Direct Transfer Trip 900MHz Radio Scheme

SUMMARY

This utility procedure provides information for the installation of 900-MHz spread spectrum radio scheme for direct transfer trip (DTT) between two existing substations.

Level of Use: Informational Use

TARGET AUDIENCE

System protection, substation test, and telecommunication personnel.

SAFETY

NA

BEFORE YOU START

NA

TABLE OF CONTENTS

PROCEDURE STEPS

1 General Information

1.1 DTT schemes for PG&E's transmission grid require dependable communication circuits between substation facilities or third-party locations, and traditionally use a Class A leased service from the local telephone company.

1.2 The use of traditional lease lines for DTT circuits is now at risk, as the traditional carriers such as AT&T and Verizon have decreased their support and investments in wire-line facilities and are moving away from providing conventional leased digital signal zero (DSO) circuits completely.

1.3 At the same time, third-party generators are increasingly dependent on leased circuits. Any failure of the leased circuit directly impacts the generators operation.

Direct Transfer Trip 900MHz Radio Scheme

1.4 A DTT scheme using radio-frequency channel uses spread-spectrum wireless radios for transmitting signals, typically under optimal conditions and with clear line of sight. In view of no physical communication path between the end entities, this method is fastest and least expensive of the communications channel for application. Radio schemes use encryption to ensure cyber security.

1.5 Repeating stations can be used in DTT applications for the following reasons:

1. To extend the range of spread spectrum from the existing limitation of 15 miles to 30 miles.

2. As 900-MHz radio schemes are line-of-sight only, a repeater station allows getting around line-of-sight barriers.

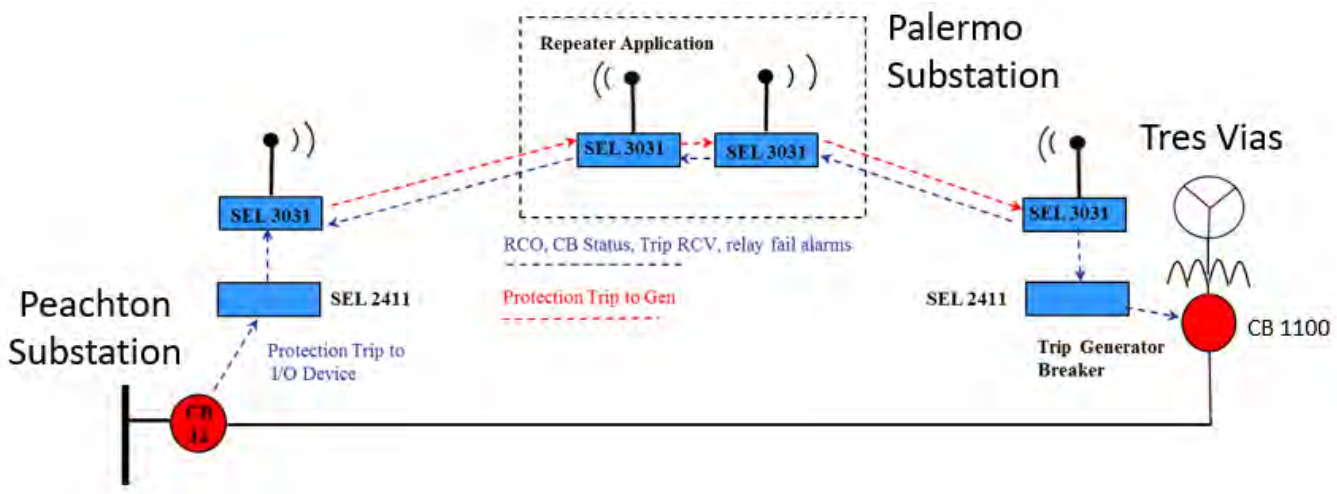

Figure 1. Illustration of a Repeater Station Application

2 Initial Test and Deployment

2.1 Two SEL-3031 radios were initially tested in an exceptionally harsh radio frequency (RF) environment between San Mateo substation and San Carlos service center, a line-of-site distance of 5.5 miles. Both locations are near airports (SFO and San Carlos Airport), in densely populated areas, and a radio path that parallels a major freeway. Consequently, the RF interference is quite high, especially in the unlicensed 900-MHz band.

2.2 Subsequent installations at Stroud and Helm substations have proven the feasibility of wireless installations for DTT applications and improvements from lessons learned are incorporate in this revision.

2.3 In 2018, a repeating station pilot at Tres Vias using two SEL 3031 radios was successful and approved for systemwide application. SEE Figure 1.

