Meridian 1

Digital telephone line engineering

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December 1, 1991

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December 1994

Standard, release 3.0. Reissued to include editorial changes and indexing. Due to the extent of the changes, revision bars are not used.

Contents

Engineer a telephone line 1

Select a loop 11

Calculate DC loop resistance 13

Perform loop diagnostic tests 15

Testing foreign voltage 15
Testing insulation resistance 15
Testing DC continuity 16
Testing capacitance unbalance 16

Measure impulse noise 17

Measure background noise 19

Calculate expected pulse loss 21

Example of applying Procedure 6 22

Measure DC loop resistance 25

List of figures

Figure 1
Engineer a telephone line 2

Figure 2
Maximum allowable impulse noise counts versus loop loss 18

Figure 3
Junction loss versus cable characteristic impedance 24

List of tables

Table 1
Conductor resistance per unit 13

Table 2
Cable attenuation at 256 kHz and 21.1 degrees C (70 degrees F) 23

Table 3
Attenuation at 256 kHz for U/C cable 23

Table 4
Attenuation at 256 kHz for D inside wiring cable 23

Engineer a telephone line

Use Procedure 1 to engineer a digital telephone line.

Procedure 1

1 Be sure that cable pair selections meet the following requirements:

- AC signal loss is less than 12 dB at 256 kHz due to all sources.
- DC loop resistance is less than 175 ohm.
- Minimum loop length (mainframe bulkhead to telephone) is 30 m (100 ft).
- Near-end crosstalk coupling loss is >38 dB at Nyquist frequency of 256 kHz (not an issue for typical 22, 24, and 26 AWG twisted pair cable).
- No bridge taps are permitted.
- No loading coils are permitted.
- Protection devices of the carbon-block and gas-filled type are permitted if the off-state shunting impedance is better than 10 MΩ resistive and less than 0.5 pF capacitive.

2 Be sure that the following criteria are met where under-carpet cabling is used:

- Characteristic impedance is at 256 kHz, 100 ± 10 ohm.
- Insertion loss is at 256 kHz, <4.6 dB/kft.
- The next pair-to-pair coupling loss is at 256 kHz, >40 dB.

3 For a typical system with 22, 24, or 26 AWG standard twisted-pair cable, the requirements translate to the following allowable loops:

- up to 915 m (3000 ft) of 22 or 24 AWG cable
- up to 640 m (2100 ft) of 26 AWG cable

4 If the selected cable pair does not work satisfactorily, select another cable pair as shown in Figure 1.

Figure 1
Engineer a telephone line (Part 1 of 8)

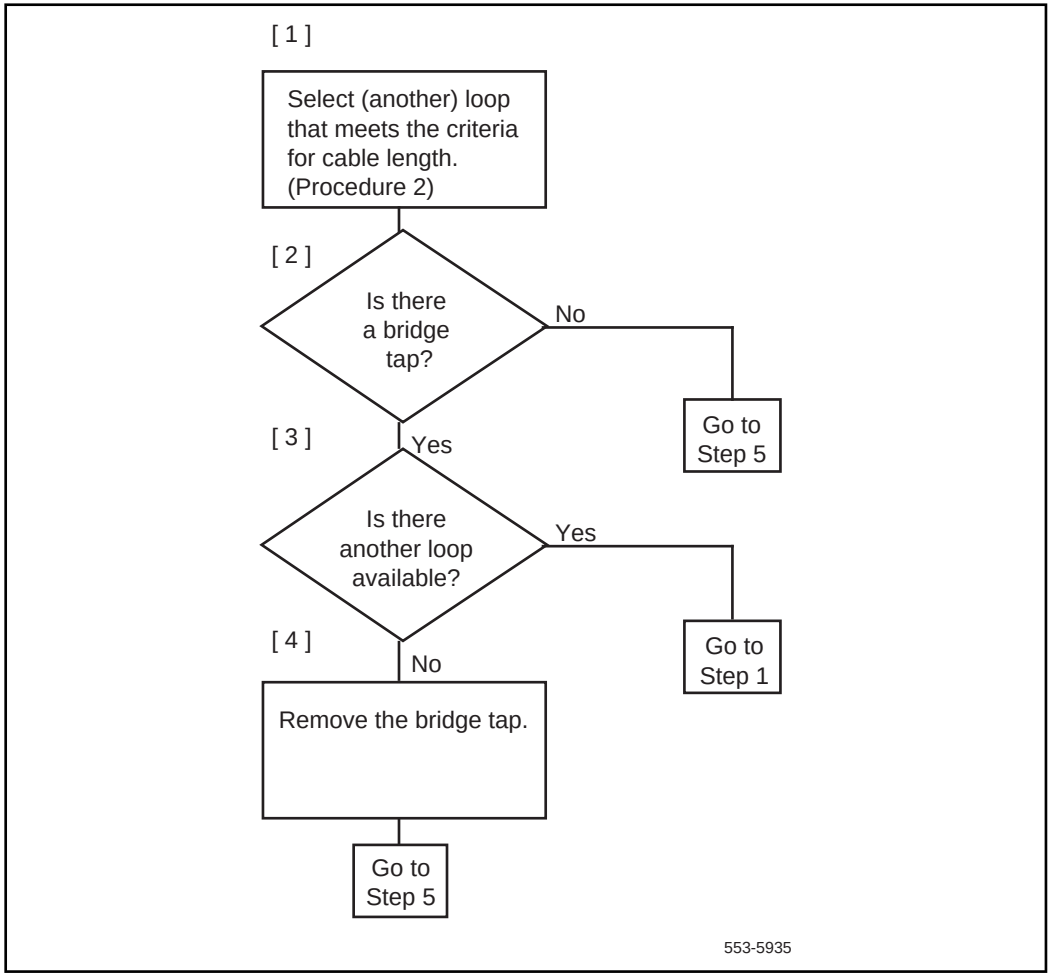


Figure 1
Engineer a telephone line (Part 2 of 8)

