HIGH BANDWIDTH PORTABLE TRANSMISSION SYSTEMS

USE OF xDSL TECHNOLOGY IN MILITARY, INDUSTRIAL AND TELEMETRIC APPLICATIONS

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ABSTRACT

This paper introduces new telemetry (communications) equipment based on Digital Subscriber Loop DSL technology (high speed transmission over copper cables) for defense and industrial applications.

A brief xDSL technology overview is followed with introduction of the new 'P3' product and its application, reviewing advantages of using copper as a communications medium whenever rapidly deployed data and voice links are essential.

An Australian Army report, detailing a specific equipment deployment's findings is reproduced as an independent reference material.

KEYWORDS

Asymmetric Digital Subscriber Loop Technology	- ADSL
Rate Adaptive Digital Subscriber Line	- RADSL
Carrierless Amplitude/Phase Modulation	- CAP
Discrete Multi Tone Modulation	- DMT
Steel Reinforced Copper Cable	- DON10
Very High Rate DSL	- VDSL

Introduction

A modern military force depends on reliable communications to ensure field success. That's why it is vital for a communications system to be fully capable of handling high data rates, be simple to install and offer flexibility of wide range of applications. That is where the new patented Portable xDSL System offers a way forward for secure telemetry transmission equipment.

xDSL technology offers fast transmission rates over standard copper cables. A new design of a portable xDSL-based transmission system, specifically tailored for defence and industrial applications, offers advantage for tactical deployed LAN extensions in terms of speed and distance and a wide range of additional features. These features, such as, meteorological monitoring stations, remote air and moisture sensors, data encryption, HP-IB and other industrial control interfaces and numerous other telemetric applications are provided by a standard PCM/CIA cards. To date, there is no equivalent product on the market in one self-contained portable package.

The strength of xDSL in defence and industrial applications is that the technology effectively provides viable high-speed communications links over a sturdy physical infrastructure (copper cable; plain or reinforced). In fact, copper remains the preferred infrastructure in many military and industrial applications. While fiber-optics clearly offer more bandwidth, the cable often breaks under strain and repair is often unpractical in the field environment. Wireless technology offers easy solutions but only where the radio waves can propagate. Copper, on the other hand can be installed rapidly and inexpensively and, used with xDSL transmission technology, offers fast transmission speeds (8Mbit/sec).

In a collaboration with the Australian Army, Defence Communications Industry, a small Australian R&D company designed a portable ***Rate Adaptive DSL (RADSL, an xDSL variant)*** transmission device, poised to be deployed widely in defence, mining, utilities and other industrial applications.

Although 60 to 80% of world's DSL market remains a domain of incumbent operators, based on the ownership of copper in the ground, there is a widely unexplored market of specialised applications for DSL. The new concept of a portable DSL-based system has been designed to occupy this niche.

In the next chapter of this paper we briefly review the ADSL technology, compare it to other similar broadband technologies and identify several potential non-telco applications. In chapter IV we resume our main focus on the new Portable RADSL system.

xDSL - Technology Overview

xDSL is simply a new transmission or modulation technique that takes advantage of the unused bandwidth or frequencies spectrum existing in telephone copper cables.

Data rates achievable are in the order of 8Mbit/sec for one direction and 1.5Mbit/sec in the other. This modulation technology is asymmetric due to the signal interference arising at such high data rates - hence ADSL (Asymmetric Digital Subscriber Loop).

These transmission speeds are well above the speed of conventional dial-up modems; in fact more then 50 times faster and require no new cabling and since xDSL modulation frequencies are above voice telephony spectrum; it leaves the phone services unaffected. The same telephone (*or copper*) line is used for both; high-speed data applications and standard telephony. This is in fact, xDSL's main attraction to service providers - *no need to install new data infrastructure*.

Telcos' main xDSL applications are fast Internet and LAN extension applications. There is a distance limitation (2..4Kms subject to line conditions). Importantly, both of these limitations are overcome with Portable RADSL Systems - described in the later chapters.

