Radio Frequency Interference (RFI) Mitigation Techniques

Contents

(continued)

Contents, continued

1. General

1.1 Purpose

This practice provides information about the mitigation of radio frequency interference at customer (station) locations.

1.2 Filing Instructions and Supersedures

File this practice in numerical order in your GTE Telephone Operations practices set.

This practice supersedes and cancels:

- All policies, procedures, general instructions, letters, and memoranda which address this subject.
- Any document which provides information contrary to the information contained in this practice.
- GTE Telephone Operations Practice 471-150-200, Installation – Radio Frequency Demodulation Suppressors.

1.3 Responsibility

This practice was published by the GTE Telephone Operations Administrative Services Department. For more information about this practice, contact the GTE Telephone Operations Headquarters contact the Headquarters Protection Engineering Support Department.

1.4 Disclaimer

This practice was prepared solely for the use of GTE Telephone Operations. It must be used only by its employees, customers, and end users when installing, operating, maintaining, and repairing GTE Telephone Operations' equipment, facilities, and services. Any other use of this practice is forbidden. The information contained in this practice may not be applicable in all circumstances and is subject to change without notice. By using this practice the user agrees that GTE Telephone Operations will have no liability (to the extent permitted by applicable law) for any consequential, incidental, special, or punitive damages that may result.

2. Overview

2.1 Introduction

Electromagnetic interference is any emission of electromagnetic energy or electrical noise which creates a disturbance or undesired response in one or more circuits, equipment, or systems causing a disruption in their normal operation

Electromagnetic interference:

- Is a generalized version of the older term, Radio Frequency Interference (RFI).
- Includes the entire frequency spectrum from Direct Current on up.

RFI is defined by the Federal Communications Commission as interference from 10 kilohertz to 300 gigahertz.

NOTE: Radio frequency interference excludes natural sources of radiated interference.

2.2 Scope

This practice provides techniques for the detection and mitigation of radio frequency interference in telephone facilities, especially those at customer locations (stations).

Mitigation of radio frequency Interference at locations with larger concentrations of equipment such as key systems, Private Automatic Branch Exchange, etc., may require:

- More than just adding filters.
- Improved grounding.
- Room shielding.

NOTE: Radio frequency interference mitigation at these locations is outside the scope of this practice.

2.3 Definitions

The following chart provides definitions for the acronyms and terms used in this practice.

Acronym or Term	Definition
Amateur Band	Any one of the several frequency groups assigned for the transmission of signals by amateur radio operations.
Amateur Operator	A home hobbyist who operates a radio in the amateur band for personal communications. Usually referred to as a ham operator.
AM	Amplitude Modulation – A system of modulation in which the envelope of the transmitted wave contains a component similar to the waveform of the signal to be transmitted.
Antenna	The pan of a transmitting or receiving system which is designed to radiate (emit) or receive EM waves.
ARRL	American Radio Relay League
ASW	Aerial Service Wire (Drop)

(continued)

2.3 Definitions, continued

Acronym or Term	Definition
ATL	Above the Line (Regulated)
Audio frequency	Any frequency corresponding to a normally audible sound wave (15Hz - 20 kHz).
BSW	Buried Service Wire
BTL	Below the Line (Nonregulated)
CA-TV	Community Antenna Television (Cable TV)
CB	Citizens Band -Groups of frequencies allocated for: • Short-distance personal or business radio communications. • Radio signaling. • Control of remote devices by radio.
CFR	Code of Federal Regulations
Choke	An inductor designed to retard certain frequencies.
CO	Central Office
CPE	Customer Provided Equipment
EM	Electromagnetic
EMI	Electromagnetic Interference -The interference in signal transmission or reception which manifests itself in performance degradation, malfunction, or failure of electrical or electronic equipment resulting from the radiation of electrical or magnetic fields (See RFI).
FCC	Federal Communications Commission
Filter	A network designed to eliminate a band of frequencies.
FM	Frequency Modulation -A system of modulation where the instantaneous radio frequency: • Varies in proportion to the instantaneous amplitude of the modulating signal. • Is independent of the frequency of the modulating signal.

(continued)

2.3 Definitions, continued

Acronym or Term	Definition
GHz	Gigahertz- 1,000 MHz
Ground	A conducting connection, whether intentional or accidental, between any electrical circuit or equipment and the earth, or to some body that serves in place of the earth.
Hz	Hertz – Unit of frequency, one cycle per second.
I/O wife	Inside/Outside wire
ISDN	Integrated Services Digital Network
Interference	Any undesirable EM coupled through the process of either radiation, conduction, or both.
kHz	Kilohertz – 1,000 Hertz
Low pass filter	A filter having a single transmission band extending from zero (0) frequency up to some cutoff frequency.
MGN	Multigrounded neutral
MHz	Megahertz – 1 ,OOO,OOO Hertz
μF	M i crofarad – 0.00000 1 Farad
Near-field	Generally, the point source distance less than 1/6 of the wavelength.
NEC	National Electrical Code
NID	Network Interface Device
Noise	Unwanted electrical signals introduced in telephone lines: • By elements of the circuit or natural disturbances. • That tend to degrade the quality of transmission.
OSP	Outside Plant
PABX	Private Automatic Branch Exchange
PSB	Product Standardization Bulletin
QT	Quiet Termination