Direct Transfer Trip 900MHz Radio Scheme

3 Spread Spectrum Limitations

3.1 900-MHz spread spectrum is unlicensed:

3.2 Requires line of sight for successful transmission, (e.g., no buildings, hills, or large trees in communication path), although a repeater station can be built. (SEE Figure 1).

3.3 Available frequency hopping, “hop” frequencies, may be limited by interference from other electromagnetic emissions resulting in degradation of signal over time.

3.4 Radiated antenna power or effective isotropic radiated power (EIRP) is limited by the Federal Communications Commission (FCC) to +36 decibel milliwatts (dBm) for the 900-MHz industrial scientific medical (ISM) band.

4 Procedures for Installing Spread Spectrum Scheme

4.1 Determine Feasibility:

1. PERFORM a path study to determine the viability of the communication path.
    a. Product specialists must PROVIDE a path analysis report to provide predicted levels of performance.
        (1) The path analysis CONSIDERS the terrain profile AND certain RF factors that could potentially affect the path.
        (2) Ideally, the path study should SHOW at least 60% of the first Fresnel zone being clear of all obstacles.
2. PERFORM a field survey to confirm line of sight.

4.2 Equipment Procurement:

1. OBTAIN the following pilot hardware, consisting of a total of four devices:
    a. Two SEL-3031 spread-spectrum radios:
        (1) 24/48-volt (V) rack mount with encryption, multimode (MM) fiber AND straight tip (ST) connectors: 30310R233XX.
        (2) 125/230 V alternating current (ac)/V direct current (dc) rack mount with encryption, MM fiber AND ST connectors: 30310R433XX.
    b. Two SEL-2411 input/output (I/O) modules; (must have ring terminations, as compression terminations are not allowed).

Direct Transfer Trip 900MHz Radio Scheme

4.2.1 (continued)

(1) SELECT from the following choices based on dc power supply requirements:

- 125 Vdc/Vac rack mount, 4 digital I/O, single 10/100 base Ethernet, fiber multimode ST: 241101A1A0X0X0X1130.
- 48 Vdc/Vac rack mount, 4 digital I/O, single 10/100 base Ethernet, fiber multimode ST: 241102C1C0X0X0X1130.
- 24 Vdc/Vac rack mount, 4 digital I/O, single 10/100 base Ethernet, fiber multimode ST: 241102B1B0X0X0X1130.

2. OBTAIN the following antenna equipment:

a. Two PCTEL model BMYD890M, Bluewave series, providing +12 dBm @ 890 – 960 MHz, or equivalent Yagi antennas designed for 900-MHz band.

b. Antenna cable: Low-loss 50-ohm cable for 900 MHz, such as ½" Heliax, LMR-400, or similar. Cable length as required for each location.

c. Cable grounding, hoisting and support:

(1) A hoisting grip to assist with installation of coaxial cable AND to provide appropriate vertical support (Andrew part number L4SGRIP or equivalent).

(2) Grounding kits (Andrew part number SGL4-0681 or equivalent) to be installed outdoors on tower with cold shrink weatherproofing.

(3) Coaxial cable support hardware is dependent on the type of support structure (e.g., steel lattice angle-iron, round pipe member, etc.).

d. Antenna mounting tower (depends on substation location AND any local requirements for height, rigidity, weather, etc.).

e. N-Type coaxial connectors (as required).

NOTE

Adverse operation may result from the use of adapters.

f. Lightning suppressor such as PolyPhaser IS-B50LN-C2 or equivalent.

g. Copper ground bus bar with insulated standoffs such as CPI 10622-10 or equivalent.

Direct Transfer Trip 900MHz Radio Scheme

4.2.2 (continued)

h. Multimode fiber as required between SEL 3031 and SEL 2411.

4.3 Installing the Antennas:

1. INSTALL Yagi antennas at height required by path study with either horizontal OR vertical polarity.

   a. Horizontal polarity is generally preferred to minimize interference from other devices on this band. However, multiple antennas on the same pole may alternate horizontal and vertical.

2. ENSURE antennas are correctly aligned with the flashed path, as hi-gain Yagi antennas are extremely directional.

3. MINIMIZE the length of Heliax or Lockheed Martin radar (LMR) 400 cabling AND the use of connectors and adapters in the RF circuit to minimize losses.

4.4 Installing the Radio Devices:

1. General Information: The SEL 3031 and SEL 2411 are generally rack mounted next to each other in a location that allows for the shortest antenna cable path to the outdoor antenna. (REFER to Appendix 3 – RF Channel Connections for DTT.)

2. In special cases where the path study indicates signal strength is marginal, MOUNTING the radio separate from the SEL 2411 to keep the antenna cable length to an absolute minimum may be required. This would be DETERMINED on a case-by-case basis.

