“Dealing With Induction”

A 30 Year History of Maintaining Communication Service to Taos Ski Valley, New Mexico

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"Dealing With Induction"

This presentation will cover over thirty years of intermittent problems caused by large amounts of induced AC voltage in the copper telecommunication cable serving the Taos Ski Valley in NM. This presentation will cover the multiple causes for the induced AC voltages, the services affected and the various solutions used over a thirty year period to maintain communication services.

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Taos Ski Valley est. 1955

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Telecommunications to the Taos Ski Valley where originally provided utilizing copper paired cable that was placed from the Central Office to the Ski Valley and distributed as needed. As the demand for service increased, analog carrier systems where installed to handle the increased needs.

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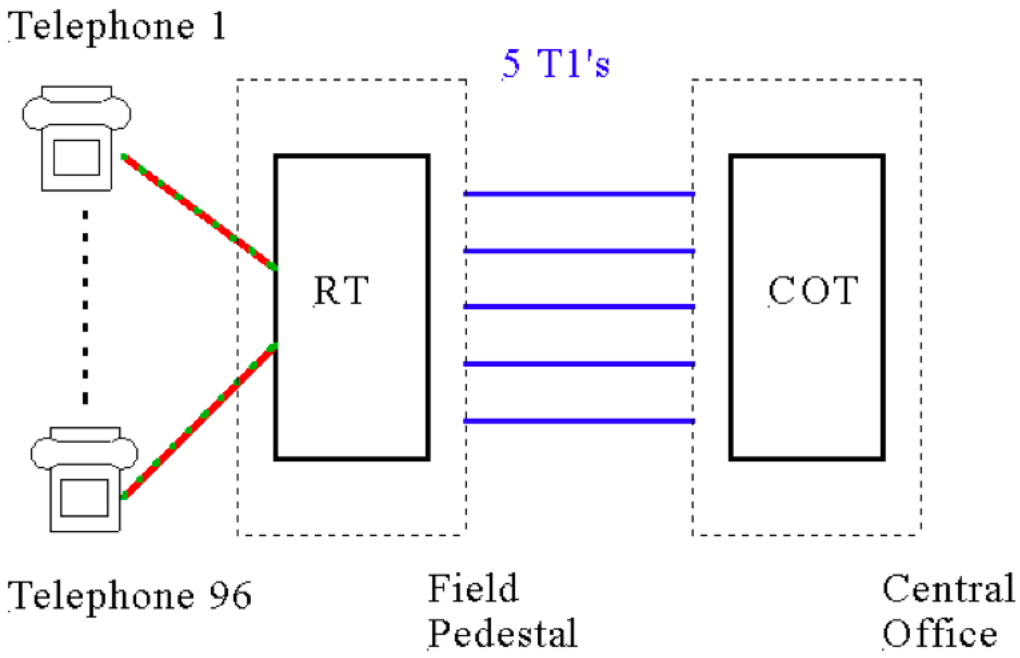
With the advent of digital loop carrier systems (DLC) that used T1 technology as the transport medium between the Central Office and a Remote Terminal; additional capacity, improved voice transmission quality and circuit diversity where gained by migrating to DLC technology.



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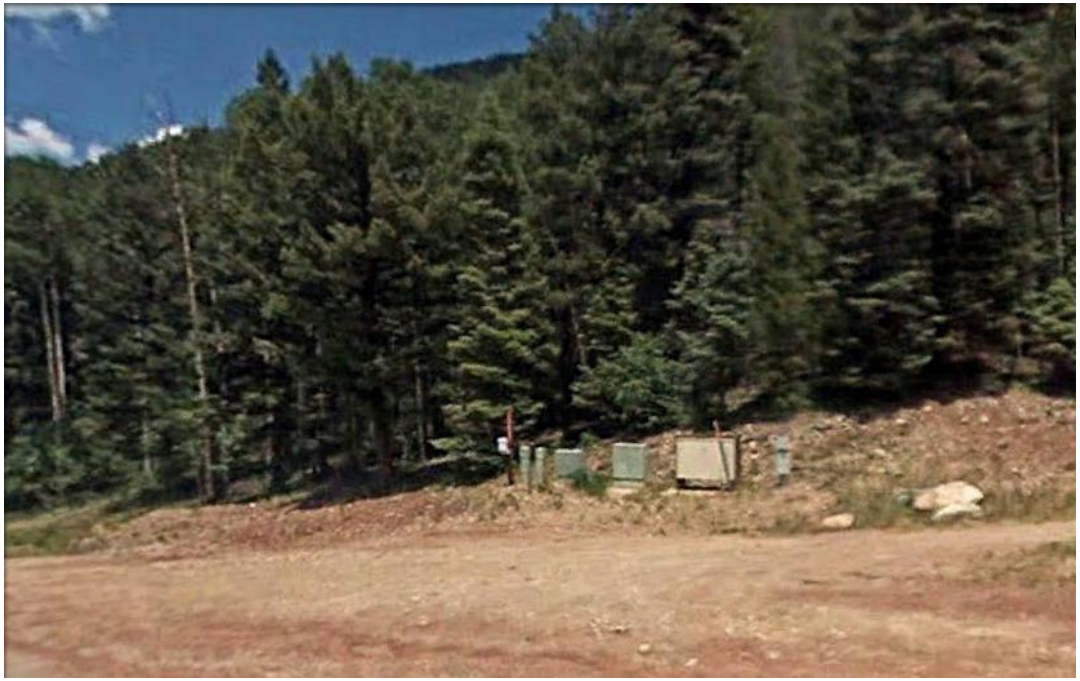
Historical Reference:

In 1980, a new buried copper cable was placed for services to the Ski Valley as a replacement for the exhausted aerial cable plant. In 1983 the first digital loop carrier system (SLC 96) was installed to replace the analog carrier systems and direct copper cable feed from the central office.



