



## **INT Application Note**

**INDUCTION NEUTRALIZING TRANSFORMER (INT)**

**DIGITAL INDUCTION NEUTRALIZING  
TRANSFORMER (DINT)**

# Introduction

These instructions are intended for telephone and power company personnel who plan to conduct tests to determine the need for an SNC Induction Neutralizing Transformer (INT) or Digital Induction Neutralizing Transformer (DINT). The instructions explain the symptoms that may indicate the need for an INT, what those symptoms mean in terms of the problem that needs to be remedied, and how to determine the proper location for a permanent INT. All testing and installation procedures are explained in detail. SNC recommends that you read the entire set of instructions before you begin field testing.

## A Message on Safety

SNC Manufacturing Co. is concerned about your safety. Read these instructions carefully. Pay strict attention to all DANGER, WARNING and CAUTION statements. When you see these statements, take heed - your personal safety, the safety of your co-workers, and the safety of your equipment may be at risk.

**DANGER:** Possibility of personal injury.

**CAUTION:** Possibility of service interruption.

**WARNING:** Possibility of equipment damage.



This safety alert symbol is used throughout these instructions to alert you to hazardous situations. When you see this symbol pay strict attention to all safety instructions that follow!

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## 1. SYMPTOMS

- False rings or signals.
- Noisy PBX trunks.
- Equipment stops working or shows electrical damage with no apparent cause.
- Impulse noise causing errors on data circuits.
- Equipment not performing correctly.
- Noisy subscriber lines.
- Wrong numbers when dialing.
- Facility is "HOT" to the touch.
- Noisy inter-office trunk circuits.
- Protectors or fuses operate more often than normal.
- Non-digital carrier circuits are noisy or analog carrier system doesn't function properly.

## 2. PROBLEMS TREATED

- Excessive steady-state interfering AC induced voltages or currents on the central office (CO) terminal equipment, PBX or key equipment, data modems, analog inter-office or subscriber line carrier systems that may be causing equipment malfunctions or damages or be creating an electrical safety hazard.
- Excessive induced AC voltages or currents caused by switching surges on nearby power lines or lightning. These voltages or currents may also cause equipment malfunctions, equipment damage, or create electrical safety hazards.
- Excessive power influence (harmonic induced AC voltages or currents) levels that may cause circuit noise.)

## 3. TEST PROCEDURES (FINDING THE SOURCE OF THE PROBLEM)

3.01 If you are experiencing any of the above symptoms tests should be performed on the serving facility.

**Note:** These tests assume there is only one source of interference. If there is more than one source additional testing may be necessary. Contact SNC if assistance is needed.

### A. Measuring Power Influence and Circuit Noise

(a) Temporarily remove the problem circuit(s) from service and disconnect all the equipment from the pair at each end.

(b) Use a Voltohmmeter (VOM) test the pair to make sure it is clear of any shorts or grounds. Any leakage to ground or across the pair should be greater than 10 megohms. (The amount of leakage on a good cable pair depends on the length of the cable. Leakage on a short cable pair should be much higher than 10 megohms.) A good leakage to ground reading may be difficult to obtain when there is high induced voltage on the pair. If there is high induced voltage on the pair, but the leakage across the pair is good, the leakage to ground is usually acceptable.

(c) Short the pair at both ends and connect the far end to a good ground. The far end is usually the subscriber or remote terminal end of a pair, while the CO is the near end. A good ground has low impedance to earth, such as a multigrounded neutral (MGN) or Central Office frame ground.

(d) Using a high impedance AC voltmeter (one with greater than 100 K ohm impedance) measure and record the AC voltage to ground of the shorted pair at the near end. This is measurement #1 (See Figure 1).

(e) Connect the shorted pair to a good ground at the near end. Remove the short and ground connection at the far end. At the far end, measure and record the AC voltage to ground (See Figure 2). Both wires of the pair should measure the same voltage to ground. If they do not, look for physical trouble on the pair.

(f) If either measurement #1 or #2 is more than 20-25 volts, the problems is most likely caused by 50/60 Hz (fundamental frequency) interference. An SNC INT will probably be required.

(g) With the near end shorted and grounded, gain access to the pair at several locations along the route. Measure and record the voltage to

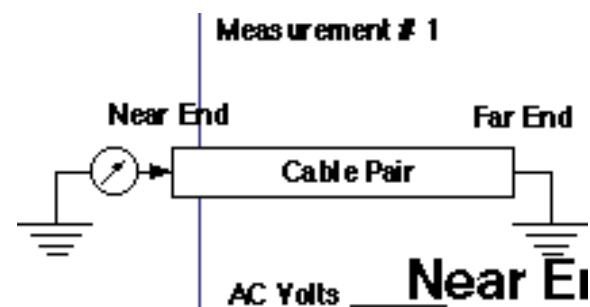


Figure 1: Measurement #1

ground (either wire) at these locations and determine the electrical center of exposure. These are measurements 2a, 2b, 2c, etc. (See Figure 2). The electrical center is the point where the voltage to ground is equal to one half (1/2) the voltage to

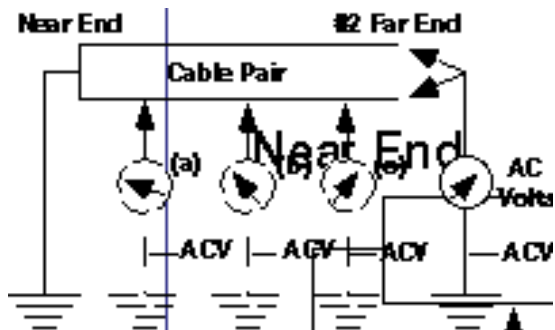


Figure 2: Measurements #2, 2a, 2b, 2c, etc.

ground at the far end (measurement #2).

(h) It may be desirable to open the pair near its mid-point and measure and record the AC voltage to ground in each direction. This should be done with both the near and far ends grounded. These are measurements #3 and #4 (See Figure 3). Measure and record the AC voltage across this open, tip (T) to tip (T) or ring (R) to ring (R). This will be measurement #5 (See Figure 3).

**Note:** The two wires of a facility are referred to as the tip (T) and ring (R). Some parts of the world refer to these as “a” and “b.”

(i) Measurements #3 and #4 should equal measurement #5. Measurements #5 and #2 should also be nearly equal. If either of these

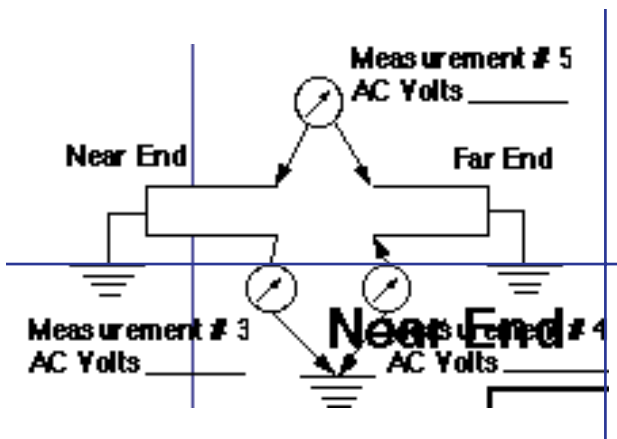


Figure 3: Measurements #3, 4 and 5

equations is not true there is probably more than one power line exposure involved.

(j) If either Measurement #1 or #2 is greater than 45-50 volts, it may be necessary to place two or more INTs in tandem along the route to keep the voltage to ground at any one point to a safe working voltage value. 50 volts of 60 Hz AC is commonly accepted as a maximum safe working voltage value in the United States telephone industry, although there is evidence this may be reduced to 30 volts. In many countries with 50 Hz power systems a figure of 60 volts of AC is considered an unsafe value.

(k) If both measurements #1 and #2 (far end) are less than 20 volts, the problem is most likely noise caused by power line harmonic interference. This is true for most circuits, but certainly not all of them. Using the pair selected for measurements #2 with the “near end” shorted and grounded but with the far

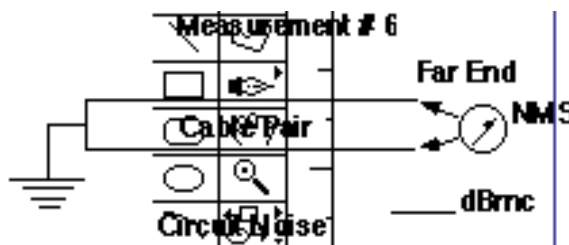


Figure 4: Measurement #6

end open, measure the circuit noise (CN) and the power influence (PI) at the far end. These are measurements #6 and #7 (See Figures 4 and 5).

(l) These measurements can be made with a telephone type noise measuring set (NMS) such as a Western Electric #3C or Wilcom T136B NMS. PI readings greater than 80 dBmrc and CN readings greater than 20 dBmrc are usually too high. The difference between these two readings provides a dB figure indicating the degree of balance of the facility.

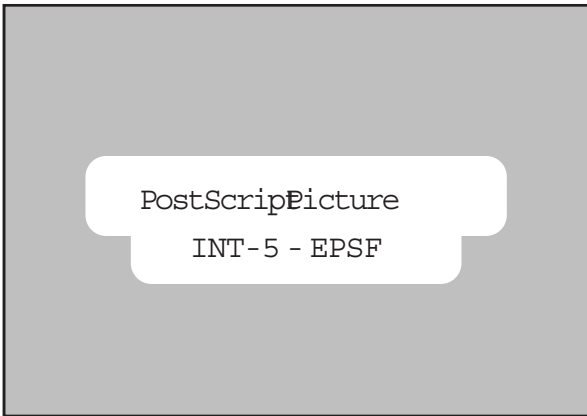
$$(PI - CN = \text{Balance})$$

(m) A balance of 60 dB or greater should be expected from a well maintained cable pair. Generally, if the PI is greater than 80 dBmrc, it may be necessary to place an INT to reduce the PI, which will in turn reduce the CN in most cases, when the INT is installed in the optimum location.

