IBM

SY31-0703-0

Twinaxial Cabling Troubleshooting Guide

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Twinaxial Cabling Troubleshooting Guide

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This guide is intended to help isolate and fix the majority of problems that can occur when attaching 5250 type displays and printers to a S/36, S/38, AS/400, 5294, or 5394, using twinaxial cabling, telephone twisted pair, IBM cabling system, or fiber optic convertors.

If after using this troubleshooting procedure, you continue to have problems, consult your Installation Planning Representative and/or your branch office support center. We would appreciate your feedback on the effectiveness of this procedure, particularly for situations that may be unique to your installation. Any question or comments on this publication can be directed to:

IBM Corporation
Department 49D Building 050-3
3605 Highway 52 North
Rochester, Minnesota 55901
Attn: Work Station Controller Engineering

Contents

1.0 Introduction

1.1 Safety

Safety cannot be overemphasized. Be extremely careful when investigating problems where faulty power or grounding situations are suspected. Be familiar with the contents of the CE handbook safety section. Pay particular attention to section 3.7 regarding CABLE HANDLING SAFETY. When connecting or disconnecting twinaxial cables or equipment as directed later in this document, it MUST be done as instructed in the CABLE HANDLING SAFETY write-up.

DANGER: If a large Ground Potential Difference (GPD) condition exists, there might be a spark as the cable is disconnected or reconnected, due to a high current flow in the twinaxial shield. If the installation has a faulty ground, there may also be a hazardous voltage present. When removing or replacing the connector, only use one hand. No other part of your body should be touching a ground point.

DANGER: Do not work with twinaxial cables during electrical storms.

If in any doubt about grounding arrangements, perform a ground impedance test first.

To provide additional safety against shocks when handling twinaxial cables, IBM introduced a program to make available plastic connector sleeves (P/N 94X3698) to slip over metal twinaxial connectors.

1.2 Ohmmeter Measurement Recommendation

It is recommended that an *ANALOG METER* be used for the DC resistance measurements on twinaxial cabling or IBM Cabling System. Some digital meters may give inaccurate results.

1.3 Starting Point

A large percentage of twinaxial cabling problems can be solved quickly by using the procedure outlined in Appendix B, "Step by Step Cable Debug Instructions" on page 29. Also, check section 14.0, "Twinaxial Device Problems and Solutions" on page 26 if a particular type of W/S is failing. For more difficult problems, it will be necessary to follow thru the remainder of this guide.

Below is a suggested order of attack to save performing every check each time you are troubleshooting a problem. Decide which category your problem fits into (A, B, C, or D). Then perform the checks in the order shown in the column under the selected category, starting with 1.

- A - New/changed installation with a solid problem.
- B - New/changed installation with an intermittent problem.
- C - Unchanged installation with a solid problem.
- D - Unchanged installation with an intermittent problem.

Problem type				See Section	Checks to perform
A	B	C	D		
3	3	1	2	14	Ensure no terminals have internal hardware failures or known problems.
	5		6	Appendix A and 2.1	Check for a valid twinaxial installation cable length, routing, number of connections, etc.
1				3	Check for a valid system configuration (device addresses, device descriptions and maximum number of terminals/WSC).
4	4	3	4	Appendix B and 4	Check cables for opens/shorts correct termination resistance.
7	10		10	8	Check for Ground Potential Difference problems.
	1		1	2.5.3 Note 1	Analyze error log / check for a failure pattern (ports/devices/times etc.).
5				5	Check all cables for correct phase connections.
	6		7	7	Check for the presence of AC noise
	7		9	9	Use TDR to analyze signal quality.
6	8	4	5	2.3	Ensure WSC card is functioning correctly and within specifications.
2	2	2	3	Appendix B Step 5	Visually check the entire twinaxial run for good wire connections.
	9		8	Note 2	Perform a ground loop impedance test on all the terminals. Disconnect the twinaxial cabling for this test.

Notes: 1) If you do not know how to check the error log, please contact your Support CE.

2) If you do not know how to perform this test, please contact your Installation Planning Representative (IPR).

2.0 System Specifications

2.1 All Systems

For all systems using twinaxial cabling (except 5520 printer lines), there is a maximum of 7 devices per cable run with addresses 0 thru 6. There is a maximum cable length of 5000 feet (1524 meters) per port. Please see section 2.2, "5520 Systems" for 5520 printer line information.

Where a cable enters or exits a building (either underground or overhead) Station Protectors MUST be installed (in pairs). There can be only two station protectors per twinaxial run.

There must be no more than 11 breaks in a twinaxial cable run:

```
319X T-connector .....1 Break
525X Cable-thru.......1 Break
Inline connector......1 Break
Bulkhead adaptor......1 Break  (no device(s) attached)
Bulkhead adaptor......2 Breaks (device(s) attached)
Station protectors....2 Breaks (for a pair)
```

The connection to the Work Station Controller does not count.

See section 11.0, "IBM Cabling System" on page 22 for information about the IBM cabling system. See section 12.0, "Telephone Twisted Pair (TTP)" on page 23 for information about using Telephone Twisted Pair.

2.2 5520 Systems

5525 printer lines require different part number station protectors than other twinaxial lines. See section 6.0, "Station Protectors" on page 14 for details. Also, they can support 8 devices per cable run with addresses 0 thru 7.

The maximum cable length per port for 5525 printer lines is 3500 feet (1067 meters).

The 5525 IP Manual GA23-1011 states "IBM recommends that the branch circuits supplying power to IBM 5520 Administration System Devices be isolated from other use."

2.3 Workstation Controller Output Levels

The WSC output can be split into 2 groups, depending on machine type:

Group 1: 5340, 5360, 5362, 5364, 5381, 5382, 5294, 5251-012, 5520

Group 2: 5363, 5394, 9404, 9406

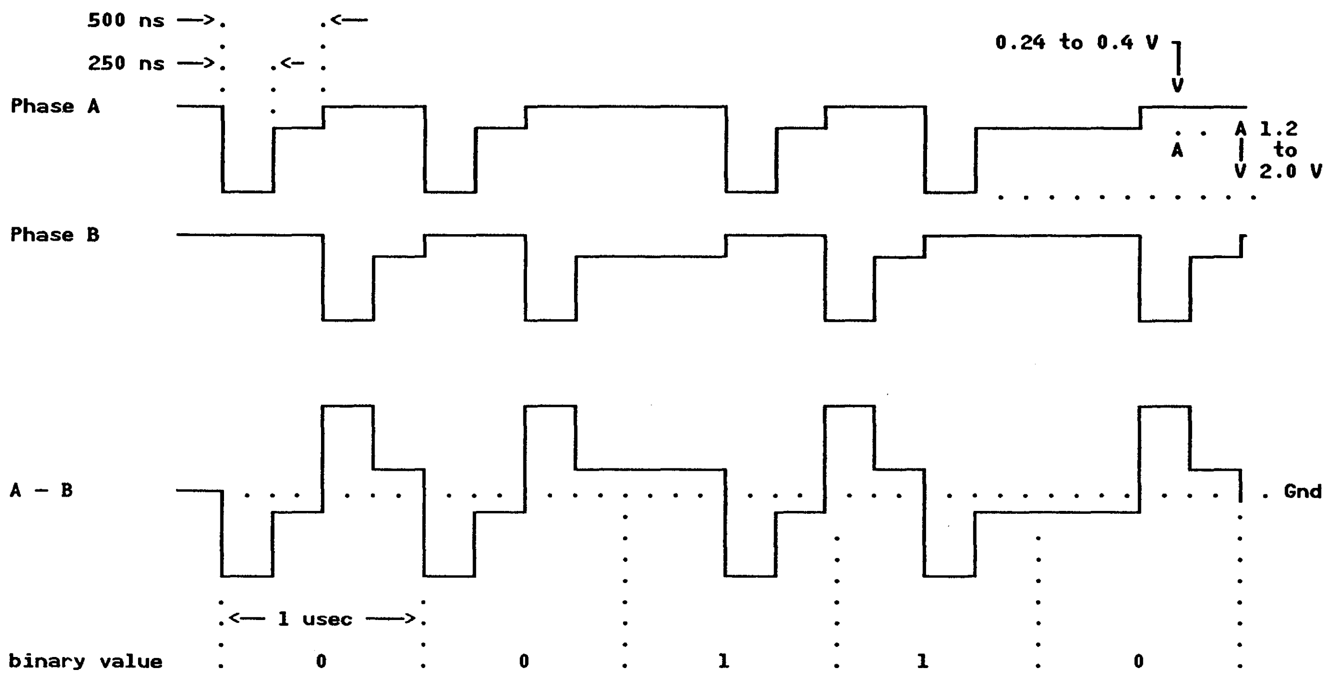
All the following figures are for a line that is correctly terminated.