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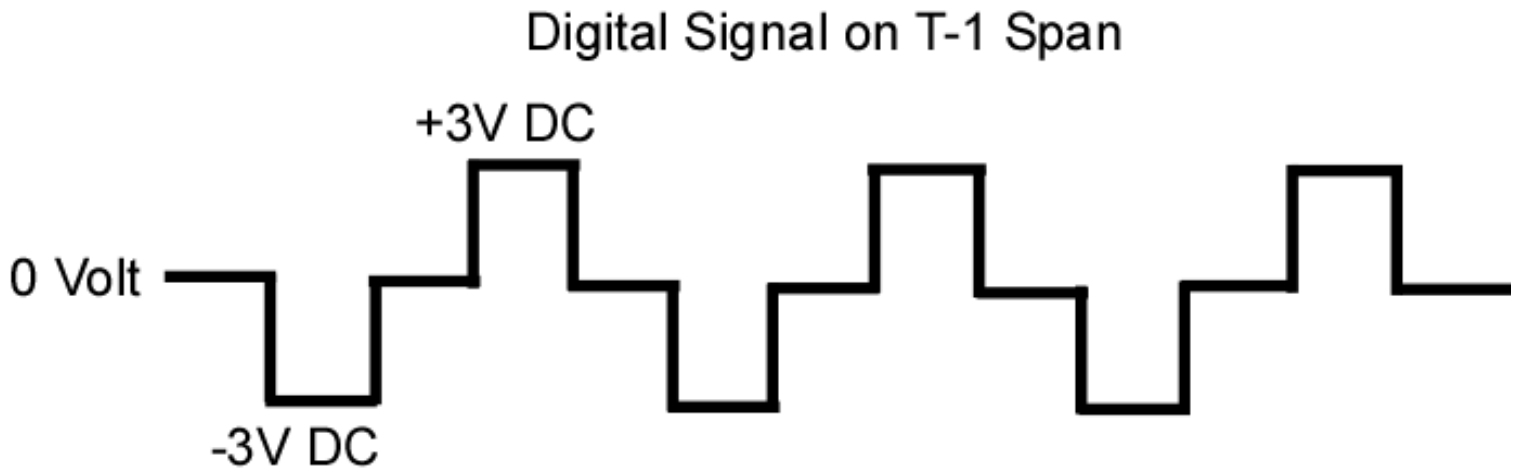

This is a very basic representation of a digital signal in the DS1/T1 format. Each positive, negative and zero voltage is an "on/ off" and constitutes a "bit" in the data stream.

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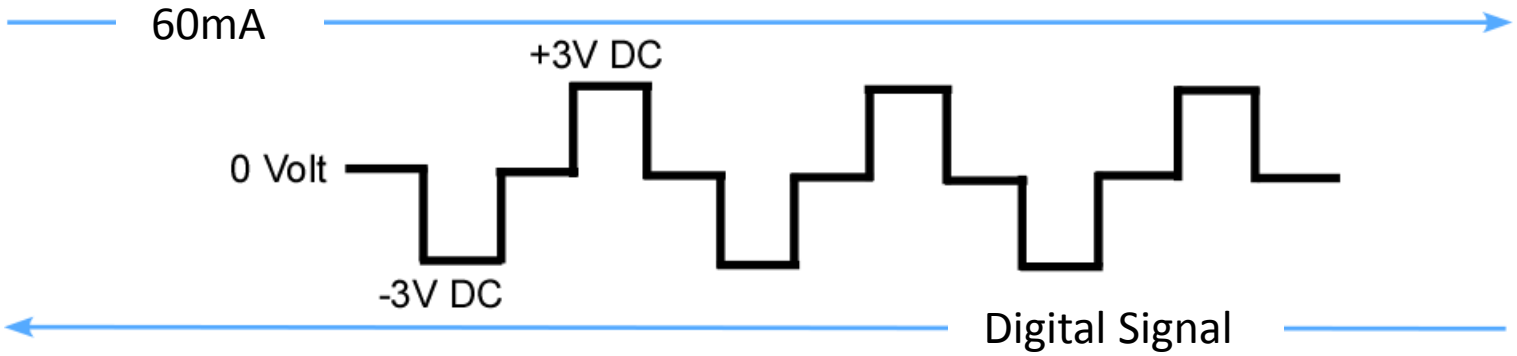

DS1 with (-130 V) 60mA DC applied (T1)
The span current flows on the cable pairs in the opposite direction of the digital signal.