(continued)

2.3 Definitions, continued

Acronym or Term	Definition
RF	Radio Frequency- Frequency band of the EM spectrum that is between the audio frequency band and the infrared frequency band. Generally from 10 kHz - 100,000 MHz.
RFI	Radio Frequency Interference -The disruption of a regular telephone signal caused by a signal whose frequency is in the radio band. The FCC defines RFI to include a range from 10 kHz - 300 GHz.
Suppressor	A term that can be applied to either filters or chokes used for the elimination of RFI.
T&P	Transmission and Protection

2.4 References

The following chart provides sources of supplementary information relating to this practice. The documents could be required for performing certain tasks.

See...	For Information About...
887-100-075	Engineering Requirements Protection at Customer Locations
903-101-070	Protection Cable Bonding and Grounding
NFPA 70	National Electrical Code (NEC)*
GTE Noise Reduction Handbook	Noise Mitigation Procedures

* The NEC is published by the National Fire Protection Association (NFPA), Quincy, MA.

2.5 Ordering Information

The following chart provides ordering information for RFI mitigation devices.

PSB *	Item	Type
3279	SE1 542A	Inductor
6205.1	Z 100	Filter
7971	150	Filter

* Product Standardization Bulletins (PSBs) are published by the GTE Telephone Operations Standardization Management Department.

2.6 Sources of RFI

Most electrical devices generate EM fields as a result of using electrical power. RFI originates mainly from a transmitter but anything that emits a RF signal can cause RFI. Some common RFI sources are:

- Electronic consumer products that contain circuitry that generate RFI, even though the product is not intended to radiate a signal, outside its enclosure are:
  - Radio receivers.
  - Stereo music players.
  - Telephone instruments.
  - TVS.

  NOTE: These products unintentionally demodulate (change into audio frequency) radio signals from other devices and cause the interfering signals that can be heard in telephone instruments, audio amplifiers, and seen or heard in TVs.
- Aircraft navigational equipment.
- Computers.
- Cordless and cellular telephones.
- Defective or dirty power line insulators.
- Ignition systems.
- Light dimmers.
- Radar and radio transmitters.
- Tools and machines with electrical motors.
  - Microwave ovens.
  - Office machines.
  - Power tools.
  - Welders.
  - Heaters.

NOTE: The primary function of a source is to emit EM radiation waves while a cause is whatever makes electronic devices receive and detect the EM waves when they should not.

2.7 Strong RF Fields

An RF transmitter normally radiates a strong RF field that decreases in intensity as the energy travels away from the transmitting antenna.

Any electronic device (including telephone instruments) within three wavelengths of the antenna is in the (so called) near-field. This near-field will most likely overload any unprotected electronic device. Strong RF fields will aiso cause interference to other devices (radios, TVs, etc.) besides interfering with telephone operations.

NOTE: **The wavelength (in meters) is obtained by dividing 300,000 by the frequency (kHz).**

2.8 Typical Frequencies

The following chart displays the type of radio system and frequency bandwidth.

Type of System	Bandwidth
AM	535 kHz - 1705 kHz
Amateur Band	1.8 MHz - 450 MHz
CB	26.965 MHz - 27.408 MHz
FM	88 MHz - 108 MHz
Short wave	1.8 MHz - 450 MHz
TV (channel 2-6)	54 MHz - 88 MHz
TV (channel 7-13)	174 MHz - 216 MHz
TV (channel 14-69)	470 MHz - 806 MHz
Two-Way Radio and Paging	30 MHz - 465 MHz

NOTE: The chart does not include the frequency allocations for other types of services. Amateurs also use frequencies above 450 MHz, but these frequencies do not generally cause interference to telephone equipment.

2.9 GTE's Responsibility

GTE's responsibilities vary depending on the location of the interference.

2.9.1 Network (ATL) Facilities

Responsibilities include:

- Equipment and cables between CO and the protector or NID.
- RFI mitigation up to the NID including any regulated (ATL) wire and equipment.

2.9.2 Deregulated (BTL) Facilities

GTE is responsible for the nonregulated (BTL) wire and equipment when included under one or more of the maintenance plans or contracts offered by GTE. This includes jacks, cords, and any RFI suppression devices on the customer side of the NID (see Section 6.24).

NOTE: GTE is not responsible for telephone instruments or any ancillary device. FCC regulations do not permit modifications to the customer's telephone instruments.