DIFFERENTIAL PHASE-TO-PHASE	GROUP 1	GROUP 2
Minimum WSC output at the System	2.4 volts	2.4 volts
Nominal WSC output at the System	3.4 volts	2.8 volts
Maximum WSC output at the System	4.1 volts	3.0 volts
Minimum WSC output measured at the line termination point (last W/S)	0.2 volts	0.2 volts
All the above figures are the peak-to-peak values. They must be measured differentially with an oscilloscope. Connect Channel A probe between Phase A and shield. Connect Channel B probe between Phase B and shield. Display Channel A minus Channel B.		

PHASE TO SHIELD	GROUP 1	GROUP 2
Minimum WSC output at the System	1.2 volts	1.2 volts
Nominal WSC output at the System	1.7 volts	1.4 volts
Maximum WSC output at the System	2.0 volts	1.5 volts
Minimum WSC output measured at the line termination point (last W/S)	0.10 volts	0.10 volts
All the above figures are the peak-to-peak values. They must be measured with an oscilloscope. Connect Channel A probe between either phase and the shield. Display Channel A. Both phases should give similar readings.		

2.4 Transmission Signal Pattern

The following diagram shows a twinaxial signal as seen at the driver. This signal, when viewed on an oscilloscope, will not look as "perfect" as this diagram. It will look similar to this, but will be more rounded and possibly have some ringing. At the end of 5000 feet of twinaxial cabling, when viewing A - B, the signal will look like a sine wave.



The transmission bit rate on twinaxial cabling is 1 megahertz. With this rate, 1 microsecond is required for each bit and 16 microseconds are required for each frame. 3196 and 3476 display stations use a slightly different frequency: 1.0368 megahertz. None of this section applies to 5520 printer lines.

2.5 AS/400 Systems

The AS/400 workstation controller has a number of important differences when compared to most other twinaxial systems.

2.5.1 Twinaxial Commands and Sequences

For performance reasons, the AS/400 handles some twinaxial command sequences differently than other twinaxial systems. Also, the AS/400 uses a larger subset of the twinaxial command set than previous systems, and transmits commands closer together (less dead time between commands). These changes do not affect IBM twinaxial devices, as they are designed to comply with these specifications. However, any OEM devices that do not comply with the entire twinaxial protocol might not work on an AS/400, although they may have functioned on other twinaxial systems without problems. Also, an out of specification cable may give a higher error rate than on previous systems (see section 2.5.3, "Error Logging" on page 6).

2.5.2 9406 System Grounding

It is important to maintain continuity of ground from card-to-card within the AS/400 card cage. Every slot in the cage must have either a logic card, or an airflow card inserted in it. All IOP, IOA, Bus Extension, and airflow cards must have the grounding clip installed. In addition, there is a grounding clip mounted on the right side (rear view) of the card cage.

New cards are supplied without these clips installed, so they must be transferred from the card being removed to the new card. These clips are important, as they provide an additional ground path for voltages present on cable shields that connect to the IOP/IOA cards (i.e. the cable from the twinaxial connector box to the 6040 card). If they are missing or faulty, the system might be more susceptible to noise and transients present on the cable shield.

If twinaxial cables are connected to the AS/400, but are not connected at the W/S end, or if the shield is open in a cable, this open cable/shield can conduct noise into the system and cause WSC or system problems. Make sure that all attached twinaxial cables are properly terminated and/or disconnect all unused twinaxial cables at the AS/400. See Appendix B, "Step by Step Cable Debug Instructions" on page 29 or section 4.0, "DC Cable Tests" on page 10 to check for an open shield.

2.5.3 Error Logging

The System/38 did not log temporary WSC or W/S errors; only permanent ones. Originally, the AS/400 logged every WSC or W/S error, both permanent and temporary. This was to allow for the identification and correction of problems causing temporary errors. Thus, a Customer migrating cabling and devices from a System/38 (where there were no errors being logged) might suddenly see a large number of errors on the AS/400.

Initially this caused problems on systems experiencing a high error rate, as the system could not log the errors fast enough, and the system would go down. Later, PTFs were produced to change the error logging so that only the first 5 temporary errors per device address (per IPL or IOP reset) would be logged. RETAIN APAR MA00449 addresses this problem. With these PTFs installed (R1.0 MF00913 and R1.2 MF01081 or later), remember that although many temporary errors may be occurring, only the first 5 will appear in the error log. One way to check if the WSC or W/S's are detecting many errors is to do the following:

1. Vary off the WSC (Check with the customer first to see if this is OK with them).
2. Vary on the WSC with reset - yes.
3. Check the error log. If a particular W/S address reports 5 errors in a short period of time (a few seconds up to a few minutes), it indicates that many temporary errors are occurring with that W/S.

It is important to check that the size of the error log for the local work stations is set at the recommended size. Failure to do this can result in misleading information on a system experiencing a high error rate. This is because the newest entries in the log overwrite the oldest. Thus, examining the log for the previous month may show no errors. In reality there were many, but they have been overwritten by newer entries.

2.5.4 WSC Output Levels

Because the AS/400 WSC nominal output level is less that that of the S/36 or S/38, it is possible that an out-of-specification cable would work on a S/36 or S/38, but cause a high error rate on an AS/400. See section 2.3, "Workstation Controller Output Levels" on page 4 for output figures. In these cases, the cable must be brought up to specification.

2.5.5 Handling Noise on Twinaxial Cables

On the AS/400, any induced voltages in the twinaxial cable shields are collected at the twinaxial connector box, and pass up the cable to the 6040 connector. From here they dissipate via the card Electromagnetic Compatibilty (EMC) spring clips and the card retaining fasteners. If these voltages exceed a certain level, they can cause problems for other cards in the cage, or even cause the unit the cage is in to power off. In these conditions, the reason for the induced voltages must be found. If the cable is within one building, a station protector added to the noisy twinaxial cable(s) may help.

If, after doing the above, you are still having problems, consult your IPR and/or your CE support group.

3.0 Work Station Controller Configuration

This section will describe the number of Work Station Controllers (WSC) and the number of Work Stations (WS) that are supported by each system.

3.1 AS/400 WSC Configuration

The WSC on the AS/400 can support 40 WS per controller. The following list shows how many WSC can be supported for each model.

1. Release 1.0
   - Model B10 - 1 WSC
   - Model B20 - 1 WSC
   - Model B30 - 3 WSC
   - Model B40 - 5 WSC
   - Model B50 - 8 WSC
   - Model B60 - 12 WSC
2. Release 2.0
   - Model B10 - 1 WSC
   - Model B20 - 2 WSC
   - Model B30/35 - 4 WSC
   - Model B40/45 - 6 WSC
   - Model B50 - 10 WSC
   - Model B60 - 15 WSC
   - Model B70 - 20 WSC

3.2 S/36 WSC Configuration

The number of WS that can be supported on a S/36 are listed by system unit type in the following list.