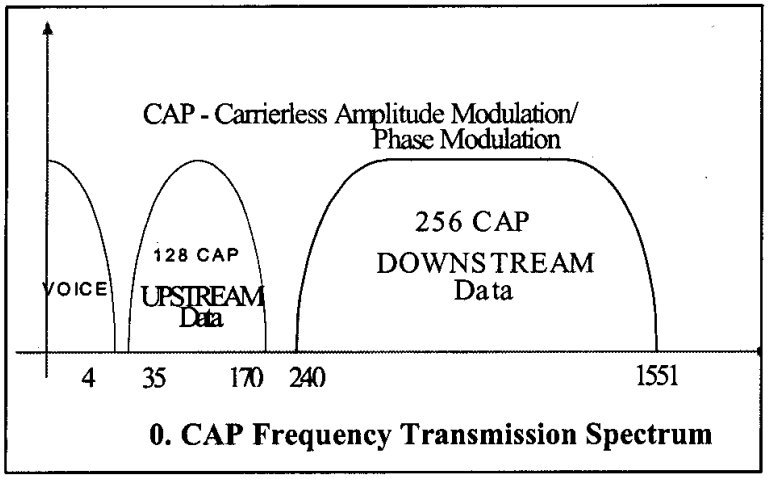
XDSL Standards

Two main standards bodies in association with the industry are deriving xDSL standards; ANSI and ETSI. In addition, the ADSL Forum, established in December 1996 actively promotes the ADSL concept, facilitating development of system architectures and protocols. The 'ADSL Forum' web site [www.ads1.com] offers wide ranging information including links to numerous ADSL manufacturers.

xDSL has been characterised into two principle modulation techniques:

- CAP (Carrier-less Amplitude/Phase Modulation and
- DMT (Discrete Multi-tone).

CAP *is a version of QAM in which incoming data modulates a single carrier that is then transmitted down a telephone line. The carrier itself is suppressed before transmission (it contains no information, and can be reconstructed at the receiver), hence the adjective "carrier-less "*



0. CAP Frequency Transmission Spectrum

Figure 0 illustrates CAP frequency spectrum. It can be seen that voice channel occupies the smallest part of the spectrum (0..4.3KHz) and can be separated (filtered) from the data frequency spectrum.

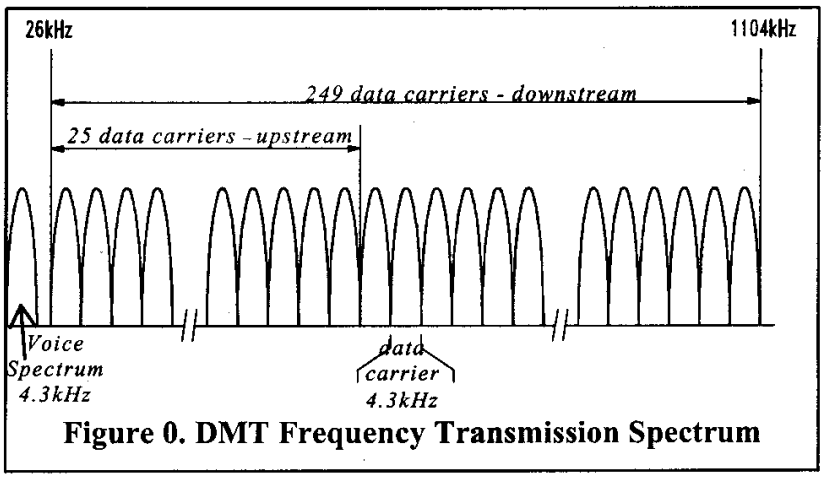


Figure 0. DMT Frequency Transmission Spectrum

DMT (*see below*) is a version of multi-carrier modulation in which incoming data is collected and then distributed over a number of small individual carriers, each of which uses a form of QAM modulation. DMT is the basis of ANSI Standard T1.413 and is becoming the prevailing standard, considered to be more resilient to electrical noise (*DMT is the preferred standard in Defence forces*).

Of interest is the fact that analogue voice telephony can be transmitted simultaneously as the data and without interference. Both frequncy spectrums in figures 1 and 2 indicate the 4.3 kHz as voice frequency 'channel' - in fact 4.3 kHz is a standard bandwidth of a voice telephony (POTS).

