DSPGenie TNE
Telephone Network Emulator
User Manual
and Technical Specification

Rev.1.2

(Referring to version 3.1 of TNE software)

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CONTENTS

FIGURES

1. INTRODUCTION

The performance of high-speed voiceband data modems and fax machines is heavily dependent on the characteristics of the telephone network connection. Impairments of various types introduced by a poor quality connection can lead to digital transmission errors and consequent increased transmission time due to the need for re-transmission of corrupted data. Developers of such data communication devices therefore need realistic network emulation to test their designs effectively, and network operators need the same network emulation capability to evaluate the products of different manufacturers.

It is primarily to satisfy this requirement that DSPG Ltd. has developed a low-cost Telephone Network Emulator (TNE). The unit is part of a range of telecommunication test equipment from DSPG. The TNE is easy to use, but capable of introducing all the main impairments that adversely affect voiceband data communications. Examples of the parameters and impairments that can be controlled are send and receive gain, echo levels, noise levels, delay, and local loop characteristics. All impairments are introduced independently in the two directions of transmission. Signal levels in the emulated connection are continuously measured and displayed.
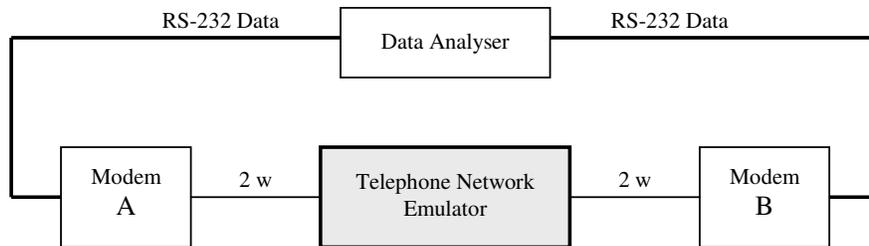
Figure 1. Using the TNE to Test Modems

In its simplest form the TNE uses a single custom-designed card plus an associated application software running under Windows 2000, installed in a very compact DSPGenie generic test platform (see section 8.4). This option provides all the necessary facilities to emulate an end-to-end PSTN connection.

There is an option to expand the TNE, adding a multi-function interface and DSP resource card, making it possible to emulate additional network elements in various configurations and also include external equipment - such as echo cancellers - in the emulation. Please refer to section 7.13 for description of expanded TNE configurations, involving PCM interfaces and external equipment.

Although the primary application of the TNE will be to facilitate tests on voiceband communication devices, the unit can also be used to connect any 2-wire telephone instruments, standard or calibrated. This allows the TNE to be used for subjective evaluation purposes, either of the telephone instruments themselves, or of some aspect of the emulated connection.

2. OVERVIEW OF HARDWARE IMPLEMENTATION

Figure 2 shows the cards in the TNE that are involved in the signal-path processing. All of the essential TNE features are implemented on a single card designated 'TNE Card' in Figure 2. This is the same card known as the Central Office Card or the Dual Subscriber Line Interface Card (DS SLIC2) from DSPG. The TNE application software implements all of the basic features required for telephone network emulation.

The TNE expansion is provided by the Dual Primary Rate PCM Interface and DSP Resource Card, known as the DS PCM2. This multi-function card allows for several different configurations to be implemented within the TNE unit and also offers connectivity to other specialised interface modules, e.g. Dual DAA module.
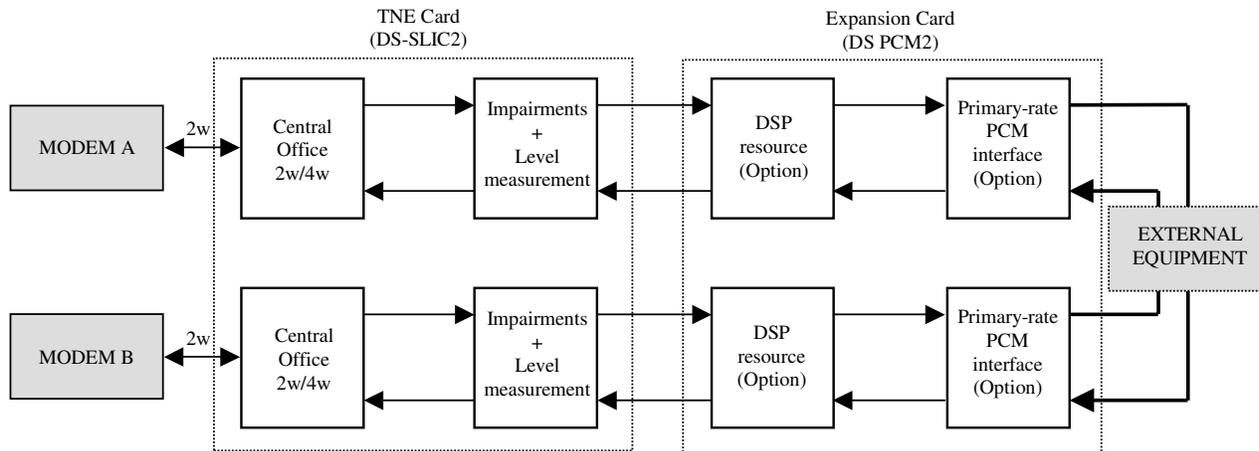
Figure 2. Hardware Concept of Expanded TNE

3. TNE CARD

The main features of the TNE card (Central Office card, DS SLIC2) are presented below. Please see section 8.1 for the CO interface technical specifications.

- Dual channel short-loop analogue line card

- Choice of resistive 600ohm or European complex line impedance and network balance (CTR21)

- Constant current loop feed (resistor programmable) with over-current protection

- Two-to-four wire conversion

- Optional On-hook transmission to the line

- Off-hook and optional dial pulse detection

- Integral ringing tone generator and amplifier with auto ring trip and cadence control

- Loop current and ring trip detection

- Tip/Ring polarity reversal

- On-board -48V battery supply (DC/DC converter)

- On-board over-voltage/over-current protection

- On-board DSP processor for tone generation/detection, line characteristics emulation, gain control, etc.

- DSPGenie compatible I/O interface implemented with in-system re-configurable FPGA

As mentioned in the list of features above, the DS SLIC2 card has an on-board DSP processor, which is used to implement all the essential additional functions for the TNE. These are as follows:

- Call progress tones: dial, busy, ring-back;

- Timing/cadence control;

- DTMF detection;

- Emulation of line characteristic

- Send and Receive gain adjustments;

- Noise injection;

- Near-end and far-end echo emulations;

- Transmission delay;

- Send and receive level measurements.

4. SIGNAL PATH DISCUSSION & CONSIDERATIONS

Figure 3 illustrates the signal path provided by the single-card TNE (Stand Alone Mode in the DSPGenie TNE unit).

4.1 SEND & RECEIVE GAINS

Although there is provision for digital gain adjustment on the TNE card, to determine the desired gain settings it is necessary to know the analogue transmit gain (2-wire to 4-wire) and analogue receive gain (4-wire to 2-wire) provided on the card.

The TNE card provides a limited range of analogue gain adjustment on both transmit and receive. DSPG have set these gains to –3dB and –6dB respectively, i.e. an analogue transmit loss (2-wire to 4-wire) of 3dB, and analogue receive loss (4-wire to 2-wire) of 6dB. These losses are advantageous to the TNE in that they augment the trans-hybrid loss of the local hybrid.