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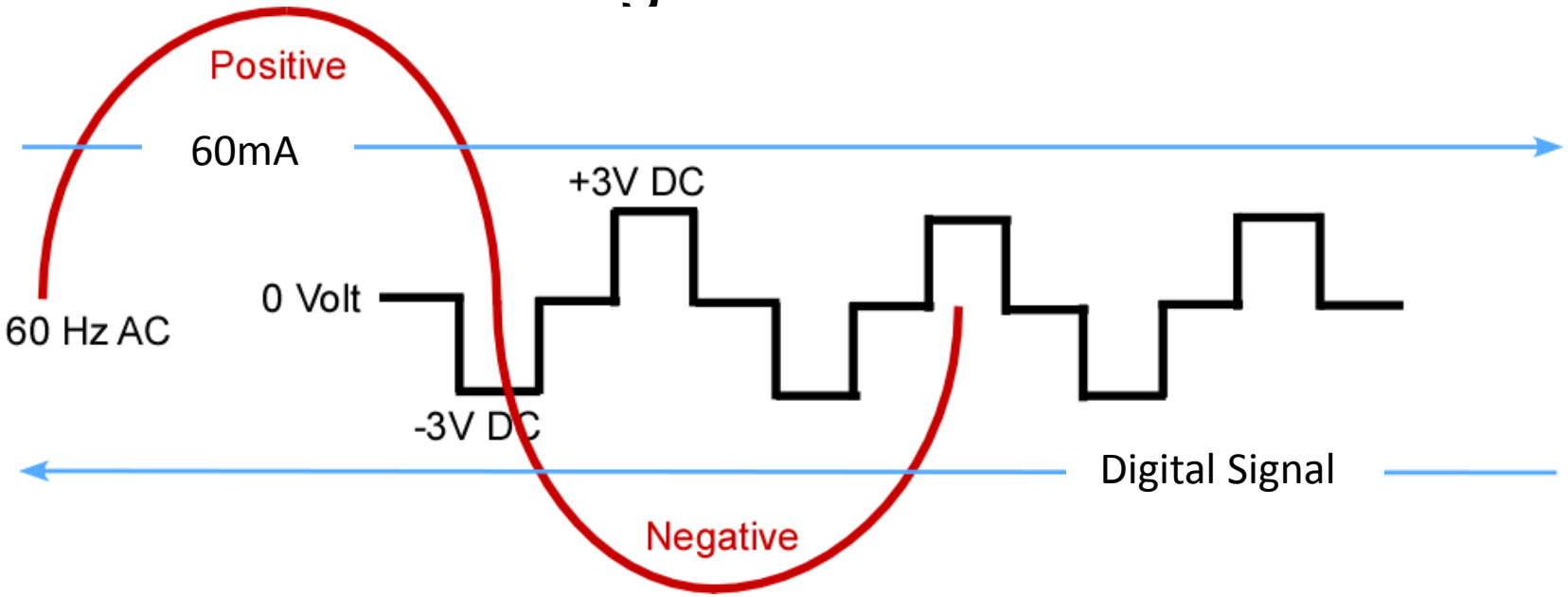

When an AC voltage is induced onto a copper cable facility with T1 services, the 60Hz AC has little to no affect on the 1.544kHz of the digital signal. Longitudinal AC current from high amounts of induced AC voltage does, however, affect the (-130V) 60mA DC span line power system.

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"T1 Span line problems associated with high levels of induced AC voltages"

- Steady-state 60 Hz longitudinally induced AC current/voltages on the T1's (-130V) 60mA DC power feed affects the power supplies of the T1 repeaters.

This results in…

- Excessive bi-polar violations/bit error rates
- T1 shuts down due to a lack of power
- Repeater or line card damage

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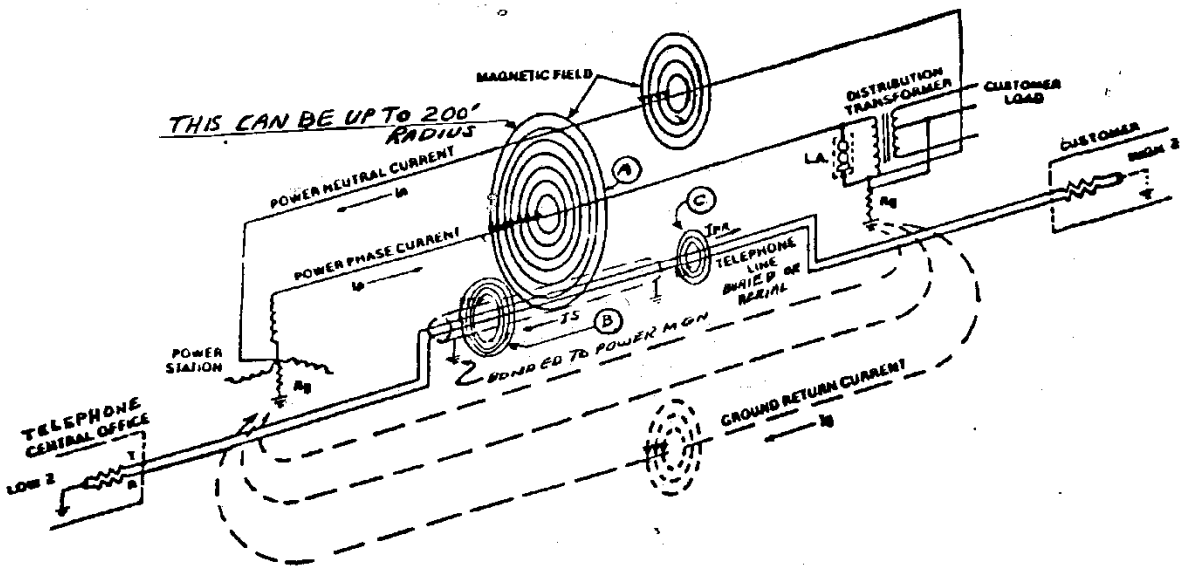

The magnetic field (A) being created on a power line inductively creates a current flow on our cable shield (B). Sheath current generates a new magnetic field and this causes current to flow on our cable pairs (C). This current developes an A.C. voltage which is 180° out of phase with the voltage developed on the shield. These two voltages partially cancel each other. Without shield current flowing, an increased and possibly unacceptable noise may end up on our customers lines.