## B. INT Location

3.02 As discussed in Section 5 – Installation

Procedures – finding the best location for an INT to solve a noise problem is not an exact science. The recommended approach is as follows:



**Figure 5: Measurement #7, 7a, 7b, 7c, etc.**

- (a) Using the pair selected for measurement #7, with the near end short and grounded, gain access to the pair at several locations along the route.
- (b) Open the pair and measure and record the PI of the pair toward the near end. These would be measurements 7a, 7b, 7c, etc. (See Figure 5). Look for the location with a PI of 80 dBnc (or slightly less). This location may be at least one place for an INT installation to solve a noisy power line interference problem. In some cases of high PI it may be best to leave the exciting pair open.

**Note:** The PI and CN of the pair, as measured above, may meet the 80 and 20 dBnc figures, but not meet the overall noise requirement of the circuit when the terminal equipment is connected on each end of the facility. This could happen if the terminal equipment at either end does not have 60 dB or better balance. An INT may be required to reduce the interfering influence being applied to this equipment and to improve the equipment's apparent balance.

**C. Measuring AC Current Flow**

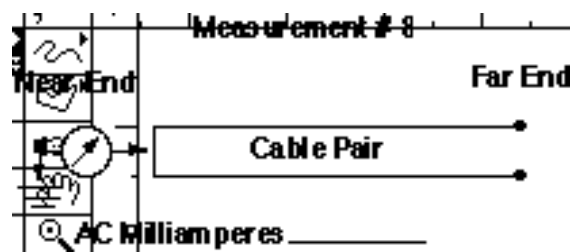
**3.03** Another way to test for power line induction problems is to measure the longitudinal AC current flow on an exposed pair. The recommended procedure is as follows.

- (a) Select a “clean” pair (See 3.01, steps a, b and c). Short the pair at the near end. The far end can be open, shorted, or might even be a subscriber's station. The important thing is that it **MUST NOT** be grounded.

**Note:** A grounded pair, or one with excessive leakage, will distort the test results because a portion of the total induced current will flow to ground before it is measured.

- (b) Using an AC milliammeter, measure and record the current flow between the shorted pair at the near end and a GOOD ground. This is measurement #8 (See Figure 6). A reading of more than 5 milliamperes indicates possible inductive interference problems and a need for an SNC INT.
- (c) An AC voltmeter and a 100 ohm, 2 watt resistor can be used instead of an AC milliammeter to make the above measurement. Substitute the 100 ohm resistor for the milliammeter and measure the AC voltage drop across the resistor. This will be measurement # 8a (See Figure 7). In this case, the AC voltage reading divided by 100 equals the AC current flow to ground (Ohm's law). Any reading of more than 0.5 volts means more than 5 milliamperes. As with measurement #8 possible inductive interference problems may exist and an INT may be required.

**Note:** If the facility is to be used for PBX, inter-office trunks or any special type circuit with a low impedance path-to-ground at the far end, measurements #8 and #8a should be made with the far end short and grounded as in measurement #1. With this test condition an AC current reading of more than 10 milliamperes indicates possible inductive interference problems and a need for an SNC INT.



**Figure 6: Measurement #8**

- (d) A chart recorder could be used in making all the above measurements. This would help most in detecting surges or temporary induced voltage conditions that can happen at times when not watching a regular meter.

**D. Conclusion**

**3.04** Remember, when analyzing the results of these tests, that power line loads and their

affect on exposed facilities can vary widely. These affects can vary with the time of day, week, and even the time of year. You may want to adjust your measured readings upward to allow for these

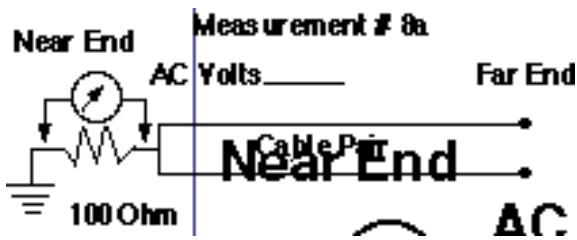


Figure 7: Measurement #8a

possible changes. If the route you are testing parallels a high voltage transmission line you should seriously consider performing an inductive coordination study, using maximum fault current values that can be obtained from the power company.

#### 4. SOLUTION PRINCIPLES

4.01 An SNC INT is made out of multipair, telephone-type cable core, wound around a laminated steel core. It is arranged for the connected pairs to go in and out of the transformer on a metallic basis. For example, tip wire in, through the winding of the transformer and tip wire out, thus providing DC continuity (See Figure 8).

4.02 An INT placed in a cable facility and provided with an "exciting pair" (primary winding) for exciting current flow, will by transformer action produce an opposing or "180° out of phase" AC voltage that will be induced into the remaining pairs (secondary windings). This one-to-one turns ratio transformer action can cancel or "neutralize" more than 95% of the induced AC voltage that would normally appear at the end of the facility.

4.03 The remaining voltage is known as the "remnant voltage" (See Figure 9). It is a function of the exciting current multiplied by the total longitudinal impedance of the exciting current path. Therefore, the remnant voltages can to some extent be reduced by paralleling exciting pairs. This low value remnant voltage should permit the circuits to perform as designed. It should reduce terminal equipment failures and damage, and reduce electrical safety hazards and power influence levels. This reduced power influence may result in a circuit noise reduction, depending on the location of the INT in the serving facility.

#### 5. INSTALLATION PROCEDURES

5.01 An INT is connected in series with a cable much the same way as a load coil with the pairs running in and out. It doesn't matter which way they go ("in" may be toward the CO and "out" toward the field or vice versa). It IS important that all pairs go through the transformer in the same direction. Failure to do so will greatly reduce the effectiveness of the INT and may even cause the INT to fail completely.

5.02 Individual SNC INTs are available in standard, off-the-shelf sizes ranging from 2 to 100 pairs. Custom design combinations are available for treating up to 600 pairs. Special designs have been provided for installation up to 3600 pairs. Standard open unit INTs are equipped with 24 inch long tails for in and out wiring, and are terminated in 3M, MS<sup>2</sup> or AT&T #710 splice modules. Custom open units are available with solderless wire-wrapped type terminals or punch-on type blocks. Steel, weather-proof enclosures are available, as are fiberglass enclosures on special request. Also available are 2 to 100 pair INTs in sealed, jelly-filled, polyvinyl enclosures equipped with 10 foot long jelly-filled cable stubs. These units

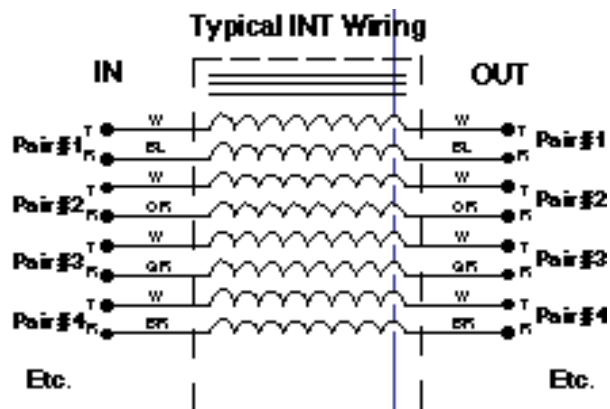


Figure 8: Typical INT Wiring

are intended for direct bury applications.

5.03 Direct bury units arranged for air pressure are also available. Units with steel enclosures can be provided with two or three element (350-500 V) gas tube protectors.

5.04 An INT may be located anywhere in a facility. An accessory package is available for relay rack mounting of INTs that will be located in a Central Office. Basic units are designed so they can be mounted on a wall or backboard. For example, one could be mounted on the wall near the interconnect block of a PBX or Key System and

cross connected into the incoming pairs. SNC's Telecommunications Line Conditioner (TLC) is an INT specially packaged for this application. Figure 9 shows typical examples of induced voltage profiles for a facility with a uniform power line exposure and a near end (Central Office), electrical midpoint and a far end (Subscriber – end user) located INT.

### A. When Treating 50/60 Hz Problems

**5.05** Normally, the best location for an INT for solving 50/60 Hz problems is at the electrical mid-point of the exposed section. The result will be that the voltage-to-ground on the pairs will be nearly equal on each side of the INT, with this voltage value being about one-half the overall unneutralized voltage. The electrical mid-point is determined by measurements #2 (Figure 2). When the overall 50/60 Hz voltage is reduced by a mid-point located INT, the harmonics (noise-to-ground or power influence) of 50/60 Hz that produce the audible circuit noise are usually reduced. This location reduces power influence at the subscriber while also assuring minimum voltage-to-ground at any point on the cable.