It is not practical for users to change these settings, as they are not under software control. However, the set values are close to those adopted in the line cards of real networks, e.g. the UK PSTN. Therefore - without further gain adjustment - if standard telephones are connected to the TNE the loudness ratings achieved will be typical of those in the PSTN. The loading of the PCM signal will also be typical of the PSTN situation. Likewise, modems connected to the TNE will be presented with a typical network scenario.

However, users may wish to trim the transmit and receive losses to the precise values used in a particular network, or perhaps to achieve worst-case scenarios. The *digital* gain adjustments provided on the card are under software control and can be used for this purpose.

For example, in the UK, the transmit and receive losses for a median length local loop to a System X exchange are 1dB and 6dB respectively. In the TNE, the user could replicate this situation by using the digital gain adjustment facility to introduce 2dB gain on the send side. Together with the 3dB analogue loss, this would provide the desired 1dB loss.

In the particular case of a System X exchange in the UK, an AGC process causes the transmit and receive loss values to be each increased by 3dB if the local loop is detected as 'short', thus making the transmit and receive losses 4dB and 9dB respectively. The extra loss compensates for the lower loss of the short local loop. To emulate this in the TNE, the digital gain adjustment facility can be used to introduce 1dB loss on the transmit side, and 3dB loss on the receive side. When added to the fixed analogue losses, this achieves the required overall values.

The digital gain adjustment facility can also be used to achieve desired loudness ratings in conjunction with calibrated telephones, or to set specific levels in the case of modem testing.

It should be noted that these digital gain/loss adjustments have a direct effect on the apparent trans-hybrid loss of the local hybrid. Therefore, situations where the sum of these two gain adjustments results in a net gain should be avoided

where possible. On the other hand, if the sum of these two gain adjustments produces a net loss, the apparent trans-hybrid loss is increased, and the range of control for the far-echo impairment is improved.
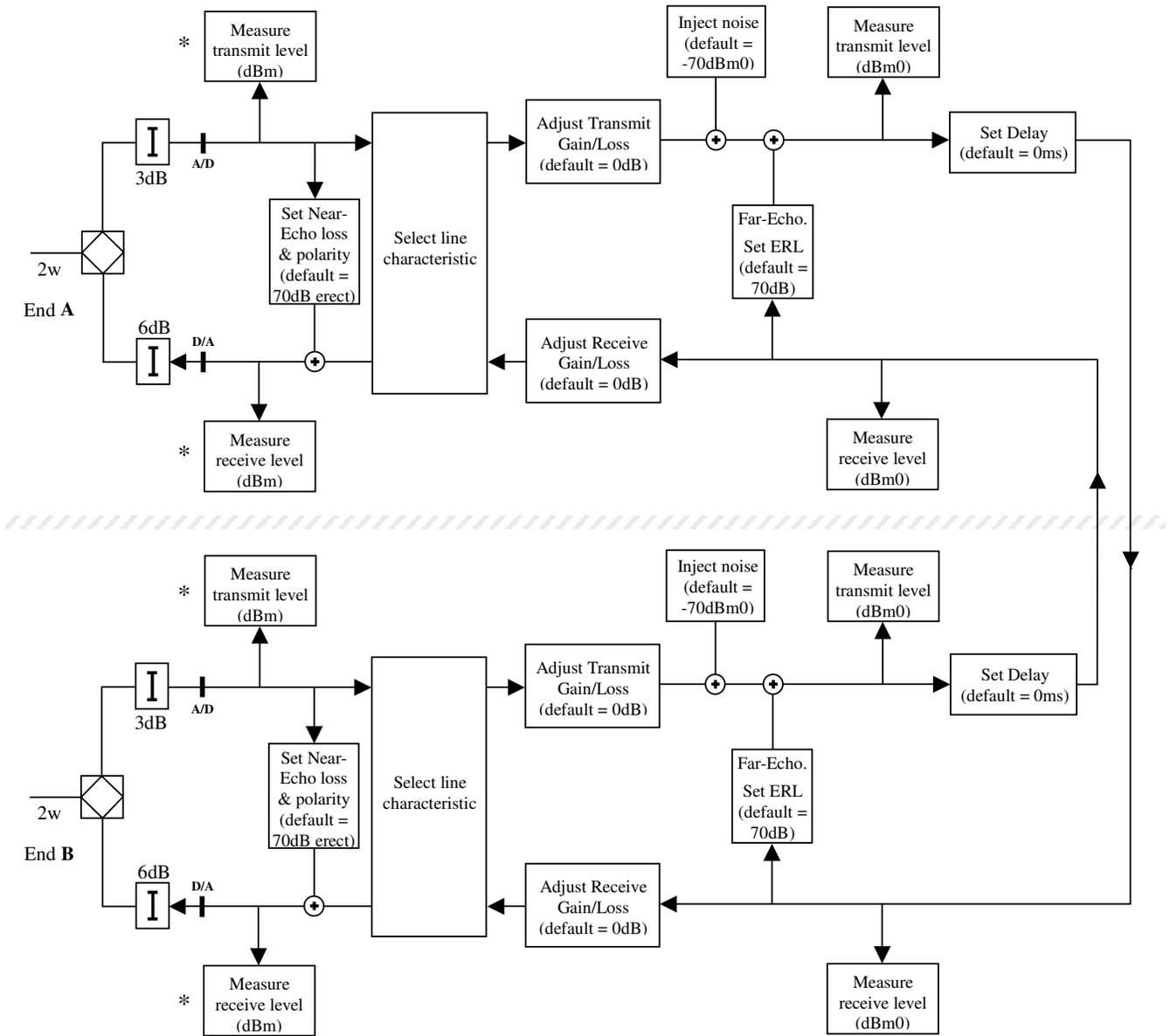
* Note: For display purposes these measurements are referred to the 2-wire interface.

Figure 3. Signal-Path provided by TNE Card

4.2 NEAR-ECHO

As a modem both transmits and receives signals over a 2-wire interface, it has to contain a hybrid device to separate the signals. Due to impedance mis-match when the modem is connected to line or to the TNE, a proportion of the modem's transmitted signal is reflected back to the modem's receiver. The time-delay is very short due to the close proximity of the reflection point.

The difficulty of obtaining perfect impedance matching means there will always be a certain amount of near-echo, but, in most cases, this will be at a satisfactorily low level. Since cases of poor impedance matching may occur in the network, the TNE allows higher levels of near-echo to be generated so that worst-case situations can be investigated.

The near-echo impairment generator consists of an attenuator connected between the 4-wire transmit and receive paths. The attenuator value displayed to the user is offset by 9dB to accommodate the fixed analogue transmit and receive losses present on the TNE card (e.g. the displayed value will be 19dB when the attenuator is set to 10dB).

Due to practical impedance matching considerations, near-echo settings greater than 25dB are unlikely to affect the overall near-echo level at the modem's receiver.

By default, an erect version of the transmitted signal is echoed back to the modem. This represents the case where the modem is connected to a terminating impedance less than the ideal matching impedance. It is also possible to select an inverted echo signal, which represents the case where the terminating impedance is greater than ideal.

4.3 FAR-ECHO

Far-echo is the result of signal reflection at the distant hybrid, and is caused by imperfect matching of the hybrid's balance impedance to the 2-wire impedance seen by the hybrid. Due to the difficulty in obtaining perfect impedance matching, there will always be a certain amount of echo from this source.

Since cases of poor impedance matching may occur in the network, the TNE allows higher levels of far-echo to be generated so that worst-case situations can be emulated for the tests. This is achieved by adding an artificial far-echo path. The amount of far-echo is determined by the echo return loss (ERL), which is user selectable.