1. 5360
   - Base - 6 WS
   - WS expansion feature - 36 WS (18 with extended input fields feature).
   - 2nd WSC feature - additional 36 WS (18 with extended input fields feature).
2. 5362
   - Base - 6 WS (3 with extended input fields feature).
   - WS expansion feature - 28 WS (18 with extended input fields feature).
3. 5363
   - Base - 16 WS (9 with extended input fields feature).
   - WS expansion feature - 28 WS (18 with extended input fields feature).
4. 5364
   - Base - 16 WS (9 with extended input fields feature).

3.3 S/38 WSC Configuration

The S/38 supports a Work Station Controller (WSC) that allows 20 WS to be attached and a WSC Extended (WSCE) that supports 32 WS. The maximum configuration is four WSC or eight WSCE.

3.4 5294 WSC Configuration

1. Base - 4 WS

2. Feature - 12 WS

3.5 5394 WSC Configuration

1. Model 01A/02A - 4 WS

2. Model 01B/02B - 16 WS

4.0 DC Cable Tests

4.1 Preparation

***DANGER:** If a large Ground Potential Difference (GPD) condition exists, there might be a spark as the cable is disconnected or reconnected, due to a high current flow in the twinaxial shield. If the installation has a faulty ground, there may also be a hazardous voltage present. When removing or replacing the connector, only use one hand. No other part of your body should be touching a ground point.*

***DANGER:** Do not work with twinaxial cables during electrical storms.*

To check the DC continuity of a cable run, vary off all the devices on that cable run, and power the devices off. Unplug the power cords of all devices on that cable run and remove the twinaxial cable from the controller or CPU tailgate. As most meters use a voltage to measure resistance, you will get incorrect results if there is any voltage present on the cable that you are testing.

4.2 Testing Cable Termination

A correctly terminated line will have two 55 ohm resistors, each connected between a phase of the cable and the twinaxial shield at the last device in the string. (Some machines, e.g. 5219, terminate the line with a transformer, therefore the D.C. tests will not show expected resistance readings). The termination resistance can be checked with an ohmmeter. An allowance must be made for the length of the cable run. For a maximum cable run of 5000 feet (1524 meters), the phase-to-shield resistance must be less than 125 ohms and the phase-to-phase resistance must be less than 220 ohms.

EXAMPLE

```
If you are measuring a good and correctly terminated cable with a
length of 1000 feet (305 meters) between phase and shield , you
should see...    55 ohms termination resistance, plus..
                 11 ohms conductor resistance, plus..
                  3 ohms shield resistance, giving a total measured
                 ____
resistance of:   69 ohms

The 2 resistance values from each phase to shield should both be
within about 2% of each other.
```

See Appendix A, "Twinaxial Cable Information" on page 28 for twinaxial cable specifications and resistance values. See Appendix B, "Step by Step Cable Debug Instructions" on page 29 for an alternate twinaxial debug method.

4.3 Testing for Shorts

With both ends of the cable open, and not plugged into a machine, the phase-to-phase resistance and the resistance from each phase to shield must be more than 1 M Ohm.

4.4 Testing AS/400 Systems

AS/400 systems are supplied with a port tester that will indicate breaks or shorts in the twinaxial cable run (it might not find an open in the shield). To use this, follow the instructions in the user's guide SA21-9944 that is supplied with the system. However, this procedure will not test the line termination. This should still be done as in section 4.2, "Testing Cable Termination."

4.5 T-Connectors

There is a twinaxial 'T' connector that some customers have used to split a cable run in two directions. Although this may work in some circumstances, it is not supported. In this configuration, if W/S's such as 319X that autoterminate are placed at the 2 ends of the cable, the line will be terminated twice, giving an incorrect termination resistance (27 ohms phase to shield, and 55 ohms phase-to-phase). Connecting a twinaxial plug (with no cable connected) to one of the 319X T-pieces will switch off the termination, and might allow the line to function better. The final solution should be to correct the cable run by removing the "T" and cabling thru from one W/S to the next.

4.6 Notes

1. If you have Station Protectors in the line you will not get valid readings. Either temporarily bypass the Station Protectors, or measure the line beyond the Station Protector. Do not do this if there is a chance of lightning.

2. If you have an IBM PC as the last device on a 5520 line, terminator P/N 7362188 must be attached to the T-Connector. Verify that the terminator switches on the PC DSEA card are turned off. These are not used in 5520/PC applications, and will give false resistance readings. It is preferable to use an external terminator for all PC applications. If correct results cannot be obtained in the above tests, request that the customer or his electrician check the cable for breaks, shorts, incorrect connector assembly, poor solder joints, etc.

5.0 Phase Tests

5.1 Preparation

DANGER: If a large Ground Potential Difference (GPD) condition exists, there might be a spark as the cable is disconnected or reconnected, due to a high current flow in the twinaxial shield. If the installation has a faulty ground, there may also be a hazardous voltage present. When removing or replacing the connector, only use one hand. No other part of your body should be touching a ground point.

DANGER: Do not work with twinaxial cables during electrical storms.

To check for correct phase connections, vary off all the devices on that run, and power the devices off. Disconnect the twinaxial cable from the machines.

The Phases within a twinaxial cable are generally called PHASE B and PHASE Y (or A). The conductor that is PHASE B at one end of the cable MUST also be PHASE B at the other end (i.e. the wires must NOT be crossed). The twinaxial cable is normally coded such that one phase is copper colored, and the other phase is tin coated, to assist in correct orientation. However, some cables are not color coded at all.

The Installation Planning documentation recommends that the copper conductor is inserted into the plug or socket hole that has a dot next to it. This is PHASE Y (OR A).

5.2 Testing for Correct Phase Connection

At one end of the cable, jumper PHASE B to the twinaxial shield. At the other end of the cable run, check for a resistance of less than 70 ohms between PHASE B and twinaxial shield (depending on line length: 0 ohms for a very short cable; 70 ohms for 5000 feet) and for infinity between PHASE Y (OR A) and twinaxial shield. If you don't get these readings, suspect the wires are reversed. Check every length of twinaxial cable for correct phase connection.

If all your cables check out good and cable to cable connectors are used, check to see that the connectors are not reversing the phases.

5.3 Testing AS/400 Systems

AS/400 systems are supplied with a port tester that will indicate reversed phases on a cable run. Follow the instructions in the user's guide SA21-9944 to perform this test.

5.4 Notes

1. If you have Station Protectors in the line you will not get valid resistance readings. Either temporarily disconnect the Station Protectors or test the line beyond the Station Protector. Do not do this if there is a chance of lightning.

5.5 End View of Twinaxial Connector

```
      * | *
    *       *
  *           *
 *             *
 *   B     Y o *
 *             *
  *           *
    *       *
      * * *
```

```
| = Key
B = Phase B
Y = Phase Y or A
o = Dot on connector
```

6.0 Station Protectors

Refer to the "IBM 5250 Information Display System: Planning and Site Preparation Guide" (GA21-9337) for detailed station protector installation information.

6.1 Requirement

Station protectors are required for each outdoor or underground cable run. Only one pair can be installed per twinaxial run, and they must be installed in pairs inside the buildings in question. They should be located where the cable enters or exits the building and as close as possible to a suitable ground as described in Section 6.2, "Grounding." It is the responsibility of the CUSTOMER to supply, install, and maintain station protectors, and to obtain spare units should they be required.

6.2 Grounding

The MINIMUM grounding requirements are a wire of at least #6 AWG (equivalent to an outside diameter of 4.7 mm, or a cross sectional area of 17.36 square mm), less than 3 meters (10 feet) long, running in a straight line to a grounding electrode with less than 10 ohms resistance to ground. The twinaxial cable attaching to the station protector next to the grounding conductor must be the one leading to the outside or the building.