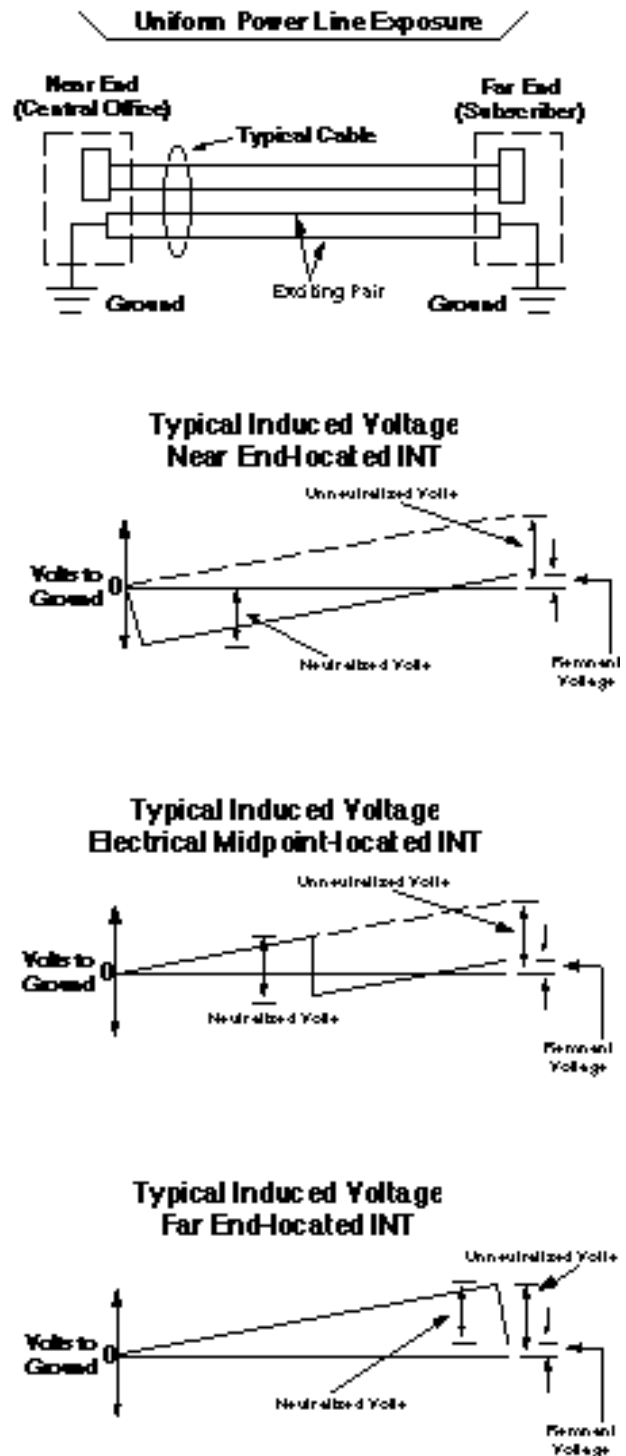
**Note:** The electrical mid-point might not always result in the most effective reduction in circuit noise. If the power influence had already acted on a circuit unbalance before the INT was able to reduce it, the noise would just pass through the INT and not be reduced. INTs do not directly suppress metallic or transverse mode voltages – they only neutralize the longitudinal induced AC voltages or currents.

**5.06** There may be times when the voltage-to-ground ( $V_g$ ) (measurements #1 and #2) or the AC current (measurement #8) will be well below the minimum problem values, but the circuits are still very noisy. This usually indicates that the power line influence is not a direct result of the 50/60 Hz fundamental frequency, but is caused by one or more of its harmonics. Other voice frequency influences or non-50/60 Hz harmonics will produce the same symptoms, but are not as common as 50/60 Hz problems.

**5.07** A noise measuring set that can measure selected frequencies (such as the Wilcom 132B or Wilcom 132EZ Spectrum Analyzers), will pinpoint the exact interfering frequencies. The INT can reduce these “other” harmonic frequencies, but it DOES require sufficient exciting current at that frequency for neutralization to occur.

### B. When Treating Noise Problems

**5.08** Solving a noise problem with an INT depends not only on the location of the INT and/or its



**Figure 9: Example of Neutralized Voltage**

exciting pair grounds, but also on the location of any unbalance irregularities or the location of harmonic influence. There are several rules that can be applied to INT use in solving noise problems.

- (a) If a circuit unbalance is in the connected terminal equipment, either CO or station located, the INT should be located between the facility and the unbalanced equipment.

(b) If a capacitive unbalance is generally lumped within the facility (such as water in the cable), locate the INT so that the neutralized  $V_g$  or PI is at its minimum at the unbalanced location. This can be done by carefully selecting the remote exciting pair ground location at a point slightly beyond the unbalance in the facility. (A minimum voltage acting on a capacitive unbalance results in a minimal transfer of the interfering energy to the facility, and therefore minimizes the noise.)

(c) If the overall facility balance is greater than 60 dB and the PI is greater than 80 dBrc, locating the INT near the 80 dBrc PI point on the facility will generally provide the maximum power influence reduction. However, this assumes that there is only one power line exposure and that the exciting pair grounds are at the end of the exposure. Placing the exciting pair grounds at each end of the power line exposure will minimize the resistance in the exciting current path, resulting in maximum exciting current and maximum performance from the INT.

### C. Multiple Power Line Exposure

**5.09** Multiple power line exposures may further complicate noise mitigation problems. The suggestions listed in paragraph 5.08 (a, b and c) may not resolve a multiple power line exposure problem. It may be necessary to treat each power line exposure section as a separate problem. This will require more than one INT to obtain maximum voltage and noise reduction. Use of the built-in INT in the SNC HumZapper Test Set, or other portable INT, may be necessary to find the best location.

**5.10** Keeping the overall  $V_g$  or PI low is one reason that more than one INT may be needed for best results. The tandem INT installation is a practical method for reducing or eliminating equipment malfunctions, electrical safety hazards and reducing noise. While providing overall cable and equipment electrical protection, the INTs will also instantaneously suppress surge induced voltages up to their rated steady-state capabilities. For example, three 50 pair INTs in a 15 mile exposed cable will suppress up to 3 x 600 volts rms, or 1800 volts rms. Peak voltage would be  $1800 \times 1.414 = 2545$  volts. See Figure 10 for a tandem or multiple INT installation.

### D. INT Excitation

**5.11** Normally only one pair is needed to adequately “excite” or “turn-on” an INT. It

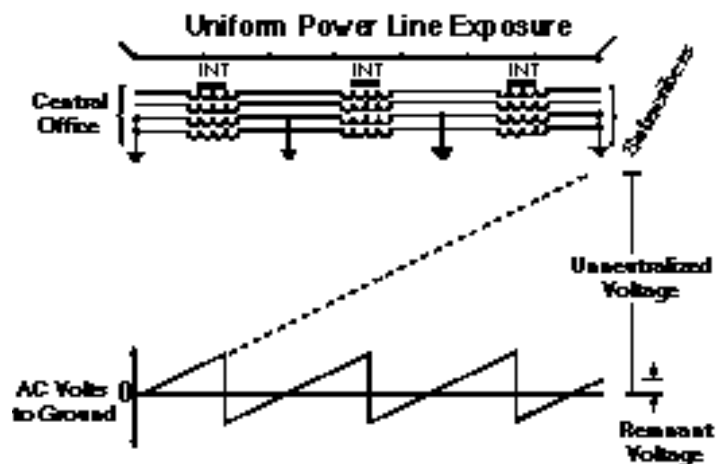


Figure 10: Tandem INT Installation

can be any pair through the transformer. It should be shorted and connected to a good ground at each end of the exposure. For convenience in single INT installations one end is usually grounded to the CO protector frame ground, while the remote end is connected to an MGN ground or other good ground at the end of the cable exposure. It is important that these two grounds are the only grounds on the exciting pair and that there are no other grounds close to a field mounted INT on any of the other pairs that run through the unit. The tip and ring conductors of the dedicated exciting pair should be shorted together at the INT terminals so that exciting current flows through the INT.

**5.12** If there is no spare pair available to excite the transformer, an SNC Transformer Exciting Network (TEN) can be placed on working circuits to provide the exciting current path. A ten can be placed anywhere a hard wire exciting pair ground would normally be placed. However, the TEN may also be placed on the CO side of the INT to help reduce the amount of cable pair resistance (thus increasing the amount of exciting current) and prevent the resulting current flow on that pair from possibly “noising-up” the other non-exposed cable pairs.

**5.13** The TEN is designed to have a low longitudinal impedance path-to-ground at 50/60 Hz and a high impedance to the metallic (T to R) path. The result is that the TEN has minimal bridging loss to a metallic working circuit but provides the needed exciting current path-to-ground for the INT. TEN is most effective at 50/60 Hz because it is tuned to those frequencies.

**5.14** SNC also manufactures a Super TEN. It is a combination of a TEN and a Harmonic Drainage Reactor (HDR). The HDR is another SNC drainage reactor product. It is designed to respond to a broad band of voice frequencies, including the harmonics of 50/60 Hz. As a result, the Super TEN responds to voice frequency harmonics in addition to 50/60 Hz. It may be substituted for the TEN at any location to take advantage of its superior noise reducing performance.

**5.15** The Super TEN is also built into SNC's Telecom Line Conditioner (TLC) to take advantage of this greater noise reduction performance.



**CAUTION: When considering an INT site for telephone utility purposes, avoid placing it close to an electric power substation or high voltage power transmission line tower line footing. This will help avoid possible ground potential rise conditions that might cause unwanted operation of any protector at the INT or exceed the INT's dielectric strength. Also avoid installation near metal flag poles or radio and TV towers because**

**of their susceptibility to lightning strikes.**

**5.16** Depending on the telephone utility's policy, INTs installed in the outside plant facility may require the use of additional spark gap devices such as gas tube protectors. The break-down value of these arresters is usually 350-500 volts and was selected to minimize their operation and allow the INT to fully neutralize voltages up to its design capability. After the INT has neutralized the high surge induced voltages and begins to saturate, the induced voltages will then operate the protectors at the INT and dissipate the energy at that point in the circuit instead of having station, central office or repeater protectors operate.

