Echo Cancellation: Why It Makes Or Breaks Voice Quality In PHS/DECT

By Goutam Mukherjee
Product Line Manager, Zarlink Semiconductor

High-quality voice is key to customer acceptance of wireless access networks. The ability to deliver voice quality depends, to a large extent, on selecting the right echo cancellation technology.

Network access systems based on straightforward wireless protocols like PHS (Personal Handyphone System) and DECT (Digital Enhanced Cordless Telecommunications) have come a long way in the past decade. Today, many PHS/DECT wireless access systems are reliably delivering voice quality almost equal to that of traditional copper cable.

This is a huge step forward: Access networks based on wireless PHS/DECT technology have always been faster, easier, and, most importantly, much cheaper to build than copper networks. Now that they also deliver the voice quality subscribers expect, and demand, they're rapidly emerging as an attractive alternative to costly copper lines, particularly in regions with little existing infrastructure.

In the PRC, Japan, Thailand, and many other countries, the PHS market is booming. The PRC alone has, in only a few short years, turned on more than 10 million PHS customers.

PHS/DECT networks are "micro-cellular" radio access systems. Unlike cellular or 3G (third-generation) wireless networks they don't require comprehensive, expensive supporting network architectures. Instead they inter-work with existing systems, such as PBXs (private branch exchanges), the PSTN (public switched telephone network), cellular networks, and ISDN (integrated services digital network) equipment.

Voice calls, faxes, and modem signals originating in the PSTN CO (central office) are sent over short, high-speed radio links to local base stations, or to media access controllers, which pass them to base stations. The base stations in turn send them to subscribers over PBXs, wired or cordless in-building phone systems, or short-reach mobile radio links.

As shown in Fig. 1 links between base stations and base station controllers are based on low-cost, wireless 32-kbit/s ISDN line interfaces. Links between base stations and the CO or PBXs are typically through a wireless base station controller via ISDN or T1/E1 connections.

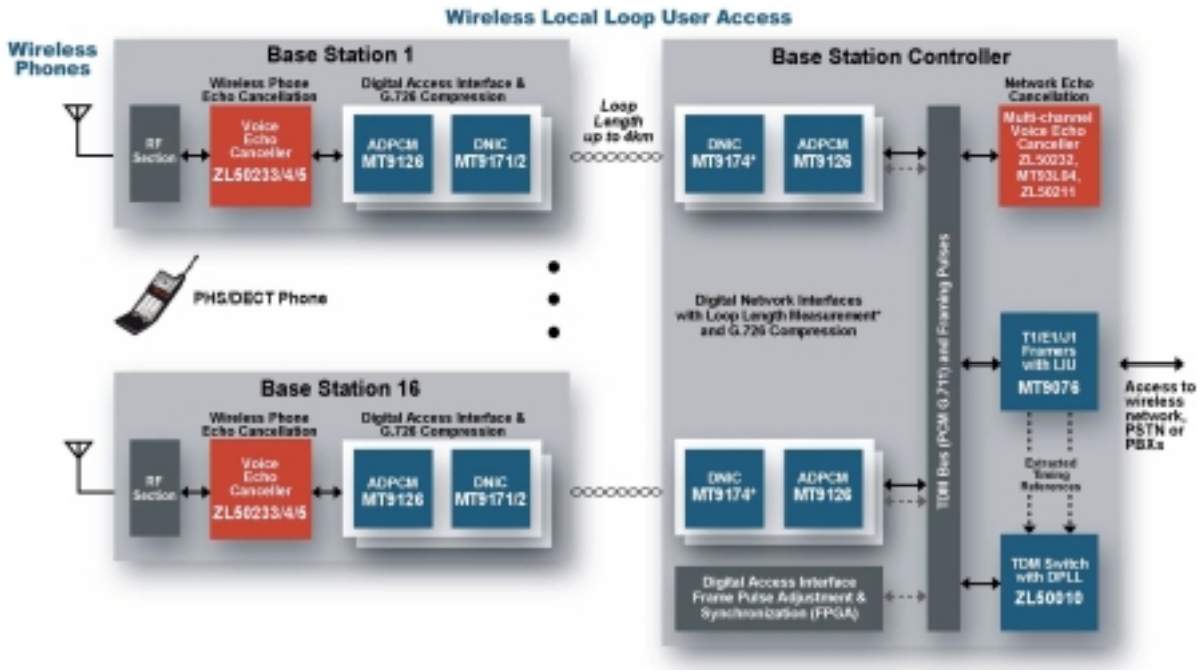

Fig. 1: Typical PHS/DECT Wireless Local Loop Application

PHS/DECT technology is being used in three types of networks:

- Wireless local loop (WLL), or “fixed wireless” networks, which provide access to PSTN-based voice, fax, and Internet services over low-cost fixed radio links
- Mobile networks which provide access to PSTN-based services over short-reach radio links to public cell stations
- Digital wireless PBX networks, which provide wireless access to PBX services

Echo Cancellation: It’s Mandatory

Regardless of the network type customer acceptance of PHS/DECT networks hinges to a large extent on the consistent delivery of high-quality voice. A fundamental factor affecting this quality level is the voice echo caused by network noise and round-trip speech delays. If audible to users small amounts of echo are annoying and larger amounts make it almost impossible to conduct real-time, two-way conversations.

The key sources of echo in PHS/DECT networks are signal reflections in the 2-wire/4-wire hybrid circuits on access line cards in the CO, PBX, or access controller, and acoustic feedback from subscriber phones. In a typical call these sources combine with network delays to produce echo tails lengths (ETLs) of at least 64 ms, and sometimes as long as 128 ms - well beyond the 50-ms threshold at which echoes become audible to users.

To ensure PHS/DECT networks deliver the high-quality voice services users expect and demand, echo cancellation technology is mandatory at each junction between the wireless network and the PSTN. Depending on the configuration, this means echo cancellation may be needed in base stations, wireless access controllers, PBXs, and at the CO.

Fig. 2 shows a WLL configuration in which echo cancellation chips are used in subscriber base stations and wireless access controllers.

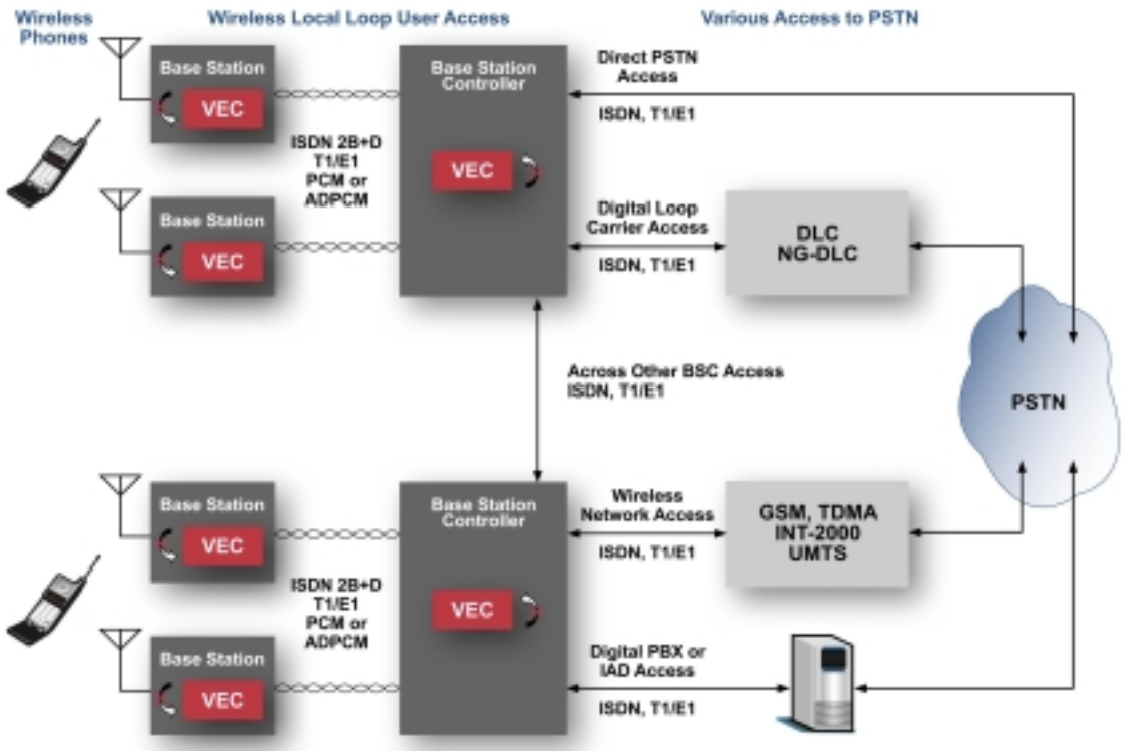

Fig. 2: PHS/DECT WLL Network Implemented With Echo Cancellers In Its Subscriber Base Stations And Wireless Base Station Controllers

Top-Grade Technology Is Critical

The type of echo cancellation chip used is crucial. PHS/DECT networks connect to different types of services, including ISDN, TI/E1, and cellular GSM/CDMA (Global System for Mobile Communications/Code Division Multiple Access.) The ETL generated by these different service types is highly variable. To ensure good voice quality in this environment echo canceller chips must be capable of handling different ETLs, and coping with unpredictable, unexpected, echo patterns.

