Meridian 1

# Digital Telephones Line Engineering

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# Revision history

**January 2002**

Standard 5.00. This document is up-issued to support Meridian 1 Release 25.40 systems.

**April 2000**

Standard 4.00. This is a global document and is up-issued for X11 Release 25.0x.

**December 1994**

Standard 3.00. Reissued to include editorial changes and indexing. Due to the extent of the changes, revision bars are not used.

**December 1, 1991**

Standard 2.00. Reissued to include technical content updates. Due to the extent of the changes, revision bars are not used.

**August 10, 1990**

Standard 1.00. Reissued for compliance with Northern Telecom standard 164.0.

# Contents

# About this document

This document applies to Meridian 1 Internet Enabled systems.

This document is a global document. Contact your system supplier or your Nortel Networks representative to verify that the hardware and software described is supported in your area.

## Who should use this document

This document is intended for individuals responsible for configuring digital telephone lines.

# Engineer a telephone line

Use Procedure 1 on page 9 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 M¾ 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 on page 10.

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

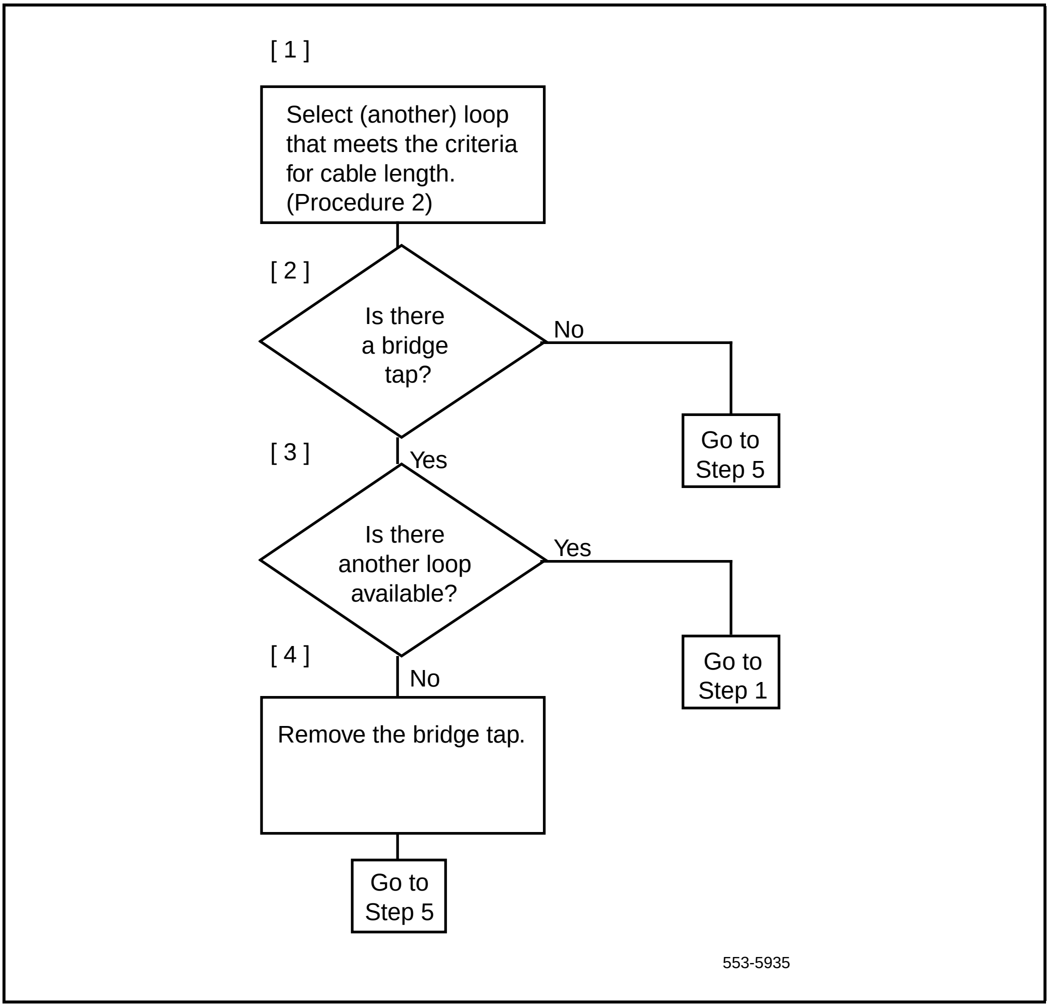


**Figure 1**
**Engineer a telephone line (Part 2 of 8)**

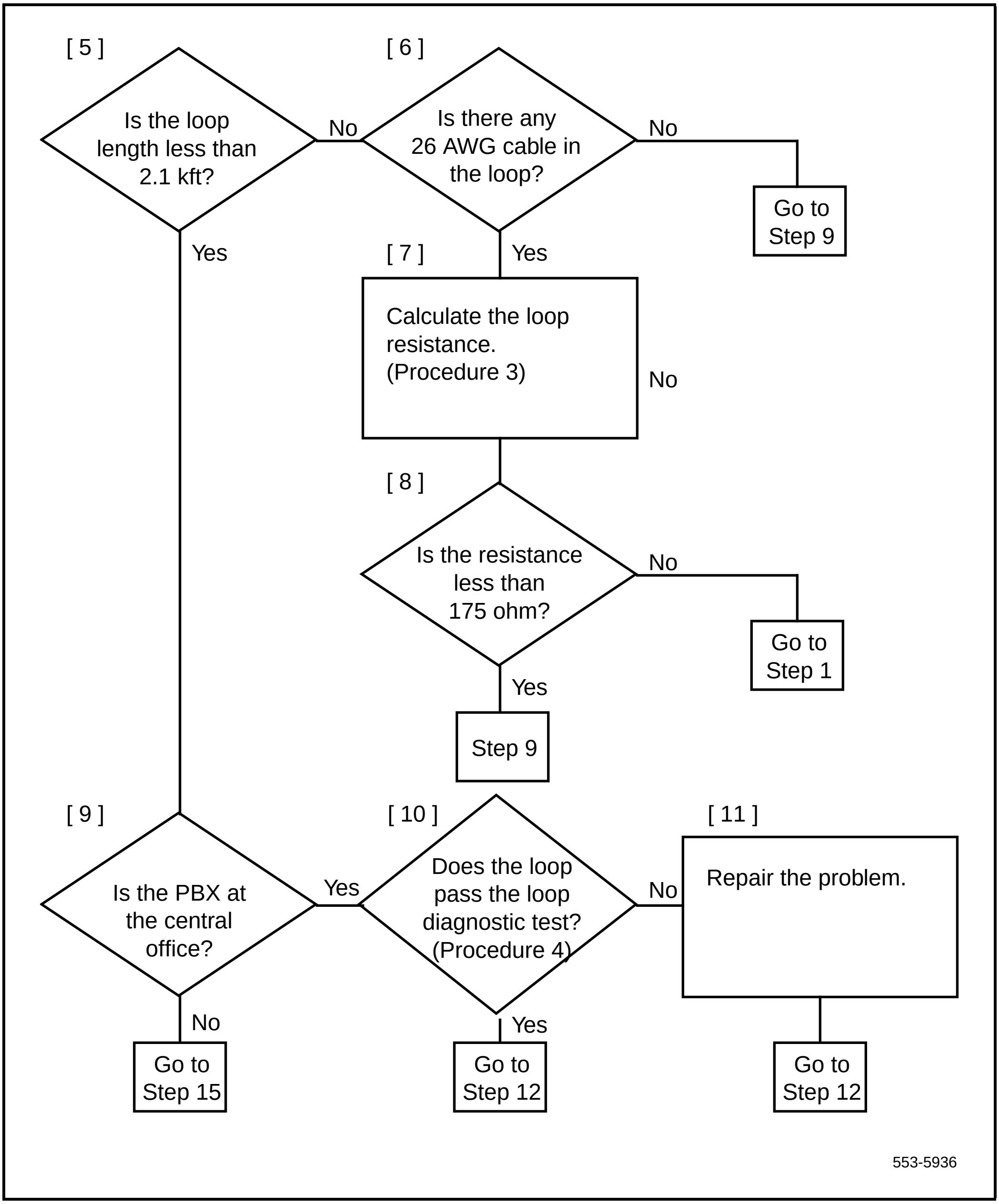


**Figure 1**
**Engineer a telephone line (Part 3 of 8)**

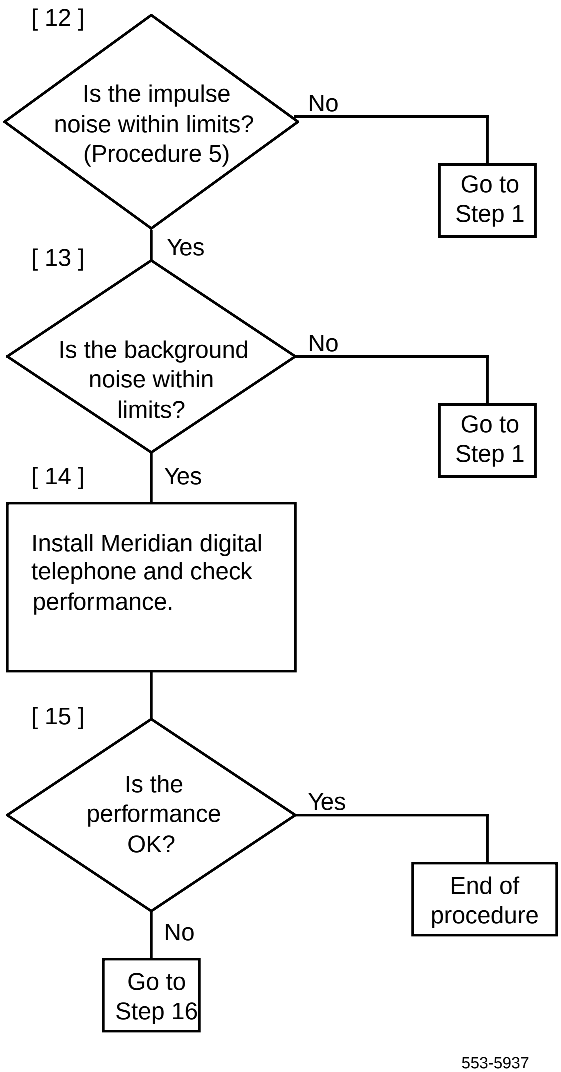


**Figure 1**
**Engineer a telephone line (Part 4 of 8)**

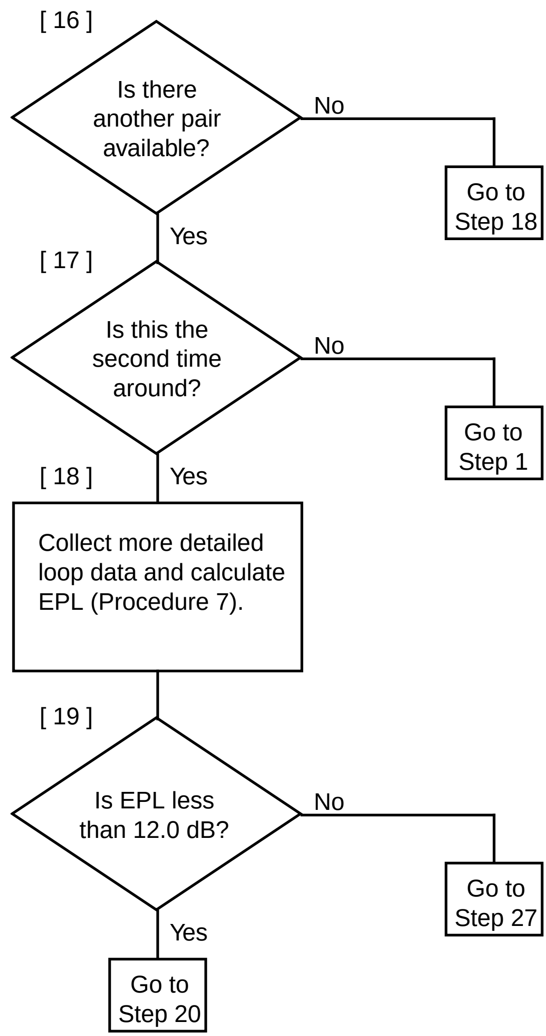