3. Master Location

   a. LOCATE OR PROVIDE sufficient telecommunications rack space in the existing substation control building for both the SEL-2411 and the SEL-3031.

      (1) The SEL-3031 is a rack-mount design of 1 rack unit (RU), while the SEL-2411 is surface-mount design.

4. Remote Location

   a. LOCATE OR PROVIDE sufficient telecommunications rack space in the existing substation control building for both the SEL-2411 and the SEL-3031.

   b. The SEL-3031 is a rack-mount design of 1 RU, while the SEL-2411 is surface-mount design.

Direct Transfer Trip 900MHz Radio Scheme

4.5 Wiring the Device Connections:

1. Master Location - Appendix 1, "Transmitter Wiring Diagram," PROVIDES one example of wiring the scheme using the SEL 3031.

   a. PROVIDE dc power (P, N) to both the SEL-3031 AND SEL-2411 devices.

   b. WIRE the SEL-2411 to the tripping relay:

      (1) Trip output.

      (2) Transfer trip confirmed.

      (3) Local SEL-2411 trouble alarm.

   c. Remote Trouble Alarms:

      (1) CONNECT the SEL-2411 to the SEL-3031 with multimode fiber (ST to ST connectors).

      (2) CONNECT the coaxial cable to the antenna port of the SEL-3031.

   d. Remote Location — SEE Appendix 2, "Receiver Wiring Diagram":

      (1) PROVIDE dc power (P, N) to both the SEL-3031 AND SEL-2411 devices.

      (2) WIRE the SEL-2411 outputs to the following inputs:

      - Transfer trip received
      - Transfer trip confirmed
      - Local SEL-2411 trouble alarm
      - Remote trouble alarms

      (3) CONNECT the SEL-3031 to the SEL-2411 with multimode fiber (ST to ST connectors).

      (4) CONNECT the coaxial cable to the antenna port of the SEL-3031.

Direct Transfer Trip 900MHz Radio Scheme

4.6 Alarming or Logging:

1. SET the tripping relay to record statistics on DTT events (success or failure, round-trip time performance).

2. SET the tripping relay to display AND log any alarms OR abnormalities such as communication failure OR false trip signals sent.

4.7 Settings:

1. DOWNLOAD the SEL template settings.

2. ESTIMATE the RF cable loss based on installed length AND number of adapters used.

3. SET the transmitter power such that EIRP is +36 dBm. EIRP = (Transmitter Power) + (Antenna Gain) – (cable and adapter losses).

4.8 Initial Testing:

1. CHECK levels at the receiver to be at least -82 decibels (dBm).

   a. A received signal strength indicator (RSSI) of -82 dBm provides a +15 dBm fade margin.

2. Initially (by default), a SEL-3031 uses channels 1 through 10 (of the 16 channels available).

   a. POWER UP the radio in service for at least 15 minutes AND CHECK each channel's availability. Ideally it is above 98%.

   b. Availability below 98% indicates interference on that frequency.

      (1) ADD any channel below 98% to the "skip list" AND TRY the next available channel (channel 11 through 16).

   c. SELECT the ten channels that, on average, provide the highest percent availability.

NOTE

Any changes made to skipped channels must be made on both radios to restore the link.

   d. CHECK the round-trip time tracked by the sequence of events (SOE) to confirm trip signaling to be less than 0.060 seconds (3.6 cycles).

Direct Transfer Trip 900MHz Radio Scheme

4.9 Maintenance:

1. After 2 or 3 days of initial operation, LOG ON to each radio AND VERIFY that RSSI has not changed from initial setup.

2. NOTE availability percentages for each channel in use.

   a. IF the availability statistics for any channel have significantly changed,

      THEN REPEAT Step 4.8.2 above. The goal is to select the 10 best out of 16 available channels based on average availability.

   b. IF overall link availability (as reported by the RAD command) is greater than 90 percent,

   c. THEN DO NOT PERFORM additional maintenance. Any value above 90 percent should ensure that a DTT has a 99.99 percent chance of being successfully sent within 26 milliseconds.

3. On an annual basis, VISUALLY CHECK antennas AND cabling for any damage.

   a. LOG on to each SEL-3031 AND CHECK RSSI AND channel availability.

   b. IF no significant changes AND no reported problems,

      THEN DO NOT PERFORM additional maintenance.

   c. IF there are significant changes or reported problems,

      THEN MAKE further corrections as needed.