GTE does not guarantee that installation of standard RFI mitigation devices will solve the RFI problem. The sensitivity of some telephone instruments may be too great or the intensity of the RF field may be too high for filters to be effective.

2.10 GTE's Liability

GTE employees must not, under any circumstances, attempt to place blame for RFI problems on the:

- Radio operators (Broadcast, Amateur Band, or CB).
- Electronic equipment manufacturer.
- Telephone instrument manufacturer.

NOTE: GTE employees must not advise customers to register a complaint with the FCC. Customers can do so, however, on their own initiative.

2.11 Customer's Responsibility

Customers are responsible for mitigating RFI problems originating in CPE. Isolation charges are applicable under existing tariffs unless a GTE maintenance plan is in effect.

2.12 Radio Operator's Responsibility

CB and Amateur Band operators have the responsibility to minimize interference by:

- Installing filters in their equipment.
- Changing the antenna orientation.
- Properly installing and grounding the tower/mast, antenna, and other radio equipment.

NOTE: NEC Article 810 Part C has the grounding requirements.

2.13 FCC Regulations

The FCC:

- Has indicated that owners/operators of transmitting equipment should take all needed measures to reduce or eliminate interference from their equipment.
- Does not require radio operators to do anything about interference if the radio station is operating entirely within FCC rules. The burden to fix the problem is placed on the customer.
- Encourages all consumers to make sure that their electronic equipment (radios, TVs, telephones, etc.) can sufficiently reject undesired RF signals.

NOTE: FCC Rule, Part 97.313(a), requires that radio operators use the minimum power to carry out the necessary communications.

2.14 Additional Assistance

The Administrator - T&P can help determine the need for specialized test equipment such as field strength meters, field sensors, spectrum analyzers, or oscilloscopes and/or additional tests to be performed.

2.15 Additional Resources

Additional resources that might assist in resolving interference problems are:

- FCC publications relating to RFI that are available from one of the FCC Regional Offices or Field Operations Bureaus.
- The ARRL list of Radio Operator Groups in different cities. These groups are very helpful with interference problems.

3. RFI and Telephony

3.1 RFI and Telephone Service

RFI rarely affects just one instrument. If the customer has more than one instrument, the chances are that all instruments will have RFI. Common sources of RFI transmission affecting telephone service include:

- Aids to navigation:
  - Radar.
  - FAA transponders.
- Amateur Band.
- Broadcast radio and TV signals.
- CB.
- CATV signals.
- Cordless and cellular telephones.
- Public safety and military broadcasts.

3.2 Nature of RFI

RFI depends on a number of variables, such as:

- Grounding and wiring of:
  - Telephone system.
  - Transmitter equipment (including antenna).
- Location of transmitting antenna in relation to the telephone instrument.
- Mode, frequency, and power of transmitter.
- Type of telephone instrument.

NOTE: Not every RFI problem is the same, nor are the solutions to one problem applicable to another.

3.3 Causes of RFI to Telephone Service

The most common causes of RFI affecting telephone service are:

- Bridge taps.
- Incorrect equipment wiring.
- Loose connections.
- Low impedance splices or connections.
- Poor shielding.
- Rectification of the RF signal by nonlinear discrete devices.
- Split pairs.
- Strong RF fields.
- Telephone hearing aids.
- Unbalanced grounded lines or pairs (cable/service wire).
- Untwisted I/O wire.

NOTE: Properly designed and constructed telecommunication facilities rarely contribute to RFI problems. The increasing use of electronic components in telephone instruments increases their susceptibility to RFI.

3.4 Demodulation

The process to convert an RF signal to RFI requires the following elements:

- Antenna.
- Tuned circuit.
- Detector or rectifier.
- Means to convert electrical signals to audible sounds.

In a typical telephone circuit the elements might be the following:

- Any wires associated with a telephone circuit that can act as an antenna.
- Telephone instrument diodes and transistors that can act as detectors.
- Defective splices, wiring, and wet cable that can act as detectors.
- Telephone handset that can act as the speaker.

NOTE: The detection or demodulation of the RF signal results in undesired audio signals (noise) appearing in the telephone receiver.

3.5 Telephone Components and RFI

Newer models of telephone instruments (tone or pulse types) have several features such as auto dialing, memory dialing, and pulse dialing. These features use semiconductor technology (transistors, diodes, etc.). Most of these electronic circuits are not designed to include interference protection.

The following telephone equipment is susceptible to RFI:

- Telephone instrument components can receive and rectify (demodulate) the RF signal. Telephone instrument speakers can also demodulate the RF signal.
- The I/O wire, handset cord, and line cords can act as an antenna under certain circumstances, especially when the I/O wire is not a twisted-pair type. Use of an improper type of I/O wire (speaker wire, thermostat wire, etc.) also increases susceptibility to RFI.
- Solid state components in ancillary devices like modems, answering machines, and other devices can also demodulate the RF signal that interferes with the normal audio.
- Cordless instruments use two-way radio signals; therefore, they are susceptible to RFI from nearby radio transmitters. Cordless instruments are also capable of causing RFI.
- Telephone instruments with AC power connected (lighted dial, etc.), could have RFI coming in through the AC power wiring. A power line filter might be needed to suppress the RFI.