Although a linear phase, flat magnitude response can be selected for the artificial far-echo path characteristic, this is not typical of real networks. Therefore, in the TNE, it is also possible to select any of the echo path models defined in ITU-T Recommendation G.168. Readers are referred to that Recommendation for details of these models, which include dispersion and magnitude responses of the type commonly found in real networks. When using these models in the TNE, the displayed ERL values are based on the use of the Composite Source Signal (CSS), as defined in the G.168 Recommendation. The ERL may be different for test signals other than CSS, especially in the case of single-tone test signals.

Practical impedance matching limitations mean that it is not possible to guarantee trans-hybrid loss greater than 32dB in the TNE, therefore ERL settings significantly greater than this are unlikely to affect the overall returned echo level.

4.4 DELAY

The delay impairment emulates the delay of the 4-wire transmission path, and can include satellite delay where appropriate. The delay in the send path is normally equal to the delay in the receive path, but can be set to different values if required.

If the expanded TNE option with primary rate PCM interface is used, it may be appropriate to implement the bulk of the 4-wire transmission delay external to the TNE card. For example, if echo cancellers are inserted into the connection, the bulk delay would be required between the echo cancellers at opposite ends of the link, and the TNE delay facility would be used to emulate the pure part of the echo-path delay (the delay from the R_{out} port to the S_{in} port of the echo canceller, excluding dispersion time due to the network elements).

Please refer to section 7.13 for description of the expanded TNE configuration with bulk delay implemented between two echo canceller channels.

4.5 LINE CHARACTERISTIC

Separate FIR filters at the A & B ends of the emulated connection may be enabled to model the amplitude and delay versus frequency characteristics of the local line. A filter library is maintained, allowing easy selection of the desired characteristic.

4.6 LEVEL MEASUREMENTS

True r.m.s. measurements are made on the signals in the send and receive paths. The displayed measurements are continuously updated.

As stated in ITU-T Recommendation G.711, the theoretical sine-wave load capacity (T_{max}) is +3.14dBm0 for A-law, and +3.17dBm0 for μ-law. Levels in digital networks can be measured on this basis, and it can generally be assumed that any digital interface is a point of zero relative level (0dBr). This also applies in the TNE, except that the digital gain adjustments and emulation of the 2-wire line characteristic (see Figure 3) represent effects that occur in the analogue part of a connection. This means the 0dBr point in the TNE must be assumed to occur after the digital gain adjustment on the transmit side, and before the digital gain adjustment block on the receive side. Levels measured at these points can be expressed directly in dBm0.

The digital gain adjustments and emulation of the line characteristic will act to reduce the available dynamic range at the assumed 0dBr point. However, modest values of gain adjustment are unlikely to have significant implications. Larger values of gain adjustment can be safely used where they are tailored to achieve or accommodate particular desired levels in the 4-wire network.

As well as the transmit and receive measurements made at 0dBr points in the TNE, and expressed in dBm0, it is often useful to know the absolute levels (dBm) at the 2-wire interface. As the r.m.s. calculations are performed in software, all measurements must be made at digital points in the emulated connection. Measurements are made at the output of the A/D and at the input to the D/A (as shown in Figure 3), and the appropriate adjustments are made to refer the measurements to the 2-wire interface. For example, a measurement of –10dBm at the output of the A/D is corrected by 3dB to present a level of –7dBm for display. Similarly, a measurement of –10dBm at the input to the D/A is corrected by -6dB to present a level of –16dBm for display.

4.7 NOISE INJECTION

White noise can be injected into the send path at the point shown in Figure 3. The level of the injected noise is selected by the user.

The injected noise level is expressed in dBm0. This allows signal-to-noise ratio to be calculated by simple subtraction of the injected noise level from the measured transmit level. In this context, note that the measured transmit level includes the contribution of the injected noise signal and the echo signal. Therefore, to derive the signal-to-noise ratio of the send-path signal it is necessary to measure the transmit level (dBm0) with negligible injected noise and no echo signal. To achieve this, the injected noise level should be set to minimum, and the transmit level measurement should be made with no signal present on the receive side.

The level of the injected noise can be converted to dBr n0 by adding 90 to the level in dBm0, i.e. dBr n0 = dBm0 + 90. The level with psophometric weighting or C-message weighting is also easily obtained by adding the appropriate correction factor.

5. DSP RESOURCES

The expanded DSPGenie TNE unit provides four additional fixed point DSP processors, which can be utilised to implement various additional network elements, ranging from network bulk delays to voice coding functionality.

Various voice codec standards are available, including GSM, G.726, G.728 and G.729, and can optionally be included in the network emulation, e.g. as illustrated in Figure 2.

6. PRIMARY RATE PCM INTERFACES

The expanded DSPGenie TNE unit offers dual programmable Primary Rate PCM interface These PCM interfaces allow external network equipment to be connected to the TNE for inclusion in the network emulation, as shown in Figure 2. Either E1 or T1 mode can be selected, according to requirements.

Please refer to section 7.13 for more details about how to configure the PCM interfaces in the DSPGenie TNE unit.

7. DSPGenie TNE OPERATION

Figure 4 illustrates the main window displayed on the SVGA type monitor screen after starting-up the TNE application (e.g. by double-clicking the 'TNE' desktop icon).
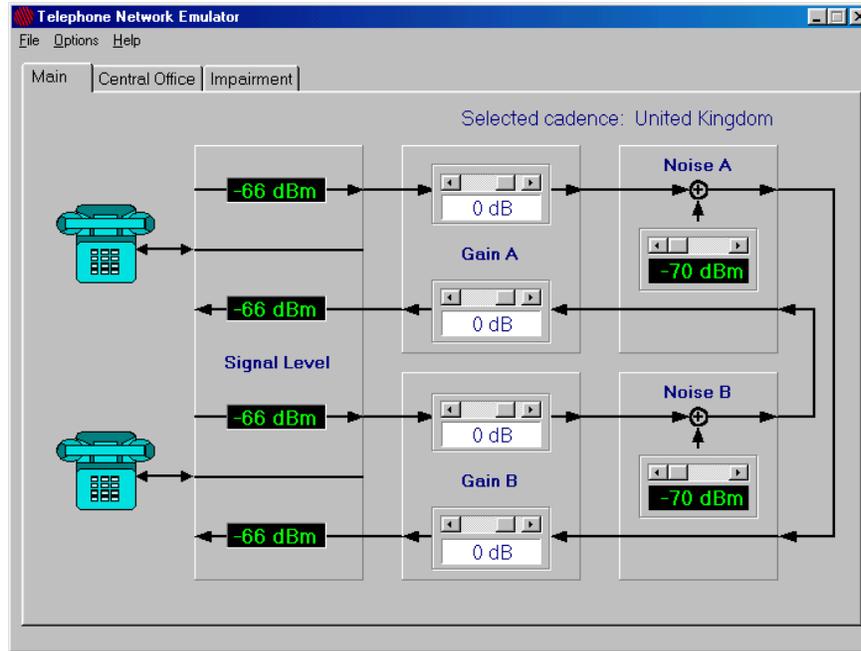
Figure 4. Main window displayed after starting the TNE Application

The default mode is always 'Stand Alone Mode'. It can also be selected in the drop-down list of options (Figure 5).

NOTE: Please refer to section 7.13 for use of expanded modes with PCM interfaces.
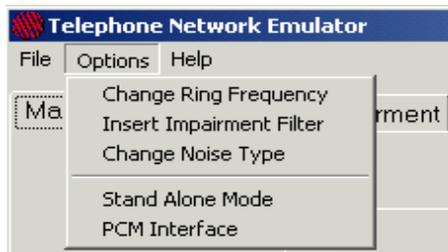
Figure 5. Selecting Stand Alone Mode

The Window shown in Figure 4 has three tabs. The tab 'Main' currently selected allows the user to set the digital transmit and receive gains, and the injected noise level. It also displays the measured transmit and receive levels referred to the 2-wire interface.