This has been utilised in the new equipment, allowing permanent voice link, even when the computer network (i.e. data link may be down). In fact the voice channel can be used as either a standard telephony extension or an back up / assistance voice channel.

Technology Variants and Acronyms

ADSL - **A**symmetric Digital Subscriber Line
RADSL - **R**ate **A**daptive DSL (*automatically adjusts the optimal transmission rate on any given copper cable link*)
HDSL - **H**igh Data Rate DSL (*symmetric*)
SDSL - **S**ymmetric DSL (*typically 640Kbitls available in both directions*)
VDSL - **V**ery High Speed DSL (*up to 52.8Mbitls over short distances of up to 300m; longer distances are achieved as the data rate is reduced*)

Comparable Transmission Technologies

Voice Modems - offering maximum speed of 56 kbit/sec and typically are 33.6 kbit/sec. These days voice modems are considered obsolete technology especially when graphic intensive files are involved.

ISDN - digital telephone lines with standard speed of 56 kbits and variants of up to 128 kbit/s. Requires special Terminal Adapters and availability of a digital switching network. ISDN is a better alternative to a 33.6 kbit/s modem but in the long term this technology is poised to be considered in the same league as voice modems.

Satellite - offering down-link speed of up to 400 kbit/s and requiring up-link transmission via a voice modem (*ie. only up to 56 kbit/s*). Satellite reception will require a mini-dish antenna. Its main advantage is wide availability in rural areas.

Cable - Offering Internet transfer speeds of up to 30 Mbit/s. Typical speeds achievable are 1.5 Mbit/s for downstream and 300 kbit/s for upstream. Importantly however, this service can only be available where existing Cable-TV (*coax cable*) passes. The other important consideration is that the bandwidth on the Cable is shared with other users. Meaning that at peak times transfer speeds would decrease. Cable is comparable with xDSL in functionality and the two technologies are likely to coexist.

Portable (RADSL) Systems for Military and industrial Applications

The Concept

Modem data applications demand rapidly established communications links of high bandwidth. This is particularly prominent in areas of defence and industrial applications (such as mining, telemetry, etc).

xDSL is one of the best technologies to cope with this demand. A niche market has been identified by the Australian Department of Defence in field deployed LAN link extensions. The concept of portable RADSL (Rate Adaptive DSL) systems has been designed with cooperation of the Australian Army and since proven in several strategic operations.

Portable RADSL Systems provide LAN (1013T Ethernet) extensions over copper wires. Their main advantages over standard telco xDSL systems are:

a) flexibility in bandwidth configuration
b) distance limitation (3..4KM) overcome configuring device as a “repeatee’
c) stand alone operation; no external computers are needed to operate or configure devices
d) battery operation

Additional and specific advantage for military applications is that copper offers a significantly cheaper and simpler medium, compared to fibre-optic based infrastructure. Fibre-optic cable damages easily in an operational environment and that is exactly where the old humble copper cable shines - as a viable broadband communications medium.

The main appeal of xDSL in defence and industrial applications is that the technology effectively provides viable high-speed communications links over a sturdy physical infrastructure (*copper cable; plain or reinforced*). In fact copper remains the preferred infrastructure in many military and industrial applications. Whereas fiber-optics clearly offer more bandwidth, the cable often breaks under strain and its repair is often unpractical in the filed environment. Wireless technology offer easy solutions but only where the radio waves can propagate. Copper, on the other hand can be installed rapidly and inexpensively and in together with xDSL offer cheap and high speed communications links.

The new portable xDSL system, designed by the paper's author was called "P4*" (**P** for portable and **4** is for four channels*). These systems can be used in a number of industrial applications; are easily configured via the onboard micro-controller (*no external computers are required*) and operate on internal battery. A variety of power sources (*DC or AC generators or solar panels could be used*) to operate the device.

The "P4" concept extend possibilities over the typical xDSL system. They can operate; from a simple point to point transparent LAN (Ethernet) link to a complex web of "P4"s and importantly, as a data repeater configuration (*effectively extending the reach of P4 from 5 to 10Kms and beyond*). The same device can operate as a line qualification, testing and measurement instrument.