## 6. ADDITIONAL INFORMATION

### A. INTs and Load Coils

**6.01** Incidental grounds on any "neutralized" pair, other than the exciting pair end grounds, may reduce the effectiveness of a field mounted INT depending on the location of the grounds.



**CAUTION: If an INT is placed at a load point, make certain the load coil windings are not in parallel with any winding of the INT. This has the same**

**Table 1: Electrical Characteristics – Regular INTs**

Number of Pairs	2	6	12	25	50	75	100
Model Number	P13652	P09374	P09375	P08620	P08621	P15907	P10849
Loop Resistance <sup>(A)</sup>	20	50	44	40	50	42	48
Typical Insertion Loss (dB) 1KHz	0.2	0.3	0.3	0.3	0.3	0.3	0.3
112 KHz	1.0	1.6	1.5	1.4	1.8	1.2	1.2
192 KHz	1.3	2.0	1.9	1.8	2.3	1.5	1.4
772 KHz	2.9	3.5	3.3	3.5	4.0	2.9	2.9
1544 KHz	4.0	5.2	4.9	5.2	5.8	4.3	4.1
2370 KHz	4.8	6.7	6.3	6.6	7.5	5.2	5.1
3152 KHz	6.0	7.5	7.0	7.4	8.4	6.1	5.9
Exciting Current <sup>(B)</sup>							
20 Volts	5	5	5	7	10	12	15
40 Volts	8	7	7	10	15	21	25
120 Volts	19	12	15	21	35	46	52
200 Volts	27	20	25	30	45	66	76
350 Volts	—	—	65	65	65	115	143
500 Volts	—	—	—	—	140	—	—
Maximum Voltage <sup>(C)</sup>	303	320	370	385	600	444	455

<sup>(A)</sup>(max. DC - Ohms) • <sup>(B)</sup>(mA required to neutralize 60 Hz voltage across INT — excludes effect of longitudinal ground return DC which increases required AC exciting current) • <sup>(C)</sup>(steady state 60 Hz rms across INT)

**effect as strapping T & R “IN” to T & R “OUT” and essentially shorts out the INT.**

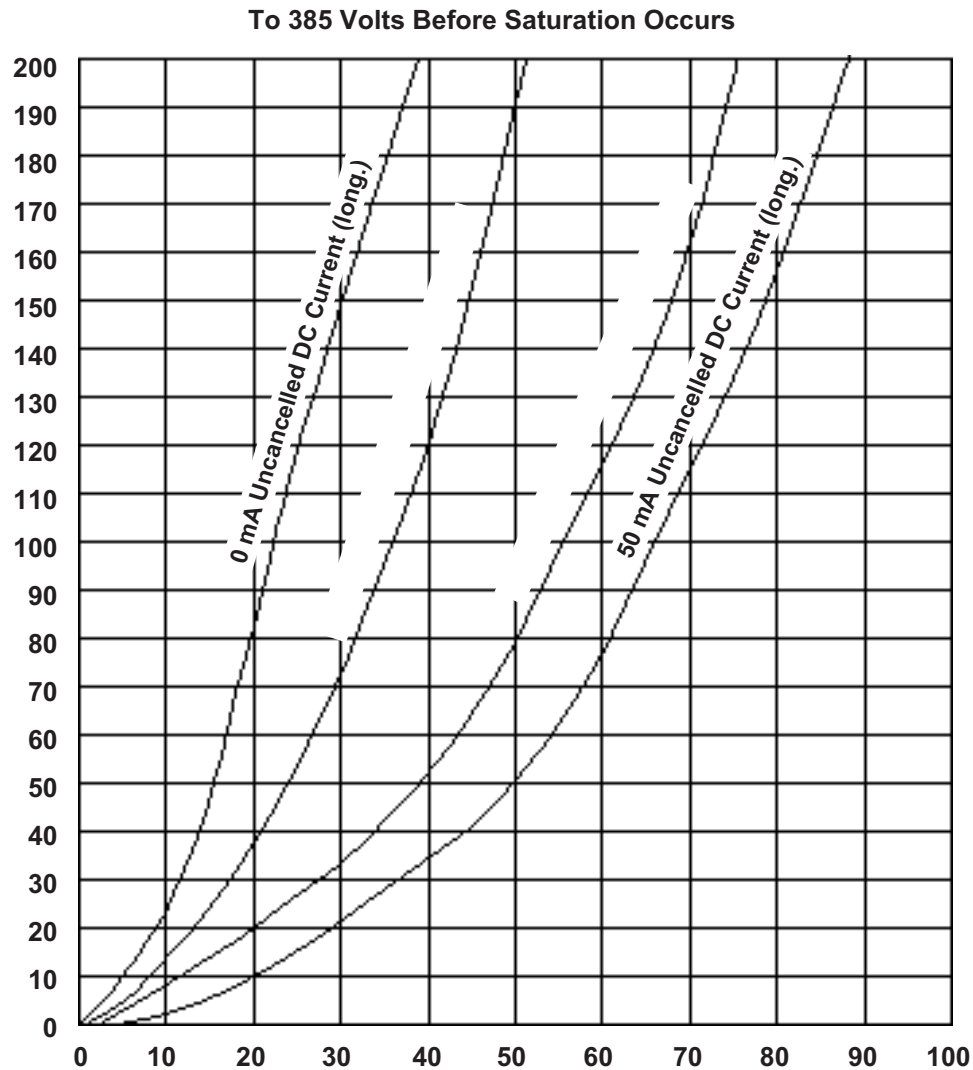
**6.02** An INT contains approximately 500 feet of unshielded and unjacketed 26 gauge cable. (The two pair INT contains about 500 feet of 24 gauge four conductor wire.

**6.03** When placed in a “loaded” cable facility, an INT will change the effective load coil spacing. Normally this does not create a serious return loss impairment, particularly if it is located beyond the third load point. If the INT is located at the CO or within the first three (3) load points, and amplification devices are required, circuit stability could be affected. However, most solid state gain units are capable of compensating for this minor irregularity.

**B. Analog Carrier Systems**

**6.04** Analog carrier systems normally work well through an INT. An INT connected into a cable does add resistance and insertion loss to the facility. The electrical characteristics for each unit are shown in Table 1. These characteristics should be considered in the transmission design of a new carrier system. On existing carrier systems, the transmission design should be evaluated to determine if the system can tolerate the additional insertion loss of the INT. It may be necessary to relocate a repeater or carrier terminal to accommodate this additional INT insertion loss.

**6.05** The longitudinal balance of an SNC INT is greater than 66 dB, as measured on a Wilcom T-207 Longitudinal Balance Test Set. Longitudinal inductances range from 6.25 to 25 Henries when measured at 60 Hz, depending on the INT.



**Figure 11: 60 Hz Exciting Current (mA) Required to Neutralize Voltage**



**CAUTION:** Caution should be used when three (3) element gas tube protectors are used on INTs that are placed in two wire analog carrier systems. Many two wire analog carrier systems power their repeaters and/or remote terminals with positive and negative DC voltages applied to the T and R wires of the facility. Most gas tube protectors have a DC holdover voltage of about 180 volts. A carrier system power scheme that uses + and - 130 volts DC, or even a combination - 48, + 130 VDC across the T and R could provide enough DC voltage to keep the gas tube protectors in a “glow mode” condition

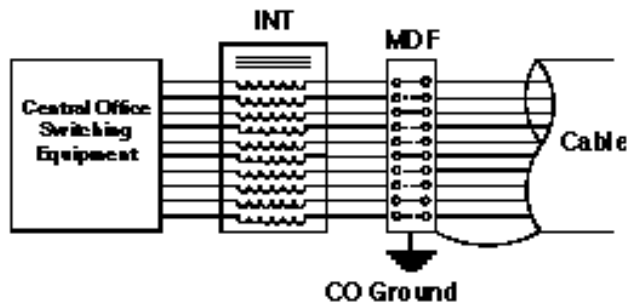


Figure 12: CO Located INT in Subscriber's Loop Cable with 'self excitation'

once they have fired. This “glow mode” can cause the protectors to overheat and become a fire hazard or possibly even burn open a pair in the INT. It would likely also cause noise on all other circuits through the INT. It is recommended that only two (2) element gas tube protectors be used where two wire analog carrier systems are DC powered across the T and R of the facility. SNC does have a retrofit unit available that provides 2 element gas tube protectors that will fit the 3 element gas tube protector mounting. Order Accessory Package AP115.

6.06 In the outside cable plant, splices are a vulnerable component subject to surge voltage breakdown. The INT has no splices, except at its points of connection to the outside plant. As a result, INTs have good conductor-to-conductor insulation ratings. The choice of using shunt surge arrester protection at the INT is a matter of operating company policy. Actually, because of its high mutual impedance, the INT limits lightning-induced impulse voltages effectively when the exciting pair and secondary pairs are coupled into

the zone of lightning induced surges.