Basics of cancelling induced AC voltages in shielded communications cables. The voltage induced on the cable pairs from the magnetic field of the shield current is 180 degrees out of phase to the AC voltage induced from the magnetic field of the power lines. This creates a cancelling affect.

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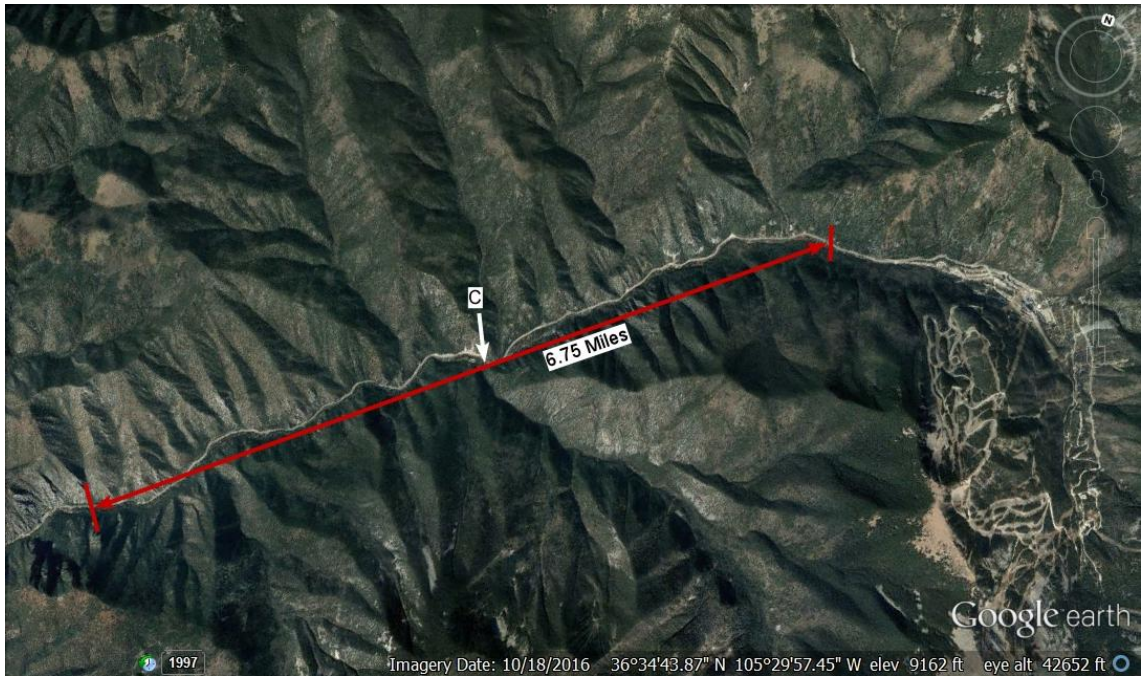

This is the main area of exposure along State Hwy 150 through Twining Canyon. The power exposure was constantly changing because the copper communications cable was placed along one side of the state highway right-of-way while the 3-phase aerial power line shifted back and forth from one side of the road to the other. This also made any bonding to the MGN vertical ground wires nearly impossible.

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Within two years of the SLC 96 installation, T1 span line issues related to high levels of induced AC voltages where being experienced by repair technicians. Due to the lack of available MGN pole vertical ground wire connections, additional grounding was added at each T1 repeater location to provide a lower impedance path to produce shield current. Sufficient shield current was produced to cancel enough of the induced AC induction that this resolved the issues for over 10 years.

Originally, step up/ step down transformers where installed at both ends of Twining canyon in an effort to provide constant voltage levels (power quality) to the Ski Valley.

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As the AC load increased in the Ski Valley, a bank of voltage regulators was installed at the upper end of the canyon to help maintain voltage levels. Additional DLC remotes and Cell sites where also added in the Ski Valley.

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1998 Taos Ski Valley T1 Failures

In the winter of 1998, service to all three DLC sites and the cellular site was effected due to (measured) 57V induced AC on all copper cable pairs with T1 repeated span lines.