There should be common grounding between the station protector, the utility ground, and all extensive metal components in the vicinity of the system. Please also see section 8.0, "Ground Potential Difference (GPD)" on page 17.

6.3 Part Numbers

P/N 7362426 is used for all twinaxial cabling applications (except 5520 printer lines)

P/N 6819750 is used for 5520 printer lines only.

6.4 Functional Check

DANGER: If a large Ground Potential Difference (GPD) condition exists, there might be a spark as the cable is disconnected or reconnected, due to a high current flow in the twinaxial shield. If the installation has a faulty ground, there may also be a hazardous voltage present. When removing or replacing the connector, only use one hand. No other part of your body should be touching a ground point.

DANGER: Do not work with twinaxial cables during electrical storms.

Although station protectors are totally the customers responsibility, the following checks can be made to ensure the devices are in good working order. The tests do not apply to station protectors used on 5525 LDC lines (Printers).

Disconnect both twinaxial cables from the protector, and remove the cover. The protector contains 24 diodes. The resistance of each diode should be more than 10,000 ohms (negative meter lead to anode) and less than 2,000 ohms (negative meter lead to cathode). The protector contains 2 capacitors. Set your voltmeter to the 100,000 ohm resistance scale. Touch the meter leads across the leads of a capacitor. There should be a noticeable instantaneous meter deflection as the capacitor charges up. No deflection indicates a defective capacitor. An analog meter should be used for this test.

7.0 AC Noise

AC Noise on twinaxial systems can be basically divided into 2 types:

1. Steady state noise that is always present.
2. Intermittent transients.

When checking for AC noise, consider the possibility that the line is more sensitive because of the number of cable connections or a cable length approaching the maximum of 5000 feet (1524 meters).

7.1 Steady State AC Noise

DANGER: If a large Ground Potential Difference (GPD) condition exists, there might be a spark as the cable is disconnected or reconnected, due to a high current flow in the twinaxial shield. If the installation has a faulty ground, there may also be a hazardous voltage present. When removing or replacing the connector, only use one hand. No other part of your body should be touching a ground point.

DANGER: Do not work with twinaxial cables during electrical storms.

This can be measured between a known good ground and twinaxial shield with an AC voltmeter or an oscilloscope, once the twinaxial cabling has been disconnected from the system or controller. A voltage present here MAY indicate a problem. If the amplitude of this noise rises above a certain level, it will corrupt the data signal and cause line checks or other errors. This type of noise is usually induced into the twinaxial cable due to the close proximity of power cables, heavy electrical equipment, fluorescent lamps, etc. (see Appendix A, "Twinaxial Cable Information" on page 28) or due to poor grounding of the devices connected to the twinaxial cable. Faulty grounding of any device on the same power circuit as the W/S's can cause noise to be induced. Twinaxial shield braiding offers a better path to ground for RF interference than a poor utility ground on a power circuit. The ground loop tester may detect a poor ground. Also, a meter should be used to verify that the power outlets (for W/S's connected to this twinaxial run) have the proper voltage and that live, neutral, and ground are wired properly.

A power line filter may help reduce interference from noise that is being introduced into the system via the main power circuit.

Also, a station protector may be inserted in the twinaxial line. As the internal capacitors in this unit offer a high impedance to 50/60 Hz, but a low impedance to twinaxial data signals, they will reduce the level of any induced 50/60 Hz noise.

7.1.1 Intermittent Transients

These are more difficult to troubleshoot especially if they are very intermittent. Check the error log to get an understanding of which devices or lines fail, how often, and at what times of day. Look for a pattern, and try to correlate the errors with something specific occurring in the environment (machines being switched on in a factory, use of fluorescent lamps or fluorescent lamps that are flickering, vending machines, typewriters, dimmer controls, power short in a circuit into which W/S's are plugged, etc.).

Check for good grounding of ALL devices on the power circuit. A power line filter may help reduce interference from noise that is being introduced into the system via the main power circuit. A power line monitor may provide useful information on the size and times of transients. Exceptionally large transients can cause permanent damage to logic cards.

7.1.2 AS/400 Systems

AS/400 Systems will not tolerate large transients, or large amounts of AC noise on the twinaxial cabling. In severe cases, for the 9406, they can cause problems to other cards in the cage, or cause the power supply (for the card cage containing the work station controller card) to shut down with one of the following errors:

- 0000 000B - Over voltage check
- 0000 000C - Under voltage check
- 0000 0001 - Over current check (at power up only)

Less severe problems may cause devices to intermittently drop off line, and large amounts of errors to be logged.

A station protector may be inserted in the twinaxial line (if the cable remains in one building). As the internal capacitors in this unit offer a high impedance to 50/60 Hz, but a low impedance to twinaxial data signals, they will reduce the level of any induced 50/60 Hz noise. If the cable connects two separate buildings, a pair of station protectors should already be installed.

If twinaxial cables are connected to the AS/400, but are not connected at the W/S end, or if the shield is open in a cable, this open cable/shield can conduct noise into the system and cause WSC or system problems. Make sure that all attached twinaxial cables are properly terminated and/or disconnect all unused twinaxial cables at the AS/400. See Appendix B, "Step by Step Cable Debug Instructions" on page 29 or section 4.0, "DC Cable Tests" on page 10 to check for an open shield.

Additionally, AS/400 logic cards should be checked to ensure they all have a grounding clip installed, and that there is a grounding clip mounted on the right side (rear view) of the card cage.

If, after doing the above, you are still having problems, consult your IPR and/or your CE support group.

8.0 Ground Potential Difference (GPD)

8.1 Description

A ground potential difference is when two or more ground points have a different electrical potential. This can cause problems for a twinaxial installation, as the twinaxial shield may well be connecting these points together. This can cause a large current to flow in the twinaxial shield, as it tries to equalize the two grounds.

8.2 Causes

Differences in ground potential generally occur when the installation has twinaxial cables running between different buildings, uses different power distribution substations in the same building, or has defective grounding.

8.3 Testing for GPD

DANGER: If a large GPD condition exists, there might be a spark as the cable is disconnected or reconnected, due to a high current flow in the twinaxial shield. If the installation has a faulty ground, there may also be a hazardous voltage present. When removing or replacing the connector, only use one hand. No other part of your body should be touching a ground point.

DANGER: Do not work with twinaxial cables during electrical storms.

You can determine if this problem exists by varying off all the devices on the twinaxial run, and disconnecting the twinaxial connector at the point in the line to be tested. For a line going between buildings, this will be at the point the cable exits the lightning protector.

Measure the voltage (both AC and DC) between the shield of the removed connector, and the shield of the connector from which it was removed. This may need to be measured at a number of places along the twinaxial run.

An alternate method of testing involves the use of a clip-on ammeter. This may simply be clamped around each cable to be tested. It is not necessary to remove the connectors, or vary off or power off the connected devices.

Devices connected to twinaxial runs generally contain zener diodes that will clamp should the voltage exceed certain limits. If the measured potential difference exceeds about 3 volts DC or AC, you MAY experience problems. The actual voltage at which failure occurs depends on the characteristics of the line in question.

8.4 Resolving GPD Problems

The "5250 Information Display System: Planning and Site Preparation Guide" (GA21-9337) specifies the recommended cable wiring between buildings. Lightning protectors are to be installed at both building entry points. Included are lightning shield wires which are grounded and attached to earth ground at the entry points of both buildings. Make sure that these ground wires are correctly installed to maintain a low GPD. Capacitors in the station protectors will act as a barrier to any DC or low frequency AC voltages.

Where GPD exists within a building, a single station protector can be used on the twinaxial cables to reduce the effect of the GPD.

Installation of a Broadband Transformer Unit (see Appendix D, "Test Equipment" on page 34) may help with GPD but use with caution as it may allow additional noise to enter the system.