**CAUTION:** If DC passes through one winding of an INT in one polarity without an equal amount of DC current passing through another winding of the same transformer with the opposite polarity, the INT's ability to neutralize

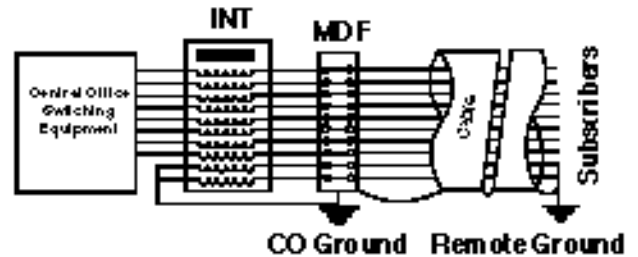


Figure 13: CO Located INT in Subscriber's Loop Cable with Dedicated Exciting Pair

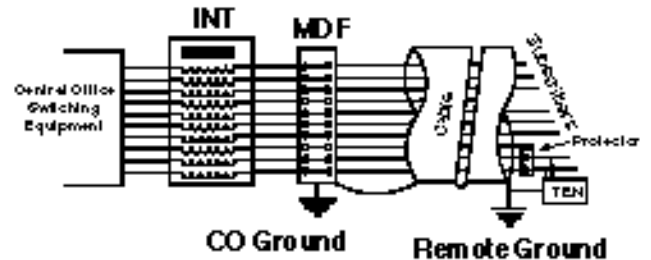


Figure 14: CO Located INT in Subscriber's Loop Cable with SNC TEN Providing Exciting Current Path at Remote End

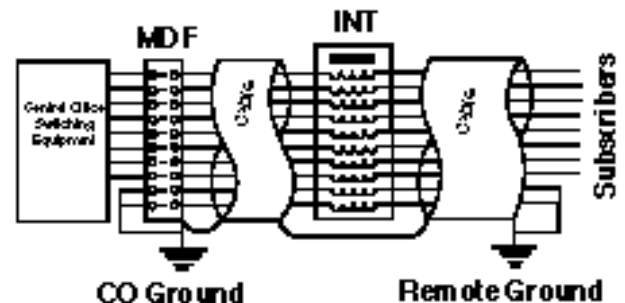


Figure 15: Non-terminal Located INT in Subscriber's Distribution Cable with Dedicated Exciting Pair

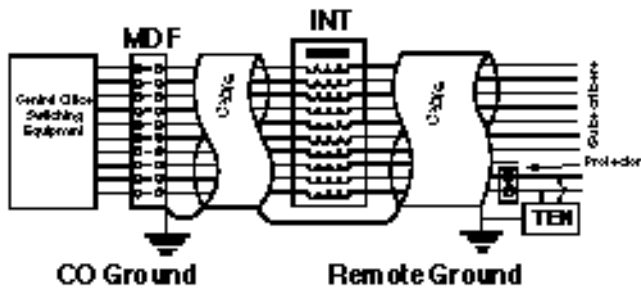


Figure 16: Non-terminal Located INT in Subscriber's Distribution Cable with SNC TEN Providing Exciting Current Path

the longitudinal AC interference will be reduced. Longitudinal DC current flowing through an INT in only one direction tends to saturate the transformer core, which makes it less efficient. For example, with no "one direction only DC" or "DC ground return current," a 25 pair SNC INT needs only about 20 mA of AC exciting current to neutralize 80 Vrms of longitudinal influence. If there were 40 mA of uncancelled DC ground return current flowing, this same transformer would require about 52 mA of AC exciting current to neutralize that same 80 volts. See Figure 11.

6.07 Although digital carrier signals will pass through a standard INT, the attenuation and crosstalk coupling at the high frequencies of digital carrier systems often make their use impractical. A digital INT, which is specially designed for lower loss and minimum crosstalk coupling, should be used on facilities carrying digital carrier systems.

#### TYPICAL APPLICATIONS

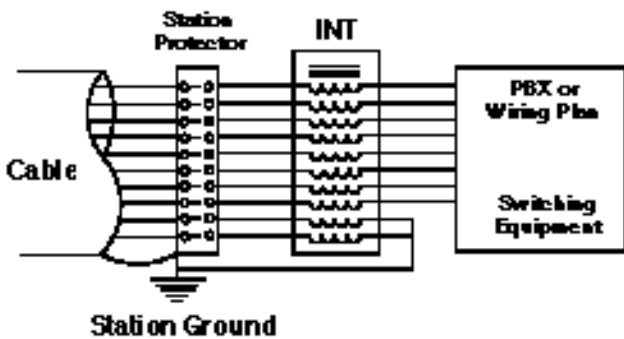


Figure 17: Station-located INT at a PBX or Wiring Plan Location with Dedicated Exciting Pair

#### A. Subscriber Loops

7.01 INTs can be located in the Central Office to reduce noise that is caused by longitudinal power line influence acting on unbalances in the Central Office equipment. They can be relay rack mounted and cross connected into the circuits between the main distributing frame and the offending equipment. This arrangement can also be the most desirable location to protect Central Office equipment that is sensitive to damage or malfunction from longitudinal induced surge voltages or currents.

7.02 Figures 12, 13 and 14 show three different ways of "exciting" CO located INTs. CO

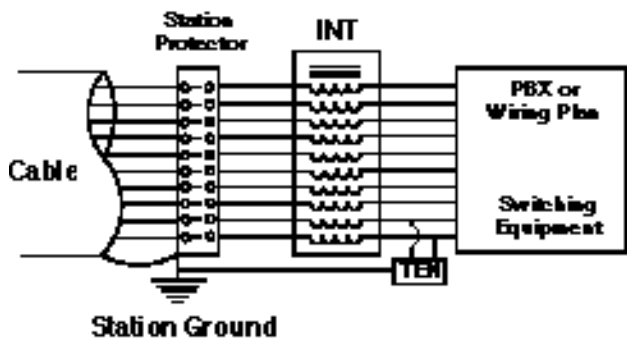


Figure 18: Station-located INT at a PBX or Wiring Plan Location with SNC TEN Providing Exciting Current Path

located INTs often self-excite – as a result, a dedicated exciting pair may not be required. See Figure 12.

7.03 Figure 13 shows a CO located INT with a dedicated exciting pair connected to remote ground. Figure 14 shows a CO located INT with a Transformer Exciting Network (TEN) connected to a working subscriber's line providing the remote path-to-ground.

**Note:** The most consistent performance of an INT is obtained when using the arrangements shown in Figures 13 and 14.

#### B. PBX or Wiring Plan Trunks

7.04 To reduce noise caused by longitudinal power line influence acting on unbalances in PBX or wiring plan equipment, INTs can be located at the equipment location. It should be connected between the primary station protectors and the

switching equipment. This arrangement also reduces the possibility of equipment malfunction or damage due to steady-state or transient power line influence. Figure 17 shows a dedicated pair being used to provide the exciting current path-to-ground. Figure 18 shows the arrangement if utilizing a TEN on one of the working circuits to provide the longitudinal exciting current path-to-ground.

### C. Inter-office and EAS Trunks

**7.05** To reduce noise, operational malfunctions or equipment damage on inter-office or EAS trunks, it is usually best to place INTs at each end of the facility. These facilities are usually rather long

and are often exposed to more than one power line influence. The circuits working in this type facility often have some type of ground at their terminals. Therefore, if an INT, as shown in Figure 12, is placed at each end, they will usually "self-excite."

**7.06** If there is significant exposure to more than one power line influence or more consistent performance of the INT is desired, it may be best to use a dedicated pair for the exciting current path-to-ground, as shown in Figure 13. The remote exciting pair ground, in this case, should be located at a point half way between the major power line influence.

**7.07** If the exposure is not too great, a single "electrical mid-point" located INT like that shown in Figure 15 may be all that is required. It

## Digital Induction Neutralizing Transformer (DINT)

### 8. SYMPTOMS

- Unexplained carrier failure alarms.
- Excessive bi-polar violations/bit error rates.
- Unexplained component failure/damages.
- Excessive pulse slip or reframing.
- Unexplained or excessive automatic switching to back-up or alternate carrier systems.
- Excessive protector or fuse operations.
- Unexplained total carrier-system failures.

### 9. PROBLEMS TREATED

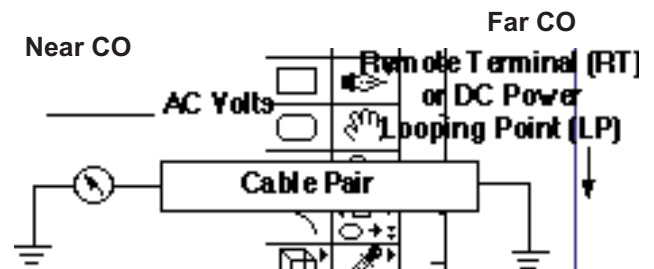
Sensitivity of digital carrier system (T, SLC 96, ITT 324S, etc.) to:

- Steady-state 50/60 Hz longitudinally induced power line currents or voltages on the carrier's DC power feed path, which affects the power regulators of the system.
- Longitudinally induced transient 50/60 Hz currents or voltages resulting from power line faults or surges that can cause component failures or damages.
- Damage and malfunctions during lightning storms.

### 10. TEST PROCEDURES (FINDING THE SOURCE OF THE PROBLEM)

**10.01** Power line loads and their inductive influence can vary with the time of day, week, or season. This should be considered when tests are made to evaluate a carrier system's facility. The

use of a chart recorder should also be considered for these tests. If the facility parallels high voltage transmission lines, an inductive coordination study, utilizing maximum fault current values obtained from the power company, should also be considered.



**Figure 19: Measurement #1**

**10.02** When carrier equipment steady-state longitudinal interference tolerances are not available, the following tests can help evaluate the performance of the carrier line facility in the presence of longitudinally induced interference.

**Note:** These tests assume there is only one source of interference. If there is more than one source additional testing may be necessary. Contact SNC if assistance is needed.

**10.03** If you are experiencing any of the above symptoms, the following tests should be performed on the serving facility.

