CAN Line Conditioning

© Malcolm Moore
23-Mar-2003

(2003, 2005, 2007, August 2012)

Introduction

If the transmission and/or signalling specification cannot be met by a direct physical pair (unconditioned local loop) – usually because the length is too long, then some form of line conditioning and/or pair gain system is employed to bring the unconditioned local loop within specifications.

A **Pair Gain System** (PGS) is a generic term for equipment that either conditions the line to work within specification over a greater distance, and/or makes a lesser number of pairs of wires appear like a greater number of pairs of wires.

Loaded Cable

Up until the1990s in Rural and Remote areas of Australia, where customer access lines were longer than about 7 km, it was common to 'Load' the customer cable with Loading Coils (88 mH balanced coils), spaced 915 m from the exchange and then every 1830 m, leaving the last customer section to be at least 1200 m. Loading had the effect of flattening out the frequency response up to 3.4 kHz, and this was very good but cable transmission in the Voiceband range is a very ugly technical issue to manage.

With Unloaded cable, the cable natural impedance is frequency and line length dependent - so the impedance is "Complex" - meaning that it changes with frequency. The frequency response is also particularly nasty because as the frequency is increased, from about 200 Hz to 3400 Hz, the line impedance falls away from about 1200 ohms to about 400 ohms (capacitive) and this combined with the inherent loop resistance in the cable pair ends up with a frequency response that falls away over about 800 Hz - resulting in speech sounding rather muffled (like speaking with your hands over your mouth).

By adding the loading coils as specified, this formed a 'lumped impedance low pass filter' that had a virtually flat frequency response giving very good speech clarity. Unfortunately the CAN impedance as seen from the exchange end was inconsistent with non-loaded CAN cable and this resulted in a major cause of echo and 'howling/screeching'. Also, unfortunately, these coils were very susceptible to lightening, and often were incorrectly installed. The commissioning procedures also very complex and very time consuming, so the chances of these working correctly for a number of years was minimal.

Voice Frequency Hybrid Amplifiers

The line conditioning replacement technology for Loaded customer cable was to introduce a Voice Frequency Hybrid Amplifier (VFHA) at the exchange end of the long customer line, and then both amplify and equalise the line response to bring the line just within maximum specifications. This practice made the service work - but it presented a nominal impedance of 600 ohms which was better than the loaded cable but still caused echo problems in many situations where the interfacing with the local exchange was difficult.

4 Channel Digital Pair Gain System

Another line conditioning replacement technology was Four Channel Digital Pair Gain Systems (4DPGS). These systems have two parts - one at the Local Exchange and the other very near the Customer Premises. At the local exchange end and from the customers end, the equipment 'looks' like an urban cable. The system has four digital bi-directional channels that operate over two pairs and the poor transmission characteristics of the customer access cable over a considerable distance are accounted for so that the system is usually well within specification for voice transmission - and it is not too bad for data/Internet for speeds up to about 24 kb/s.

Remote Customer Multiplexer (RCM)

With technology advances in the 1980s one option that became financially practicable was to install a 2 Mb/s link to a remote curb-side cabinet and install an Exchange Unit (that interfaced to the MDF with speech bridges and signal interfacing to the 2 Mb/s link) and Remote Unit equipment (that interfaced to the 2 Mb/s link and emulated the ring-down/ loop disconnect signalling along with speech bridges) so that 30 channels could be extended from the MDF in a local exchange to a suburban area that had too few physical cable pairs. This technique has put as many as 480 circuits through to single remote sites in the CAN.

This engineering approach had merit as it saved on the very expensive process of laying of copper customer cables (which technically reach their use-by date at about 45 years in service). Unfortunately the RCM approach prohibits the use of ADSL over the same cables to the customers - and a forward solution was imperative.

In Regional and Remote areas the RCM engineering technique has shown particular value and interfacing through point-to-point radio between the EU and RU have been very successful. There was a major transmission problem in that each transmission channel worked its way down to a single physical pair on the MDF before working its way back to digital in the CAN. The technological step was to find a way to remove the local switch, and connect at a 2 Mb/s DDF interface to avoid multiple translations between digital and analogue transmission modes, and the other sticking point was managing the signalling interfaces to integrate the multiplexer.

Remote Integrated Multiplexer (RIM)

With advances in network signalling technologies, it became possible to create an integrated multiplexer much like an ISDN Exchange Unit that provided a direct connection of up to 30 channels per 2 Mb/s link with common system signalling for those channels and acted as a very small terminal interface from a Node Exchange.

This type of Pair Gain systems (PGS) is a Remote Integrated Multiplexer (RIM). Like the RCM, this has an Exchange Unit (EU) and a Remote Unit (RU), but the main difference is that the EU is located in the Node/District exchange and it connects like an Integrated Services Digital Network (ISDN), so it is digital right to the EU. The network connection point is the Digital Distribution Frame (DDF) and all this equipment is part of the CAN.

As said before, the RIM EU sits in the Node Exchange site and the RU is located remote to the Node/District exchange – usually on a curb in a cabinet - or in a Small Country Automatic Exchange (SCAX) hut (with the original Step-by-Step or Crossbar

equipment removed). The RIM would be mains powered and has battery backup in case of short-term blackouts, and a RIM probably has a digital link to the parent exchange, with anywhere from 30 to 480 phone lines to customer premises.

This is a typical SCAX hut in a more remote situation, and it most likely has a RIM in it and is probably connected to its' parent Node exchange with an Optical Fibre based transmission system, which is all part of the CAN from the Node exchange DDF.

No Picture here

ARCS/DRCS/HCRC Radio

This rural and remote access infrastructure is a beamed radio (much like a torch light) link between a local exchange-based radio tower and customer premises, with interfacing equipment located in the local telephone exchange and the customer premises.

The first generation was the Analogue Radio Concentrator System (ARCS), then the Digital Radio Concentrator System (DRCS), and both of these systems directly replaced copper wires providing a voice (only) connection. In the case of ARCS the data speeds were compromised by an extra set of modulation and demodulation and associated voice band filters. In the case of DRCS these conditions were far further exacerbated by voice encoder algorithms that were particularly unfriendly with data - resulting in very low usable data rates.

As far as I am aware, all ARCS and DRCS equipment has been removed and replaced with HCRC equipment.

The replacement for ARCS and DRCS was HCRC (High Capacity Radio System), and this functions in a very similar mode to a Remote Integrated Multiplexer (RIM) except that the transmission channel is not pair cable or optical fibre - it is a point-to-point radio system with enough bandwidth to take (multiple) 2 Mb/s digital streams. With digital radio regenerators, this type of system can be relayed several 100 km between the EUs and the RUs.

The Exchange Unit (EU) of the HCRC has its IEN-CAN connection point at the Node/District exchange DDF just like a RIM, and most of the remote unit (RU) is also just like a RIM. This type of Pair Gain system has great value in Rural and Remote areas as it is able to provide very good service standards in telephony / dial-up Internet to remote customer locations.

Complex Remote Multiplexer (CRM)

This is an advance on the RIM where a second set of optical fibres are used to carry an STM-1 (155 Mb/s) data stream to a small Digital Services Line Access Multiplexer (DSLAM) so that customers can have telephony and ADSL services from a RU. Even with technology advances this solution is still proving elusive because of overheating in the confined space of the RU.

 Comments and Corrections are welcome