft. from the central office (see **Figure 3** for typical results). This combination is especially effective in bringing cost-effective DSL to rural areas using embedded copper plant.

FIGURE 3: DSL RATE AND REACH GAINS WITH SMART COIL & ADRENALINE

DSL Rate[1]	Smart Coil only (on 24 AWG)	Smart Coil with AdrenaLine (on 24 AWG)[2]
Up to 512 Kbps	18-24 Kft	18-28 Kft
Up to 768 Kbps	18-22 Kft	18-28 Kft
Up to 1.5 Mbps	18-20 Kft	18-25 Kft
Up to 3.0 Mbps	*Not Obtainable*	18-22 Kft

[1] Smart Coil does not increase the rate nor the reach of the DSL signal, but rather allows DSL to reach its maximum distance. Rate levels shown are typical, but not guaranteed.

[2] Rates shown reflect the performance of Smart Coil with Charles' AdrenaLine DSL Line Conditioner. Smart Coil is also compatible with other manufacturers' DSL Line Conditioning products. Attainable distances will vary depending on the conditioner used.

HIGH SPEED VOICE AND DATA LINK (HVDL)

Target Application: Extended-Reach DSL up to 112 Kft.

The Charles' High-Speed Voice & Data Link (HVDL) enables a single copper pair to deliver up to three voice channels and one high-speed Ethernet data channel to small business and residential subscribers, both urban and rural. Utilizing low-noise, low-power TCPAM (G.shdsl) line coding, the system multiplexes three 64 Kbps Clear channel voice lines and one high-speed data line for transport, then demultiplexes at the subscriber's Remote Terminal (RT). The system, which supports advanced CLASS services, consists of a Central Office Terminal (COT) line card, shelf, RT and optional repeaters. The RT and repeaters are line powered.

HVDL allows providers to offer high-speed internet connections to more of their total service area. An optional line-powered repeater allows the system, depending on the application and wire gauge, to deliver the full payload data rate of up to 1Mbps up to 44,000 feet or 128 Kbps up to 56,000 feet using a single repeater. Greater distances may be achieved using additional repeaters. Using the Local Power RT option, HVDL can extend high-speed data connections up to112,000 feet!

Unlike DSL systems that require large initial equipment investments, HVDL can be deployed one customer at time. The system requires only a Central Office Terminal (COT) line card, shelf and RT to deploy. HVDL's pay-as-you-grow scalability allows service providers to deploy high-speed data lines without the prohibitive cost of a DSLAM. Suddenly, bringing the internet to small subdivisions and other sparsely populated areas can be both practical and profitable.

HVDL is also ideally suited to replacing Digital Added Main Line (DAML) systems in the event that a DAML-served customer wishes to upgrade their subscription to include high-speed data services.

SUMMARY

Charles comprehensive portfolio of extended-reach, copper-based DSL solutions offers something for every service provider's "tool box" of DSL solutions. Smart Coil can be used to deliver POTS and DSL up to 24 Kft. AdrenaLine can bring DSL to customers up to 28 Kft. from the central office. For the most hard-to-reach customers, HVDL can provide high-speed internet access with up to a 112 Kft. reach. These results are summarized in **Figure 4**.

Charles extended-reach DSL solutions are often the most economical way for service providers to offer their customers affordable DSL with reliable performance. By utilizing embedded copper assets, these solutions are quick to deploy and quick to provide a return on investment.

For more information on the solutions featured in this whitepaper, please call your Charles representative or visit the Charles Industries website at **www.charlesindustries.com**.

FIGURE 4:
MAXIMUM REACH OF CHARLES EXTENDED-REACH DSL SOLUTIONS

Maximum DSL Distances Attainable Using Charles Extended-Reach DSL Solutions

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