If your installation is unusual and these recommendations are not effective, consult your IPR and/or the your CE Support Group.

9.0 Line Signal Quality Tests

9.1 Description

These are best described in the maintenance manual for the machine in question. They are sometimes referred to as "Time Domain Reflectometry".

5340	Maintenance Manual	11-500
5360	Maintenance Information Manual	70-310
5362	Maintenance Information Manual	7-4
5363	Maintenance Information Manual	7-3
5364	** Not in maintenance package	**
5381/2	Theory and Maintenance Manual	40-050
5520	Maintenance Manual Volume 1	95-500
9404	** Not in maintenance package	**
9406	** Not in maintenance package	**

For those machines where the procedure is not contained within the on-site documentation, it can still be used as a troubleshooting aid, but instructions must be obtained from one of the above manuals which contain the procedure.

The following tools are required for this test:

1. Oscilloscope.
2. BNC T-connector P/N 1650789.
3. Probe tip to BNC adaptor P/N 453199 or 2 foot BNC to BNC cable.
4. Coaxial cable, BNC one end, alligator clips the other P/N 1650790.
5. Resistor assembly P/N 7362344 if the twinaxial cable is unterminated

This test will help diagnose the following conditions: (it will NOT detect crossed (reversed) phases).

1. Open circuit phase(s).
2. Short circuit phase(s).
3. The cable length to the fault.
4. Noise or Ground Potential Difference problems.

More information can be obtained from the publication "An Oscilloscope Measurement Procedure for Twisted and Coaxial Cables" (S226-3913).

9.2 5360 Systems

5360 systems have a utility program on the system to help locate open circuits, short circuits, and phase reversals in twinaxial cables. See Maintenance Information Manual section 01-525 for details.

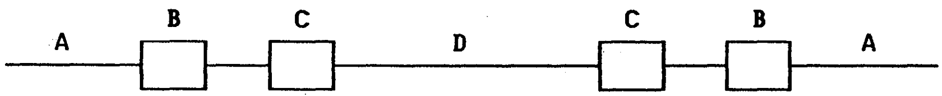
9.3 5520 Systems

The method of testing 5520 lines described in Maintenance Manual Volume 1, 95-000 does not apply to printer lines. To test printer lines, the cable must be removed from the printer, and terminated with a resistor assembly P/N 7362344. If this procedure is not followed, the waveform displayed on the oscilloscope will appear as a short.

10.0 Polyquad Cable - UK only

10.1 Requirement

A customer may wish to connect devices to the system or controller, but they are physically divided by a public highway or other obstruction. In these situations, a possible solution is to utilize British Telecom trunking if this exists. BT does not permit twinaxial cable to be run in their trunking, but will install polyquad cable together with the required adaptors at each end.



A: TWINAXIAL CABLE   B: NOLTON 1180 or ATS 200 LINE ISOLATOR

C: TERMINATING UNIT 9A   D: POLYQUAD-4 CABLE

10.2 Notes

It is the responsibility of the customer or his contractor to connect the twinaxial to the line isolator units which contain a 4 way terminal block numbered 1 to 4.

The characteristics of POLYQUAD-4 cable are:

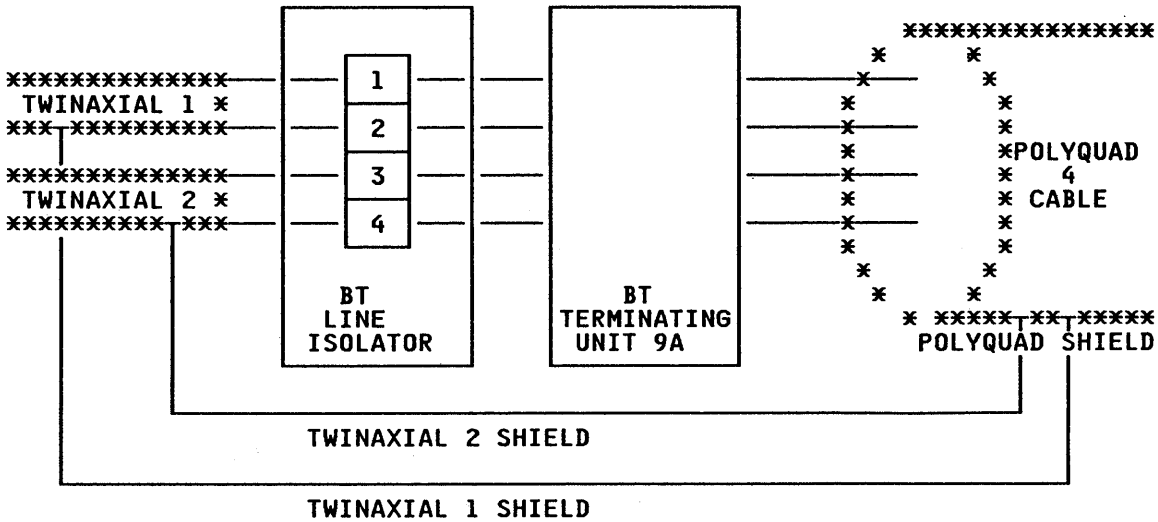
Number of wires:	4
Conductor Material:	Copper
Conductor size :	1.27 mm diameter
Conductor resistance:	13.5 ohms/kilometer
Characteristic Impedance:	140 ohms

It should be noted that the IBM CABLING SYSTEM does NOT support the use of POLYQUAD-4 cable.

It is possible for one polyquad cable to carry the signals for one or two twinaxial cables. Refer to the next page for connection information.

It is likely that signal losses in a line partially comprised of polyquad cable will be higher than an equivalent run using just twinax. Because of this, great care should be taken with the installation to ensure that preventable losses are not introduced. Particularly, the number of cable connections should be kept to a minimum.

10.2.1 Connection Diagram



11.0 IBM Cabling System

The IBM Cabling System enables a customer to install a signal distribution system that is capable of handling various IBM communication products. For example, assume that the cabling system is initially installed for a system that requires coaxial cable. Later, if a system that requires twinaxial cable is installed, no rewiring is required. The changeover is made by installing different accessories in the wiring closet and work areas.

The cables used in the IBM Cabling System are shielded twin twisted pairs.

This system is fully described in the manual GA27-3361 ″IBM Cabling System Planning and Installation Guide″.

A Problem Determination guide has been produced for the IBM Cabling System used in twinaxial applications. This Manual contains details of special equipment needed to diagnose problems with the IBM Cabling System. Please refer to this manual, GA21-9491 for more details.

Appendix B, "Step by Step Cable Debug Instructions" on page 29 can be used for finding problems with the IBM cabling system. The difference is that the resistance would be 95 ohms (instead of 55 ohms) when measuring from the system end towards the termination at the last W/S. Termination at the last W/S can be done in two ways:

1. Use a 150 ohm termination plug (P/N 6091068) at the last W/S. This is the recommended method.

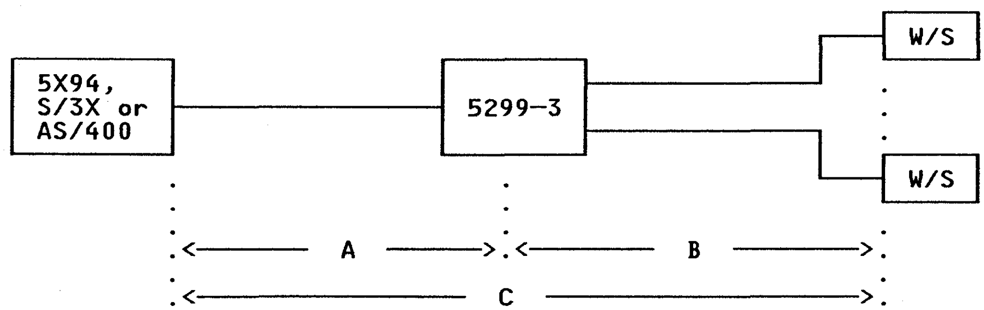
2. Use the Impedance Matching Device (at the last W/S) for going from the IBM cabling system to twinaxial cable and terminate the last W/S as you would if this were a twinaxial line.

