DIGITAL COE RETURN LOSS

Return loss (RL) is the method chosen in telephony to compare the similarity or difference between two impedances. Return loss compares both the magnitude and phase relationships of two impedances, is expressed in decibels (dB), and can be readily calculated and measured. Return loss is calculated:

$$RL\ (dB) = 20 \log \left| \frac{Z1 + Z2}{Z1 - Z2} \right|$$

Z1 is the impedance being compared to the Z2 reference impedance. A comparison of 600 and 900 ohms (Z1 = 600 ohms and Z2 = 900 ohms) yields 14 dB return loss.

A major use of return loss is to characterize end office equipment and facilities that terminate the telephone network. The end office (equipment and facilities) is viewed as a termination to the telephone network. Specifications and measurements are applied to the end office to control echo on long distance telephone calls.

Return loss is measured using weighted noise in three bands. Echo return loss (ERL) covers the middle of the voice passband which is approximately 500 to 2500 hertz. Singing return loss (SRL) covers the passband edges. SRL-LO is approximately 250 tO 500 hertz and SRL-HI is approximately 2500 to 3200 hertz. A standard impedance of 900 ohms in series with 2.16 microfarads is used for end office return loss measurements.

Return loss measurements are applied to all digital central office equipment (COE) trunk and line ports. For this discussion, return loss is illustrated for a two-wire trunk to line connection. The same principle applies to all two wire trunk and line ports.

Return loss is measured as illustrated in Figure 1. The measured return loss in dB describes the match between the digital COE (the trunk to line connection as a network termination) and the standard reference impedance of 900 ohms in series with 2.16 microfarads. It is a measure of the near end (measuring end) trunk port or hybrid as a termination <u>and</u> the transhybrid balance at the far end. The digital COE hybrid may be an active or passive device. A passive coil hybrid is illustrated in this discussion.

The input or terminal impedance of the port is determined by hybrid design. It is a function of the coder and decoder impedances and the hybrid coil turns ratio. The coder and decoder act in parallel to terminate a signal entering the hybrid two wire line port. The near end balancing network has an insignificant effect on the input impedance unless the coder and decoder impedances are severely mismatched.

The transhybrid balance at the far end has a significant effect on the near end return loss measurement in a conventional full duplex connection. The digital COE is set at a low loss between the two wire ports. A signal entering the near end trunk port passes through the hybrid, is coded, switched, and decoded at the far end line port. The degree of mismatch between the COE network impedance and the line termination impedance (and perhaps the hybrid design) permit some of the signal to "spill" across the hybrid to the far end coder. This is described as transhybrid balance. The return signal is coded, switched and decoded at the near end. This return signal acts to partially add to or cancel the original signal which modifies the basic hybrid input impedance. Poor transhybrid balance at the far end affects the near end impedance and return loss. The input impedance at the near end (measuring end) is a function of the basic design near end impedance, loss from near to far end ports, transhybrid balance at the far end, and loss from far to near end ports.

Four wire return loss is measured by injecting a weighted noise signal into the near end coder and measuring the return signal at the near end decoder. Thus, the four wire return loss is determined primarily by the far end transhybrid balance plus the small loss between the near and far end.

Network Impedances

A standard impedance of 900 ohms in series with 2.16 microfarads has been used to characterize the end office impedance for several decades. Central office equipment was essentially designed with passive components; systems with active components (i. e., carrier equipment) were designed to be operated at net circuit loss to provide stability. The introduction of digital central office equipment marked a rapid trend from passive to active central office equipment transmission paths. These digital switches were set at low transmission loss resulting in marginal stability from oscillation or "singing".

To improve the digital COE stability margin, digital COE manufacturers initiated studies to better characterize end office loops. Different studies provided different loop impedance characteristics. Confusion reigned. With the Bell System as the largest potential user of digital COE, the AT&T impedances (or slight variation) were gradually adopted as standard balance networks for hybrid balance (See Figure 2). They were used to match (A) loaded loops, (B) nonloaded loops and (C) trunks and special services (lines and trunks). The input impedance of all end office ports would be the standard 900 ohms in series with 2.16 microfarads; but only trunk and special service circuits would use that impedance for hybrid balance networks.

REA discouraged the use of craft selected balance networks based on loop type to minimize error and COE instability. (REA permitted up to 2.0 dB loss for local calls for stability). Digital COE design evolved toward automatic selection of the balance network.

To reduce complexity, the balance network choice was loaded or nonloaded; the standard 900 ohms in series with 2.16 microfarads was eliminated. Automatic balance network selection represented an improvement in system operation and maintenance, but does have two significant shortcomings. These are initial acceptance tests and connections to lines with active transmission elements (voice repeaters, carrier equipment, etc.). While it is not a serious concern, it is ironical that the balance network for active transmission circuits is being eliminated with the trend toward that type of subscriber circuit for voice, data and other services.

Acceptance Tests

Return loss acceptance tests are made as illustrated in Figure 1. The impedance of the two wire end office trunk or line circuit is 900 ohms in series with 2.16 microfarads. The return loss test set uses a standard termination of 900 ohms in series with 2.16 microfarads at the near end (measuring end). Other terminations may be used as far end line terminations.