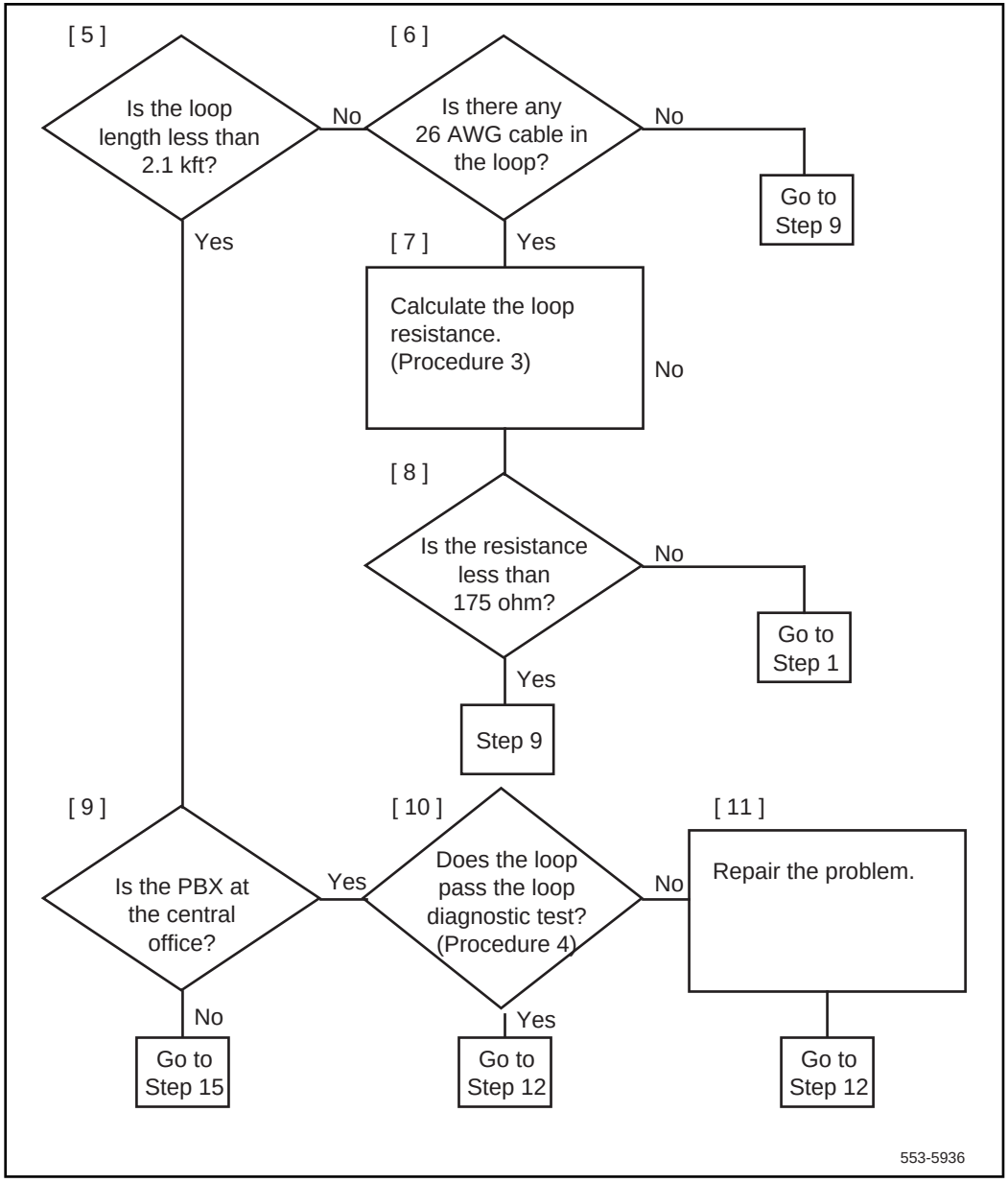


Figure 1
Engineer a telephone line (Part 3 of 8)