12.0 Telephone Twisted Pair (TTP)

12.1 IBM Equipment (US and Canada Only)

Telephone Twisted Pair (TTP) wiring can be used in place of twinaxial wiring. The IBM 5299-3 (TTP fanout box) and IBM twinaxial to Twisted Pair Adapters (TTPA) require TTP cable that meets the IBM Type 3 Media Specifications. See Appendix C, "Telephone Twisted Pair Cabling Information" on page 33 for details of these specifications, or refer to the "IBM 5299 Terminal Multiconnector Model 3 - Planning, Setup, and Maintenance Guide" (Pub. No. GA27-3749) for details. The above document also contains a problem analysis procedure.

The following diagram illustrates the maximum cable lengths supported.



The following defines the maximum cable length when all TTP is used:

- A - From host to 5299 - 1000 feet (305 meters)
- B - From 5299 to W/S - 900 feet (274 meters)
- C - From host to W/S - 1000 feet (305 meters)

To achieve a greater distance, twinaxial cabling can be used from the host to the 5299. The following defines the maximum cable lengths for this:

- A - From host to 5299 - 2000 feet (610 meters) twinaxial
- B - From 5299 to W/S - 900 feet (274 meters)
- C - From host to W/S - 2000 feet (610 meters)

Cabling thru of W/S's is not supported on TTP. Also, at the W/S end, you should not connect twinaxial between the TTPA and the W/S. The TTPA should be connected right at the W/S.

When only one W/S is connected to a 5299-3, it might not work. This can be fixed by adding more W/S's to the 5299-3 or by connecting a 110 resistor from pin 2 to pin 5 on an RJ11 jack and inserting this in one or more of the unused RJ11 plugs on the 5299-3. The 5299-3 works best with a balanced load on the output.

The IBM 5299-3 is basically a power splitter, so it isolates the seven W/S's (and cabling) from one another. This maintains the correct impedance of the cabling system as seen by each W/S and as seen by the AS/400.

12.2 OEM Equipment

Some non-IBM TTPA's and fanout boxes that work OK on a S/3X might not work on the AS/400. The AS/400 WSC transmits commands much closer together on the cabling (less dead time between commands) than the S/3X. This was done to improve performance. This is the cause of some problems with some non-IBM TTPA's and fanout boxes.

It is also important to use Type 3 TTP (22-24 AWG, solid wire). Other TTP may have greater attenuation or a different impedance.

Also, some of the non-IBM fanout boxes are just a 1 TTP to 7 TTP adaptor (ie, just wires and connectors, sometimes called "passive" boxes). So, as more devices are added, the 55 ohm terminating resistors in the displays or printers are connected in parallel which alters the impedance of the line and can cause reflections. This can cause some or all of the W/S's to not work correctly. An example of what can happen might be that 1 to 4 W/S's operate correctly, but as the 5th, 6th, or 7th are added, some or all W/S's on this fanout box stop working.

Some OEM fanout boxes are active (they repower the signal). These seem to work better than the passive boxes.

13.0 Fiber Optic Convertors

IBM does not make a twinaxial to fiber optic convertor, but, there is a variety of OEM devices available. Most often fiber optic convertors are used in extremely noisy environments, such as high RF activity or high ESD activity areas. Two types of convertors are currently available:

1. Single port (1 twinaxial cable to one pair of fibers).
2. Multiplexors (4 or 8 twinaxial cables to one pair of fibers).

Most (if not all) of the multiplexors require that only cables from one controller can be attached. You can not attach cables from different controllers to one 4 or 8 port multiplexor.

The fiber optic convertors seem to work best if the cable network attached to them is kept simple. Some accounts have had problems when a mix of twinaxial cables, TTP, and fiber optics were used. If the customer uses just twinaxial cable with the fiber optic convertors, they will be less likely to have problems.

14.0 Twinaxial Device Problems and Solutions

14.1.1 3197

This unit MUST have the Auto-termination (T-connector) unit plugged in. The twinaxial cables plug into the Auto-termination unit. The 3197 Auto-termination is P/N 94X3678.

Some early 3197's had a capacitor from each twinaxial signal to ground. This caused the 3197 to place a highly capacitive load on the twinaxial line. This may make it impossible to get the maximum of 7 devices working on that run. On the logic board, these capacitors are C7 and C8. They can be removed. The latest level of this logic board has these removed.

3197's also seem to be very susceptible to reflections on the twinaxial. If you encounter 3197's that do not work, and have checked out cabling, termination, etc, try a different type of display in its place. If this display works without errors, try changing cable lengths or connect a single station protector (assuming an indoor run) between the system and the failing 3197(s).

14.1.2 3196

This unit MUST have the Auto-termination (T-connector) unit plugged in. The twinaxial cables plug into the Auto-termination unit. The 3196 Auto-termination is P/N 81X5387.

Some early 3196's have an incorrect logic board impedance. This causes the screen to place a high load on the twinaxial line, and reduce the signal strength, with the result that it may prove impossible to get the maximum of 7 devices working on that run.

14.1.3 3179

This unit MUST have the Auto-termination (T-connector) unit plugged in. The twinaxial cables plug into the Auto-termination unit.

Some early 3179's had a capacitor from each twinaxial signal to ground. This causes the 3179 to place a highly capacitive load on the twinaxial line. This may make it impossible to get the maximum of 7 devices working on that run. On the logic board, these capacitors are C29 and C30. They can be removed. The latest level of this logic board has these removed.

The 3179 may not work well on long cables (5000 feet). The - 5 volt supply is inadequately decoupled. Call the 3179 support structure for details on how to handle this problem.

14.1.4 PC/PS2

It is possible to terminate some of these devices internally (by a switch on the emulator card) or externally by the use of a 'T' connector. Ensure that the device is only terminated once, and only if it is at the end of the run. Generally, it is preferable to terminate externally using a 'T' connector.

14.1.5 5251

Some 5251 displays with ferroresonant power supplies can create noise when powered off, causing other WS on the line to fail. There is an 'as required' EC to fix this problem

The 5251 has jumpers for keyboard identification. This needs to be setup correctly for the display to work with an AS/400. The 5251 also has jumpers for the cable thru feature. If these are on when the cable thru feature is installed, double termination (27.5 Ohms instead of 54.9) can result. Refer to the 5251 MIM for jumper information.

Depending on cable lengths, some 5251's may not work on the same cable as a 3197. The ending sequence from a 3197 transmission can be interpreted as a start of transmission by a 5251. There is no EC to fix this, but an "as required" modified 3197 logic board is available in very limited quantities thru IBM Raleigh. Call the 3197 support structure for details on how to handle this problem.

14.1.6 3180

Some older 3180's may not work on short cables (eg, 20 feet or 6.1 meters). This is because of the routing of the twinaxial signal internal to the display. A longer cable or cabling more W/S's on the same port usually will fix the problem.

14.1.7 5291

Some older 5291's may not work on short cables (eg, 20 feet or 6.1 meters). A longer cable or longer cables between W/S's on the same port usually will fix the problem.

14.1.8 Any

A failing device logic unit may present a low impedance to the twinaxial line, thus dropping the signal strength and causing problems on other devices. This can be checked by measuring the resistance between phases on the device twinaxial connector. This resistance will obviously vary, but any device with a reading significantly lower than the others can cause problems.

Problems have sometimes been overcome by changing the length of twinaxial cables. This may be due to standing waves occurring in a badly balanced line. These may also be due to reflections, which are dependent on the magnitude of a discontinuity in the cable, cable length between devices, excess capacitance, transformer coupling, transient suppressors, improper termination, or driver/receiver input impedance.