Pictured here is the location of the three DLC sites and the "H" repeater

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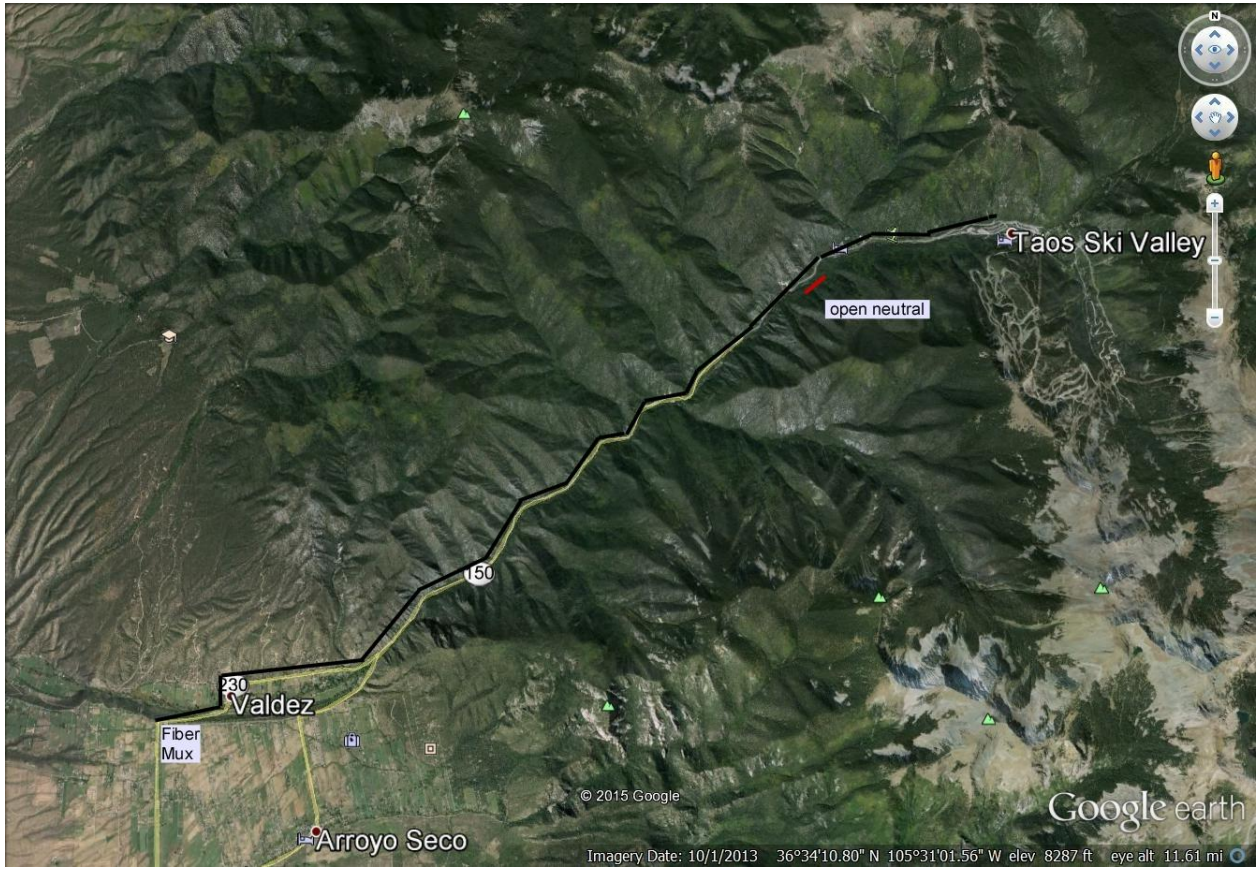
1998 Taos Ski Valley T1 Failures

In this case, the neutral conductor was knocked down by a falling tree on the 3-phase distribution line serving the Taos Ski Valley.
57V AC was measured on all copper cable pairs in the CO feed cable.
All (31) T1 lines in the 200 pair copper cable where taking errors or failed . This included Span lines to the three DLC sites as well as T1’s serving a cell site.



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1998 Taos Ski Valley T1 Failures

239 T1 repeater

T1 repeaters are powered by the DC current and are not voltage dependant to operate correctly.

239 Inelegant Line Repeater

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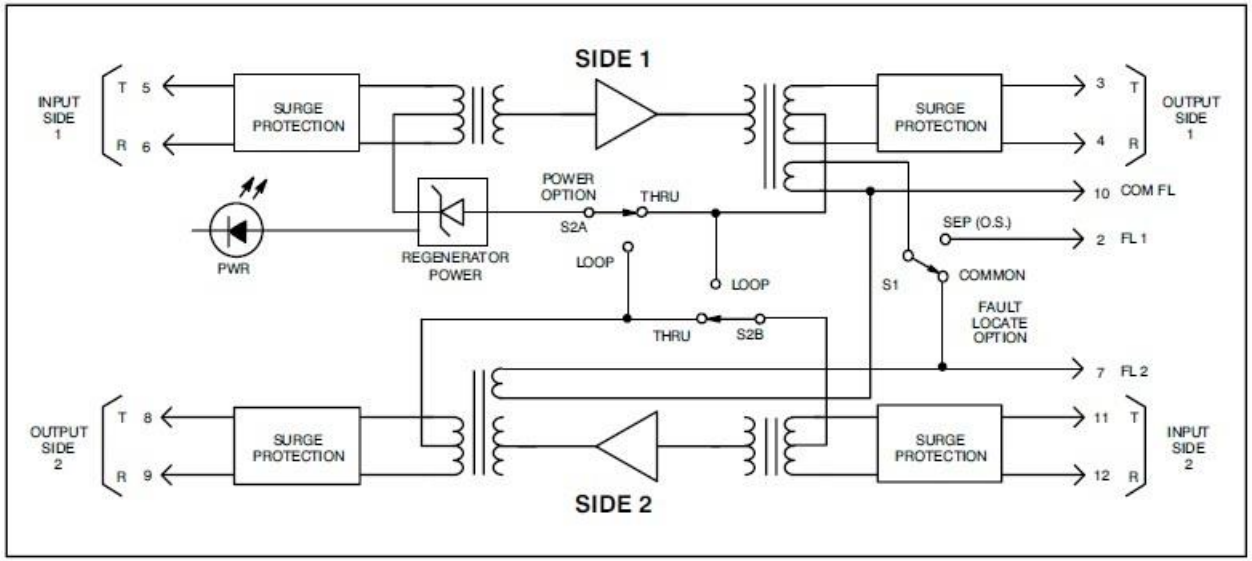
1998 Taos Ski Valley T1 Failures



T1 Repeater Block Diagram

Basic schematic diagram of a 239 type T1 repeater.