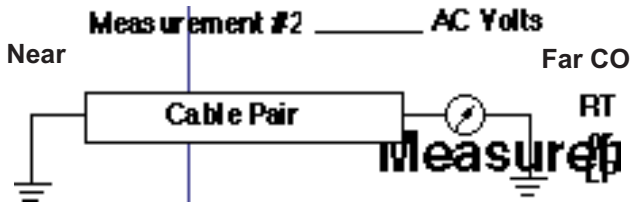


Figure 20: Measurement #2

**A. Measuring AC Volts**

(a) Find a pair on the existing or proposed carrier route. This pair should extend from the near central office (CO) to the carrier DC power looping point (LP), to the remote terminal or to the far end CO if powering end to end. (The near CO is usually the higher class office if involved with inter-office trunk cable facilities.) The pair should be cleared of all equipment and be tested to make sure it is clear of any shorts and grounds. The insulation resistance to ground or across the pair should be greater than 10 megohms.

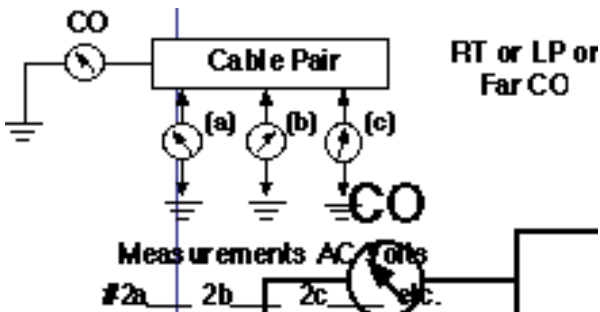


Figure 21: Measurements 2a, 2b, 2c, etc.

**Note:** The amount of insulation resistance on a good cable pair depends on the cable length. A short cable pair insulation resistance should be much higher than 10 megohms.

(b) It may be hard to get a good insulation resistance-to-ground reading when there is high induced voltage on a pair. If this happens, but the insulation resistance across the pair is good, the insulation resistance-to-ground will usually be acceptable. Any type pair, loaded or non-loaded, may be used for this test.

(c) Short the pair at each end and connect it to a good ground at the far end. (DC power looping point, RT or far CO.) A good ground is one

with a low impedance-to-ground, such as a multigrounded neutral ground or CO frame ground.

(d) Using a high impedance AC voltmeter, measure and record the AC voltage-to-ground on the shorted pair at the near CO. This is measurement #1. See Figure 19.

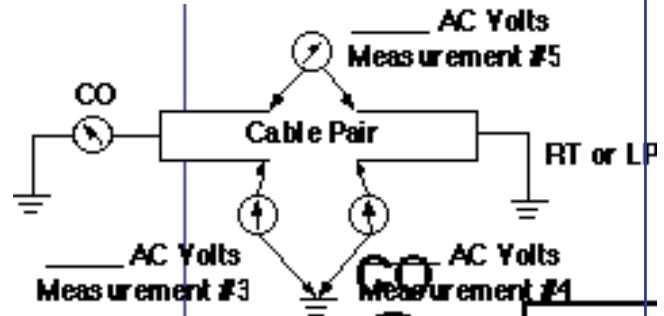


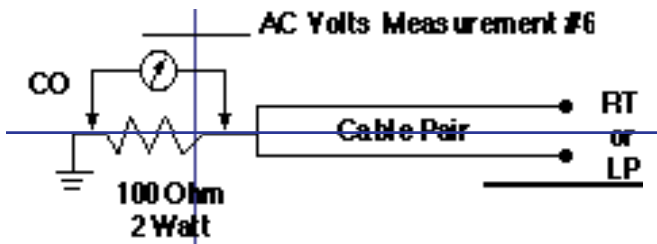
Figure 22: Measurements #3, 4 and 5

(e) Connect the shorted pair to a good ground at the near end and remove the ground connection at the far end. Measure and record the AC voltage-to-ground of the pair at the far end. This is measurement #2. See Figure 20.

(f) With the near end still shorted and grounded, gain access to the pair at several locations along the route. Measure and record the voltage-to-ground (either wire) at these locations. These will be measurements #2a, 2b, 2c etc. From these measurements, determine the electrical center of exposure. This is the point where the voltage-to-ground is equal to one-half (1/2) the voltage-to-ground at the far end. See Figure 21.

(g) It may be desirable to open the pair at the midpoint. With a short and ground at both the near and far ends, measure and record the voltage-to-ground in each direction. These will be measurements 3 and 4. Next, measure and record the AC voltage across this open. This will be measurement #5. See Figure 22.

**10.04** Measurements #3 and 4, when added together should approximately equal measurement #5. Measurements #5 and 2 (far end) will also be nearly equal. If these equations do not add up it is likely that more than one power line exposure is involved. If the differences are substantial each section of power line exposure may have to be considered a separate problem and treated individually.



**Figure 23: Measurement #6**

### Evaluation of Steady-state Test Measurements

- If measurements #1 and 2 or #5 are greater than about 40 volts, power line interference problems could definitely be experienced on a digital carrier line.
- If the value of measurements #3 or 4 is more than 25 to 30 AC volts, the facility could be a candidate for power line interference problems.

### B. Alternate Test Procedure

**10.05** Another method of testing for potential steady-state power line interference problems on the DC powering pairs of a carrier system is to measure the induced longitudinal AC current flow. This is measurement #6 (Figure 23).

- Measure the AC voltage drop across a 100 Ohm resistor connected between a shorted carrier pair and frame ground at the CO.

**Note:** The far end of the carrier pair should be open while measuring so the facility is equivalent to a working carrier system with looped DC power or a remote terminal.

- AC voltage readings above 2 volts (indicative of 20 mA of longitudinal AC current flowing) can indicate potential power line interference problems.

**Note:** All of the above measurements could have been performed by using a chart recorder to analyze a surge or transient induced voltage problem over a period of time.

## 11. SOLUTION PRINCIPLES

**11.01** Digital Induction Neutralizing Transformers (DINTs) are multipair neutralizing transformers specially designed for use with digital carrier systems. They have two separate groups of pairs, one for each direction of transmission. The

pairs are wound on the same core, but are separated by an electrostatic shield to minimize crosstalk coupling.

**11.02** One or more Digital INTs placed on the digital carrier system's pairs and provided with an exciting pair will cause an opposing, or 180° "out of phase" AC voltage to be induced into the DC power feed path. This can reduce or "neutralize" up to 95% of the induced AC voltage or current on these pairs. The reduction of this power line interference will allow the current and/or voltage regulators of the carrier system regenerators to operate within their design parameters and also reduce component failure and damage.

## 12. INSTALLATION NOTES

**12.01** Digital INTs are installed into a cable facility in series with the cable pairs, in much the same way as a carrier repeater. Digital INTs are available for treating 1, 6, 12, 25 and 50 carrier systems. Additional pairs are provided in the INTs for fault locating and order wire circuits.

**12.02** All standard Digital INTs are equipped with 24 inch long cable tails. These tails are terminated in 25 pair splice modules with separate modules for Side 1 in, Side 1 out, Side 2 in and Side 2 out.

**12.03** The maintenance pairs of the 25 and 50 system Digital INTs do not conform to the standard 25 pair group concept of splice modules. They are, therefore, left unterminated for individual connection as required.

**12.04** All standard Digital INTs are available in metallic weather-proof enclosures. These enclosures are either 24 x 24 x 12, or 36 x 30 x 12 inches. They are designed to provide mounting for the appropriately sized INT.

**12.05** Digital INTs in enclosures are also available with 3 element gas tube protector mountings. This allows modular connecting of the INT to the serving cable. Also offered are 2 electrode gas tube protector models, equipped with binding post terminals.

**12.06** When cutting a Digital INT into a cable facility it is important to keep the two directions of carrier transmission in the separate groups of the Digital INT, but they must be within the same transformer to prevent saturation from the DC

power loop.

**12.07** The most common location (but not the only available choice) for a Digital INT is at the electrical mid-point of the exposed section. The electrical mid-point is found with the measurement #2a, 2b, 2c etc. that was equal to one half of the value of measurement #2 (See Paragraph 10.03, steps e and f). Location is pinpointed further by placing it midway between two repeaters. These two choices help achieve a similar goal:

(a) One divides the interfering induced voltage equally on either side of the transformer, thereby keeping this voltage at any one point to a minimum.

(b) The other divides the carrier signal levels from adjacent repeaters in half. This minimizes the signal level differences at the transformer, which in turn reduces possible crosstalk coupling. This is done even though the Digital INT is designed to limit this coupling with an electrostatic shield between the windings of the transformer that are used for each direction of transmission.

**12.08** Normally only one pair is needed to adequately excite a Digital INT. It can be any pair in either group. This pair should be shorted and grounded to a low impedance ground at each end of the exposure. For convenience in single Digital INT installations one end is usually grounded to the Central Office frame with the other end being connected to a multigrounded neutral (MGN) ground at an RT location or near the DC power looping point of the carrier system. It is important that these two grounds be the only grounds on the exciting pair. If there is no spare pair available for use to excite the transformer, one or more Transformer Exciting Networks (TEN) may be used

to provide the exciting current path on one of the working circuits.



**DANGER:** Avoid placing Digital INTs close to electric power substations or high voltage power transmission line tower footings. It is also best to avoid metal flag poles or radio/TV towers.

### 13. ADDITIONAL INFORMATION

#### A. Gas Tube Protectors

**13.01** Incidental grounds on any “neutralized” pair, other than the exciting pair end grounds, may reduce the effectiveness of the Digital INT depending upon the location of the grounds.



**CAUTION:** Many two wire carrier systems power their repeaters and/or remote terminals with positive and negative DC voltages applied to the two wires of the pair. Most gas tube protectors have a DC holdover voltage of about 180 volts. A carrier system powering scheme that uses + and - 130 volts DC, or even a combination - 48, + 130 VDC across the pair could provide enough DC voltage to keep the protectors in a “glow mode” condition once they had been fired. This glow mode can cause them to overheat and become a fire hazard or possibly even burn open a pair in the INT. It would likely also cause noise on all other circuits through the INT. SNC recommends that only 2 element gas tube protectors be used where two wire carrier systems are DC powered across the two wires of the pair.