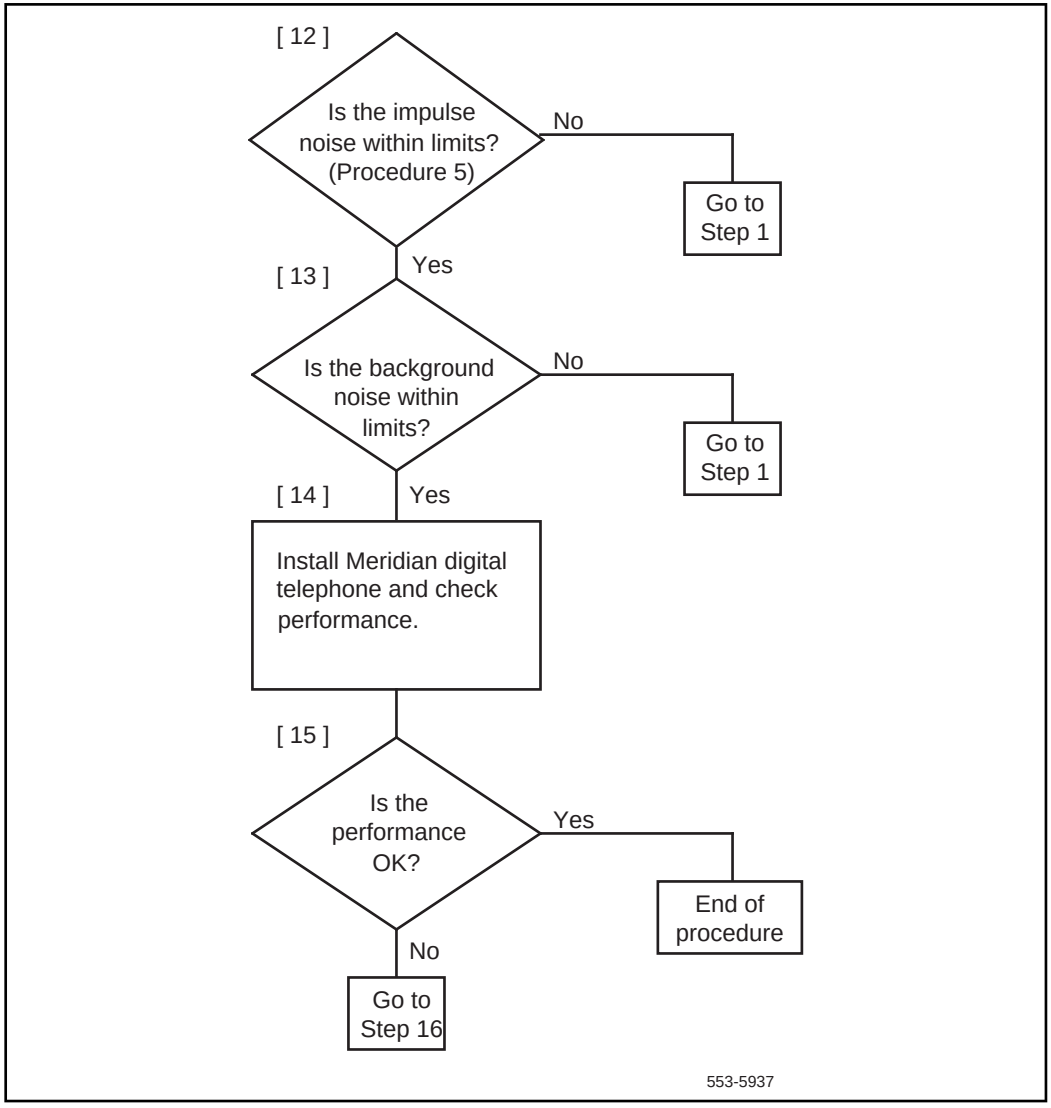


Figure 1
Engineer a telephone line (Part 4 of 8)

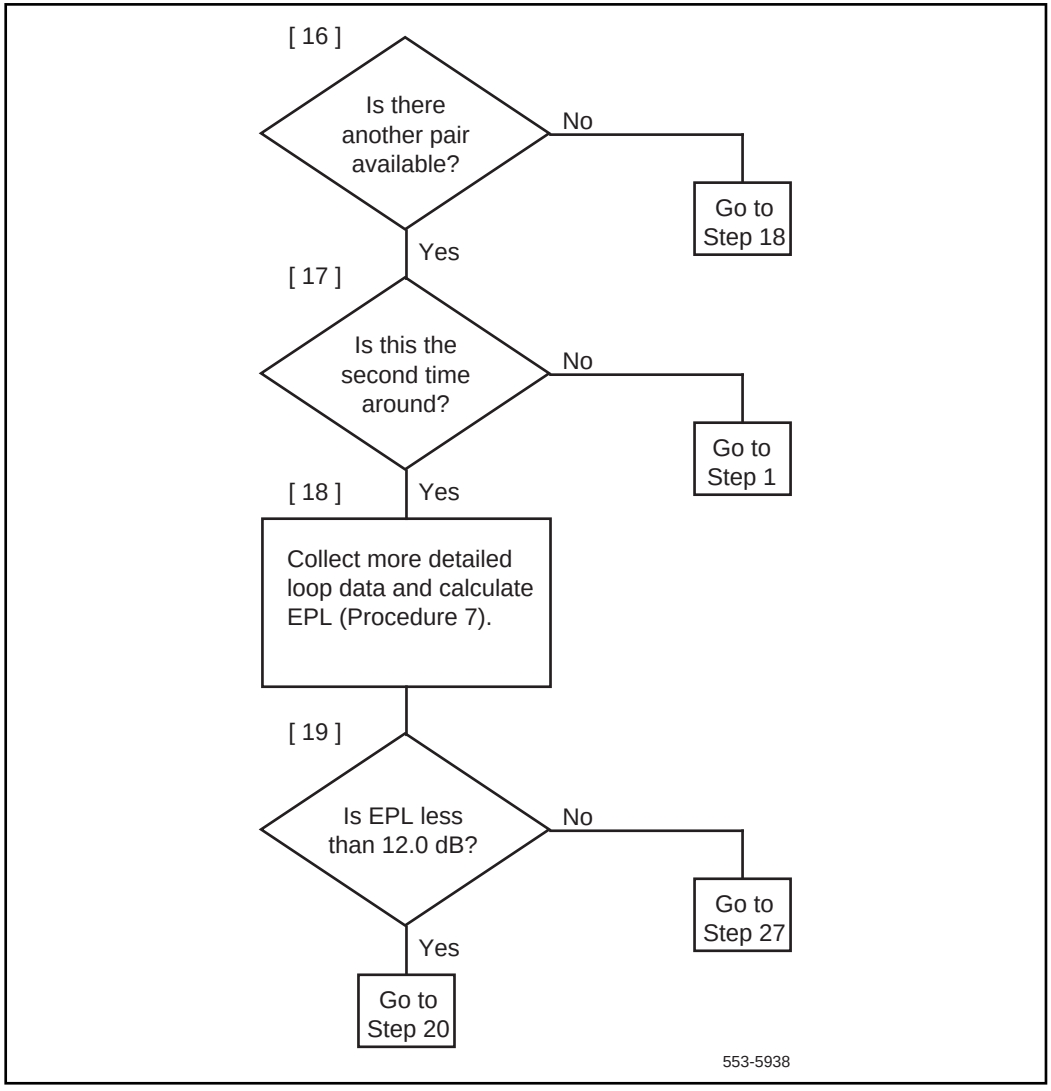


Figure 1
Engineer a telephone line (Part 5 of 8)