3.6 Mitigation Devices

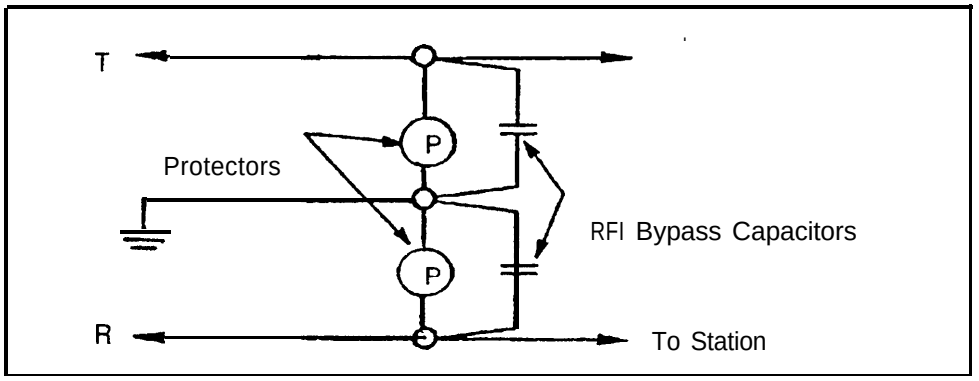
There are no clear cut or simple ways to mitigate RFI. Possible alternatives are presented in this section:

NOTE: The devices listed in this section might not be effective with digital telephone service, such as ISDN.

3.6.1 Capacitors

Capacitors between each conductor (tip and ring) and ground will bypass the radio signals to ground. Capacitors are usually effective for suppressing radio signals below 10 MHz. Typical values are .01 - .03 microfarads.

The following illustration shows typical capacitor installation at the station protector.

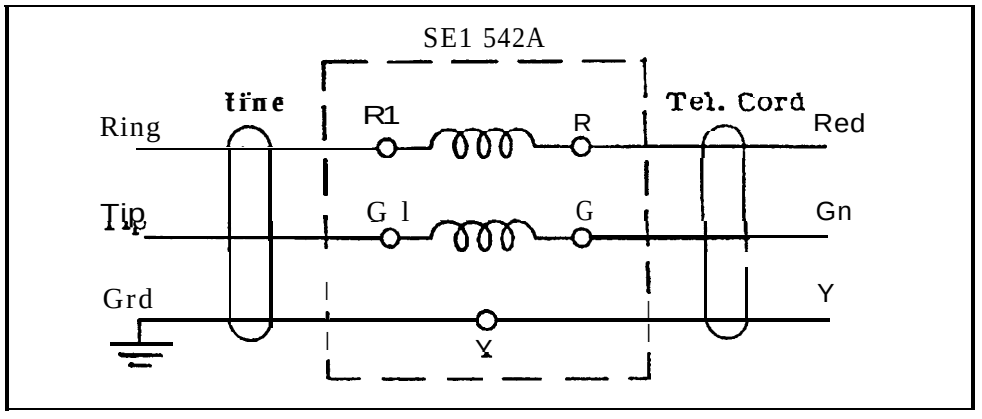


NOTE: Sometimes capacitors might be effective in suppressing Amateur Band and CB signais (up to 27 MHz).

3.6.2 Inductors

Inductors tend to attenuate radio signals picked up by the I/O wire. Inductors are not effective with RF signals above 10 MHz.

The following illustration shows the typical installation of inductors.



3.6 Mitigation Devices, continued

3.6.3 Filters

Filters (combination of capacitors and inductors) on the telephone line:

- Prevent the RF energy from being received.
- Act as a series resonant circuit over a wide frequency band shorting out the RF energy between conductors (tip and ring).
- Are generally available with either modular plugs or spade tips.