Selecting the right chip can, however, be confusing. The ITU-T G.168 (2000) standard for voice echo cancellers guarantees functionality but gives no assurance of speech quality.

In fact, there is no reliable, objective method for evaluating this elusive attribute. Chip designers and network operators usually focus on ITU-T G.168 parameters, such as the signal-to-distortion ratio, which give a measure of how well the echo has been cancelled, or the convergence time of adaptive filters. However, these parameters can be misleading: Test results vary with the echo path, speech patterns, and the test material (i.e. whether real speech or composite source signals are used.) The parameters also give

no indication of the ability of the echo canceller to handle variations in signal levels or double talk.

In general, high-quality echo cancellation should be completely unnoticeable to users. They should allow natural two-way conversations by completely eliminating echoes, without double talk distortion, background noise contrast, or other disturbing phenomena. The chips should also be extremely robust, capable of working under all possible circumstances, such as with background noise, echo-path variations, non-linear acoustic echo, and differential ERL (echo return loss) values in the 2-wire/4-wire hybrid circuits.

Commercial DSPs: not good enough

The best way to ensure voice quality in the unpredictable PHS/DECT network environment is to use echo cancellers based on hard-wired, dedicated circuitry. There are four excellent reasons why dedicated chips are better than echo cancellers based on commercial DSP devices:

1. Dedicated cancellers are "full band" To reliably clean up the variable ETLs in PHS/DECT networks, "full-band" echo cancellation is required. Echo cancellers based on commercial DSPs often use a design simplification technique called *windowed adaptive filtering* to reduce their computational complexity. This approach, which produces a "partial-band" solution, is not robust enough for PHS/DECT networks because it cannot adequately cancel echoes that divert from expected patterns, or extend beyond certain lengths.
2. Dedicated cancellers are non-linear DSP cancellers use linear filters which, depending on how well the echo path is modeled, reduce echoes by 10 dB to 35 dB. In PHS/DECT networks, which typically have non-linear elements in the echo path, such as ADPCM (adaptive differential pulse code modulation) links or acoustic echo, echoes must be reduced by 35 dB at a minimum. Many echoes in PHS/DECT networks are thus out of range for a linear echo canceller, and have to be further suppressed by a non-linear processor (NLP.)
3. Dedicated cancellers are better with background noise Echo cancellers for PHS/DECT networks must be capable of eliminating large amounts of background noise. The traditional approach, designed for low levels of background noise, is to inject a minimal amount of noise on the line, resulting in an almost imperceptible mismatch between the injected noise and natural noise. However, when used in PHS/DECT networks this approach leaves residual echo signals due to the non-linear nature of uncompressed PCM channels and distortion from 2-wire/4-wire hybrid circuits. To remove these residual echoes cancellers need a non-linear processor to "clip" them out without touching the background noise. Many DSP-based echo cancellers have poor implementations of this non-linear process, where the device clicks on and off at the wrong time, resulting in clipped segments of speech at the beginning and end of words and phrases. By contrast most dedicated cancellers have advanced NLPs that are designed to handle situations like these.
4. Dedicated cancellers are easy and fast to use Echo cancellers based on commercial DSPs implement algorithms in software. Designing this software in-house is a complex, time-consuming, and expensive process. Some companies have opted instead for third-party echo cancellation software code. This approach saves some effort but system integration, test, and debugging still takes time, and can be tricky.

The code may need tweaking to meet standards. By contrast, dedicated off-the-shelf echo cancellation chips are easy to configure, install, and maintain. Access to internal registers ease functions like fault detection and supervision.

Superior ICs

Zarlink Semiconductor recently launched four low-density echo canceller chips (ZL5023x) with 4-, 8-, 16-, and 32-channels with advanced capabilities to eliminate variable/unpredictable echoes in PHS/DECT base stations. These ICs, implemented on dedicated circuitry, feature a proprietary NLP algorithm with “full band” coverage, handle ETLs up to 128 ms, have exceptional background noise cancellation capabilities, and deliver best-in-class double-talk performance.

These echo cancellers connect easily via the ST-BUS to a range of other ICs for high-quality PHS/DECT equipment including the MT9126 quad ADPCM transcoder (which supports the 32 kbit/s speech compression used in base stations), the MT9173/4 ISDN digital line interface circuits, which provide frame synchronization and loop delay measurement, and the MT9074/6 framers: Which support T1/E1 connections.

References

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