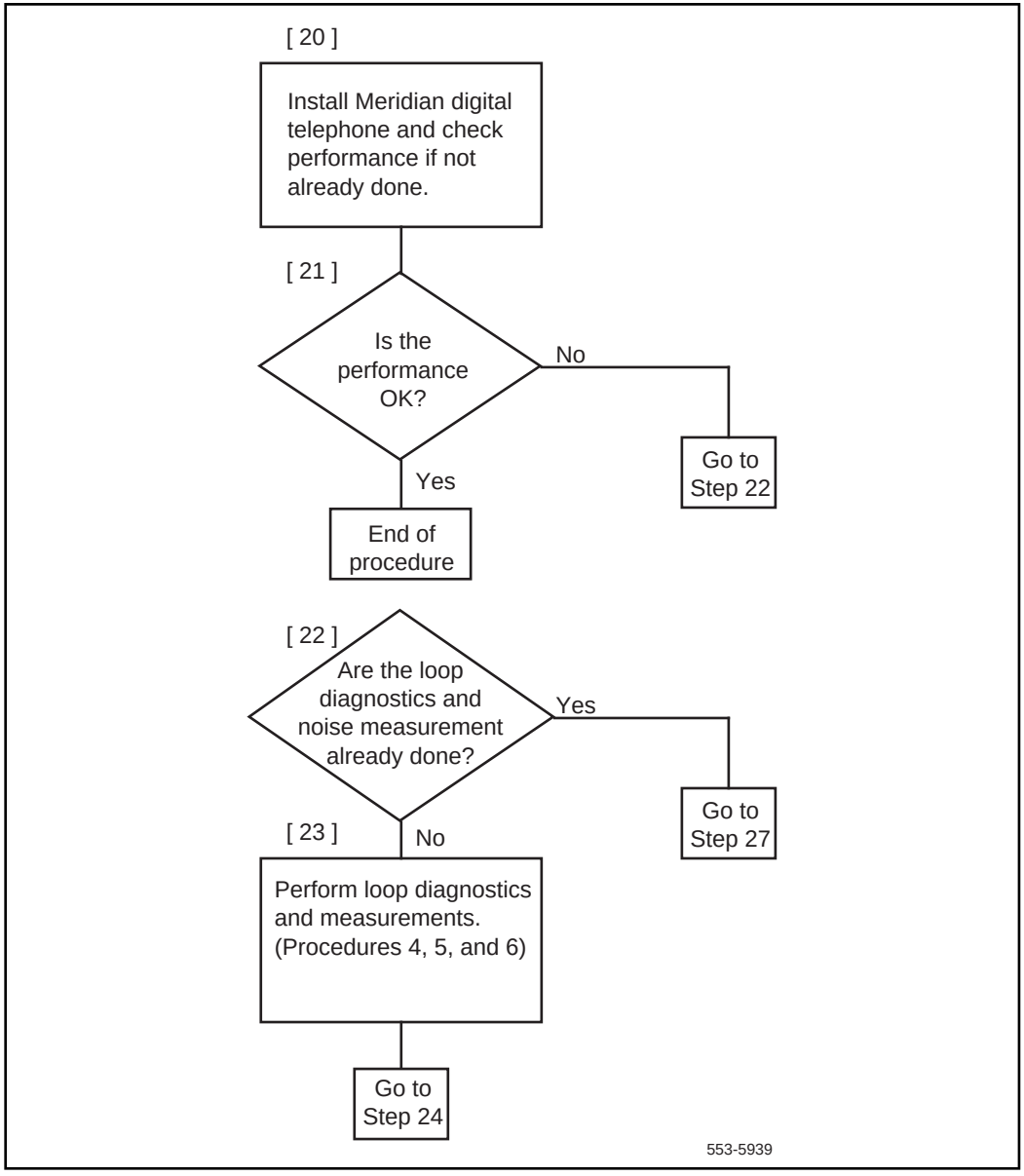


Figure 1
Engineer a telephone line (Part 6 of 8)