Appendix A. Twinaxial Cable Information

Conductor resistance (max) per 1000 feet or 305 meters	11 Ohms
Shield resistance (max) per 1000 feet or 305 meters	3 Ohms
Characteristic Impedance at 1 Mhz	107 +/- 5 Ohms
Capacitance (maximum)	16.2 pf /foot
Max. attenuation at 100 MHz and 25 degrees Celsius. per 100 feet (30.5 m)	4.5 dB

The color of the outer protective jacket is Black (Vinyl Covering) or White/Light grey (Teflon Covering). The teflon covered cable is a low-smoke cable.

Operating temperature range is -40 to +80 degrees C. Operating humidity range is 10% to 90%

Twinaxial cable must NOT be installed near equipment or power lines using 440 volts or more. The minimum distance between twinaxial and equipment or power lines using less than 440 volts is as follows, depending on the power consumption :

	2 KVA or less	2-5 KVA	over 5 KVA
twinaxial and unshielded power lines	5 inches	12 inches	24 inches
twinaxial in grounded metal conduit and unshielded power lines (or vice versa)	2.5 inches	6 inches	12 inches
twinaxial and power lines both in separate grounded metal conduit	1.2 inches	3 inches	6 inches

The minimum distance between twinaxial cables and fluorescent, neon, or incandescent lighting fixtures is 5 inches.

Appendix B. Step by Step Cable Debug Instructions

DANGER: If a large Ground Potential Difference (GPD) condition exists, there might be a spark as the cable is disconnected or reconnected, due to a high current flow in the twinaxial shield. If the installation has a faulty ground, there may also be a hazardous voltage present. When removing or replacing the connector, only use one hand. No other part of your body should be touching a ground point.

DANGER: Do not work with twinaxial cables during electrical storms.

The following procedure can be used on twinaxial cabling or the IBM cabling system. Step 3 of this procedure explains the difference between the ohmmeter reading for twinaxial cabling versus the IBM Cabling System.

Twinaxial cable or device problem determination can be a very time consuming and difficult task. Often, many unnecessary hours and parts are used in trying to do problem determination. The following procedures have been time tested in the field and have proven to be very dependable and fast.

It is assumed that the problem is not an obvious problem with one device such as a distorted display or failure to power up.

Typically, one or more devices on a string will not come on line or will come on line and periodically drop off (lose communications with the host). On an AS/400, if no W/S's come on line, make sure the latest level PTFs are loaded on the system.

These procedures look long and complicated. Typically, you will quickly complete problem determination with the first step. Remember, you are doing problem determination. It is the customer's responsibility to fix bad cables or connectors.

These procedures will not isolate all possible problems. They will determine the source of most of the common problems that are experienced on twinaxial cable. If you use them, you will save a lot of time and have a happier customer.

Follow these steps in sequence.

1. Question the customer to gain a clear understanding of the problem.

    a. Has the string ever worked?

    b. Have any devices or cables been added to the string?

    c. Have they moved any devices?

    d. How many devices fail and how often?

2. Indoor cable? GO TO STEP 3

    Outdoor cable? GO TO STEP 11

3. Meter the cable for correct termination.

    NOTE: USE AN ANALOG METER FOR THE FOLLOWING STEPS. DO NOT USE A DIGITAL METER.

    The readings given are for a short twinaxial cable allowing for no resistance of the cable itself. You will have to use some judgement based upon your knowledge of the length of the cable. For twinaxial cabling, the minimum reading for termination is 55 ohms and the maximum is 125 ohms. (55 ohms termination + 14 ohms per 1000 feet of cable.) For the IBM Cabling System, the minimum reading for termination is 95 ohms and the maximum is 165 ohms. (95 ohms termination + 14 ohms per 1000 feet of cable.)

a. Disconnect the cable from the Host. (S/3X, AS/400, 5X94, etc.)

b. Meter from each phase conductor to the shield for proper termination. The reading should be 55 ohms (95 ohms for IBM Cabling System). The readings should be approximately the same for each phase conductor.

c. Reverse the meter leads and meter again. The readings should be the same regardless of which meter lead is on the shield and which lead is on the conductor.

d. Meter from phase to phase. The reading should be 110 ohms. (190 ohms for the IBM cabling system).

- GO TO STEP 4.

4. Based upon the results of STEP 3 above, branch as follows.

   a. Readings correct - 55 ohms, GO TO STEP 5.

   b. Readings correct with meter leads one way but low the other way, ie: 55 ohms one way and 40-45 ohms the other, GO TO STEP 6.

   c. Readings low - 25-30 ohms, GO TO STEP 7.

   d. Readings = 0 ohms, GO TO STEP 8.

   e. Readings very low in both directions, ie: 10 ohms, GO TO STEP 9.

   f. Readings = infinity, GO TO STEP 10.

5. You are here because the cable and termination metered out correctly. Your readings were 55 ohms on each center conductor regardless of the polarity of the meter leads.

   Thus far, you have proven that the cable appears to be OK and that it is properly terminated. Ask the customer to walk the cable with you and look at each terminal on the cable. As you walk the cable, look at and check the following:

   a. Verify the physical address of each device. Two devices with the same address will keep one or both of these devices from working.

   b. Twist and pull on each cable at each connector to see if the cable will twist inside the connector. If so, the cable is not assembled correctly and will cause line checks and terminals will lose communications with the host. The problem is most likely that the shield is not placed over the braid clamp in the connector. It will touch and make enough contact for the meter reading but will cause noise when an operator kicks a cable or shifts a terminal around on a desk. The cable **will not** turn in the connector if it is assembled correctly. Refer to page A-10 step 3 of the 5250 Planning and Site Preparation Guide GA21-9337. Please note that the bad connector may be 3 or 4 terminals away from the failing terminal.

   c. Look for improper cabling practices such as improper use of "T" connectors. "T" connectors are only used on devices with one port such as 3179's. Some customers have tried to use them on devices such as 5251's. Some customers are making their own "T's". Be aware that the length of the "T" cable can not be over 12 inches.

   d. Count the number of junctions in the cable. 11 is the maximum. Wall plates can be a big offender. Some customers will wire every office with a wall plate in anticipation of future growth. You can end up with a cable that has 7 devices on it and 30-40 junctions. This can cause intermittent and flaky problems.

e. Take note of where each terminal is plugged in. It needs to be in a grounded receptacle.

f. If the problem is still not identified, you may have to meter each cable section for correct polarity and/or inspect each connector. Cold solder joints, pins that are not soldered to the conductors, etc., will meter OK but will cause intermittent problems. Word of caution: do not take apart a customer connector unless you have to. Once you do so, the customer might want you to fix it. Also look for pins pushed back in the connector and attempt to push pins back into the connector. Often a pin will push back into the connector when it is mated to the female connector. If this happens, you will have sufficient contact to get a good meter reading but the signal will not pass thru the connection dependably. If assembled correctly, the pins will not push back.

- GO TO STEP 12.

6. You are here because the cable termination metered correctly with the meter leads one way and it measured low with the meter leads reversed, ie, 55 ohms one way and 40 ohms the other way. This condition indicates that you have a defective logic element on one of the displays on the cable. Usually the defective device works correctly but keeps other devices on the cable from coming on line. If the devices are attached by "T" connectors, the fastest thing to do is leave your meter on the cable with the **bad** reading showing. Disconnect "T" connectors one at a time from the devices until the reading returns to normal (55 ohms). The disconnected device that allowed the reading to return to normal is the defective unit. This failure normally only shows up on newer devices such as 3180 and 3179's. If you suspect a device without a "T" connector, use a splice connector to bypass it or break and terminate the cable as you continue to meter the cable.

   - GO TO STEP 12.

