SkyWave ELECTRONICS LTD.

DIGITAL VOICE AND DATA TERMINAL FINAL REPORT

DSS FILE NO: 06QD.36001-6-3521
SKYWAVE FILE NO: C8713

JANUARY 14, 1988

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1. BACKGROUND

The Communications Research Centre (CRC) has developed a Linear Predictive Codec (LPC) which is capable of encoding voice for transmission at 2400 bps. As designed, the LPC could not be connected into the telephone network without modification.

Connection to the telephone network would require specific analog interfaces, including 2-Wire, 4-Wire and E&M interfaces. A full-duplex voice-band modem would also be required.

In addition, relaying of signalling information between two DVDTs required modifications of the LPCs to insert control bits in the data stream. Also, specific telephone signalling and supervision protocols had to be observed.

2. OBJECTIVE

The purpose of this contract was to develop interface and signalling capabilities for the LPC so that it could be connected to the telephone network in a variety of configurations. This was to include, as a minimum, connection as an extension telephone, Tie trunk, or foreign exchange link. Since an additional 2400 baud serial data option was also required, the resulting system was called a Digital Voice and Data Terminal (DVDT).

3. SCOPE

The scope of the work was analysis of interface requirements, and the development of the analog interfaces and protocols required to connect the LPC to the telephone network. SkyWave Electronics Ltd., as the licensed manufacturer of the LPC, agreed to modify the LPC software to provide the insertion of signalling bits in the data stream.

4. SYSTEM OVERVIEW

Digital voice communication requires two DVDTs, connected by a communications link; either a two or four wire voice circuit, or a 2400 baud synchronous digital link. It may be operated as a ringdown telephone, extension telephone, PBX Tie trunk, or as a foreign exchange link.

The DVDT includes an LPC, an auxiliary processor for handling signalling and supervision protocols, a modem for digital communications on VF circuits, two 2-Wire interfaces (one emulates a telephone, the other a central office), two 4-Wire interfaces, and one E&M Type I/II interface. For more information on the modes of operation and design of the DVDT, consult the DVDT installation and user manual.

5. PROJECT ACTIVITIES

The project took place of the interval of June to December, 1987. What follows is a description of the development effort over the course of the program.

The preliminary design and performance specifications were drawn up in June. The Preliminary Planning Compliance Review was held on June 29. At this meeting a number of DND telephony experts were present, and agreement was reached on the interface and protocol requirements.

The hardware design was completed in July, along with the majority of the psuedo-code for an auxiliary processor (required to handle signalling protocols). The high-level design for the LPC modifications was also completed during this period. The test plan was then drawn up, and the mechanical design finalized. The interim design review meeting was held on August 13. The hardware and software design was reviewed and found to be satisfactory.

During September, the LPC processor software modifications were completed and tested with the LPCs back-to-back. During these modifications, a new fast synchronization technique, using the new signalling frames, was added. As a result, the Fire code error correction could be restored since some more frame bits were available, even with the original 56 bit frame. During this time, the test plan was also completed, and a final design review was held on September 15. During the meeting, the mechanical and software designs were reviewed, and found to be satisfactory. The test plan was discussed, and a further meeting was scheduled to determine what facilities were required from DND.

All hardware was completed by the end of October, and hardware testing was completed in early November. During this time. Software and system testing continued until mid-November.

An on-site test planning meeting was held on October 2. SkyWave agreed to support testing at Valcartier and Petawawa although it was noted that this is not a contractual requirement. The dates for testing were finalized for both Petawawa, and Valcartier. The DVDTs were to be tested for Extension and Tie Trunk modes at Petawawa, and Link mode at Valcartier. SkyWave was later informed that testing at Valcartier would not be possible.

On-site testing for the PBX Tie Trunk mode was held at Petawawa on November 19. Unfortunately, problems were encountered in using the SL/1 PBX due to the type of interface cards available. It was decided to return on November 24 to perform tests using an SG/1 PBX. Upon returning, it was discovered that the required SG/1 cards had been removed several months before, and the Tie Trunk tests could not be performed. Link (foreign exchange) mode was tested, however, and the audio quality was found to be very good.

In December, the operating manual was completed. On December 18, the DVDTs were demonstrated to the scientific authority at SkyWave premises. Ringdown mode was demonstrated under normal operating conditions. Link mode was demonstrated using a PSTN line under normal operating conditions. Extension Telephone and Tie Trunk modes were demonstrated using a Wilcom Line Access Set to emulate PBX hardware. Following this, the units were delivered.

6. TESTING

6.1 INTERFACE TESTING

6.1.1 Two Wire "CO" Interface

The 2-Wire "CO" interface was tested for Ring Generation, Ring Trip, and Hook Status indication. This was tested using a standard telephone set and the Wilcom Line Access set. The interface was found to perform as required.

The transhybrid isolation was found to depend on the impedance of the device connected to the interface. In order to accommodate a range of impedances, a potentiometer was added to the interface card.

6.1.2 Two Wire "DAA" Interface

The 2-Wire "DAA" interface was tested for ring detection and off-hook generation using the Wilcom Line Access Set. It was found to reliably detect the presence of ring signal, and presented the required load to the line when off and on hook.

Transhybrid rejection was found to be very good using the transformer hybrid, but again depended on the impedance of the far end of the line. Unfortunately, when connected to the PSTN, the echo characteristics vary depending on the path, and it is therefore likely that echo cancellers will be necessary.