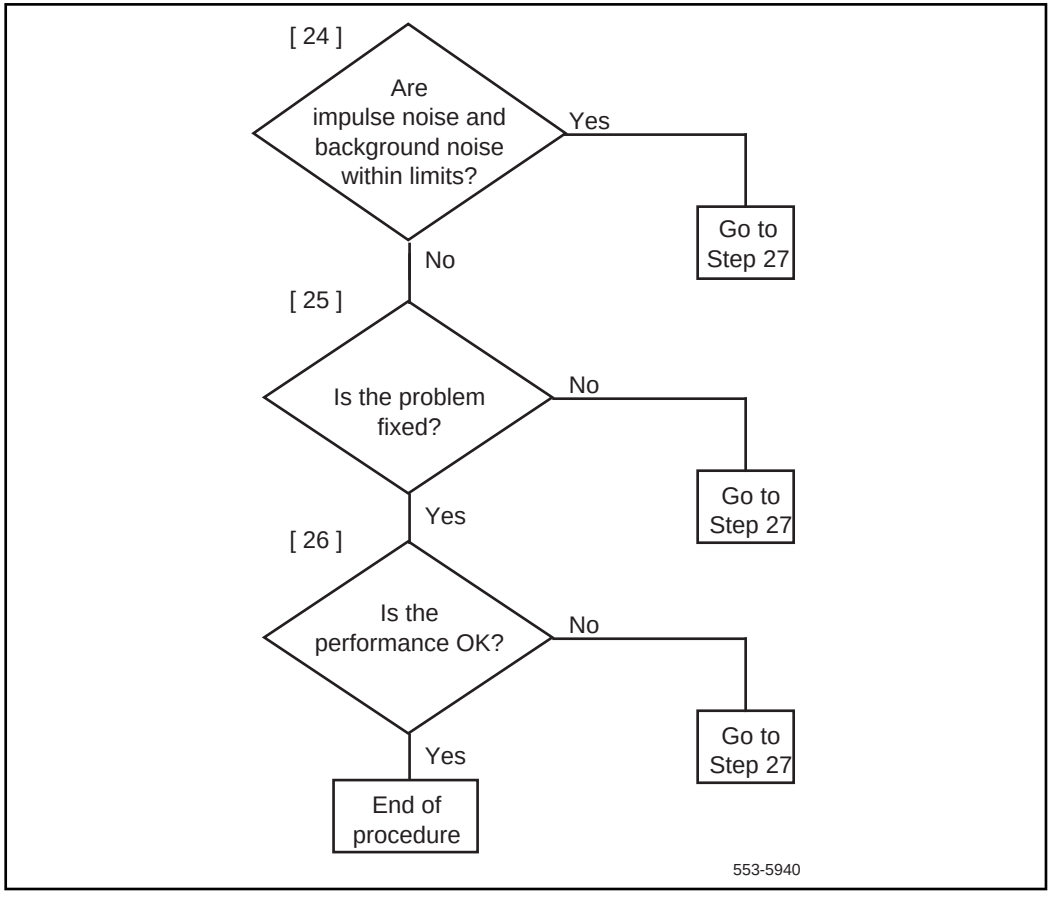


Figure 1
Engineer a telephone line (Part 7 of 8)

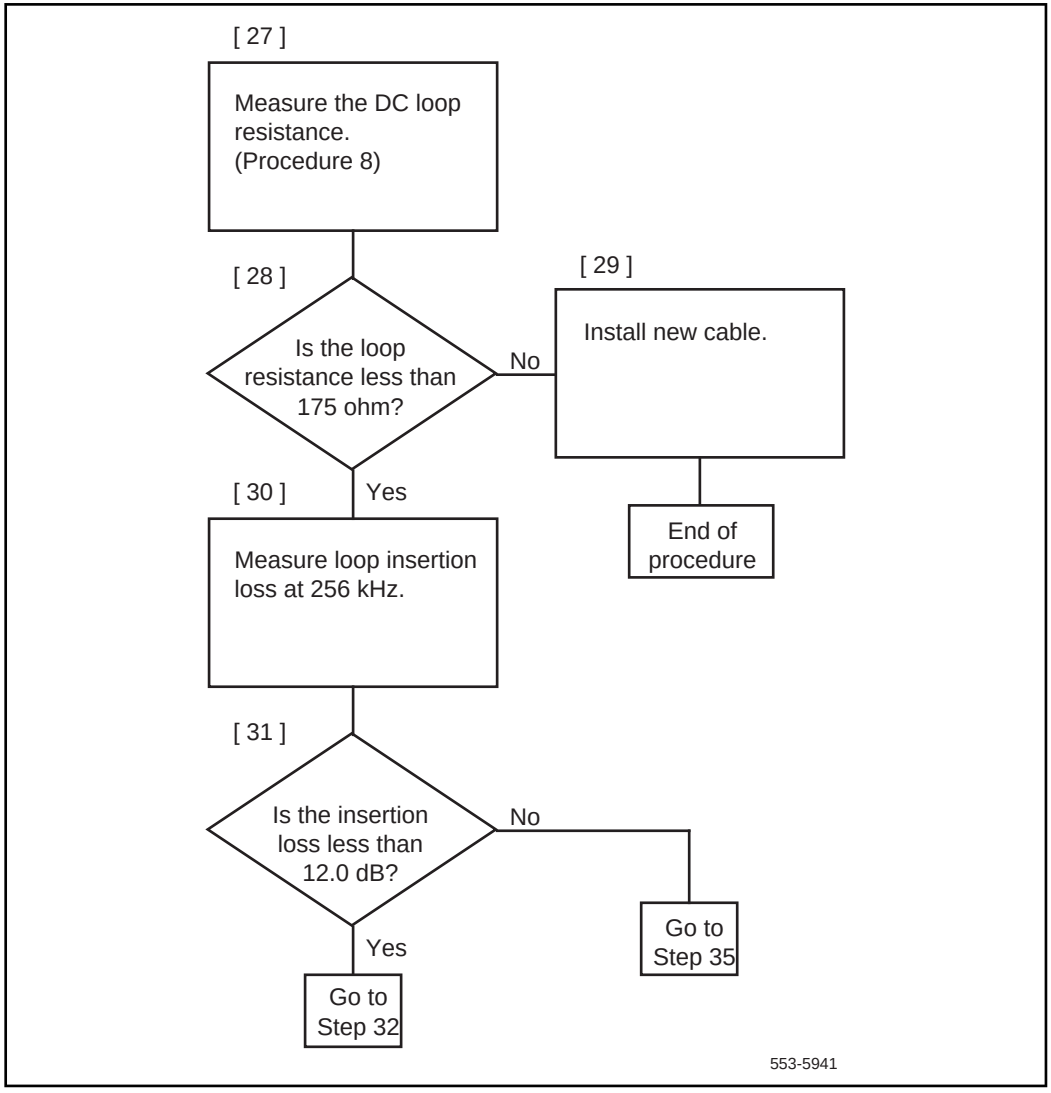
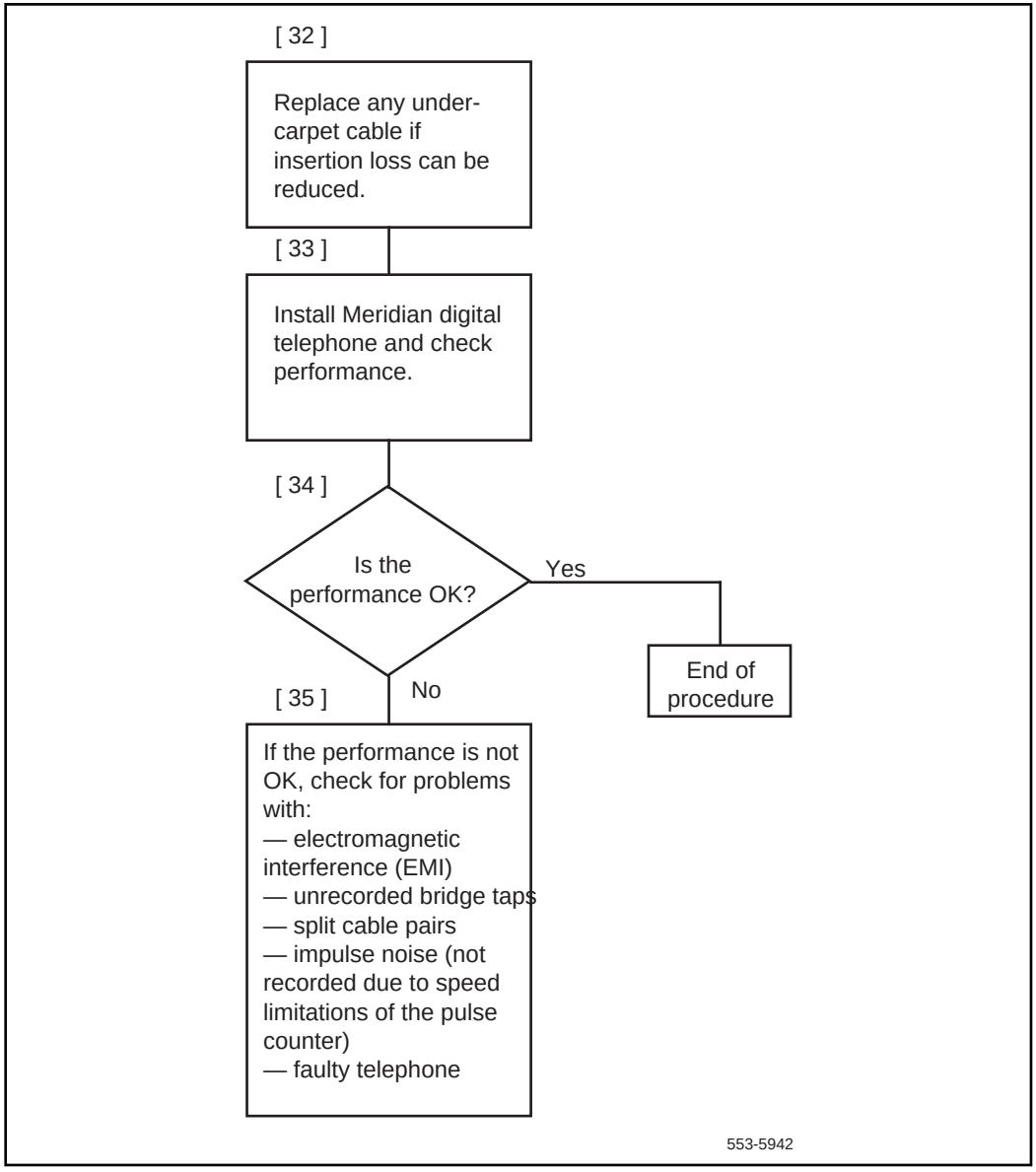