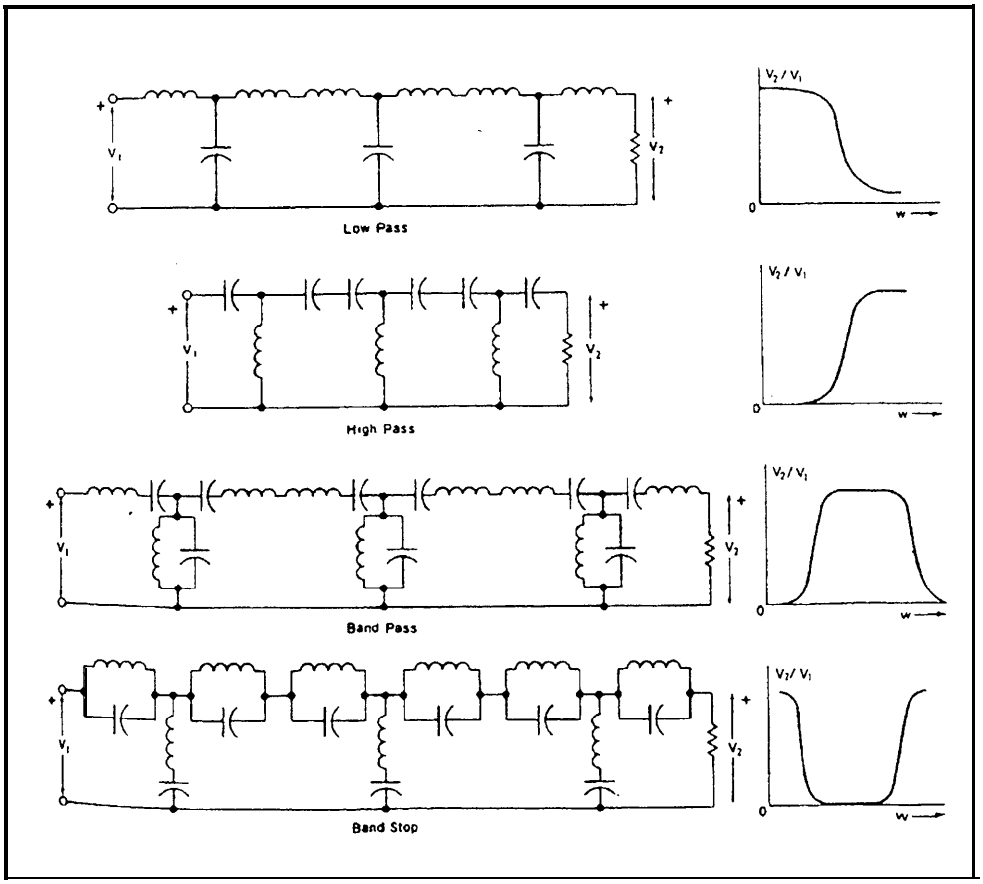
NOTE: The effectiveness of RF filters vary according to the type of telephone instrument used. The cost of a telephone instrument is not indicative of RFI protection.

3.6.4 Types of Filters

The four basic types of filters that can be used in RFI mitigation are:

- Low Pass-Shunts out high frequencies and passes low frequencies and is the most used and most effective in suppressing RFI.
- High Pass-Shunts out low frequencies and passes high frequencies.
- Band Pass-Combines Low Pass and High Pass filters to allow a certain frequency band to pass.
- Band Stop-Shunts out a specific band of frequencies.

The following illustration shows the four basic types of filters.



3.6 Mitigation Devices, continued

3.6.5 Shielding

Shielding of telephone instrument electronic components may be necessary if filter(s) do not suppress RFI.

3.6.6 RFI-Free Instruments

The degree of effectiveness of instruments with RFI filters and shielding built-in depends on the:

- Type of filters.
- Amount of shielding.

NOTE: A **small percentage of the RFI-free instruments are still susceptible to near-field overload conditions.**

4. Preliminary Investigation

4.1 Basic Information

Obtain the following (minimum) information from the customer:

- When does the interference occur (i.e. time of day)?
- Is there a pattern (i.e. does it occur every day, same time, just weekends)?
- Does it effect more than one telephone instrument?
- What devices (radio, TV, etc.), other than the telephone(s), are being affected by RFI?
- Is the interference noise or a voice?
- Is it intelligible?
- Is it the same interference at each occurrence or is it different?
- Is the customer aware of neighbors having similar problems?

NOTES: **During the customer interview, a GTE employee must not make any promises (Section 2.9 and 2.10). The customer should be told that tests are to be conducted and every effort will be make to find a solution.**

During customer contacts a GTE employee must not refer the customer to the FCC.

4.2 Area Survey

After talking to the customer, but before making any tests, make a quick survey of the area/neighborhood near the affected customer. This survey might reveal a transmitting tower or other possible source. Conversations with occupants of nearby facilities might provide an indication of the geographic extent of the problem.

NOTE: Intermittent interference usually indicates an Amateur Band or CB operator in the area.

4.3 Analysis

The area survey and the customer's comments will usually indicate where to look for the RFI sources.

4.3.1 Survey

RFI is typically caused by something within 1,000 feet (305 meters) that is radiating RF energy in the local area. Look for the following:

- Readily available antenna sources:
  - Amateur Band.
  - CB.
- Sources that are not readily apparent:
  - Contact several adjacent neighbors to determine if the RFI problem is widespread.
  - Determine the direction the RFI is coming from.
  - Check if the customer's distribution cable and/or ASW is near a CATV distribution amplifier.

4.3.2 Customer Comments

If the customer's comments indicate intelligible voices, ask what is normally said.The following chart describes the source and some characteristics of interference.