**13.02** If 2 element gas tube protection is desired, SNC has an optional accessory package of two, 2 element gas tube protector units combined so they will fit in the 3 element holder. This is known as an AP115 and allows a mixture of 2 and 3 element gas tube protectors within the same INT and/or enclosure.



**CAUTION:** DC current passing through one winding of a Digital INT in one polarity without an equal amount of DC current passing through another winding of the same transformer with the opposite polarity, will reduce the transformer's ability to neutralize the longitudinal AC interference. Longitudinal “uncancelled” DC current flowing through any digital INT in one direction only tends to

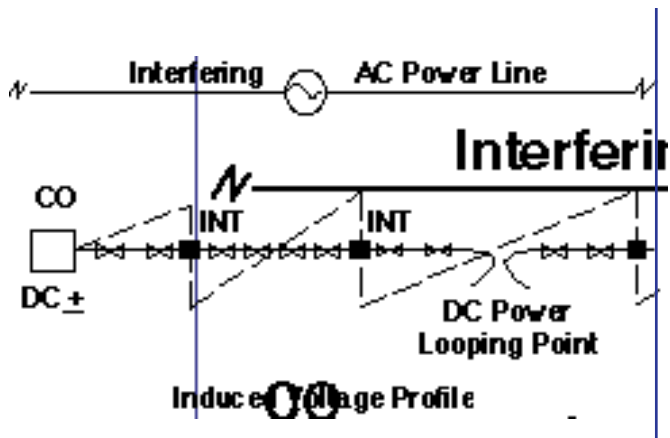


Figure 24: Tandem Digital INT Installation

**saturate the transformer core, making it less efficient.**

**13.03** Severe power line interference on a digital carrier route may require several Digital INTs in tandem (Figure 24). This is usually done to keep the maximum voltage-to-ground within safe working values over the entire length of the cable route.



**CAUTION: If a Digital INT is placed at a load point make sure there are no load coil windings in parallel with any winding of the INT.**



**CAUTION: Any attempt to bypass the Digital INT by strapping T&R “in” to T&R “out” on any or more pairs will short out the transformer and make it ineffective.**

**13.04** Digital INTs work equally well on metallic voice frequency circuits. These circuits may be intermixed with the high frequency pairs of the carrier system.

**13.05** A Digital INT connected into a cable adds resistance and transmission loss to a facility. These values must be considered in the design of the carrier system.

**13.06** The fault locating, order wire, etc. pairs of a Digital INT are divided equally on either side

of the electrostatic shield within the transformer. This should be considered in the assignment of these circuits within the serving cable.

**B. How Carrier Repeaters are Damaged During a Power Fault**

**13.07** Induced voltage from a faulted power line will often damage series circuit components of repeaters in a carrier span line, even though the line is equipped with protectors from line to ground. Because the voltage-to-ground is often too low to operate the protectors, damage occurs to the repeater resistors, thyristors or power supply zeners as longitudinal current flows through the repeater.

**13.08** For example, on a carrier route with paralleling power for two or three miles the protectors at each end of the exposure will operate during a power fault. This causes a momentary low longitudinal impedance at each end while reducing the voltage-to-ground at the middle repeater to a level that is insufficient to fire its protectors. Damaging surge current flows through the circuitry of this repeater because the voltage-to-ground is not high enough to operate the repeater’s protectors.

**13.09** A properly placed Digital Induction Neutralizing Transformer (DINT) reduces the magnitude of surge current, saving repeaters and office fuses and keeping the system operational. By

**Table 2: Electrical Characteristics – Digital INTs**

Part Number	P12160	P12864	P12865	P11507	P12055
<b>Pairs</b>	4	14	28	54	104
<b>Type</b>	PCM	PCM	PCM	PCM	PCM
<b>Loop Resistance (A)</b>	14	14	14	17	16
<b>Insertion Loss (dB)</b>					
1 KHz	0.1	0.1	0.1	0.1	0.1
112 KHz	0.3	0.7	0.7	0.5	0.5
192 KHz	0.6	1.0	1.0	0.7	0.7
772 KHz	2.8	2.2	2.2	1.6	1.6
1544 KHz	4.7	2.9	3.0	2.0	2.2
2370 KHz	4.0	3.5	3.6	2.6	2.6
3152 KHz	3.5	4.3	4.5	3.2	3.3
<b>Exciting Current (B)</b>					
20 Volts	28	10	15	10	20
40 Volts	48	20	30	20	40
120 Volts	109	45	65	50	80
200 Volts	171	65	90	70	117
350 Volts	—	200	—	110	180
500 Volts	—	—	—	200	500
<b>Max. Voltage (C)</b>	333	365	340	515	515

(A)(max. DC - Ohms) • (B)(mA required to neutralize 60 Hz voltage across INT — excludes effect of longitudinal ground return DC which increases required AC exciting current) • (C)(steady state 60 Hz rms across INT)

lowering induced AC voltages the neutralizing transformer also raises or lowers carrier powering voltages and reduces bit errors and system shutdown.

### C. Treating Digital Carrier System Sensitivity

**13.10** The use of Digital Induction Neutralizing Transformers (DINTs) on digital span lines is not a new technology. Normally, DINTs are used to treat steady-state 50/60 Hz longitudinally induced power line currents or voltages on the carrier's DC power feed path, or as a protection device from power surges and lightning storms.

**13.11** DINTs are intended for placement on digital span line pairs that serve remote electronic devices such as Digital Line Concentrators, Remote Switches, or Subscriber Carrier Systems. They can also be used effectively on interoffice digital span lines to clear up problems like excessive repeater loss, blown fuses, and temporary service interruption caused by switching back and forth between the main span line and the spare span line during lightning storms and power surges.

**13.12** If the span line being treated has fewer than nine repeaters, one DINT will usually do the job. When the route has more than nine repeaters, 2 DINTs are recommended. A span line with excessive A.C. induced voltage on the pairs, or exposure to harsh electrical conditions such as switching capacitor banks, power substation, etc., may require additional DINTs.

**13.13** Proper placement of DINTs is critical to their performance. The first DINT should be placed midway between the 2nd and 3rd repeater from the Central Office. The second DINT, if needed, should be placed midway between the 2nd and 3rd repeater from the DLC location. DINTs should never be placed at DLC or repeater locations. A good rule of thumb is to maintain a minimum distance of 200 feet between DINTs and DLC or repeater locations.

### 14. SPLICING INFORMATION

**14.01** All standard SNC INTs are equipped with 25 pair cable splice modules arranged with standard blue, orange, green, etc. color coded cable pair counts on all modules.

#### A. Regular INTs – 6, 12, 25, 50 and 100 Pair

**14.02** The 6, 12 and 25 pair INTs have two splice modules, one labeled "in" and one labeled "out." The 50 and 100 pair units have 4 and 8 splice

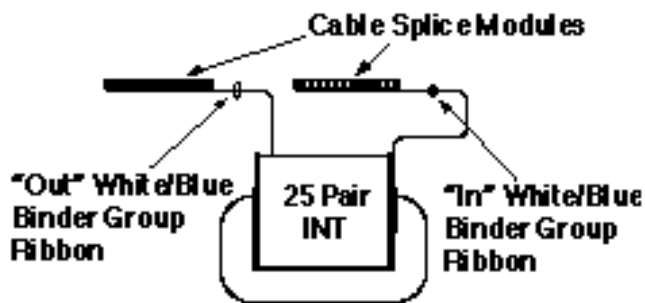


Figure 25: Regular INT

modules respectively.

**14.03** The "in" modules are labeled and have standard white/blue, white/orange etc. binder group ribbons on the cable tails. The "out" modules are also labeled and have the same colored binder group ribbons as the "in" cable tail.

#### B. Digital INTs – 6, 12, 25 and 50 Systems

**14.04** The 6, 12 and 25 system Digital INTs each have four splice modules, a Side #1 "in" and "out" and a Side #2 "in" and "out." The Side #1 and Side #2 is not designated, but a "Side" can be determined by observing that the "in" and "out" cable tails both come from the same side of the electrostatic shield that divides the INT in half.