Figure 1
Engineer a telephone line (Part 8 of 8)



Select a loop

For a Meridian digital telephone, the loop must be without bridge taps, less than 175 ohm DC resistance, and less than 12.0 dB loss at 256 kHz. For single-gauge 22 and 24 AWG cable, and D inside wiring, the length limit is 914.4 m (3000 ft). For single-gauge 26 AWG cable, the length limit is 640.08 m (2100 ft).

The allowable loop length assumes there is no under-carpet cable. If there is under-carpet cable that is a different type than Western Electric (WE) 4-pair cable, reduce the allowable loop length by using the following equation:

$$LM = [12 – (UC \times UL)] / LL$$

where:

LM = loop length limit in km (kft) (excluding the length of the under-carpet cable)

LL = loop loss in dB/km (dB/kft) at 256 kHz

UC = length of the under-carpet cable in km (kft)

UL = loss of the under-carpet cable in dB/km (dB/kft) at 256 kHz (see Table 3 for dB values)

Calculate DC loop resistance

Use Procedure 2 to calculate the DC loop resistance.

Procedure 2

1 Calculate the DC loop resistance by adding the resistance of each cable section. Calculate the resistance of each cable section by using the following formula (cable resistances are given in Table 1):

LRi = CRi x SLi

where:

LRi = DC resistance for cable section *i*

CRi = conductor resistance per unit length for the cable section *i*

SLi = length of cable section *i*

2 Add the total of all cable sections. If the total of all sections exceeds 175 ohm, select another loop.

Note: The loop resistance limit of 175 ohm must be reduced by 1 ohm for each percent of the loop that is aerial cable (see Table 1).

Table 1
Conductor resistance per unit

Gauge	Ohm per loop kft	Ohm per loop km
26	83	278
24	52	173
22	33	109
19	16	54

Perform loop diagnostic tests

The following equipment is required for the loop diagnostic tests in Procedure 3:

— one volt-ohmmeter (VOM) for each test

— one 77 cable analyzer or equivalent for each test

Procedure 3

Testing foreign voltage

1 Set the VOM range switch to a scale 60 V dc/V ac or greater.

2 Connect the VOM test probes to the loop at the line card or distributing frame.

3 Measure the DC and AC voltage between the following points under no-load conditions:

— tip (T) and ring (R)

— T and ground (GND)

— R and GND

Requirement: Voltage readings should be less than 1 V dc/V ac.

Testing insulation resistance

1 Set the VOM range switch to ohm x 10,000 and adjust the meter to zero.

2 Connect the VOM test probes to the loop at the line card or distribution frame.

3 Measure the resistance between the following points under no-load conditions:

— T and R

— T and GND

— R and GND

Requirement: Resistance readings must be greater than 10 M ohm.