6.1.3 Four Wire Interface

The four wire interfaces were tested for correct operation using the Wilcom Line Access Set, and operated as expected.

6.1.4 E&M Interface

The E&M interface was checked for correct Type I and Type II operation using the Wilcom Line Access Set. Correct signalling operation was observed, and voltage level, current, and slew rates were as designed.

6.2 HARDWARE INTEGRATION TESTING

The insertion of LPC data into the frame was tested over a loopback circuit. Error correction was tested by inserting errors into the data stream and observing the results. Performance was as expected. The remaining tests were performed on an error-free channel.

The transmission of DTMF tones was checked end-to-end. The DTMF tones were transmitted correctly up to the maximum specified dial rate.

The same test was performed for call progress tones. In this case, the decoder took longer to detect the signal, resulting in a momentarily garbled tone being heard at the far end. Since this is only an audible indication, this does not cause any problems.

The transmission of dial pulses was also checked at the maximum permitted dial rate. The DVDTs relayed signals which exceeded specifications by 5%.

The above tests were performed in all operating modes for the DVDT.

6.3 FUNCTIONAL TESTS

Audio quality was judged to be excellent in all modes of operation, and comparable to standard LPC-357 performance (using the supplied handsets). Some telephone handsets produced poorer-quality audio; however all recent-model Northern Telecom sets tested had identical performance. When used over the PSTN, echo problems degraded the signal substantially on some connections.

The DVDTs were testing in Ringdown mode using digital, 2-Wire and 4-Wire trunks. Signalling was tested as follows:

1. Pick up one handset. Ringback tone heard, and remote set rings.
2. Pick up ringing set. Ringback tones stops, audio is connected.
3. DTMF digits dialed at either end should be transmitted without distortion.
4. Hang up one end. Audio should be cut off, and reorder tone heard at the off-hook end.
5. Lifting the handset again restores audio.
6. Place both sets on hook. Sets should not ring.
7. Repeat steps 1-6 to ensure proper reinitialization.

Link (foreign exchange) mode was tested using a standard telephone on one unit, and a Central Office line on the other. In order to test communications, a second telephone set was connected directly to another CO line. Both digital and 4-Wire trunks were used between the DVDTs. Signalling was tested as follows:

1. Take DVDT telephone set off hook. Dial tone should be heard.
2. Dial first digit of own telephone number using DTMF. Check for dial tone off.
3. Dial remaining digits. Check for busy tone.
4. Place telephone set on hook, then off hook again. Check for dial tone.

5. Dial remote telephone set. Ringback tone should be heard, and other set should ring.

6. Answer remote telephone. Audio should be connected. DTMF tones should be relayed in either direction.

7. Hang up both ends.

8. Dial DVDT from remote telephone. DVDT handset should ring.

9. Answer DVDT telephone. Ringing should stop, and audio should be enabled.

10. Repeat steps 1-9 but use dial pulses instead.

Extension Telephone mode was tested using two standard telephones and two Central Office lines, as follows:

1. Dial telephone set at DVDT #1 to call DVDT #2. Operation should exactly as for a normal telephone.

2. Answer call at DVDT #2. Check for audio.

3. Press Bypass switch at each end. Check for LPC audio.

4. Check transmission of DTMF tones.

5. Tap the hook switch at each end. Check for normal audio.

6. Press Bypass switch at each end again. Check for LPC audio.

7. Hang up both ends, and repeat steps 1-6 calling from the other end.

Tie Trunk mode was tested using the Wilcom Line Access Set, since a test could not be arranged using a PBX. This test was performed using four-wire audio, and Types I and II E&M. The test was performed as follows:

1. Set E&M off hook at one end only. Check for transmission of DTMF tones, dial pulses, and call progress tones, but not audio.

2. Set E&M off hook at the remote end. Check for transmission of LPC audio, DTMF tones, and call progress tones.

3. Set one end on hook again. Check for transmission of call progress tones, and LPC audio off.

4. Set other end on hook. Check for no audio or tone transmission.

6.4 ON-SITE TESTS

Due to problems at Petawawa, and the lack of availability of the facilities at Valcartier, only the link mode test was successful. The same test was performed as for the functional tests, with the same results.

Attempts to test the PBX Tie Trunk mode with the SL/1 PBX were inconclusive. Apparently the trunk cards were not programmed correctly because the they could not be made to work in a direct loopback using the Wilcom Line Access Set.

7. CONCLUSIONS

The DVDT was tested and found to operate correctly with actual telephone equipment in the Extension Telephone, Ringdown, and Link modes. It was tested using the Wilcom Line Access Set in the PBX Tie Trunk mode, and found to operate as designed.

The audio quality was excellent when the units were used with several different recent-model Northern Telecom telephones (connected directly). When used with other sets, there was some degradation in audio quality. The most serious impairment occurred when connected to the public network. In this case, echo control was not possible due to the different paths used on different calls. On some calls, the problem was severe. Therefore, a very useful enhancement would be the addition of echo cancellers. SkyWave would be willing to discuss a follow-on contract to add built-in echo cancellers to the DVDT.

With the addition of the signalling capabilities, the utility of the LPC is greatly enhanced. Further, it is likely that additional modes of operation could be developed with minimal effort.