

## NO. 4 ESS OFFICES

### TERMINAL BALANCE

### GENERAL INFORMATION

#### 1. GENERAL

**1.01** This section provides a basic understanding of the purposes, requirements, measurements and techniques encountered in the terminal balancing of No. 4 ESS trunks. For related information, refer to Section 660-460-010, No. 4 ESS Balance Records, and Section 660-460-301, No. 4 ESS Balance Requirements.

**1.02** When this section is reissued, the reason for reissue will be given in this paragraph.

**1.03** Terminal balance is the process of measurement, adjustment, and evaluation used to control echo and singing on toll connecting (TC) trunks. Terminal balance applies only to TC trunks. TC trunks are trunks which terminate on class 5 entities, either end office switchers or end office switchboards, and a class 4 or higher switcher.

**1.04** TC trunks terminate on No. 4 ESS as 4-wire and must convert to 2-wire either in the No. 4 ESS office or local office before terminating in the class 5 entity. The termination of the 4-wire facility and the conversion to 2-wire transmission is accomplished by a 4-wire terminating set that employs a transformer-type hybrid coil with a balancing network. This type of interface is designed to permit the desired transfer of power from the 4-wire facility receiving path into the 2-wire facility and from the 2-wire facility into the 4-wire facility transmitting path. However, the nature of the hybrid is such that any impedance mismatch between the 2-wire path and the balancing network causes undesirable reflected power. Therefore, control measures are necessary to achieve the best match of the impedances.

**1.05** Control of echo and singing involves matching the impedance of the balancing network in the 4-wire terminating set to the impedance of

the 2-wire facility or termination to minimize power reflections in the transmitting path of the 4-wire facility.

**1.06** Balance basically consists of adjusting the capacitance of the balance network in the 4-wire terminating set until the balance network is the electrical equivalent of the 2-wire line or termination.

#### 2. 4-WIRE TERMINATING SET

**2.01** To reduce the possibility of transmission impairments, networks are designed to match the impedance of 2-wire facilities over a specified frequency range to a degree sufficient to limit the reflected power to acceptable levels. The network is called a "balancing network," and the resultant degree of impedance match is called "balance."

**2.02** The degree of balance is usually expressed in terms of return loss (RL) in dB at specific frequencies. RL can be most clearly defined by means of a specific example of measurement.

**2.03** If a short is placed across the 2-wire line at the 4-wire terminating set and a known amount of power is sent into the receive leg, the reflected power can be measured at the transmit leg (refer to Fig. 1A). For example, if a frequency of 1000 Hz at a power of 0.0 dBm is sent into the receive leg and the power measured at the transmit leg is -7.5 dBm, the total 1000 Hz loss from the receive leg input to the transmit leg output is 7.5 dB. This is the loss of the hybrid from the receive leg to the transmit leg and is generally referred to as the transhybrid loss (THL), with 0 dB RL (total reflection of power) at the 2-wire terminals. The actual measured THL will depend on the type of hybrid and the loss of the receive and transmit pads (if any) in the measuring path.

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**2.04** With the short removed, the 2-wire side of the 4-wire terminating set connected to its 2-wire line facility, and the distant end of the 2-wire line facility terminated in the correct impedance, another measurement is taken with the same input power and frequency at the receive leg. The power measured at the transmit leg will be lower than with the 2-wire leg shorted because the network and the 2-wire line facility with its terminating impedance will absorb most of the power sent in at the receive leg. For example, if the power measured at the transmit leg is now -26.5 dBm, the loss from the receive leg to the transmit leg is 26.5 dB (at 1000 Hz). Since the losses of the hybrid and pads (if any) are common to both tests, the 7.5 dB loss is subtracted from the 26.5 dB, leaving 19.0 dB. This 19.0 dB is the RL and represents the degree of balance between the 2-wire line facility and the balancing network at the frequency of the applied power. Higher degrees of balance are indicated by larger values of RL.

### 3. DEFINITIONS

**3.01** RL is the measurement of the reflected power at a specific frequency. It represents the degree of balance between the 2-wire line facility and the balancing network at the frequency of the applied power. Higher degrees of balance are indicated by larger values of RL.

**3.02** Echo return loss (ERL): Under certain conditions, the power reflected at a 4-wire terminating set due to impedance mismatch between the network and the 2-wire line may cause transmission impairments. If sufficient power in the range of 500 to 2500 Hz is reflected, the talker may hear his own voice returned, or echoed to him to the extent that it will interfere with his ease of conversation. This effect is called "talker echo," and is expressed or measured in terms of ERL, the average loss of the returned signal weighted by the RL measuring set over the 500 to 2500 Hz band.

**3.03** Singing return loss (SRL): The weighted average return loss in the singing bands of 200 to 500 Hz and 2500 to 3200 Hz. It is the lower of the values measured in the two bands (high band or low band) as measured by a return loss measuring set (RLMS). The SRL in the 2500 to 3200 Hz band is referred to as SRL HI.

**3.04** Singing point (SP): A measure of the RL at a single frequency in the 200- to 3000-Hz voiceband. The single frequency at which the SP applies is usually the frequency having the poorest RL at the hybrid interconnection; it is the critical frequency in the voiceband at which gain and phase relationships may cause singing. While singing may occur in theory at any frequency in the voiceband, the critical frequency is usually found near the upper or lower end of the band because of 2-wire circuit impedance characteristics. The KS-20501 RLMS furnished with the 51A test position will not measure SP.