Source	**Characteristics**
AM radio	Music, talk, or commercials.
TV/FM radio	Garbled music, talk, or commercials.
Amateur Band	Voice (language) switches on and off. Station call letters used. Amateur signal sideband signals give distorted audio interference on a telephone.
CB	Voice switches on and off. Station call letters not used.
Cordless phone	Conversation.

Unintelligible voices and or sounds (noise) might require some actual tests. Noise (raspy static, pulsing, tones, ets.) can be caused by:

- CATV leakage.
- Amateur Band.
- Radar.
- Computers.
- Modems.

NOTE: The source of interference is not always detectable with commonly available test equipment.

4.4 RFI Scenarios

The following chart provides information about the most difficult RFI case scenarios.

If the RFI Is...	The Case...
On the customer's side of the NID and the customer does not have a maintenance contract.	Is resolved if the customer: • Agrees to pay the costs of the tests. • Accepts the fact that there are no guarantees of the problem being fixed.
In a CPE telephone instrument and the customer does not have a maintenance contract.	Requires that the customer contact the telephone instrument's manufacturer, retailer, or authorized repair shop. **NOTE: Customer is to be informed that GTE employees are not allowed to work on telephone instruments.**
In a device other than a telephone instrument (modem, answering machine, etc.).	Requires that the customer contact the device's manufacturer, retailer, or authorized repair shop. **NOTE: Customer is to be informed that GTE employees are not allowed to work on non= telephone instruments.**
In a near-field condition. (This type of RFI situation is usually beyond GTE's control .)	Requires the customer be told: • That the RFI is caused by a near-field condition. • What near-field RF energy is. • Why there is no possible solution that GTE can implement. **NOTE: GTE employees might suggest that a possible way to resolve RFI, in this case, is through a meeting with the operator of the RFI source and a mediator.**

5. Determining the Source of 5.1

5.1 Test Equipment

A handset (butt end), modified to include RF suppressors or filters, is useful for determining where RFI detection is taking place. The handset may be modified (hardened) by:

- Connecting a 0.01 μF or a 0.02μF ceramic disk capacitor (rated at 500V minimum) across both the transmitter and the receiver (see Section 6.2.1).
- Using the shortest leads possible (insulating if possibte) to make the connection. The test cords from the handset should not exceed 18 inches (0.45 meters) in length.

NOTE: Obtain capacitors from a focal electronic parts supply store.

Oscilloscopes are helpful in analyzing interference waveforms in difficult interference cases.

5.2 Testing Procedure

Use a systematic approach when analyzing RFI problems. Sufficient information must be obtained to either solve the problem or acquire data that would expedite corrective action. RFI can occur at any of the following locations:

. ASW.

- Inside wire (I/O wire).
- Instrument line cord.
- Handset cord.
- Telephone instrument.

5.3 Documentation

Results of all tests performed should be kept. This information will be helpful to the Administrator - T&P when their assistance is necessary. Test results should be documented in case RFI problems in that area reoccur and for future reference.

5.4 Conducting Tests

Conduct the initial tests at the NID to determine if the problem is in the network or the non-network facilities.

NOTE: Do not make tests on the customer's equipment unless the customer has a maintenance contract or the customer agrees to pay the appropriate charges.

5.4.1 Initial Test at the NID

Disconnect and isolate the customer's equipment at the NID. Using the hardened handset, dial the QT line, and listen for RFI. Use the following chart to isolate RFI after completing Sections 4.1 through 4.3.

If...	Then...
RFI is heard	RFI is in the network. Refer to Sections 5.4.2, 5.4.3, and 5.4.4.
No RFI is heard	RFI is in the customer's wiring and/or equipment. Refer to: • Section 5.4.5 if the customer has a maintenance contract. • Section 5.4.6 if the customer does not have a maintenance contract.

NOTE: Make tests at the usual time the interference occurs. Make arrangements with the radio operator to transmit during isolation tests.

5.4 Conducting Tests, continued

5.4.2 Loop Transmission Tests at the NID

Test for physical trouble on the line with **GTE** Standard Test gear (T136BGM – Noise Measuring Test Set, etc.) by performing the usual loop tests (refer **to** the GTE Noise Reduction Handbook).

NOTE: The customer's loop should meet ail GTE's transmission requirements. if it does not, corrective action will be needed before proceeding further with the RFI investigation.

5.4.3 Sectionalizing OSP Facilities

If RFI is heard, move toward the CO accessing the cable pair one terminal at a time until RFI is no longer heard.

At the section(s) where RFI was heard check for corroded connections, abandoned service wires (drops), loose wiring, bad splices, etc. Correct as necessary.

If the problem is with the ASW relocate it, replace it with shielded ASW or BSW or install a filter at the NID and the serving terminal.

NOTE: Repeat test (see Section 5.4.1) after corrections have been made.