Testing DC continuity

1 Short circuit the T and R at the far end.

2 Using the VOM, measure the resistance between the T and R.

Requirement: Resistance measurement should be approximately equal to the calculated loop resistance as described in Procedure 2.

Testing capacitance unbalance

— Using the cable analyzer, measure the capacitance between the following points:

— T and GND

— R and GND

Requirement: The difference between the two readings must be <0.002 μF.

Measure impulse noise

Use Procedure 4 to measure impulse noise.

Procedure 4

1 Measure impulse noise on selected lines during busy hours. Use an NE–58B noise measurement set or the equivalent.

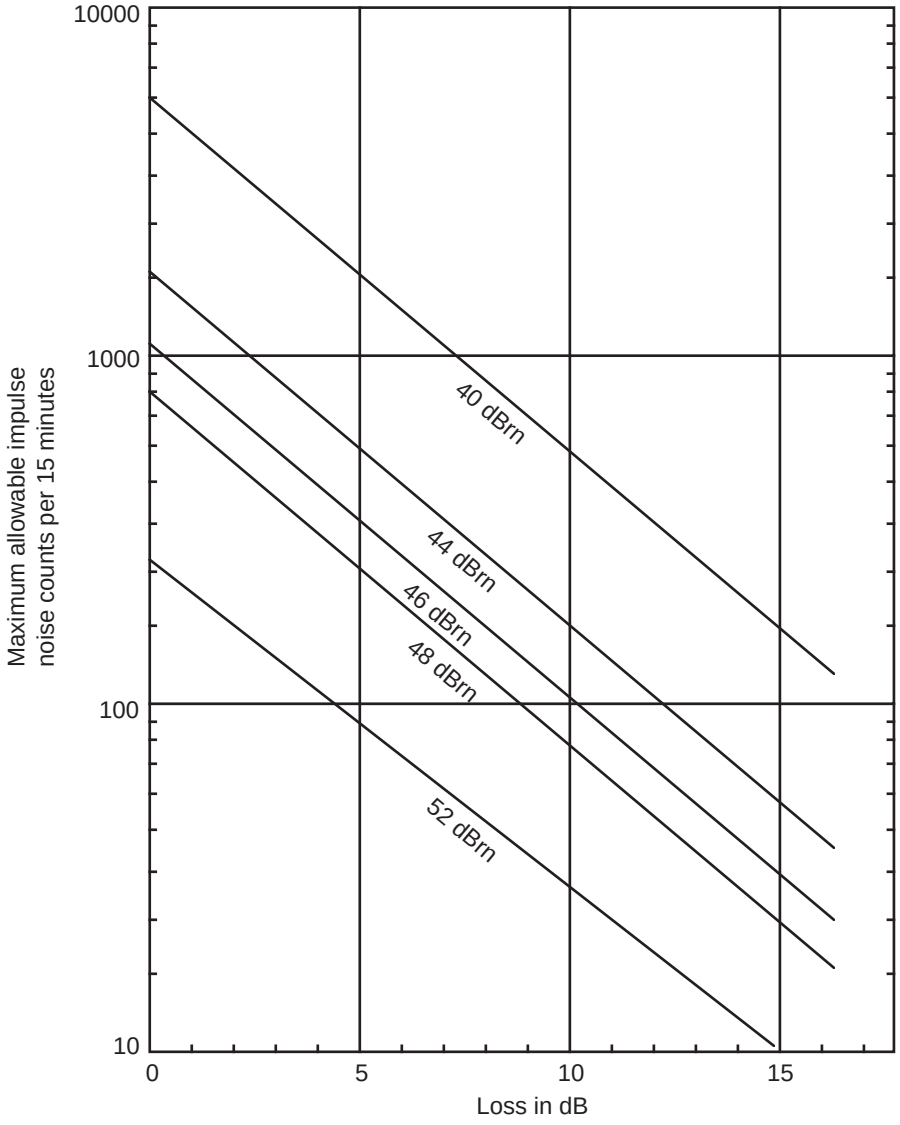
Note: The termination and weighting filter required are 135 ohm and 100 kHz, respectively, and the blanking interval is 25 µs.

2 Using Figure 2, determine that for a given loop loss and noise threshold the impulse noise counts for each 15-minute interval are below the corresponding curve.

Note 1: The values in Figure 2 were derived by assuming that the counter has a count rate or 512 pulses per second.

Note 2: Due to the inaccuracy of the noise-measuring set, additional errors may occur during the blanking interval, and the reading consequently will be lower than the actual measurement.

Figure 2
Maximum allowable impulse noise counts versus loop loss



Note: Impulse noise counter weighting is 100 kHz. Termination is 135 ohms.

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Measure background noise

Use Procedure 5 to measure background noise.

Procedure 5

1 Measure background noise on the loop by using an NE-58B noise-measuring set.

Note: The weighting and termination to be used are 100 kHz flat and 135 ohm, respectively.

2 Reject the loop being tested if the measured background noise is not less than 51 dBrn.

Calculate expected pulse loss

Use Procedure 6 to calculate expected pulse loss.

Procedure 6

1 Collect loop makeup data between the line card and the terminal. For each cable section, the data required is:

- cable type (PIC or pulp)
- gauge
- length
- type of plant construction (underground, aerial, or in-building)

2 Calculate individual cable section losses by using the figures in Tables 2 through 4, and the following equation:

CSLi = SLi x Li

- CSLi = cable section loss for section *i*
- SLi = section length of section *i*
- Li = loss per unit length for section *i*

3 Correct individual cable section losses for maximum cable temperature by using the following equation:

TCLi = CSLi x TCFi

— TCLi = temperature corrected loss for section *i*

— TCFi = temperature correction factor for section *i*

Correction factors:

— aerial cable TCF = 1.1

— underground cable TCF = 1.04

— in-building cable TCF = 1

4 Determine junction loss (see Figure 3).

Note: Junction loss due to gauge discontinuity of outside plant cables and D inside wire varies between 0.03 dB and 0.07 dB and can be ignored. However, AMP 25-pair under-carpet wiring has a characteristic impedance of 40 ohm at 256 kHz, and its junction loss is approximately 2 dB. This must be included in the calculation.