Data throughput, achieved over 1 to 3Km lengths of copper cable is typically in the order of 8Mbit/sec in one direction and 1Mbit/sec in the other direction. As the distance of the link increases the effective throughput stars to decrease (e*.g. 4Km of steel reinforced copper cable, operating in adverse conditions, produces data rates of 4.6Mbitlsec and 1Mbit1sec in respective directions*).

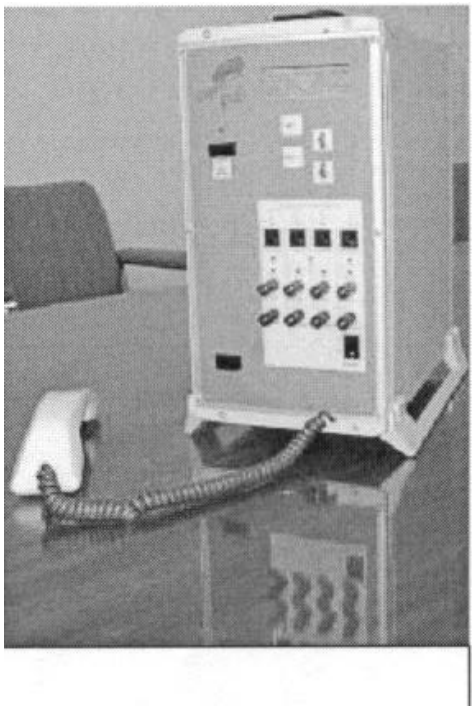
Other applications for Portable ADSL systems include general LAN network extensions and fiber-optic based LANs back-ups in any of the following general areas;

Telemetry applications
Defence
Fire Brigades
Police
Mining
etc.

P4's unique design, incorporating both "master" and "slave" transceiver modules, provides for an effective range extender (repeater) configuration. This effectively extends the physical reach of ADSL in hops of 3..5 Km. This is an important feature as it allows very effective LAN extensions over long distances (E.g. Rail Lines, Oil Pipelines, Airport Security perimeters and similar).

The Proof Of Concept

In April 1999 the first functional prototype of the new portable **RADSL** system was manufactured . The product came with batteries making it possible for operation in isolated locations without power, as well as, operation from a variety of AC and DC power sources.



Another important feature of P4 is to offer voice communications over the same copper cable, independent of the data transmission (*the so called "engineering wire " that can be interfaced into any telecommunications network*).

The bandwidth, maximum possible transmission between any two P4s, is automatically set depending on the line condition (*the so-called Rate Adaptive DSL - RADSL protocol, similar to the way a common telephone modem negotiates. The best speed possible is selected; typically 8Mbit/sec in one and 1Mbit/sec in the other direction*). P4 displays actual line operating parameters on its status display during its operation.

In total 10 x P4 were made, of which 9 were delivered to Australian army for trials.

Australian Army 'P4' Field Trials (incl. the Army report extract)

Australian Army tested P4s in several operations, most prominently, during its East Timor mission.

Below is a report extract by WO2 Peter Thornton and Major Ian Thomas of the Australian DoD (Signals and Army HQ); who effectively instigated and promoted xDSL technology within the Australian Department o Defence;

"New Technology - WDD A/TT (Don-10) Network"

Army uses fibre-optic cable to provide a communications infrastructure for logistic support. The fibre optic cable, kevlar-armoure especially for Defence, is an expensive medium and suffers breakages from being caught up in the track link of tanks or broken by forklifts. These accidents, actual events during Exercise Phoenix, normally occur during night under blackout conditions. Although the fibre can be repaired, such repair requires return to base and expensive facilities.

Army traditions uses Don-10 copper wire strands reinforced with strands of stainless steel wire to carry voice in the field. This cable, capable of withstanding heavy stress, still gets broken but is easily repaired by users. Wire cable deployment is also considerably easier to achieve than laying fibre optic cable. P4 xDSL was employed during Operation Phoenix and Crocodile West to prove an ability to replace fibre optic cable segments with Don-10 on selected long runs.

The following are some first hand impressions and feedback from Army users of the Don-10 technology on Operation Phoenix; "Soldiers understand this and they can fix it" (meaning wire and breaks that occur as opposed to fibre optic cable); "Can I get some more; "This is great"; and "Hey, it works".