**Figure 1**
**Engineer a telephone line (Part 5 of 8)**

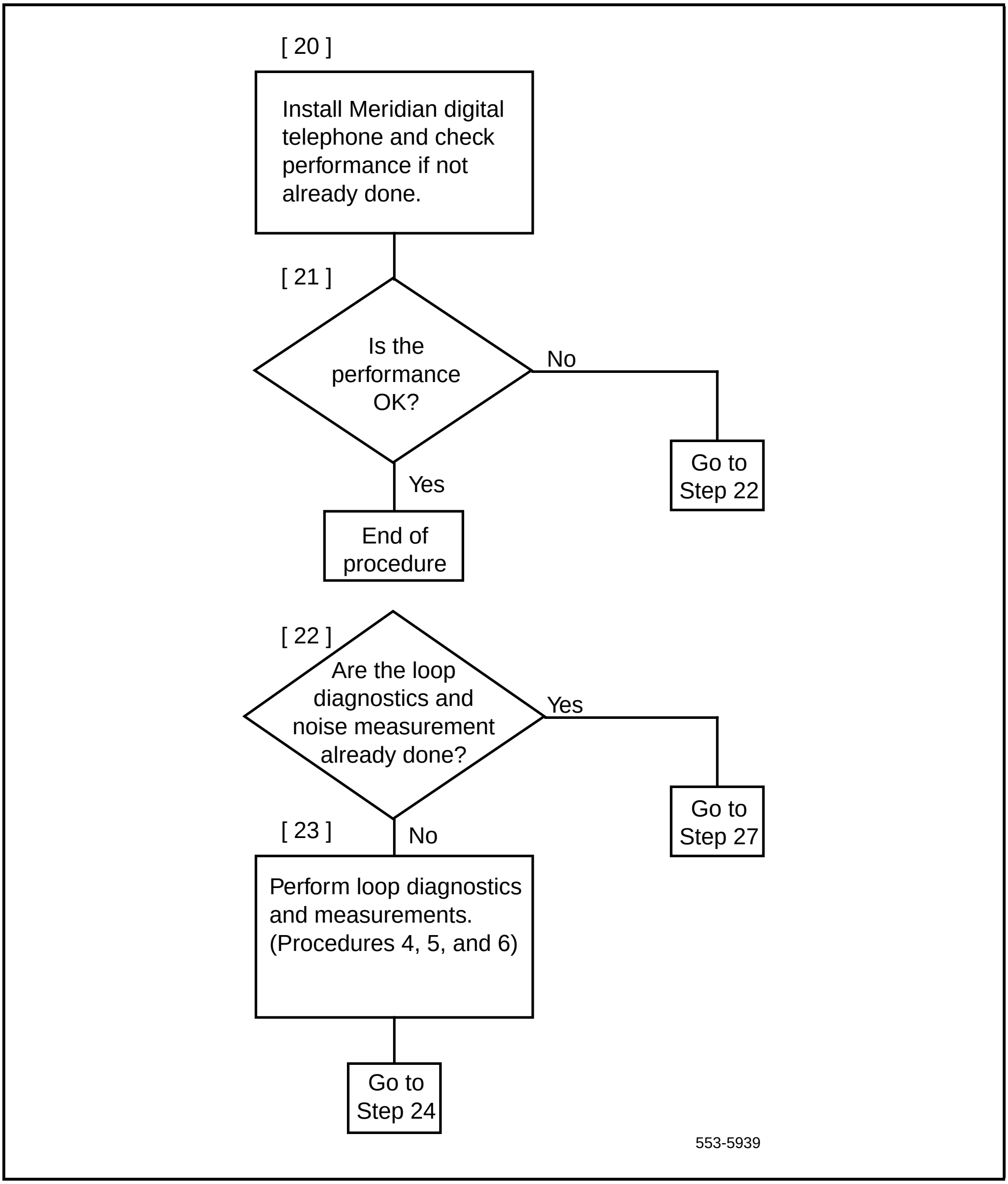


**Figure 1**
**Engineer a telephone line (Part 6 of 8)**

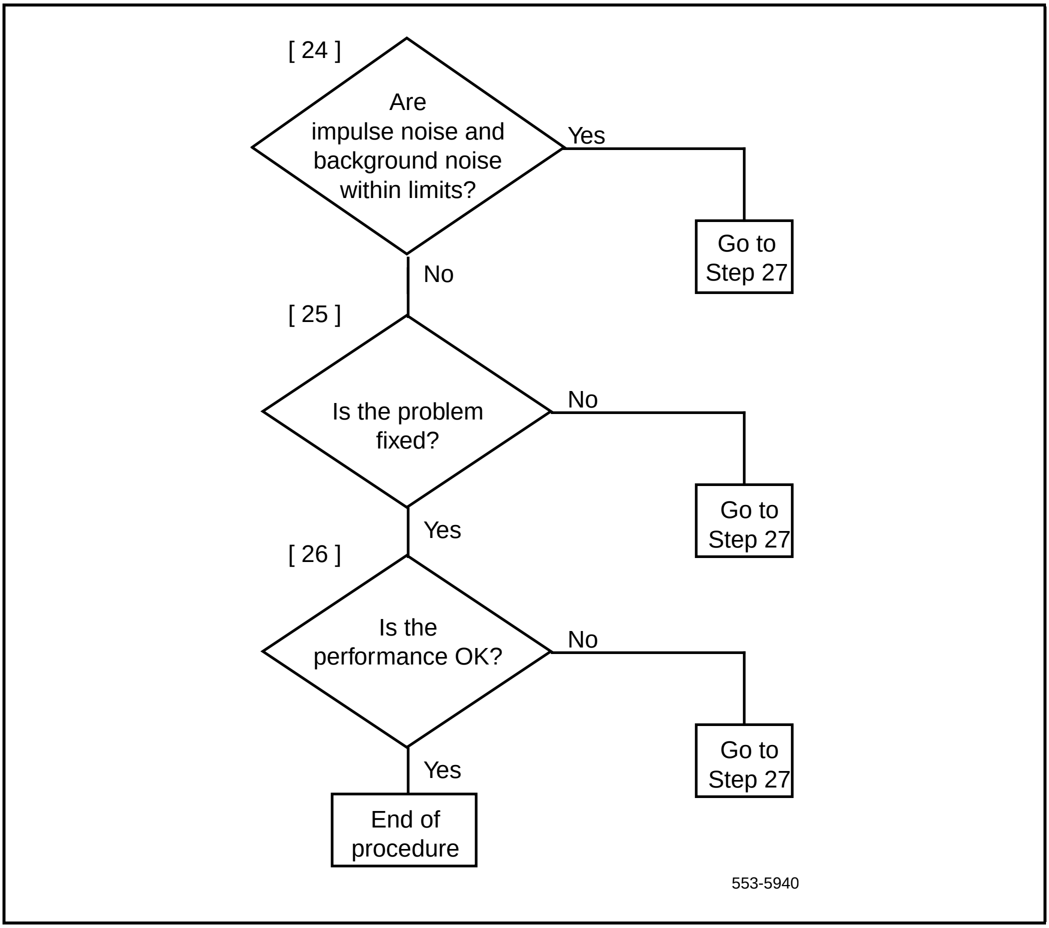


**Figure 1**
**Engineer a telephone line (Part 7 of 8)**

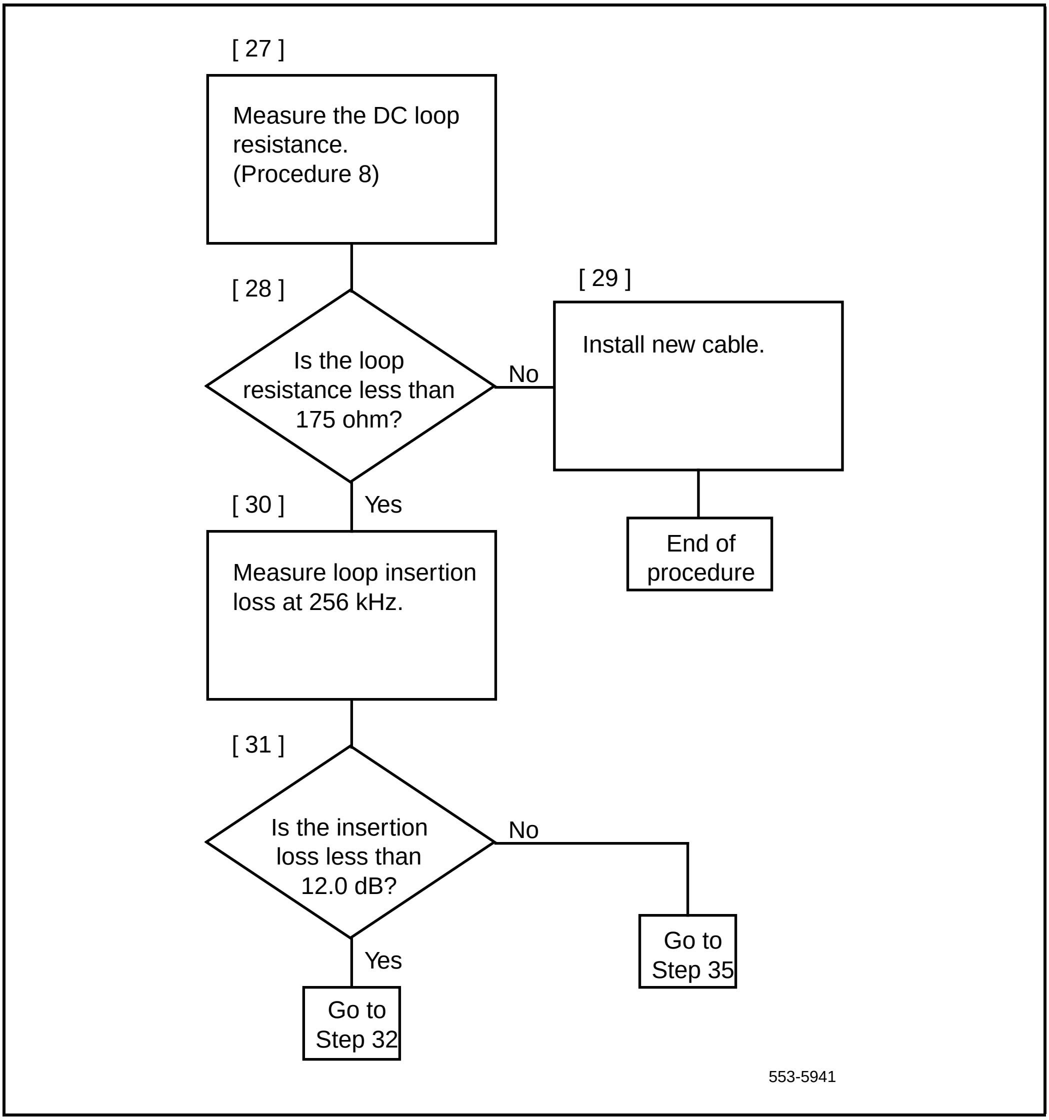
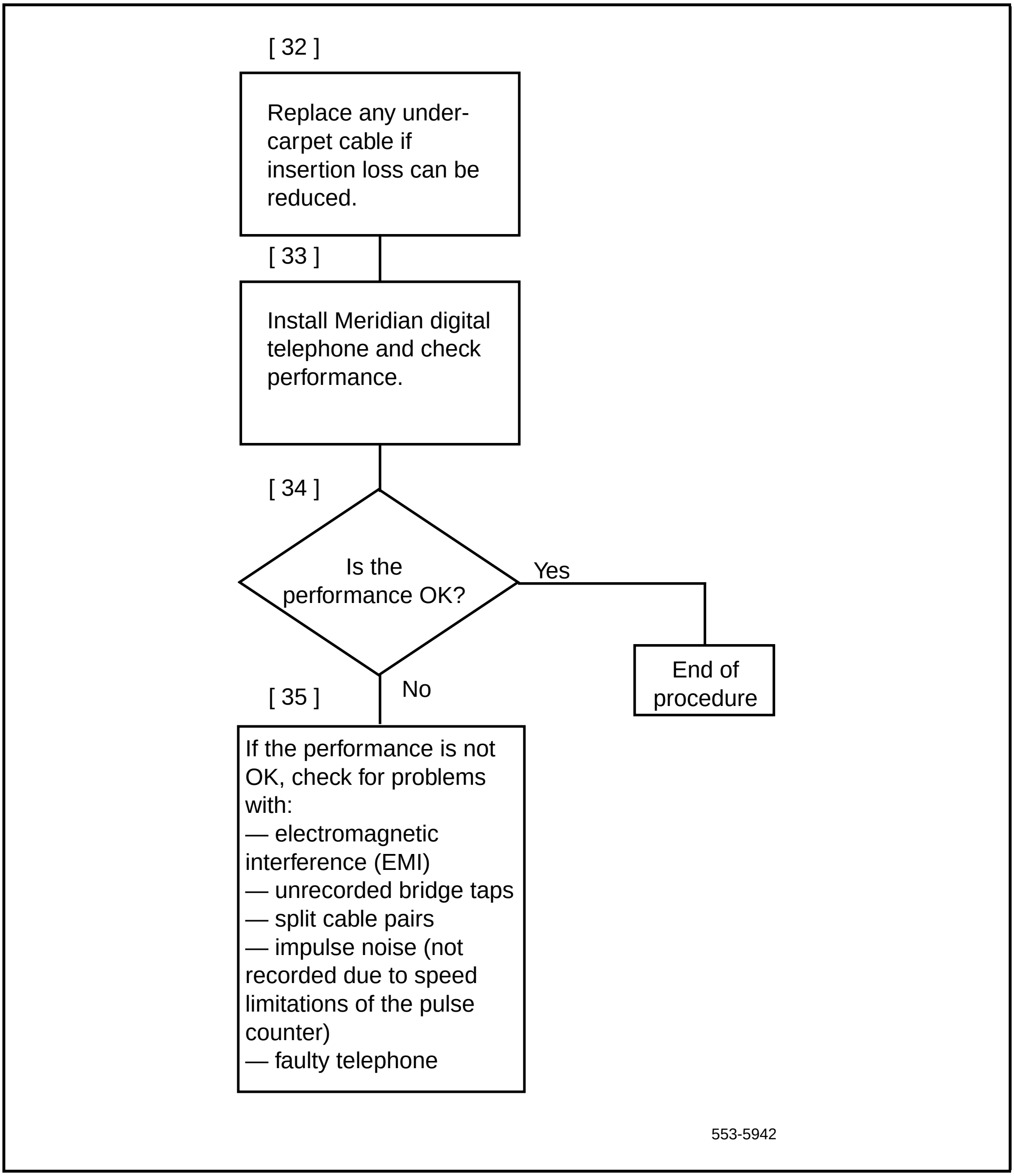