Clicking on the 'Impairment' tab allows the near-echo loss to be set, and a filter modelling the 2-wire line characteristic to be chosen. Also controlled from this screen are the transmission delay, the far-echo ERL and the echo path model. The 4-wire transmit and receive levels are displayed.

Clicking on the 'Central Office' tab allows the signalling frequencies and timings to be changed from their default values, and also allows setting of the dial-numbers for the external 2-wire terminal devices.

7.1 ABSOLUTE LEVEL MEASUREMENTS

The four boxes displaying levels towards the left-hand side of Figure 4 (displaying –66dBm in Figure 4) are transmit and receive levels referred to the 2-wire interface point. They are absolute levels, expressed in dBm. The measurements are continuously updated and require no action by the user.

7.2 GAIN ADJUSTMENTS

Independent gain adjustments are provided on transmit and receive at both ends of the emulated connection. The controls for these are shown towards the centre of Figure 4 as 'Gain A' and 'Gain B' respectively for the two ends of the link.

Each of the four gain adjustments is controlled by means of the associated scroll bar. Clicking on the left or right scroll arrow adjusts the gain down or up by 1dB per click. For large gain adjustments, click and hold within the scroll bar, or click and drag the scroll box. The range of adjustment is from +12dB to –60dB. The default value is 0dB.

7.3 INJECTED NOISE

White noise can be injected into the send path at both ends of the emulated connection. The controls are shown as 'Noise A' and 'Noise B' towards the right-hand side of Figure 4.

Adjustment of the injected noise level is made using the associated scroll bar. Clicking on the left or right scroll arrow adjusts the level down or up by 1dB per click. For large level adjustments, click and hold within the scroll bar, or click and drag the scroll box.

The range of adjustment is from 0dBm0 to –70dBm0. The default value is -70dBm0, and this level is used instead of a separate 'noise-off' setting.

7.4 NEAR-ECHO LOSS

To be able to control the near-echo loss (and also the local line characteristic, the far-echo loss, and transmission delay) it is necessary to click on the 'Impairment' tab in the menu bar shown in Figure 4. The display changes to that shown in Figure 6.
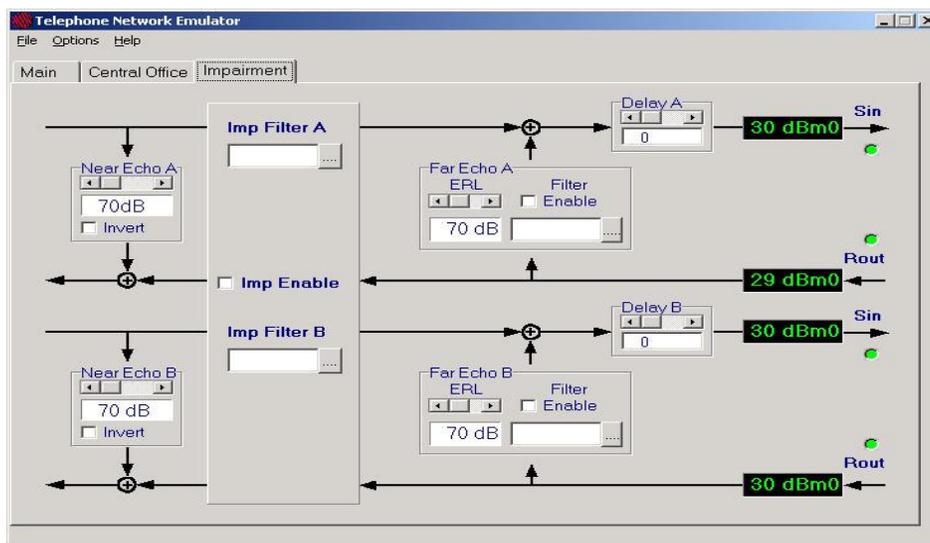
Figure 6. The Echo, Delay and Impairment Filter Controls

There are separate near-echo loss controls for the two ends of the emulated connection, and these are shown as 'Near Echo A' and 'Near Echo B' towards the left-hand side of Figure 6.

Adjustment of the echo loss is made using the associated scroll bar. Clicking on the left or right scroll arrow adjusts the loss up or down by 1dB per click. For large level adjustments, click and hold within the scroll bar, or click and drag the scroll box.

The range of adjustment is from 0dB to 70dB. The default value is 70dB.

The echo signal can also be inverted using the 'Invert' check box (section 4.2 explains the reason for this facility).

NOTE: The 'Impairment' window also provides four PCM status indicators, located on the right side of the window, for the TNE expanded mode with PCM interface. Their function is described in section 7.13.

7.5 LOCAL LINE CHARACTERISTIC

FIR filters are used to model the characteristics of the local line at both ends of the link.

The controls that allow selection of the filters are labelled 'Imp. Filter A' and 'Imp. Filter B' in Figure 4. To select a filter, click on the button to the right of the message box (alternatively, click on 'Options' in the menu bar, then click 'Insert impairment filter' in the drop-down list shown in Figure 5).

The dialogue box that appears displays the default folder for the filter library (Figure 7). To select a filter in another folder, simply navigate within the dialogue box to the required folder. Otherwise, double-click on the required filter in the displayed list, (or single-click on the filter, then click the 'Open' button).
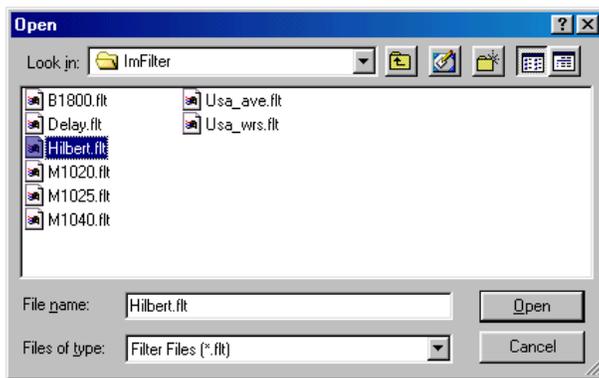
Figure 7. The Impairment Filter Library

The filter name appears in the message box (see Figure 8). Before the filters can be enabled, it is necessary to select filters for both end A and end B. The filters can then be enabled or disabled using the 'Imp. Enable' check box. When enabled, a wavy line appears in the display to make it evident that the filter is active.
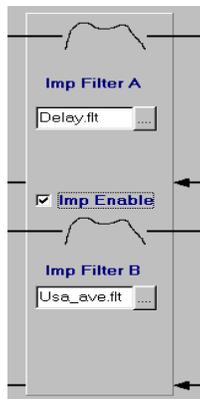
Figure 8. Enabled Filters

7.6 FAR-ECHO LOSS

There are separate far-echo loss controls for the two ends of the emulated connection, and these are shown in the 'Far Echo A' and 'Far Echo B' boxes towards the centre of Figure 6.

Adjustment of the echo loss is made using the 'ERL' scroll bar. Clicking on the left or right scroll arrow adjusts the loss up or down by 1dB per click. For large level adjustments, click and hold within the scroll bar, or click and drag the scroll box.

The range of adjustment is from 0dB to 70dB. The default value is 70dB.

It is also possible to select a filter to model the echo path characteristic. To do this, click on the button associated with the filter controls within the 'Far Echo A' or 'Far Echo B' box.