**3.05** The difference between SRL and SP is in the two methods of measurement. The SRL is conveniently measured by a weighted noise technique similar to that used for ERL measurements but measurement is confined to the singing bands. The SP is a single-frequency RL measured at the critical frequency. The two values are, in practice, essentially the same in a given circuit and may usually be considered equivalent. (It should be noted that the effect of talker echo is dependent upon the loss of the circuit, the degree of balance at the distant end of the connection, and the round-trip transmission time between the talker and the distant end. Singing depends upon the degree of balance at both ends of a circuit, the frequency response, and the phase relationship between the original and reflected power.)

### 4. TEST PROCEDURES

**4.01** Detailed procedures for performing balance tests and measurements on No. 4 ESS trunks are found in Section 234-150-001. Description and operation of the KS-20501 RLMS are found in Section 103-106-115. Fig. 1B and the following discussion are presented to give a basic understanding of the procedures involved. A trunk must meet the level, gain slope, and noise requirements before balance tests are made.

**4.02** On a 2-way or outgoing TC trunk, the 51A test position operator accesses a far end termination via a Test Access Trunk (TAT). If the far end is not equipped with an expanded ROTL or 100-type test line, a predetermined number is accessed and the far end will physically terminate the 2-wire appearance of the trunk.

**4.03** On an incoming-only TC trunk, the far end will access the 51A test position by dialing

101. The far end then terminates the 2-wire appearance of the trunk. The termination for a 2-wire switching office or switchboard is 900Ω resistance in series with a 2.16 μF capacitor.

4.04 The KS-20501 RLMS on the 51A console is then switched into the 4-wire appearance at the console. With the RLMS in the ERL mode, the capacitance of the balance network at the far end is adjusted for a maximum combined reading of the RLMS meter and switch. The ERL measurement must meet or exceed the median requirements in Section 660-460-301. Trunks below the median value must be referred to the Transmission Engineer for analysis.

4.05 With the balance network adjusted for a maximum ERL, the SRL and SRL HI

measurements are made. The SRL and SRL HI are compared and the lowest figure (worst case) of the two is used to meet the objectives in Section 660-460-301. As the ERL and SRL interact, the balance network may require a compromise adjustment to meet both ERL and SRL median requirements.

**Caution: A measurement of 40 or higher may indicate an invalid test connection.**

4.06 The ERL measurement and the lower figure (worst case) of the SRL and SRL HI measurement are recorded on the 403 display of CMS per Section 234-150-001 and on Form E6006 per Section 660-460-010.

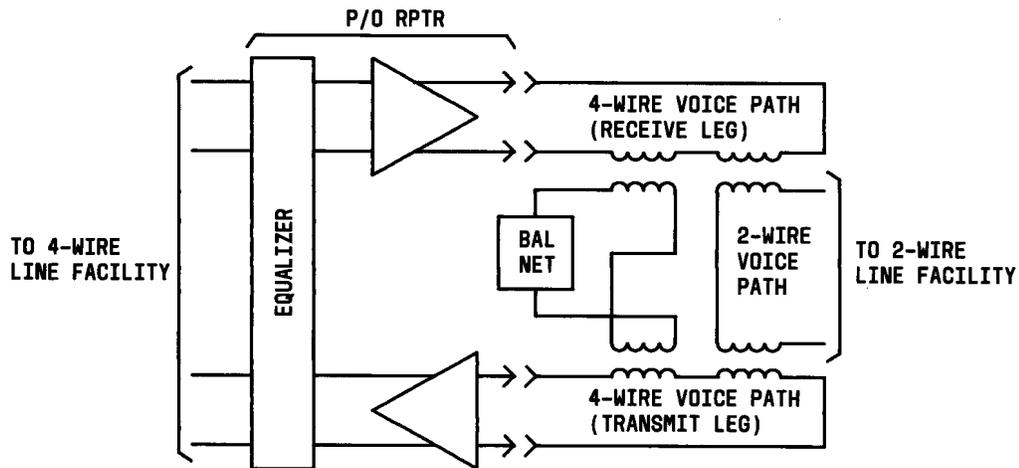


FIG. 1A - 4-WIRE TERMINATING SET

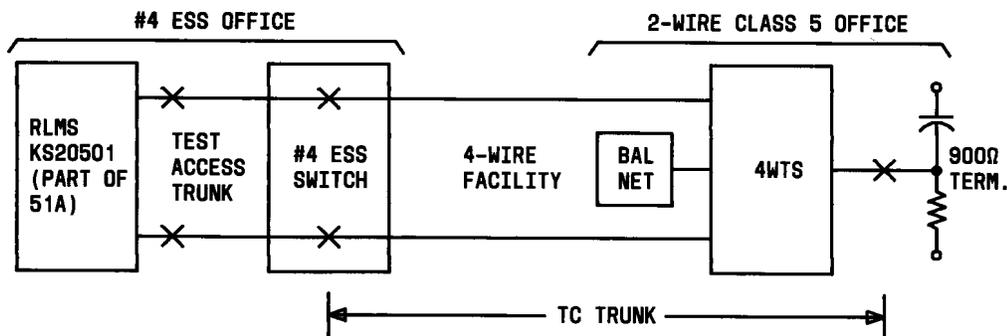


FIG. 1B - TERMINAL BALANCE TEST ARRANGEMENT

Fig. 1—4-Wire Terminating Set and Terminal Balance Test Arrangement