5.4.4 Inspections at the NID

Perform the following inspections prior to proceeding to isolation of CPE:

- Inspect the NID grounding and bonding.

  NOTE: **The NID should be bonded to the AC power service entrance (MGN).**
- Disconnect and/or remove all abandoned or telephone drops.
- Repair all corroded or rusty connections on the outside wiring.
- Inspect and repair all loose wiring or terminations (service wire and I/O wire).
- Disconnect (or ground) any unused I/O wiring still connected to the NID.

  NOTE: Grounding ail unused I/O wire leads at the protector will create a quasi-shield.
- Reroute or bury drop wires that are in close proximity to the radio antenna.
- Replace carbon protectors with either gas tubes or solid state protector modules.

5.4 Conducting Tests, continued

5.4.5 Isolating CPE

Use the following procedures when isolating CPE problems:

- Advise the customer if there is a need to make additional tests from inside the premises (at the telephone instrument, distribution block, etc.).
- Keep the customer posted of your activities but do not state definitely that a cause has been found or that there is a solution to the problem.

NOTE: Check company records for maintenance contract information before proceeding.

- If the customer has a maintenance contract and/or accepts charges for isolation activity, proceed with the following tests (If they do not have a maintenance contract, refer to Section 5.4.6):
  - Inspect/test all jacks for corrosion and high joints. Correct as necessary.
  - Replace long line cords with short line cords (less than 10 feet [3 meters]) to the telephone instrument.
  - Use the modified handset to start the isolation process to determine where the RF signal is being demodulated (changed to audio frequency).
  - Use the handset to listen at each telephone instrument location. Disconnect any telephone instrument where RFI was detected.
  - Test the I/O wire from the telephone instrument to the NID for shorts or grounds. Test with all telephone instruments and other devices disconnected. If RFI is still present (in the I/O wire), place a short at one end of the I/O wire, between tip and ring. Place handset at opposite end and listen for RFI. If present, it is an indication of a near-field overload condition (see Section 2.7).

NOTE: Replacement of the transmitter or receiver capsules often solve RFI problems.

5.4.6 Customers without Maintenance Contracts

If the customer does not have a maintenance contract or does not accept the charges for trouble isolation, explain to the customer:

- What kind of tests he or she can do.
- Which mitigation devices are available.

NOTE: It is recommended that a recent copy of the FCC Field Operations Bureau Bulletin on telephone interference be given to the customer (see Section 2.15).

6. Mitigation

6.1 Explaining the Findings

Once the source has been determined and a solution selected:

- Inform the customer.
- Advise the customer of charges (if any) to implement the solution.

  NOTE: Customer must agree to the charges before the solution is implemented.

- Do not antagonize the customer, especially when the RFI appears to be caused by a neighbor's CB or Amateur Band transmitter.
- inform the customer that the proposed solution might (as opposed to will) solve the RFI problem.
- Advise the customer who to call if the problem reoccurs.

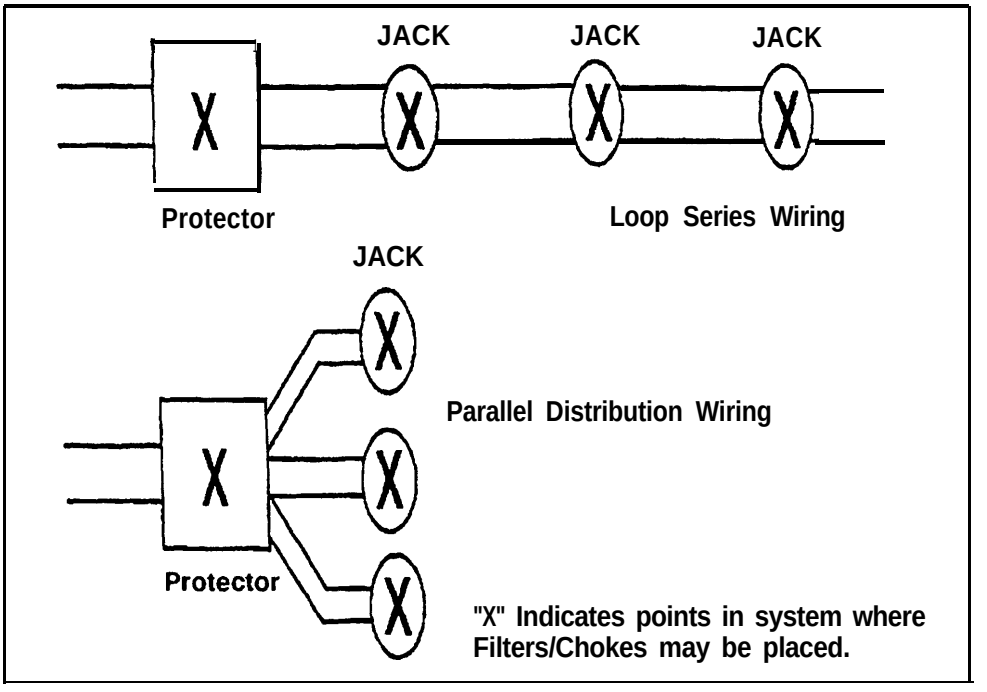
6.2 Installing Filters

If the procedures in Sections 54.2, 54.3, and 5.4.4 do not correct the RFI problem, use the following procedures when installing RFI suppression devices (See Section 2.5 and Exhibit 1 for ordering information):