The dialogue box that appears displays the default folder for the echo path filter library (Figure 9). To select a filter in another folder, simply navigate within the dialogue box to the required folder. Otherwise, double-click on the required filter in the displayed list, (or single-click on the filter, then click the 'Open' button).
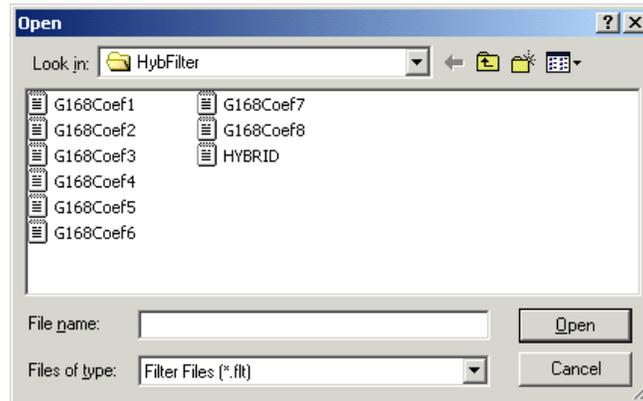
Figure 9. The Echo Path Filter Library

The filter name appears in the message box (see Figure 10), and can be enabled or disabled using the 'Filter Enable' check box.
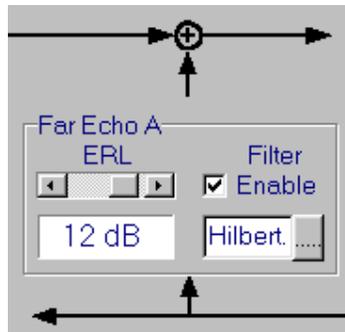
Figure 10. The ERL and Echo Path Filter Controls

7.7 TRANSMISSION DELAY

Delay can be inserted into the send path at both ends of the emulated connection. The controls are shown as 'Delay A' and 'Delay B' towards the right-hand side of Figure 6.

Adjustment of the delay is made using the associated scroll bar. Clicking on the left or right scroll arrow adjusts the delay down or up by 1ms per click. For large delay adjustments, click and hold within the scroll bar, or click and drag the scroll box.

The range of adjustment is from 0ms to 255ms. The default value is 0ms.

7.8 LEVEL MEASUREMENTS

The four boxes displaying levels towards the right-hand side of Figure 6 are transmit and receive levels in the emulated 4-wire network. They are expressed in dBm0 on the basis that the measurements are at 0dBr points in a digital network. The measurements are continuously updated and require no action by the user.

7.9 SIGNALLING (CADENCE & TONES)

It is possible to control all aspects of the signalling frequencies and timings used to establish a call. To control these parameters, it is necessary to click on the 'Central Office' tab in the menu bar shown in Figures 4 and 6. The display changes to that shown in Figure 11.
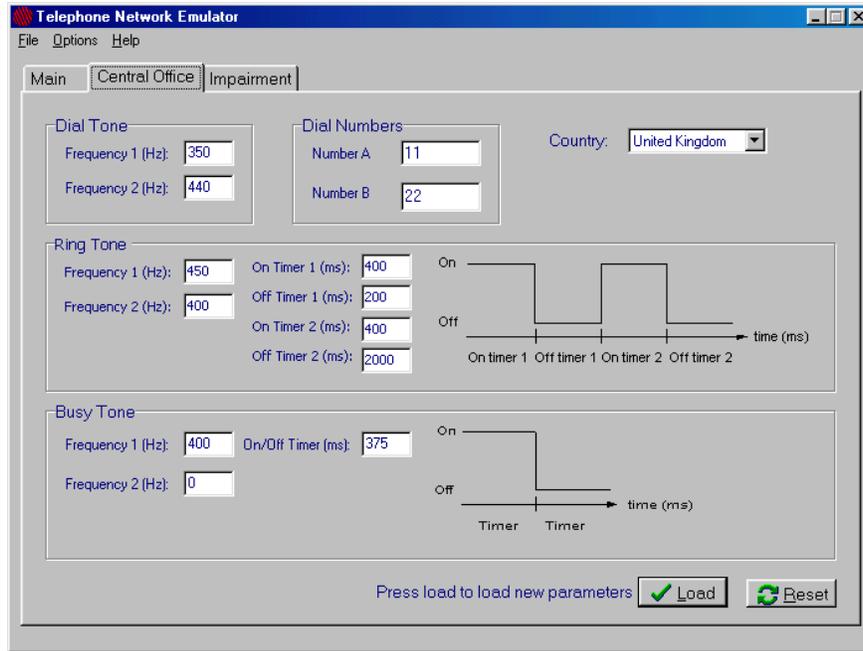
Figure 11. The Signalling Controls

The default values are the dial tone, ring tone and busy tone frequencies and timings used in the UK. The standard values for many other countries can be quickly loaded using the drop-down list box shown near the top right-hand corner of Figure 11, and in Figure 12a. Simply click on the desired country, then click 'OK' in the dialogue box that appears (Figure 12b).

Figure 12a. Selecting a country   ***Figure 12b.***
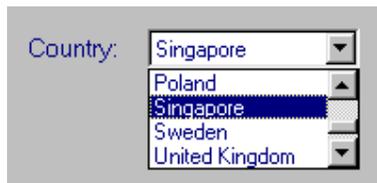
Whichever country is selected, any of the individual frequencies and timings displayed in Figure 11 can be modified. Simply click on the value to be changed, and edit it with the keyboard. The new values must then be loaded by clicking the 'Load' button near the bottom right-hand corner of Figure 11. This causes the displayed country to change to 'User defined', and a dialogue box will appear (Figure 13) in which the user should click 'OK'.
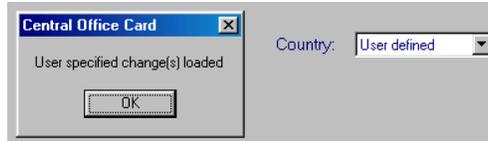
Figure 13. Confirming User-Specified Changes

At any time, the user can return to the UK default values, either by selecting the UK as the desired country in the manner described above, or by clicking the 'Reset' button in the bottom right-hand corner of Figure 11. In the latter case, clicking the 'Yes' button in the dialogue box that appears (Figure 14) will restore the UK defaults.
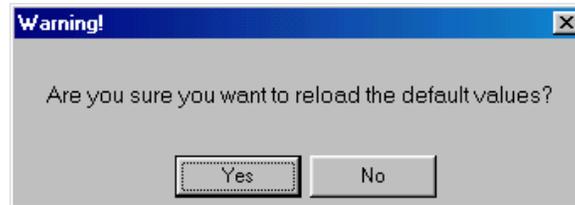
Figure 14. Confirming a reset of default values

7.10 DIAL NUMBERS

The Window shown in Figure 11 is also used to set the numbers to be dialled from the 2-wire telephones or other terminal equipment in order to establish a connection. The default numbers are '11' and '22' respectively for the two ends of the connection, as shown towards top-centre of Figure 11.

These numbers can be edited and loaded in the same way as described above for the frequency and timing boxes. However, unlike those boxes, the dial numbers are not reset to their default values by the 'Reset' button.

The default numbers are set each time the application is run.