Where the balance network is craft selected, acceptance tests for return loss can generally be made by selecting the standard balance network of 900 ohms in series with 2.16 microfarads. In actual service, most balance networks will be set for nonloaded and loaded loops. It is recommended that acceptance tests for return loss be made with those balance networks also. When the loaded or nonloaded COE balance networks are chosen, the far end line termination should be a standard loaded or nonloaded network (Figure 2A or 2B).

Where the balance network is automatically selected by the digital COE software, the choice will be between a loaded network or a nonloaded network. A balance network of 900 ohms in series with 2.16 microfarads is unlikely to be available with automatic network selection. It is recommended that acceptance tests for return loss be made with loaded and nonloaded COE balance networks. The far end line termination should be standard loaded or nonloaded network (Figure 2A or 2B).

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FIGURE 1 - RETURN LOSS TEST FOR DIGITAL COE (TWO WIRE)

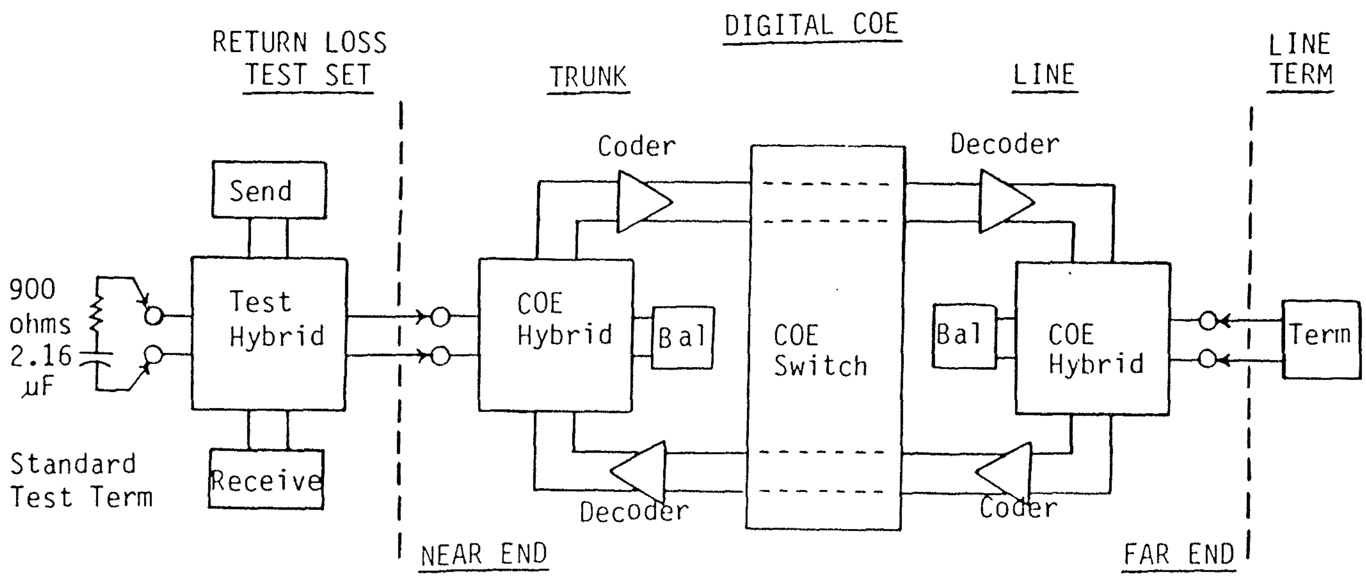
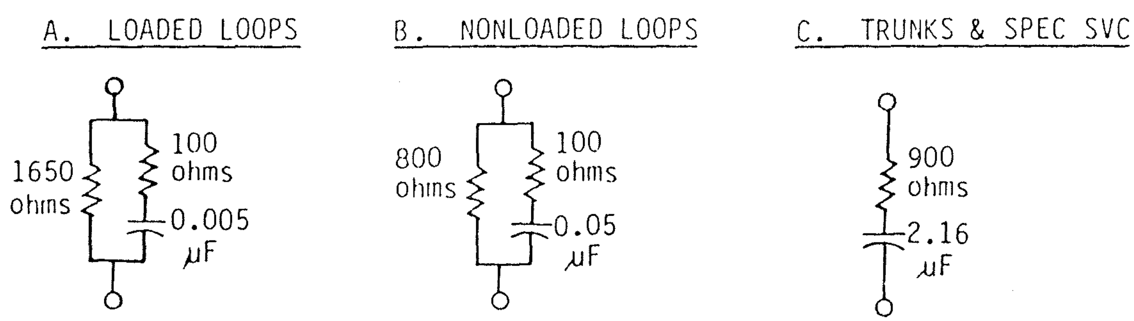


FIGURE 2 - STANDARD TWO WIRE BALANCE NETWORKS



Note: The networks above may also be used as test terminations. Only Network C is used as a near end test termination. Networks, A, B or C may be used as a far end test termination.