**Figure 1**
**Engineer a telephone line (Part 8 of 8)**



# 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, “Attenuation at 256 kHz for U/C cable,” on page 31 for dB values)

# Calculate DC loop resistance

Use Procedure 2 on page 21 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, “Conductor resistance per unit,” on page 22):

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, "Conductor resistance per unit," on page 22).

**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 on page 23:

- 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 on page 21.

## Testing capacitance unbalance

**1** 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 on page 25 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.

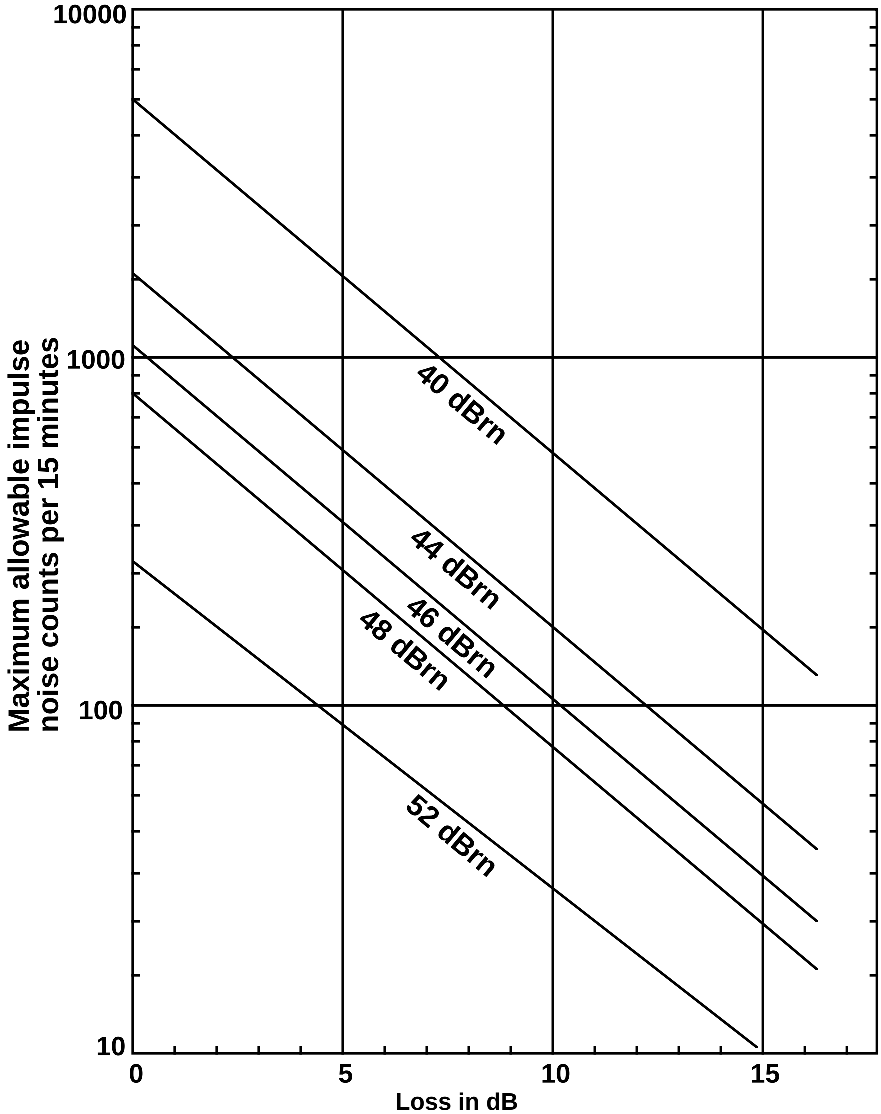
***Note:*** The termination and weighting filter required are 135 ohm and 100 kHz, respectively, and the blanking interval is 25 µs.