7.11 RING FREQUENCY

The default ringing frequency is 25Hz. A facility to change the ringing frequency is provided, and is accessed via the menu bar in Figure 11. Click on 'Options', then click on 'Change Ring Frequency' in the drop-down list. The dialogue box shown in Figure 15 appears, and allows selection from four ring frequencies by means of option buttons. Click the desired option button, then click 'OK'.
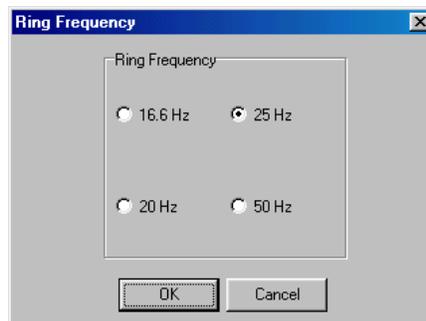
Figure 15. Changing the Ringing Frequency

7.12 ESTABLISHING A CONNECTION

A standard dial and answer routine is used to establish a connection between two 2-wire terminal apparatus at the two ends of the emulated telephone network.

- Both terminal apparatus are initially on-hook.
- The dialling end goes off-hook e.g. by lifting the telephone handset.
- Dial tone is received.
- Dial the number of the distant end. (If the default dial numbers have not been changed, dial '22' if calling from end A, dial '11' if calling from end B.)
- Ring tone is received, and ringing signal is applied to the distant end.
- The connection is established when the distant end goes off-hook.

NOTE:

If the distant end is already off-hook, the busy tone is received instead of the ring tone and the connection cannot be established. Also if any wrong number is dialled, the busy tone is received instead of the ring tone.

7.13 TNE EXPANDED MODE WITH PCM E1/T1 INTERFACE

If the 'PCM Interface' option is selected in the drop-down list of options (Figure 5), the TNE unit is reconfigured to additionally include two primary rate PCM E1/T1 interfaces and additional DSP resources, and a new dialogue box is displayed as shown in Figure 16.

- Certain framing options and line coding for both PCM E1 and T1 interfaces can be selected by clicking the appropriate check-boxes.

   The initial set-up of the E1 Interface is:

     CCS framing mode (31 channel mode), HDB3 line coding, no CRC4 multi-framing.

     Default 8-bit companding is A-law.

NOTE: At present the TNE does not control nor support the signalling bits of the PCM multi-frame.
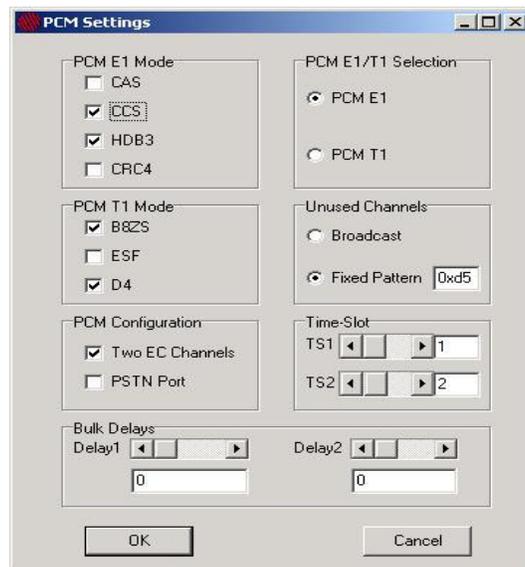
Figure 16. Configuring the PCM Interface

- The active PCM timeslot can be specified for interface A and B: simply scroll the displayed number up or down in the 'TS1' or 'TS2' box.
- The 'Unused Channels' selection permits choosing between two options:

     Broadcast: The unused channels are loaded with the same signal as the active channel.

Fixed Pattern: A fixed 8-bit word is selected, and is transmitted repetitively on all unused channels. (Default value 0xd5 represent A-law idle code.)

NOTE: Click on 'OK' button in the configuration dialogue box to <u>confirm</u> any changes made to the PCM mode. If you close the PCM configuration box and then re-open it, all the parameters will be reset back to defaults.

There are two status lights for each PCM interface A and B. These are located on the right side of the 'Impairment' window (Figure 6). In normal conditions all should be green, indicating that both PCM interfaces are connected to the external PCM equipment and configured properly.

The expanded PCM mode supports various TNE configurations, described in the following sections. It also offers two analogue monitoring outputs, which are providing audio signals corresponding directly to the digital signals received in selected slots by the PCM interfaces on each side, before entering the CO sections A and B (as shown in Figure 17).

7.13.1 External DUT connected via two PCM trunks.

This TNE configuration is provided when both the *'Two EC channels'* and the *'PSTN Port'* checkboxes are <u>not</u> selected (Figure 17) and allows an external Device-Under-Test (DUT) to be inserted between two CO sides, using a pair of PCM trunks - PCM A and PCM B. The active channel is defined by specifying time slots on the PCM trunks (TS1 and TS2, default TS1=TS2), with the PCM framing options and line coding also user selectable.
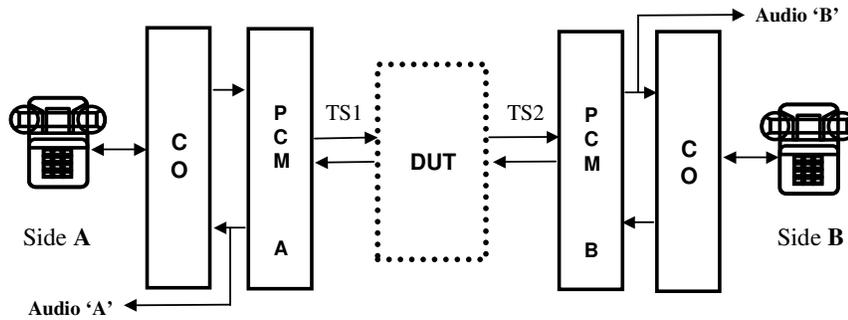
Figure 17. TNE Configuration with the PCM Interfaces

7.13.2 Bulk network delay between two DUT channels

If the *'Two EC channels'* checkbox is selected (but the *'PSTN Port'* checkbox is <u>not</u> selected), the TNE will be re-configured to include bulk network delays between two DUT channels (e.g. EC channels) as shown in figure 18.

This set-up utilises two channels from the multi-channel Device-Under-Test to represent the required test configuration, but still using only two PCM trunks - PCM A and PCM B - instead of four. The two EC channels are defined by specifying two different time slots on each PCM trunk (TS1 and TS2). The PCM framing options, line coding, bulk Delay 1 and Delay 2 are all user selectable, but the 'Broadcast' option for unused channels is not available here.

NOTE: The DUT can be easily by-passed if required, using a PCM crossover cable between PCM sockets A and B.
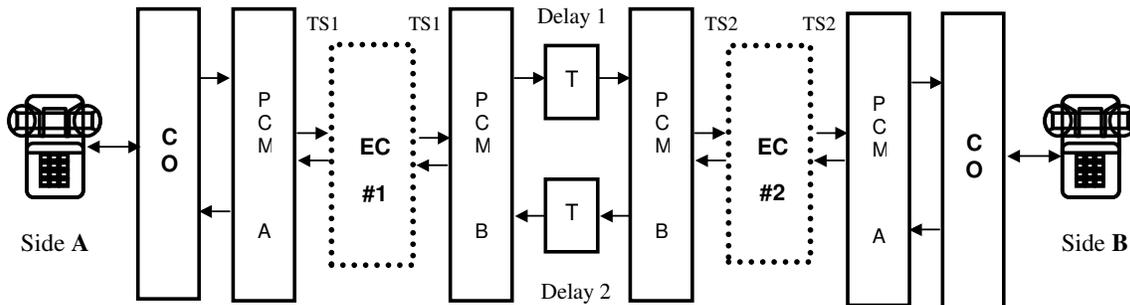
Figure 18. TNE configuration with bulk network delays between two DUT.

