LESSON 27:
ANALOG TERMINATION REQUIRMENTS, BORSHT CONFIGURATION AND DIGITAL TERMINATION REQUIRMENTS

Objective

To provide a detailed understanding of the concepts Analog termination requirements, BORSHT configuration and Digital Termination requirements

Introduction

Analog Transmission Requirments

The design, implementation, and maintenance of any large and complex system require partitioning of the system into subsystem. An interface is associated with each subsystem. The interface defines the input and the output independent implementations. Well-established interfaces are fundamental requirement to maintain compatibility between old and new equipments. The principle analog interfaces used in the periphery of the networks are:

1. Subscriber loops
2. Loop-start trunks
3. Ground-start trunks
4. Direct-inward-dial trunks
5. E&M trunks.

1. Subscriber loops:

The most common interface in the network involves the two-wire connection of individual telephone lines to end office switch: the subscriber loop interface. Because of the nature of history standard telephones and the electromechanical switches to which they were originally connected. This interface has a number of characteristics that are difficult to satisfy with modern IC technology.

This interface has the following fundamental characteristics:

1. Battery: Application of DC power to the loop (48V normally) to enable DC signaling and provide bias current for carbon microphones.
2. Overvoltage Protection: Protection of the equipment and personnel from lightning strikes and power line induction or shorts.
3. Ringing: Application of a 20Hz signal at 86V rms for ringer excitation. Typical cadence is 2 second on and 4 second off.
4. Supervision: Detection of off-hook/on-hook by flow/no-flow of DC current.
5. Test: Access to the line to test in either direction toward the subscriber or back into the switch.

In case of a digital end office, two more functions are necessarily required:

1. Two-wire-to-four-wire (2W/4W) conversion i.e. Hybrid
2. Analog-to-Digital(A/D) coding [Digital-to-Analog (D/A) decoding]

These seven functions in order.

2. Loop-Start Trunks

A loop-start (LS) trunk is a two-wire connection between switches. This type of connection is usually made between a central office and a PBX. From an operational point of view, an LS trunk is identical to a subscriber loop. Thus an LS interface in a PBX emulates a telephone by choosing the loop to draw current for call origination and by detecting ringing voltages for incoming calls. To send address information, the PBX interface generally waits for a few seconds and assumes that a dial tone is present before sending DTMF tones or generating dial pulses by interrupting loop current. Some PBX, provide dial tone detection so faulty equipment or connections are more easily recognized and addressing can be sent as soon as the other end is ready.

One significant difficulty with two-way LS trunks arises when both ends of the line think they are originating a call, the line becomes hung. This situation is commonly called glare. If the PBX detects a dial tone before sending digits, it will recognise the glare condition by timing out on the wait for dial tone and can then generate a disconnect to release the glare condition but drop the incoming call. More commonly, the PBX blindly sends the address digits and connects the originating PBX station to the line. Generally, this means the incoming call gets connected to the wrong station. For this reason, LS trunks are normally used only as one-way trunks: either one-way incoming or one-way outgoing.

3. Ground-Start Trunks

The aforementioned problem with glare on two-way LS trunks can be largely resolved by augmenting the call origination process to use ground-start (GS) procedures. When originating a call, the end office applies a ground potential to the tip lead of the tip and ring pair and waits for the PBX to acknowledge the seizure by drawing loop current. When the PBX originates a call, it first applies ground to the ring lead and closes the loop waiting for loop current. (The CO does not apply battery during an idle state as it does in an LS interface.) The CO acknowledges the connect request by applying battery to the tip/ring pair and momentarily applying ground to the tip. Maintaining low-noise circuits requires removal of all paths to ground during the connected state. A GS protocol prevents simultaneous seizures unless the originations occur within a few hundred milliseconds of each other. In contrast, an LS protocol allows multiple seizures to occur with windows up to 4 sec (the silent interval between ring bursts). Moreover, a glare condition on GS trunks can be recognized by the interface equipment so it can be resolved by redirecting the calls to different trunk circuits.

Another advantage of GS trunks is the ability of the CO to signal network disconnects to the PBX (the CO removes battery). With LS trunks the network does not generally provide disconnect signalling so the PBX must rely on the end user to hang up. (A situation that often produces hung trunks with data connections.) Furthermore. when the CO places an incoming call that eventually gets abandoned, because no one answers, a CO immediately signals the abandonment by removing ground from the tip lead. With LS trunks, abandoned calls can be recognized only by the absence of ring voltage, which can take 6 sec.