**2** Using Figure 2 on page 26, 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 on page 26 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 on page 27 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 on page 29 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 Table 2, "Cable attenuation at 256 kHz and 21.1 degrees C (70 degrees F)," on page 31 through Table 4, "Attenuation at 256 kHz for D inside wiring cable," on page 31, 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 on page 32).

***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 Table 2, “Cable attenuation at 256 kHz and 21.1 degrees C (70 degrees F),” on page 31 and Table 3, “Attenuation at 256 kHz for U/C cable,” on page 31:

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 |

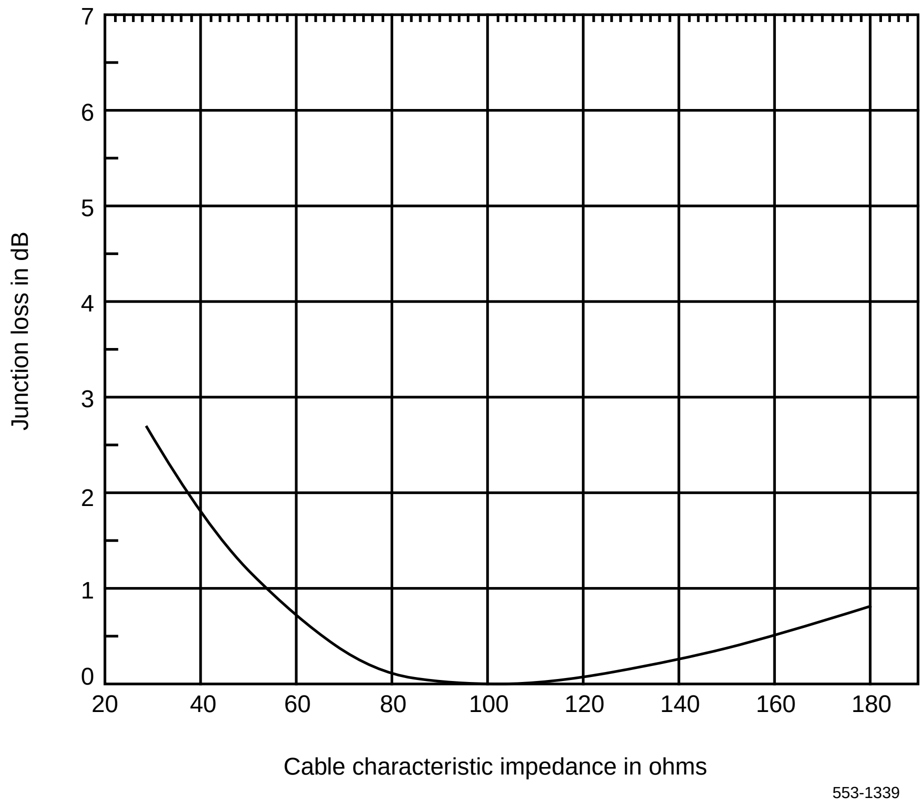
**Table 3**
**Attenuation at 256 kHz for U/C cable**

| 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 on page 33 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.

# Index

Meridian 1

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