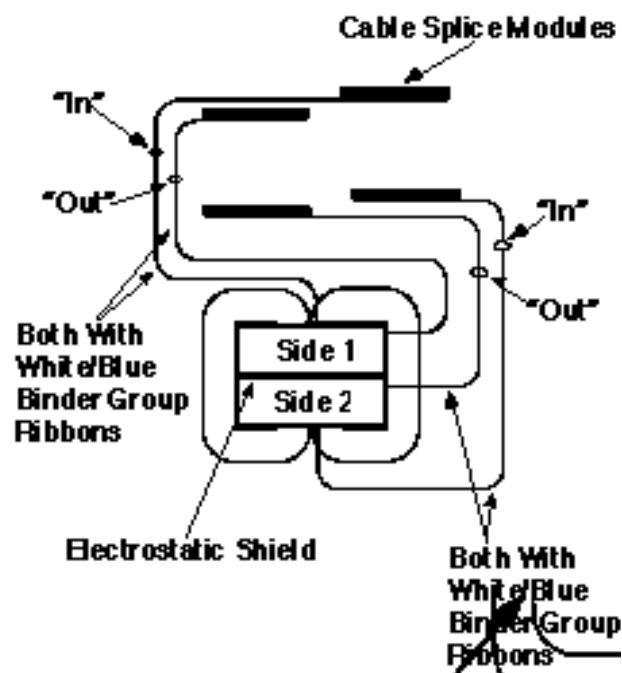
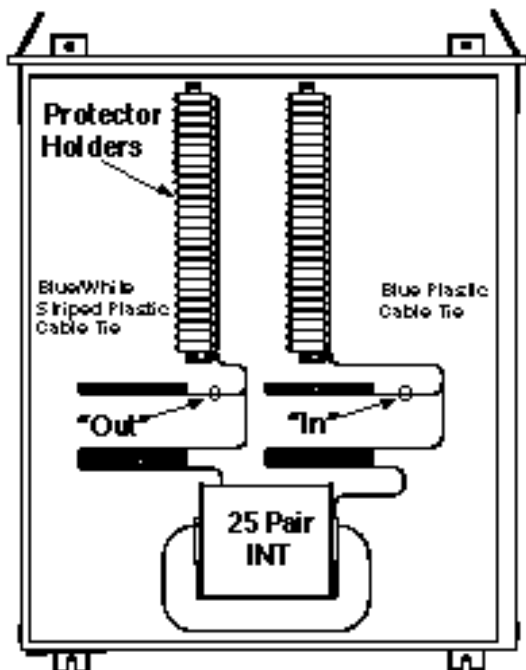


Figure 26: Digital INT

Either "Side" can be designated as Side #1 or Side #2, but the "in" and "out" assignments of both Sides must be in the same direction within the serving cable if the INT is to function properly.

**14.05** The 50 system Digital INT has eight splice modules. There are two Side #1 "in" and two Side #2 "out." modules. Each Side #1 module has a standard white/blue or white/orange binder group ribbon on its cable tail, both "in" and "out." There are two Side #2 "in" and two Side #2 "out" splice modules. Each Side #2 module has the same colored binder group ribbons as on Side #1 and should not be confused or intermixed with those of Side #1. As with the other Digital INTs, either side

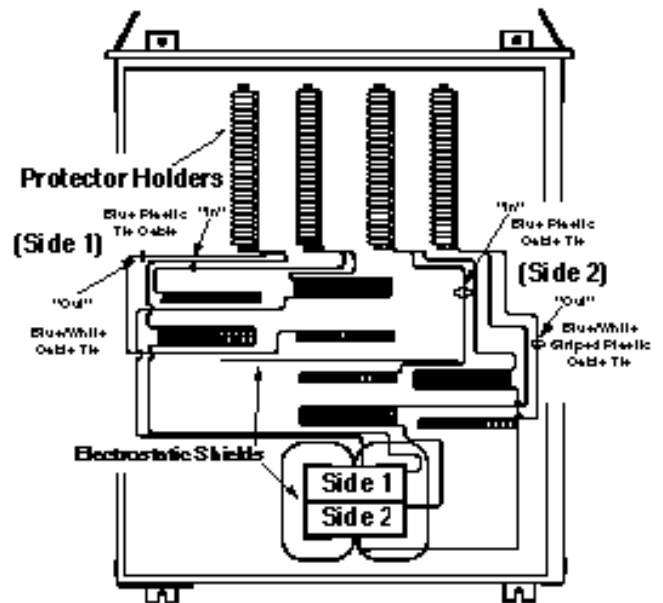


**Figure 27: Protected Regular INT**

can be designated as Side#1 or Side#2, but the "in" and "out" assignments of each Side must be in the same direction within the serving cable for the INT to function properly.

**14.06** The maintenance pairs of the 25 and 50 system Digital INTs do not conform to the standard 25 pair group concept of splice modules. As a result they are left unterminated for individual connection as needed.

### C. Protected INTs



**Figure 28: Protected Digital INT**

**14.07** All standard INTs in enclosures that are equipped for gas tube protection are arranged to connect into the serving cable using 25 pair cable splice modules.

### D. Protected Regular INTs

– 6, 12, 25, 50 and 100 Pair

**14.08** The "in" and "out" pairs of the INTs are designated by colored plastic cable ties placed around the cable tails that connect the splice module to the protector mounting. The "in" pairs have solid colored blue, orange, green or brown ties on the 1st, 2nd etc, cable binder groups. The matching "out" pairs have striped blue/white, orange/white, etc. cable ties on their cable tails. This plastic cable tie arrangement is carried out on all protected INTs.

### E. Protected Digital INTs

– 6, 12, 25 and 50 Systems

**14.09** Protected Digital INTs have a Side #1 and a Side #2. Each Side has an identical set of plastic cable ties designating its "in" and "out." To keep the Sides separate, the splice modules of each Side are placed in one of two plastic wire ducts. These ducts are physically and electrically separated by a metallic electrostatic shield. As with unprotected INTs, either side can be designated as Side #1 or Side #2. However, the "in" and "out" designation refers to a physical direction of the serving cable, NOT the direction of digital transmission, and must be maintained if the INT is to perform correctly.

# INT Connections

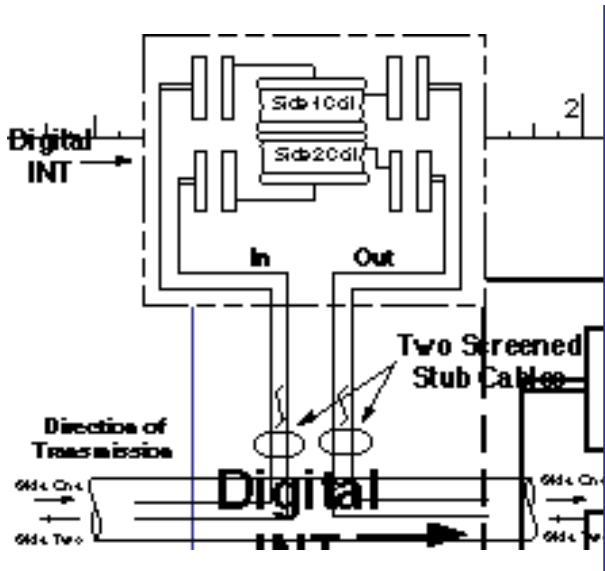


Figure 29: Single Sheath Operation with Two Screened INT Stub Cables

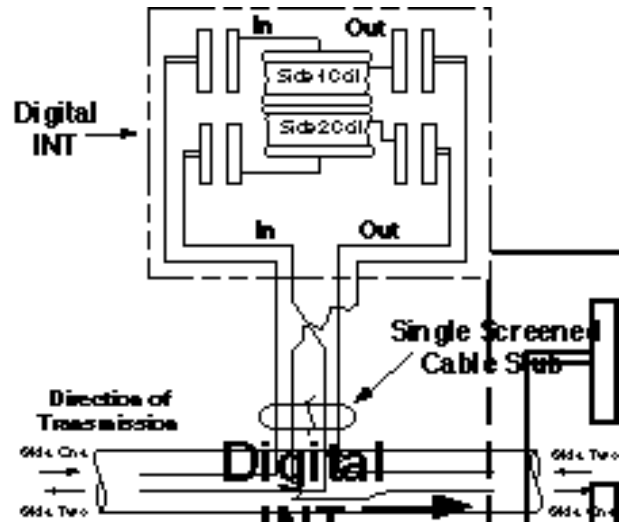


Figure 30: Single Sheath Operation with Single Screened INT Stub Cable

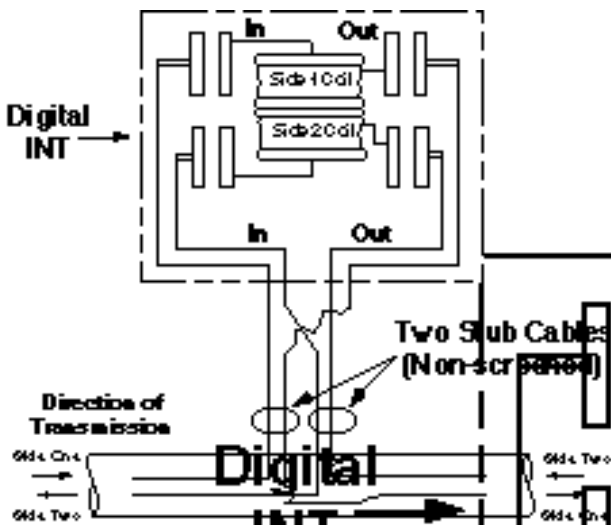


Figure 31: Single Sheath Operation with Two Non-screened INT Cable Stubs

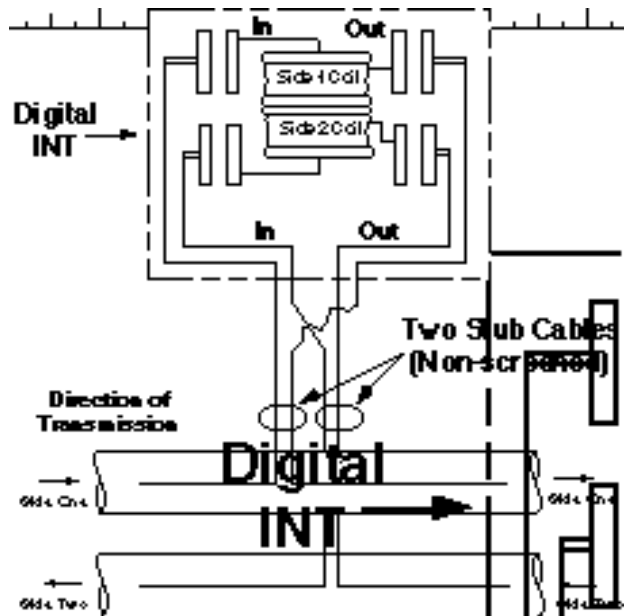


Figure 32: Two Cable Sheath Operation