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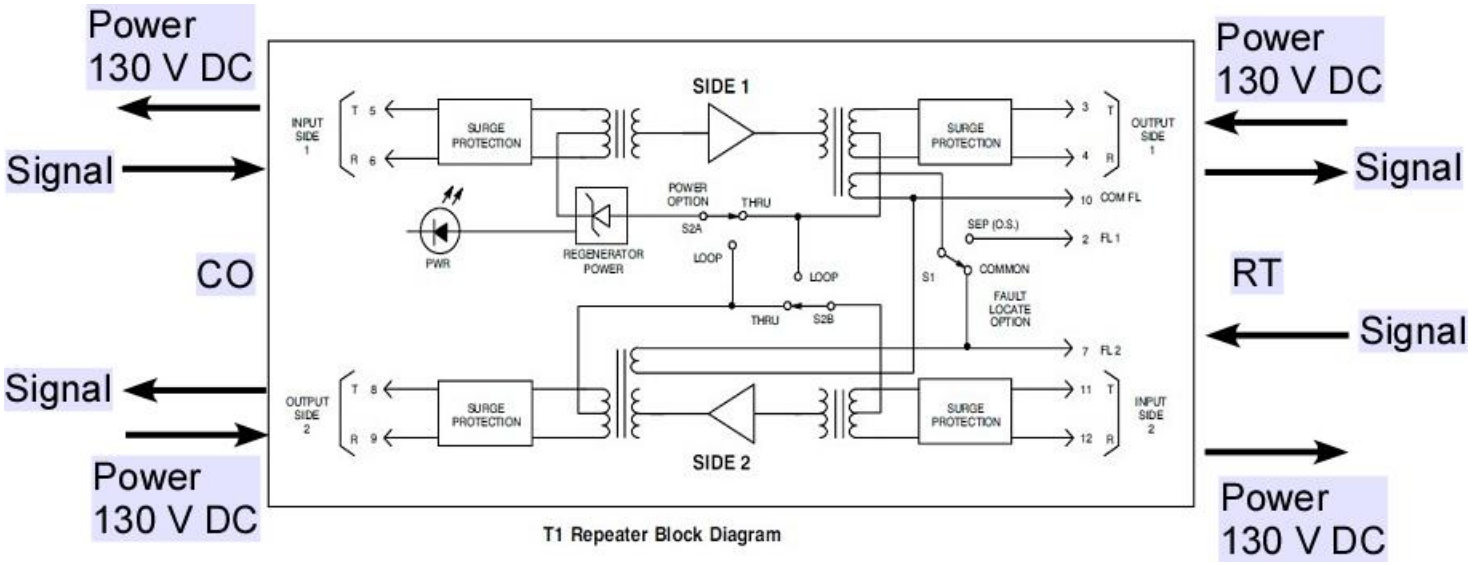
1998 Taos Ski Valley T1 Failures



T1 Repeater Block Diagram

Direction, Signal vs. Power (current)

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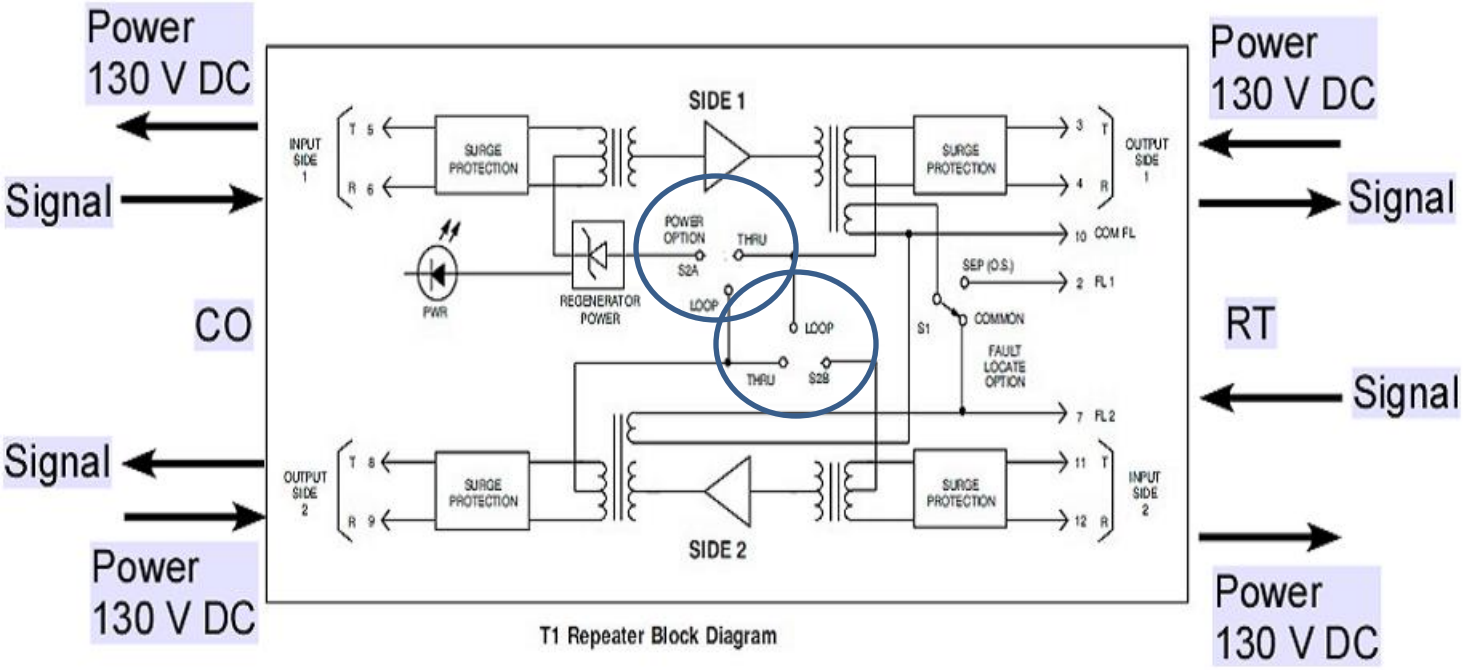
1998 Taos Ski Valley T1 Failures