7.13.3   TNE Side A access to the PSTN

If both the *'Two EC channels'* and the *'PSTN Port'* checkboxes are selected, the TNE configuration with bulk network delays (as described before) is modified to replace the Side A Central Office interface with the DAA interface.

This option (Figure 19) allows the TNE unit to connect with remote equipment over the PSTN network. The DAA interface module is closely coupled with one of the DSP processors, which provides a DTMF dialing generator and network tones detection.
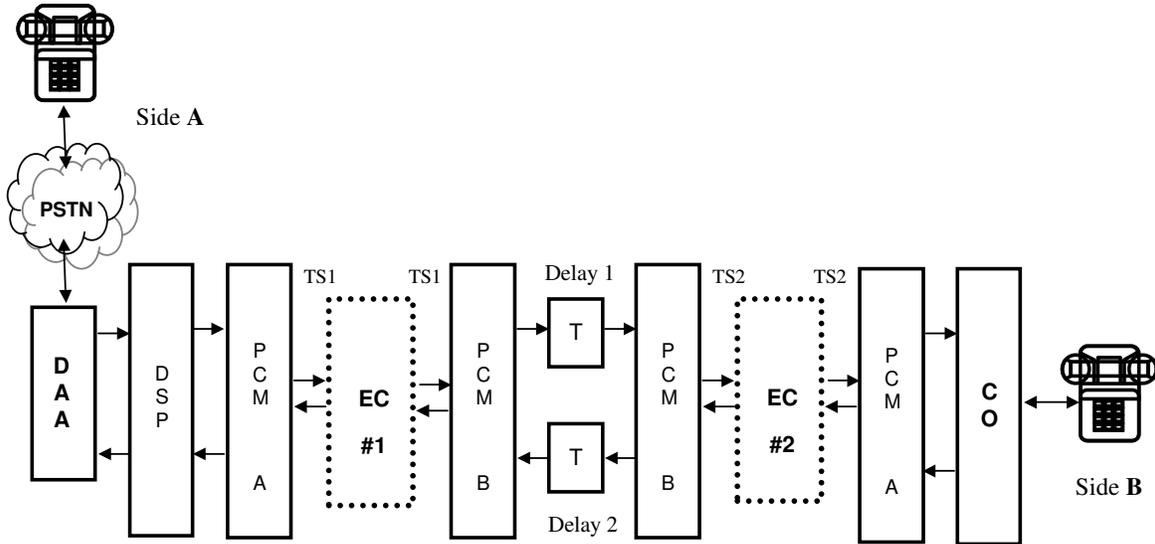
Figure 19. TNE configuration with the CO interface at Side A replaced by the DAA interface

When the *'PSTN Port'* option is selected, a new dialogue box opens as shown in Figure 20.

Figure 20. PSTN Port configuration

A pre-set dial number box is used here to define the real remote telephone number to dial out as described below. The 'Hang-up' button is used to manually force the DAA into idle (on-hook) state.

- If the **'Signalling-transparency'** checkbox is **not** selected, the side B apparatus should dial a dummy number pre-set in Dial Number A in the Central Office control window (Figure 11), after short delay the DAA will go off-hook and dial-out using a pre-set number from the PSTN Port dialogue box (Figure 20). Incoming PSTN call progress tones will be detected and reported as messages in the status box of PSTN Port window

NOTE: In the present version of the application software the dummy Dial Number B in the Central Office control window (Figure 11) **must** be preset to **22** (default) when using the PSTN port.

NOTE: The answering device on the PSTN side should respond after minimum of three rings.

- If the **'Signalling-transparency'** checkbox **is** selected, an internal control configuration will directly force the DAA off-hook when the side B goes off-hook. This way all the dialing and signaling tones of call progress can be exchanged between the Side B apparatus (via the Central Office B) and the PSTN network (via the DAA interface) **over the PCM interfaces and any DUT connected**.

- A call from the PSTN will always make the DAA detect the ringing and the TNE side B (CO) will ring as well. If the telephone (or any other apparatus) at Side B will then go off-hook, this will be detected by the CO and the DAA at Side A will also go off-hook, finalising the connection.

The selection of 'PSTN Port' is independent from selection of 'Two EC channels' mode. Hence the DAA module can replace Side A Central Office function also in a configuration depicted in Figure 17, when a single channel Device-Under-Test (DUT) is inserted between two PCM trunks, without any network bulk delay.

NOTE: When the 'PSTN Port' is enabled, the Side A Central Office is not used and all its controls presented in the TNE 'Main' widow (Figure 4) and 'Impairment' window (Figure 6) have no effect.

8. SPECIFICATION

8.1 CENTRAL OFFICE INTERFACE

- Constant current feed to line   nom. 24mA
- Adjustable loop current range   (14 - 55) mA
- Max. operating loop resistance @24mA   1800ohm
- Tip or Ring to GND, over-current protection   typ. 100mA
- Switch hook detect threshold   typ. 8.5mA, (4 - 13) mA
- Ringing drive capability (trapezoidal)   40V rms into REN=5, short loop
- Receive gain Off-Hook (4-Wire to 2-Wire)   (-6.0 +/-0.5) dB
- Transmit gain (2-Wire to 4-Wire)   (-3.0 +/-0.5) dB
- Frequency response (300 – 3400Hz)   (0.0 +/-0.5) dB
- Total harmonic distortion   max. 1%
- Common mode rejection ratio   min. 48dB
- Line impedance and balance impedance   600 ohm default (opt. complex, according to CTR21)
- Trans-hybrid loss (300 – 3400Hz)   min. 32dB
- Return loss at 2-Wire (300 – 3400Hz)   min. 18dB
- Frequency response   0.0 dB   +/-0.5 dB (300 – 3400) Hz
- Line connectors   2x RJ11 (international pin-out)

Two standard RJ12 FCC-68 Modular sockets are mounted at the DSPGenie front panel, marked as '2-wire I/O' - socket 'A' and 'B'. Their pin-out and signal definition is listed below.

Pin 1: NC
Pin 2: NC
Pin 3: Tip
Pin 4: Ring
Pin 5: NC
Pin 6: NC

NOTE: The wiring of the RJ12 sockets is compliant with the US/international standard.
For the UK market an adapter is needed, with cross-connected pins 3 - 2 and 4 - 5.

8.2 DAA INTERFACE

- Transformer-less 2-to-4 wire conversion

- Full duplex voice and data transmission

- Parallel apparatus activity detection and On-Hook reception (non-obtrusive monitoring mode)

- Built-in over-voltage/over-current protection

- DTMF generation/detection (via associated DSP processor)

- Call progress tones detection (via associated DSP processor)

- Line impedance and network balance   600ohm default (opt. complex, according to CTR21)

- Line current limiter   CTR21/French requirements (option)

- Ringing voltage sensitivity   17 Vrms

- Receive gain (4-Wire to 2-Wire)   nom. 0 dB

- Transmit gain Off-Hook (2-Wire to 4-Wire)   nom. 0 dB

- Transmit gain On-Hook (2-Wire to 4-Wire)   nom. 0 dB

- Frequency response   (300 – 3400Hz)   (+/-0.5) dB

- Trans-hybrid loss   (300 – 3400Hz)   min. 25 dB

- Return loss at 2-Wire (300 – 3400Hz)   typ. 24 dB (600 ohm)

- Idle channel noise   (A-law)   typ. -70 dBm0p

- Single frequency distortion (1015Hz, 0 dBm0)   max. -46 dB

- Line connector   RJ11 (international pin-out)

A standard RJ12 FCC-68 Modular socket is mounted at the DSPGenie front panel, marked as 'PSTN'. Its pin-out and signal definition is listed below.