- Select the appropriate filter based on the frequency of the interfering signal to maximize the suppression effects. The filter should have the same bandwidth as the interfering signal (see Section 2.8).
- Install the suppression device at the first identified point of RFI presence that is pan of the GTE network or that is covered under the provisions of a maintenance contract.
- Install the filters or capacitors at the NID (the best location is the customer side of the protector). Proper installation is critical for the effective performance of all filters and chokes.

NOTE: Some experimentation may be necessary to determine the optimum filter location.

See the following possible filter location illustration.

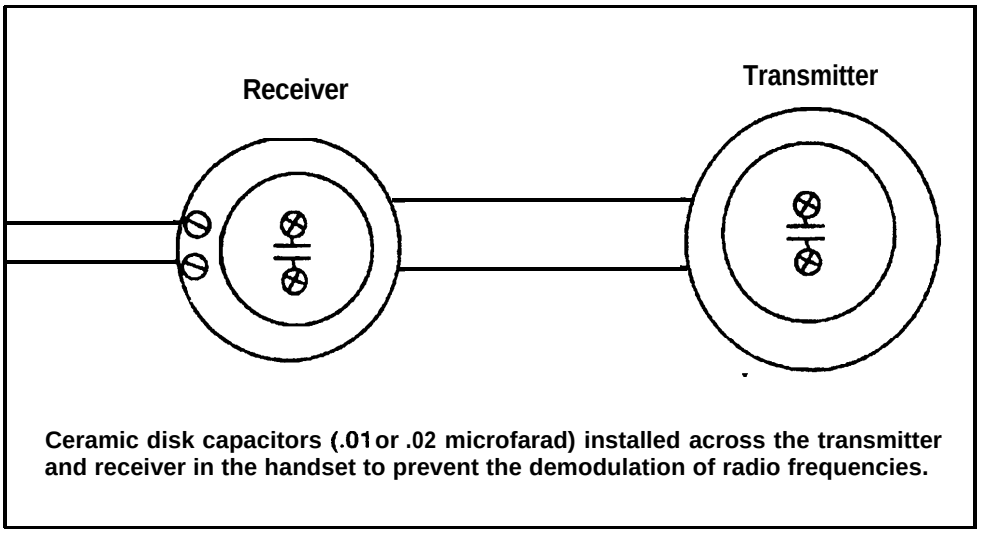


6.2 Installing Filters, continued

6.2.1 Rotary Instruments

RFI in older rotary (dial type) instruments can usually be suppressed by installing a 0.01 µF disc ceramic capacitor (500V minimum) in the handset. Use the shortest possible leads.

See the following rotary (dial type) instrument illustration.



Ceramic disk capacitors (.01 or .02 microfarad) installed across the transmitter and receiver in the handset to prevent the demodulation of radio frequencies.

NOTE: Obtain capacitors from a local electronic parts supply store.

6.2.2 Speakerphones

A ceramic disk capacitor 0.01 µF or 0.02µF (500V minimum) across the speaker leads will short out most of the RF energy, preventing it from being demodulated and interfering with normal audio.

NOTE: Obtain capacitors from a local electronic parts supply store.

6.2.3 Cordless Instruments

Before installing RF filters to cordless instruments (base unit), verify that the interference is not caused by a neighbor's cordless instrument operating at the same frequency.

6.2 Installing Filters, continued

6.2.4 Telephone Instruments

The following chart discusses telephone instrument regulatory constraints.

If instrument is...	Then...
CPE	Refer customer to dealer or manufacturer's service representative.
Leased from GTE	Replace instrument with a similar one.

NOTE: Telephone instruments may only be internally modified by the manufacturer or an FCC-registered telephone refurbisher.

Modifications might void FCC registration of the instrument.

6.3 Requesting Assistance

Call the Administrator - T&P for technical assistance if the procedures outlined in this section fail to solve the problem.

PSB	Model	Bandwidth	Application
6205.1	ATTZ1 OOB	500 kHz to 100 MHz	AM, FM, CB, Amateur
3279	1542-A	540 kHz to 1.6 MHz	AM
7971	150	Up to 150 MHz	AM, FM,, CB, Amateur

MC	Model	Bandwidth	Application
304030	Coil 12-12C	500 kHz to 2MHz	AM, Amateur
304031	Coil 12-14C	500 kHz to 2MHz	AM, Amateur

Exhibit 1 RFI Filter/Frequency Matrix