T1 Repeater Block Diagram

Through Power vs. Looped Power

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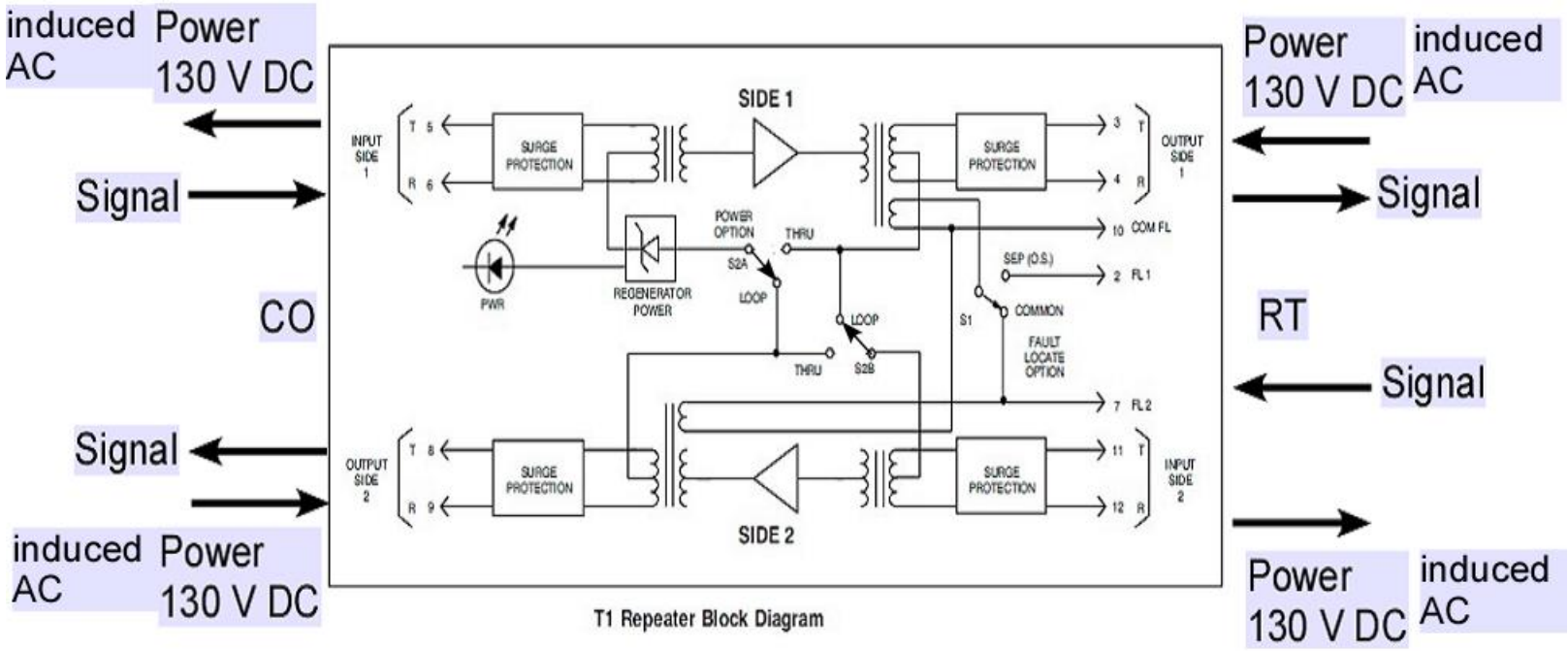
1998 Taos Ski Valley T1 Failures



T1 Repeater Block Diagram

When power (current) is looped at a T1 repeater, all power (current) is looped including the longitudinal AC current/voltage.

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1998 Taos Ski Valley T1 Failures

Looping the power (current) in the T1 repeaters at the "H" repeater and utilizing the back powering ability of the digital loop carrier systems cut the induced AC exposure which reduced the AC voltage level to a point (21 to 31V DC) that the T1's restored. It also restored the cell site T1's that where not back powered.