Portable xDSL systems provide data rates over copper or steel cables that are acceptable with significantly reduced capital costs. P4 primary application during Operation Phoenix was to enable a transparent LAN extension within a large logistic area, located in the bush near Tindall.

A number of specific future requirements have been discussed. One such special development is a simple back to back xDSL modem, providing the Army with rapid deployment multimedia infrastructure over copper cable. It greatly reduces the cost-per-line factor due to the elimination of the more cumbersome subrack assembly of a standard system. This technology successfully provided the logistic LAN backbone on Operation Crocodile West, 150 km SW of Tennant Creek, when fibre optic breakages and distance limitations proved difficult to overcome.

The WDD A/TT (Don-1 0) LAN extensions are robust, cost-effective and well-accepted by soldiers. Tempest-rated within the restricted environment, the solution is now a Defence Infrastructure standard within the strategic environment however it is not yet formally accepted in the tactical arena.
end of report

This field exercise clearly indicated viability of portable xDSL systems. There have been several other successful strategic deployments of the technology by the Australian DoD over the last two years including; HMAS Cerberus, Holsworthy Barracks, Fort Queenscliff and other bases.

Royal Australian Air Force (RAAF) Airborne Telecommunications Unit (ATTU) has deployed a number of RADSL systems for its remote communications requirements.

In summary, the Australian DoD views the deployment of xDSL as "copper cable resurrection" and the recent operational deployments have clearly proven it.

In the most recent "real" event, the Australian Army deployed the 8 P4 systems in East Timor for INTERFET peace-keeping operations.

The Future Of Portable (RADSL) Systems (*Copper Resurrection*)

Following the product's initial deployments, we plan to release the redesigned version of the portable RADSL system, suitable for Defence, Mining and Utilities Markets and a wide range of industrial telemetric applications.

P3 (Portable 3 channels) is a portable stand-alone device, requiring no external devices to configure or operate it. This is an important feature in rugged industrial applications. All unit's management is established via the internal microprocessor. P3's internal batteries provide and-by operation for up to 8 hours. Internal encryption chip provide optional security over copper lines.

P3 – Functioning Prototype : April-01

The product is particularly suitable for telemetry applications where a rapid deployment of data networks is essential, including;

- Defence
- Emergency Services (Fire Brigades, Police)
- Mining
- Remote Meteorological Weather Stations
- Gas/Oil Utilities
- Remote Sensors Control/Management etc

P3 will also function as an effective line qualification and testing tool, offering automatic loop-back facility and measuring line/s performance. One of the configuration options of the device could be a new generation (high bandwidth) data logger. Its design, incorporating both " master" and "slave" programmable transceiver modules, provides for effective flexible configurations for its many applications. P3's unique feature is to be configured as a range extender (repeater), effectively overcoming the physical reach of RADSL (of about 4Km). Any number of P3s can be cascaded together.

An important new feature is introduction of USB interfaces significantly extends 'P3' applications (e.*g. instrumentation and sensors reading, video surveillance, tele-medicine and many others). All of these optional interfaces will run transparently over the RADSL channels.*

Integrated handset provided telephone function between any P3s and can be interfaced into the telephone network.

The phone operates even if the data link fails. Other new features considered for future product releases are VDSL transmission (up to 52Mbit/sec), as well as, radio and fibre-optic modules.

Conclusions

The pivotal factor in successful xDSL technology introduction is the product's suitability for any given application. Considering, essentially industrial applications for portable RADSL systems, it transpires that, in a similar way that any business or domestic customer can benefit from the additional bandwidth derived by the technology, an industrial customer can too, substantially benefit from the extra bandwidth. This is specifically relevant in the area of industrial telemetry.

A standard telecomms xDSL system requires telephone exchange infrastructure to operate it. Portable, stand-alone systems does not. Further, it offers advantages of stand alone operation, configuration flexibility and numerous USB compatible products considerably extending the systems' functionality.

Portable, stand-alone RADSL systems are likely to find substantial popularity in industrial and defence applications, wherever usage of copper cable is considered to be the preferred infrastructure for communications.

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