4. Direct-Inward Dial Trunks

Direct-inward dial (DID) trunks are particularly simple two-wire trunk interfaces because they are always one-way trunks: incoming only with respect to a PBX. As implied by the name, they allow a serving CO to forward the extension number of incoming calls so a PBX can immediately route the call to a destination without going through an attendant. In contrast to LS and GS trunks, the PBX end of a DID trunk provides battery voltage so the CO can signal an incoming call by merely closing the loop to draw current. After the PBX reverses battery momentarily (winks) to signify it is ready to receive digits, the CO either generates dial pulses or DTMF tones to send the extension number (two, three, or four digits). After the designated station answers, the PBX reverses battery again to signify the connected state and holds that state for the duration of the call. DID trunks are also referred to as “loop reverse-battery super vision” trunks with variations in the signalling protocol depending on the type of CO.

6. E & M Trunks

As indicated in Fig.27.1, an E&M trunk is defined as an interface to a transmission system and not a transmission system itself. The interface in Figure 27.1 has a four-wire voice path, an E lead with an associated return lead (SG), and an M lead with an associated return (BB). Thus there are eight wires in this interface (referred to as a type 11 E&M interface). Other types of E&M interfaces are defined with as few as four wires (a two-wire voice path, a E lead, and an M lead with earth ground returns).

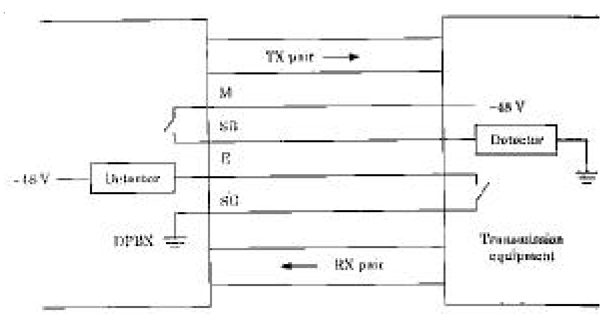

Fig. 27.1: Type II E & M interface

In any type of E&M interface, supervision signalling is always conveyed on the E and M leads and not on the voice pair (or pairs). The PBX signifies off-hook by closing the M-SB loop to draw current while the transmission equipment indicates off-hook by closing the E-SG loop to draw current. How the transmission equipment conveys the supervision is a function of the transmission link. A variety of timing protocols are defined for the start of address signalling, which can be in-channel DTMF tones or dial pulses generated by momentary opens on the respective E and M leads.

Although E&M signalling is formally defined as just an interface, they are often used (with up to four pairs of wires) as direct connections between PBXs. Because of the requirement for multiple pairs, such applications usually occur when the PBXs are located within a single building or campus complex. The availability of external control leads allows the use of E&M interfaces for special applications such as paging systems, where the M lead can be used to turn on the loudspeaker.

Borscht Configuration

Signalling and voice transmission on the subscriber lines requires that the exchange performs a set of functions. These functions are performed by an interface at the telephone exchange end known as subscriber loop interface. Some functions are required in analog networks, some in digital networks and others in both. The complete set of functions performed by an interface at the telephone exchange end are known by an acronym BORSCHT which stands for:

B = Battery feed

O = Over voltage protection

R = Ringing

S = Supervision

C = Coding

H = Hybrid

T = Test

High voltage, low resistance and current requirements of many of these functions are particularly burdensome to IC implementations. First generation digital end office switches reduced the termination costs by using analog switching (concentrators) to common codes.

The DMS-IOO of Northern telecom and the No.5 ESS of AT & T use analog concentration at the periphery. IC manufacturers have worked diligently to implement the BORSCHT functions in what is called a subscriber loop interface circuit (SLIC). Per-line SLICs allow implementation of per-line BORSCHT functions. SLICs can be used ‘in PBX applications with a minimum of other external components. In central office applications, where lightning protection and test access are more demanding. SLICs typically need other components for a complete interface.

Borscht

1. Battery feed and hybrid
   - transformer (Fig.27.2)

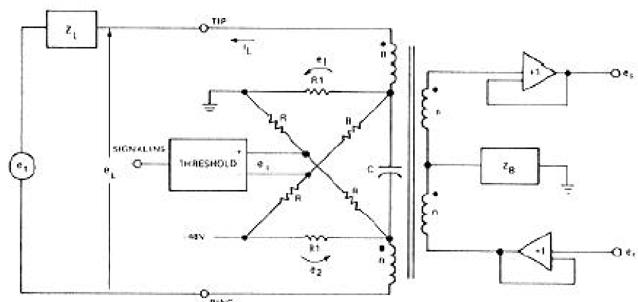

Fig.27.2 Battery feed and hybrid with transformer.