7. You are here because the meter readings were low when termination was checked (25-30 ohms). This condition usually indicates double termination on the cable. Look for termination switches set wrong and/or terminate jumpers installed on the logic boards.

   - GO TO STEP 12.

8. You are here because the meter readings were 0 ohms. This indicates that the phase conductor(s) are shorted to the shield. Break the cable into sections to determine the bad cable. Internal shorts can look like a shorted cable.

   - GO TO STEP 12.

9. You are here because the readings were very low in both directions. This indicates a defective device on the cable, such as a 5291 or a PC with 5250 emulation. Usually the failing device does not come on line. On PC's, disconnect the "T" connector from the PC and see if the reading returns to normal. On 5291's, bypass them with splice joints and see if the reading returns to normal.

   - GO TO STEP 12.

10. You are here because the meter readings were infinity. This indicates that the cable is unterminated or is open. Check for:

    a. Terminate switch setting on last device set to 1.

    b. Faulty "T" connector on last device (they fail to terminate at times).

    c. Plunger switch defective or stuck on devices with the plunger built into port 2 of the device (ie. 3180) or the metal box type "T" connector.

    d. Meter at last device to verify termination. If OK, find the open in the cable. If you read 110 ohms from conductor to conductor and infinity from conductors to shield, the shield is open. Otherwise, one or both conductors could be open or the entire cable may be open (the cable might have been cut into or is disconnected from a device or splice joint some place).

    - GO TO STEP 12.

11. You are here because you are dealing with an outdoor cable that should have station protectors installed. If so, be aware that you can not meter through the station protectors. It is recommended that you replace the station protectors with splice joints and return to STEP 3 of these procedures. If everything checks out correctly in STEP 3, have the customer try the line without the station protectors.

    CAUTION: DO NOT BYPASS OR LEAVE THE STATION PROTECTORS OUT OF THE LINE IF THERE IS ANY CHANCE OF AN ELECTRICAL STORM.

    If the line works OK without the station protectors, check for the following.

    a. A defective station protector.

    b. One or both protectors installed backwards. The outdoor cable must go to the end of the station protector that has the ground wire.

    c. Excessive AC current flow on the shield of the cable caused by a difference in ground potential between the buildings. You may need the help of your IPR to solve this problem.

    d. No grounds or missing grounds on the station protectors.

12. You are here because a previous step directed you here. If your problem has not been resolved, go back to STEP 3 and double check the path you took. If still not resolved, use a scope to do the TIME DOMAIN REFLECTOMETRY procedure. While scoping the cable, have someone shake the cables at each device. Look for momentary shorts and or opens to appear.

    These procedures should fix 95% of your problems. If the problem is still not fixed, return to section 1.3, "Starting Point" on page 2 and follow thru this guide. If after following thru this guide you are still stuck, I suggest you call for technical support.

Appendix C. Telephone Twisted Pair Cabling Information

The twisted pair wiring must meet the following specification (IBM Type 3 Media Specifications).

- #22 or #24 AWG (American Wire Gauge).
- Solid copper twisted pair wires with at least two twists per 308 millimeters (12 inches).
- A maximum of 28.6 Ohms DC resistance per 305 meters (1000 feet).
- Impedance characteristics
  - 90 to 120 Ohms at 256 KHz
  - 87 to 118 Ohms at 512 KHz
  - 85 to 114 Ohms at 772 KHz
  - 84 to 113 Ohms at 1000 KHz
- Maximum attenuation per 305 meters (1000 feet)
  - 4.00 dB at 256 KHz
  - 5.66 dB at 256 KHz
  - 6.73 dB at 256 KHz
  - 8.00 dB at 1000 KHz
- In addition, all type 3 Specified Media must meet at least one of the following industry specifications:
  - ANSI/ICEA S-80-576-1983
  - REA PE-1
  - Bell System 48007

TTP cable must NOT be installed near equipment or power lines using 440 volts or more. The minimum distance between TTP and equipment or power lines using less than 440 volts is as follows, depending on the power consumption :

- At least 128 millimeters (5 inches) from power lines carrying 2 KV AC or less.
- At least 308 millimeters (12 inches) from power lines carrying 2 KV to 5 KV AC.
- At least 923 millimeters (36 inches) from power lines carrying 5 KV AC or more.
- At least 128 millimeters (5 inches) from fluorescent lights.

Appendix D. Test Equipment

There are various pieces of test equipment that can be useful in troubleshooting twinaxial installations..

D.1 Noise Filters

A power line filter Unit can be used to filter noise components from the utility A.C. Power, or to suppress a known noise source as a problem determination aid.

A single station protector may also be inserted in the twinaxial line. The internal capacitors in this unit offer a high impedance to 50/60Hz, but a low impedance to twinaxial data signals, so they will reduce the level of any induced 50/60Hz noise.

D.2 GPD Isolation

A Broadband Transformer Unit can be used to isolate a device from the twinaxial ground. This will prevent ground potential differences from affecting the devices, and enable the potential difference to be measured.

D.3 Power Monitors

An OEM Power Disturbance Analyzer can be used to measure voltage sag, surge, and impulse (including impulse duration) on single and three phase AC supplies. With the appropriate plug in module, it will also record DC voltages. The output is numeric on a paper tape roll.

Another OEM power monotor provides 8 channel digital storage of external voltage waveforms. The recorded waveforms may be displayed on a screen. The recording is triggered when a disturbance occurs that exceeds a predefined limit.

D.4 RF Measurement

An RF probe can be used to measure high frequency current in electrical conductors. In conjunction with a 'Zapper', it can be used to determine how quickly the system ground can dissipate RF noise.

D.5 Useful Part Numbers

```
Cable to Cable twinaxial adaptor to connect two plugs: P/N 7362230
twinaxial panel mounting socket:                       P/N 7362179
twinaxial plug:                                        P/N 7362229
Plastic twinaxial plug insulating sleeve:              P/N 94X3698
Station protectors:                                    P/N 7362426
5520 LDC line station protectors:                      P/N 6819750
20' twinaxial lead & plugs:                            P/N 4236482
```

Appendix E. Bibliography

Further information can be found in the following publications :

	FORM NUMBER
An Oscilloscope Measurement Proc. for Twisted & Coax Cables	S226-3913-1
IBM Cabling Sys. Problem Determination Guide for twinaxial Applications	GA21-9491-1
IBM Cabling System Planning and Installation Guide	GA27-3361-7
Using the IBM Cabling System with Communication Products	GA27-3620-1
IBM 5250 - Info. Display System-Planning & Site Prep. Guide.	GA21-9337-8
IBM 5360 - Planning to set up your computer	SA21-9439-5
IBM 5362 - Setting up your computer	SA21-9487-4
IBM 5363 - Preparing to install your work stations	SA21-9931-0
IBM 5364 - Preparing to install your work stations	SA21-9845-2
IBM 5381 - S/38 Installation Manual- Physical Planning	GA21-9293-13
IBM 5394 - Introduction & Installation Planning Guide	SK2T-0316-1
IBM 5520 - Installation Manual - Physical Planning	GA23-1011-
IBM 9404 - AS/400 Planning Guide	GA21-9914-0
IBM 9406 - AS/400 Planning Guide	GA21-9913-0
IBM 9404/6 AS/400 Attaching Work Station & Comms Cables	SA21-9957-0
IBM 9404/6 AS/400 Port Tester User's Guide	SA21-9944-0
5250 Information Display System to System /3X System Units Product Attachment Info.(Available from Industry Relations)	---NONE---

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Reader's Comments

Twinaxial Cabling
Troubleshooting Guide

Publication No. SY31-0703-0

Use this form to tell us what you think about this manual. If you have found errors in it, or if you want to express your opinion about it (organization, subject matter, appearance, etc.) or make suggestions for improvement, this is the form to use.

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