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2015/2016 Taos Ski Valley T1 Failures

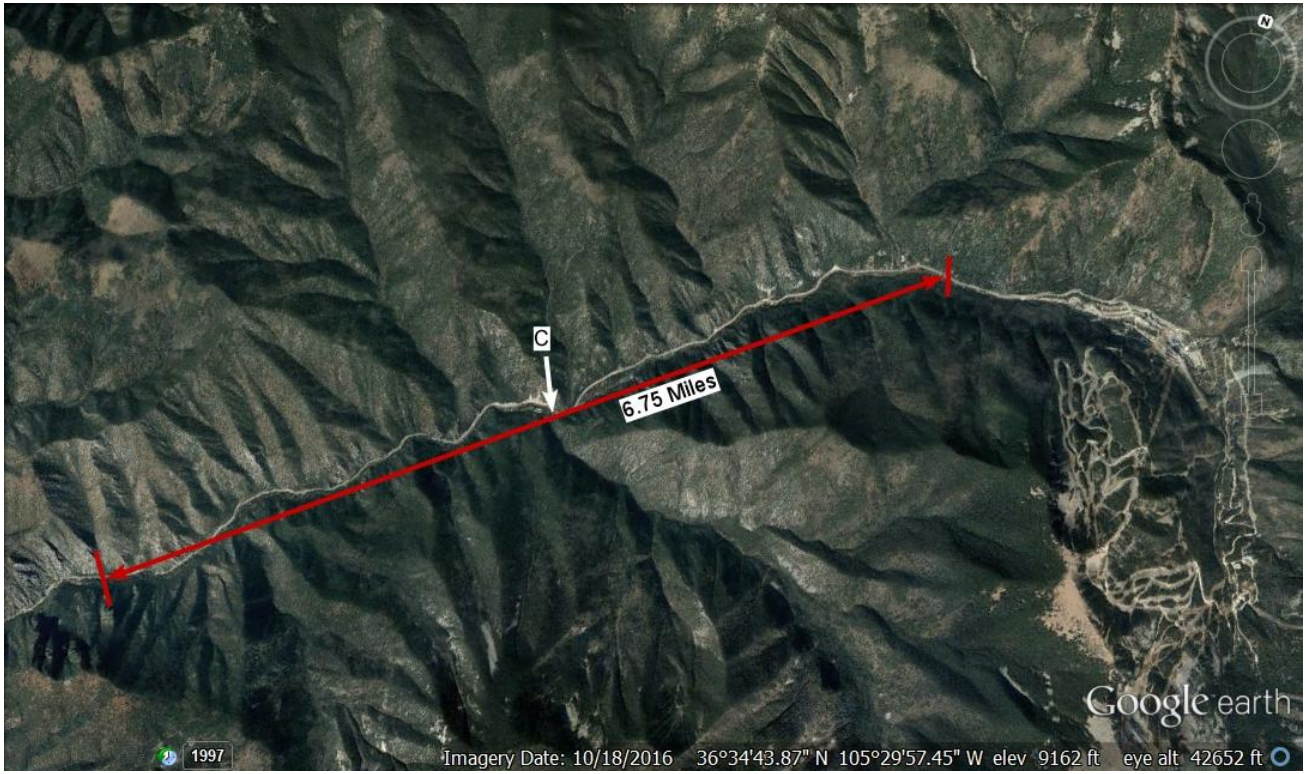
“Dealing With Induction”

2015/2016 Taos Ski Valley T1 Failures

Area of exposure:

C designates the approximate center of the cable exposure to be treated.

For this failure 80V of induced AC was measured on the cable pairs throughout the exposure. 2 to 3 amps of AC current was measured on all cable shields in the area of exposure. The power loops where confirmed to be in place at the H repeater. All T1 circuits where scrolling errors, bouncing or down hard.



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2015/2016 Taos Ski Valley T1 Failures

The latest commercial power configuration has voltage regulators placed at both the bottom of Twining Canyon and at the top of the canyon. There are no step-up or step-down transformers being used to maintain power quality. These banks are a regular source of trouble when the 3-phase lines become severely unbalanced due to random failures of the regulator control circuitry. In January, 2016, phase balance at the lower voltage regulators was measured @ (A= 51amps, B= 45 amps, C=60 amps) and the percentage of imbalance calculated as:

A-B=12%, A-C= 15%, B-C= 25%.

This phase imbalance was the root cause of the 80V AC being induced into the local exchange cables serving the Taos Ski Valley.

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2015/2016 Taos Ski Valley T1 Failures

Concerning Induction Neutralizing Transformers (INT's).

- An INT is a simple, passive device composed of standard, pic insulated, color coded, twisted and transposed cable pairs.
- 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 turn ratio transformer action can cancel or "neutralize" up to 95% of the induced AC voltage that would normally appear at the end of the facility.
- An INT is spliced in series with a cable much the same way as a load coil or carrier repeater 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 including the excitation pair go through the transformer.

Information source, SNC MFG

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2015/2016 Taos Ski Valley T1 Failures

The 6.75 mile cable exposure was cut in half. Each half of the affected cable was treated with an INT.

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2015/2016 Taos Ski Valley T1 Failures

Exciter pairs where tested for continuity and grounded at both ends of their respective sections. All exciter pairs where measured for AC current. 2 to 2.5 amps AC was measured on each pair.

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2015/2016 Taos Ski Valley T1 Failures

After installation of the INT’s, AC induction was reduced from 80V AC to 22V AC. All T1 span lines returned to normal operation.

"Dealing With Induction" Conclusions

- Changing conditions may cause different approaches for mitigating large amounts of induced AC voltage to be implemented.
- A close working relationship with the local power provider is essential
- Cost consideration must be a part of the process for determining the best mitigation method.

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