- current source and OP amp (Fig.27.3)

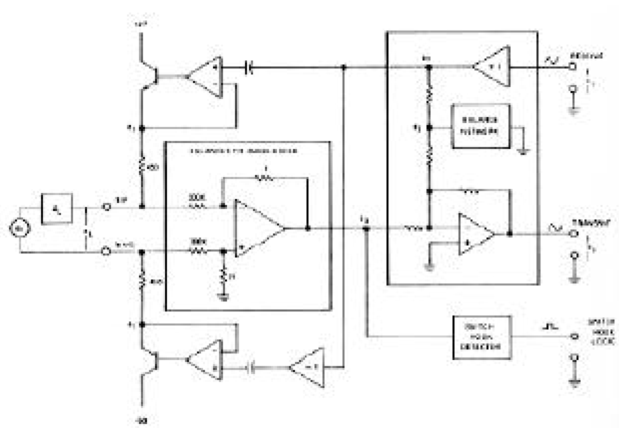

Fig.27.3 Battery feed and hybrid with current source and OP amp.

Reasons for negative battery feed

1. to protect plating-off process of the copper wire when it is exposed to moisture resulting from small leaks in the cable sheath
2. to protect plating-off process of the (gold-)plated relay contacts

2. Overvoltage protection

a. waveform for voltage/current stress tests (Fig.27.4)

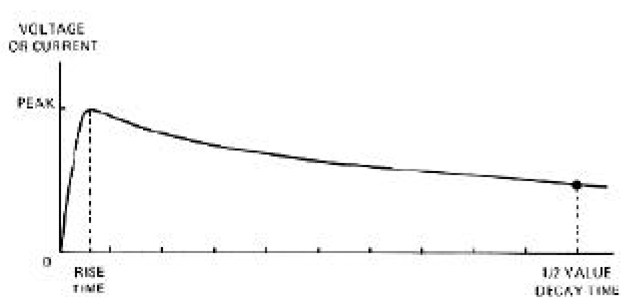

Fig.27.4 Waveform

b. Lab simulation test methods

method	peak	rise time	1/2 decay time	remarks
current surge	500A	10μs	1ms	- tip/ring
voltage surge	2500V	1.2μs	50μs	- ac power supplier
voltage surge from high imp. source	1000V	10μs	1ms	- tip/ring - primary protector at MDF removed
breakdown delay of arrester	3 times σ of arrester breakdown voltage	100V/μs	average turn-on time	- arrester removed
ac power fault	10A current is applied. max 11cycles of 60Hz signal			- tip/ring

c. surge protector (Fig.27.5)

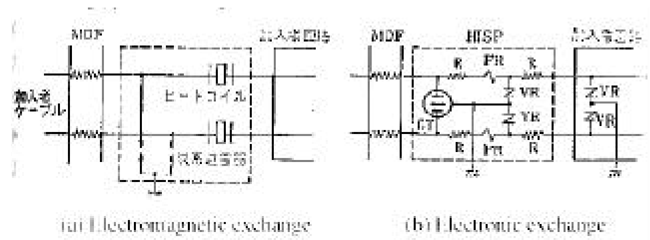

Fig.27.5 Surge protection.

d. primary protection

1. located at MDF
2. carbon block: surge may occur due to the difference of response time of 2 carbon blocks
3. 3 element gas tube: less variability in breakdown voltage/ short response time/ large current absorbing capability/ higher clamping voltage
4. secondary protection
5. varistor: lower clamping voltage/ small current absorbing capability
6. zener diode, power resister

3. Ringing (Fig.27.6)

1. ring voltage: 70~90Vrms/ 16, 20Hz/ cadence
2. required power: terminating traffic/ mean ringing time/ ring trip delay time/ ringer impedance (10K/ 50.)
3. ring trip
4. operation of the ringing current injection relay: synchronized to zero crossing point of the ringing signal to prevent the surge