5 Calculate the expected pulse loss (EPL) by finding the sum of the items.

6 Reject loops whose expected pulse loss is greater than 12 dB.

Example of applying Procedure 6

Section 1:
Mainframe bulkhead to DF1 - 500m, 26 AWG PIC, underground

Section 2:
DF1 to DF2 - 200m, 26 AWG PIC, inside

Section 3:
DF2 to terminal - 24 AWG NT D-inside

Therefore:
SL1 = 1.5 km, SL2 = 0.2 km, SL3 = 0.1 km

From Tables 2 and 3:

L1 = 13.7 dB/km, L2 = 13.7 dB/km, L3 = 13.3 dB/km.

Using the equation in Step 2, we arrive at the following:
CSL1 = 6.85 dB, CSL2 = 2.74 dB, and CSL3 = 1.33 dB

Temperature corrections:

Using correction factors of TCF1 = 1.04, and TCF2 and TCF3 = 1, and using the equation in Step 3 results in TCL1 = 7.12 dB, TLC2 = 2.74 dB, and TCL3 = 1.33 dB.

Expected pulse loss (EPL) value:

Neglecting any junction loss (see the note in Step 4), Step 5 results in an EPL value of TSL1 + TSL2 + TSL3 + 0 = 11.19 dB.

This is under the 12 dB limit and meets the criteria.

Table 2
Cable attenuation at 256 kHz and 21.1 degrees C (70 degrees F)

Cable type	26 AWG		24 AWG		22 AWG		19 AWG	
	dB/kft	dB/km	dB/kft	dB/km	dB/kft	dB/km	dB/kft	dB/km
PIC	4.2	13.7	3.1	10.2	2.5	8.1	1.7	5.6
Pulp	4.3	14.3	3.5	11.4	2.7	9.0	2.0	6.6

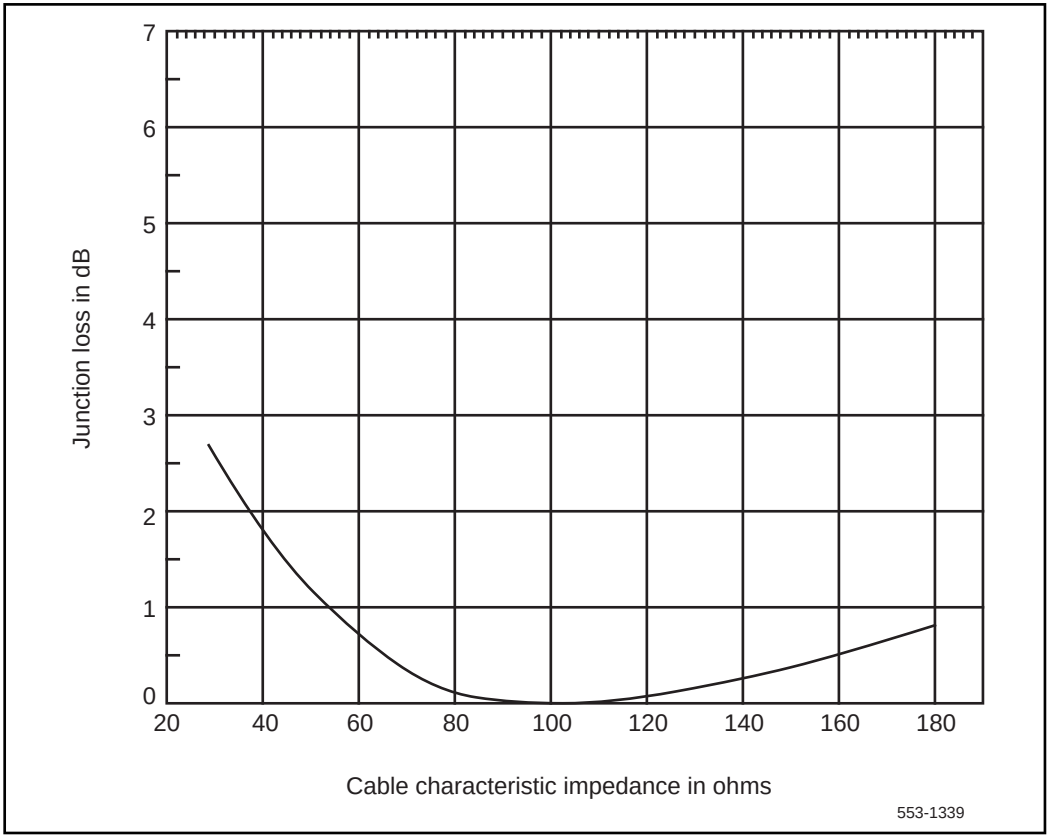
Table 3
Attenuation at 256 kHz for U/C cable

WE 4-pair		AMP 25-pair	
dB/kft	dB/km	dB/kft	dB/km
4.6	15.3	19.0	63.3

Table 4
Attenuation at 256 kHz for D inside wiring cable

NT		WE		Superior		General	
dB/kft	dB/km	dB/kft	dB/km	dB/kft	dB/km	dB/kft	dB/km
4.0	13.3	3.2	10.7	3.7	13.3	4.6	15.3

Figure 3
Junction loss versus cable characteristic impedance



Measure DC loop resistance

Use Procedure 7 to measure DC loop resistance.

Procedure 7

Measure DC loop resistance by using standard procedures.

Note: The DC loop resistance limit of 175 ohm should be reduced by 1 ohm for each one percent of the total loop that is aerial cable.

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