Pin 1: NC

Pin 2: NC

Pin 3: Tip

Pin 4: Ring

Pin 5: NC

Pin 6: NC

NOTE: The wiring of the RJ12 socket is compliant with the US/international standard.

For the UK market an adapter is needed, with cross-connected pins 3 - 2 and 4 - 5.

8.3 PRIMARY RATE PCM INTERFACE

E1 interface mode (user selectable)

- CEPT/E1 (2.048 MHz) Primary Rate short-haul PCM interface.

- 75 ohm or 120 ohm (balanced) line termination, software-selectable

- Compliant with ITU specification G.703, G.706 and G.732

- Jitter attenuation to G.732, G.823 and CTR12.

- AMI or HDB3 line coding

- CAS (PCM30) and CCS (PCM31) framing formats, with additional CRC4 multi-framing option

- Internal /Master system timing mode (default in TNE)

- Monitoring mode with resistive loss compensation (opt.)

NOTE: As the 75 ohm E1 line termination is selected by default, it is recommended to use a RJ45-to-BNC transitional adapter that splits TX and RX signals from a single RJ45 plug into two 75 ohm BNC sockets.

T1 interface mode (user selectable)

- ANSI T1 (1.544 MHz) Primary Rate short-haul PCM interface.

- 100 ohm line termination (balanced)

- Compliant with relevant ITU, ANSI and AT&T specification

- Jitter attenuation to TR62411.

- AMI or B8ZS line coding

- D4 and ESF framing formats with CRC6

- Internal/Master system timing mode (default in TNE)

- Monitoring mode with resistive loss compensation (opt.)

Two standard RJ45 FCC-68 Modular socket are mounted at the DSPGenie front panel, marked as 'PCM I/O' - trunk 'A' and 'B'. Their pin-out and nominal signal assignment is presented below.

RJ45 Line Connector

Pin Number	Signal	Signal Direction
1	Receive Ring	From DUT
2	Receive Tip	From DUT
3	Unassigned	
4	Transmit Ring	To DUT
5	Transmit Tip	To DUT
6	Unassigned	
7	Unassigned	
8	Unassigned	

8.4 ANALOGUE MONITORING INTERFACE

The DSPGenie TNE offers two analogue monitoring outputs, which are providing audio signals corresponding directly to the digital signals received in selected slots by the PCM interfaces on each side before entering the CO sections A and B (see Figure 17).

These analogue monitoring outputs allow the user to listen to the received signals in *real-time*, giving additional information about the system behaviour.

- Dual unbalanced analogue outputs

- Low impedance output stages (22 ohm typ.)   can drive directly 300 ohm loads

- 0dBm0 level   equivalent of 0.375 Vrms at the outputs (nom.)

- Output gain (D-to-A)   -6.3 dB nom.

- Overload level   1.5 Vpp

- Frequency response   (300 – 3000Hz)   (+/-0.25) dB

- Single frequency distortion (1015Hz, 0 dBm0)   max. -36 dB

- Idle channel noise (D-to-A)   max. -70 dB0p

Standard phono (RCA) type sockets are used at the DSPGenie front panel, marked as 'Analogue I/O' - interface 'A' Out and interface 'B' Out.

The usual contact arrangement is followed here: the centre contact is an active signal, the outer contact is an analogue ground (and a cable screen).

NOTE: The outer contact (an analogue ground) in all phono sockets is isolated from the metal front panel to reduce noise pick-up and avoid ground loops.

8.5 DSPGenie PLATFORM

- Built-in SBC   Pentium class CPU, with IDE hard disk drive and Windows 2000/XP installed
- Rear panel connections   SVGA monitor, PS/2 keyboard and PS/2 mouse, 10/100 Mbps LAN
- Power Supply: 90 to 264 volts AC, 47 to 63Hz; with active Power Factor Correction (PFC)
- Power consumption: 40 watts (typical)
- Housing: portable 2U aluminium case
- Dimensions: 115 x 264 x 312 mm (h .w .d) / 4.5 x 10.4 x 12.3 inches   (including handle).
- Weight: 10kg / 22 pounds approx. 5 kg
- Front panel connectors   DSPGenie TNE variant, see Figure 21 below
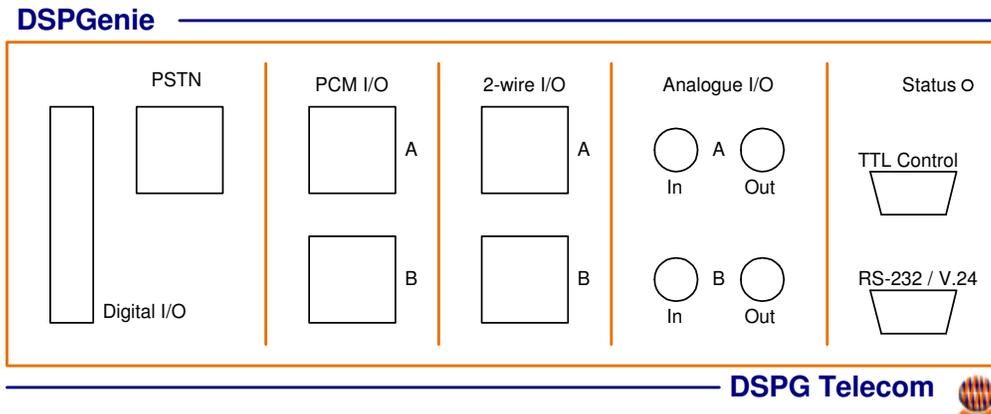
Figure 21. DSPGenie TNE front panel

NOTE: All connectors and sockets are always present on the front panel, regardless which optional interfaces are actually installed and enabled in the DSPGenie platform.

9. HISTORY

Issue	Date	Author	Summary of changes
Draft 0.1	12/07/00	Rod Mack	Initial Proposals
Draft 0.2	21/07/03	Rod Mack	Modified and updated to reflect operational hardware.
Draft 0.3	25/07/03	Rod Mack	Modified and updated to reflect changes to software.
Ver.1.0	26/09/03	Mietek Golos	Modified and updated to include PCM interface and VNC remote control.
Ver.1.1	21/03/06	Dalan Wang	Modified and updated to include DS PCM2 expansion and new PCM configurations
Ver.1.2	28/09/07	Mietek Golos	Updated for to reflect changes in PCM expansion (TNE v3.1)

Appendix A: Impairment and Hybrid Filters

1) Impairment/ Hybrid filters file format

filter type: FIR

maximum number of taps: 128

file type: text file, each coefficient in a separate line

data format: floating point data, minimum value -1 and maximum value 0.99999

2) Impairment library folder \ImFilter

m1020.flt   CCITT M1020 gain filter

m1025.flt   CCITT M1025 gain filter

m1040.flt   CCITT M1040 gain filter

B3002.flt   Bell 3002 gain filter

USA_ave.flt   USA average gain filter

USA_wrs.flt   USA worse case gain filter

3) Hybrid library folder \HybFilter

 G168coef1.flt   ITU-T G.168 model 1

G168coef2.flt   ITU-T G.168 model 2

G168coef3.flt   ITU-T G.168 model 3

G168coef4.flt   ITU-T G.168 model 4

G168coef5.flt   ITU-T G.168 model 5

G168coef6.flt   ITU-T G.168 model 6

G168coef7.flt   ITU-T G.168 model 7

G168coef8.flt   ITU-T G.168 model 8