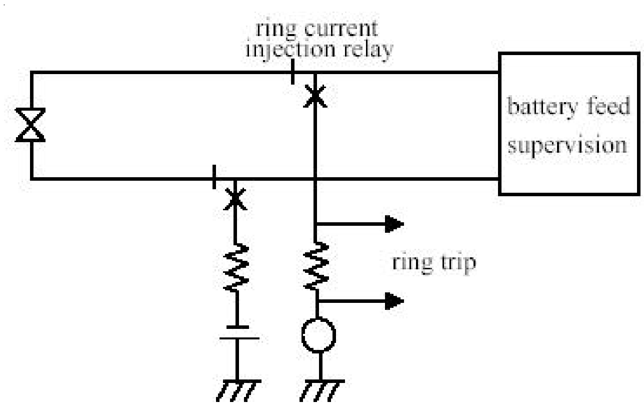

Fig.27.6 Ringing

4. Supervision

1. seizure/release/DP detection/ring trip at the max loop resistance
2. handling of metallic contact bouncing

5. Testing

1. out test

2. DC voltage of tip-ground/ring-ground/tip-ring
3. AC voltage of tip-ground/ring-ground/tip-ring
4. loop resistance
5. loop leakage resistance
6. loop capacitance
7. in test
8. loop current
9. DP/DTMF transmit
10. various tone detection
11. ring trip
12. transmission loss

6. Codec and filter

1. PCM μ/A-law coder/decoder
2. bandpass filter for TX/ lowpass filter for RX

Digital Termination Requirments

In case of a digital end office, two additional functions are necessarily required:

1. Two-wire-to-four-wire (2W/4W) conversion. It is a Hybrid conversion.
2. Analog-to-Digital (A/D) coding or Digital-to-Analog (D/A) decoding

Following seven functions are required for digital termination.

1. Battery
2. Over voltage Protection
3. Ringing
4. Supervision
5. Coding
6. Hybrid
7. Testing

Requirements

a) Line code: bipolar code for T1 carrier, 2B1Q code for DSL

b) Frame format: T1, CEPT frame format/ super frame/ extended super frame/ SONET/ SDH

c) Signaling: communication of signaling states

i) Signaling bits by bit robbing

ii) CCS

iii) 64 kbps D channel in the ISDN primary-rate interface

d) one's density

i) B8ZS

ii) ZBTSI (zero-byte time slot interchange): zero bytes from the user are substituted with a new byte with 1's and the fact is signaled over the facility data link channel in the ESF so that it can be reversed at the end of the link

e) 64 kbps clear channel: B8ZS/ ZBTSI

f) Synchronization

i) Synchronous means that 2 systems have the same average bit rate

ii) Incoming bit streams are synchronous only if

iii) TX clock is loop-timed with the derived receive clock

iv) All digital switches have internal clocks synchronized together via network synchronization

v) Phase alignment

g. Maintenance and alarms (No.4 ESS)

i) Reports

ii) Slip: 4/24hr

iii) Framing loss: 17/24hr

iv) Bipolar violation: 1/106 bits

v) Alarms

vi) Local alarm: OOF for 2.43 sec, digit 2 to zero (next to MSB of the time slot) on all outgoing channels

vii) Remote alarm: digit 2 zero for 464msec

Functional block diagram (Fig.27.7)

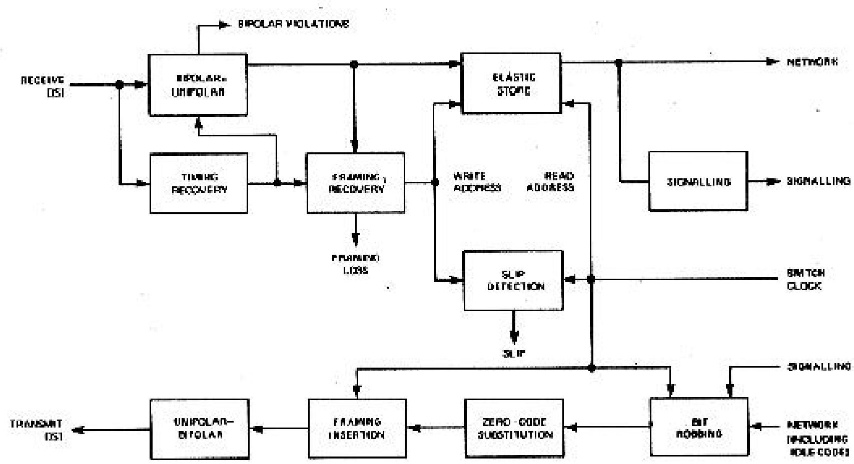

Fig.27.7 Block diagram of digital termination.