Direct Transfer Trip 900MHz Radio Scheme

5 Operation Functions

5.1 The DTT scheme has several indications AND a Trip test feature.

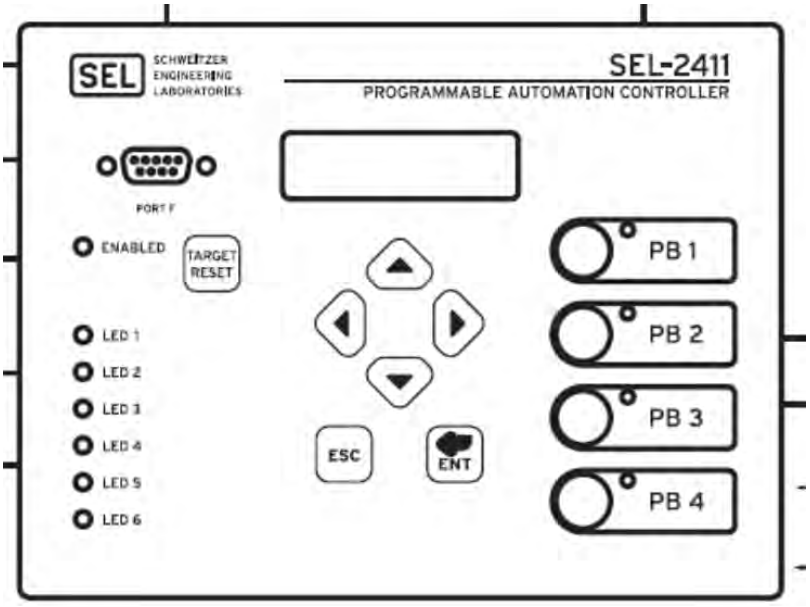

Figure 2. Substation (Transmitting) Site

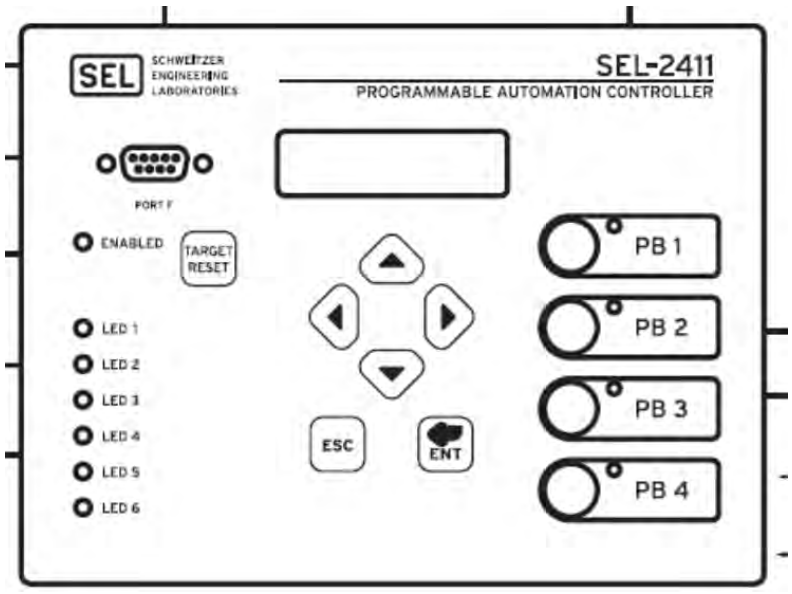

Figure 3. Generation (Receiving) Site

Direct Transfer Trip 900MHz Radio Scheme

5.2 Substation Transmitting Station

1. Indications:

   a. Trip Sent – Trip was initiated from the substation.

   b. Trip Receiver (RCV) – Trip was received at the generating facility and echoed back to the sending end.

   c. Comm Alarm - Loss of communication with generation device.

   d. Test Mode – Permissive for sending trip to generation site. (Pushbutton must be held in to enable.

   e. Generation (GEN) Circuit Breaker (CB) Close (CLO) – Generation breaker closed.

   f. GEN remote cut-out (RCO) cut-in (C/I) –Generation side DTT cut in.

2. Control:

   a. Test Mode – PUSH to place in test mode allows for trip to be sent from the transmitting station.

   b. ENSURE generation is offline OR generation site RCO is cutout before send trip.

   c. Send Trip – PUSH in conjunction with test mode push button to send trip to generation site.

3. Operational Condition:

   a. Normal Condition

      (1) Substation

      - Trip Sent – Off.
      - Trip RCV – Off.
      - Comm Alarm – Off.
      - Test Mode – Off.
      - GEN CB Open – Off generation breaker closed.
      - GEN RCO C/O – Off generation side DTT cut-in.

Direct Transfer Trip 900MHz Radio Scheme

5.2 (continued)

(2) Generation End

- Trip RCV – Off.
- Comm Alarm – Off.
- Test Mode – Off.
- Radio Fail – Off SEL 3031 not in failure mode.
- GEN CB Open – Off generation breaker closed.

b. Trip Condition:

(1) The “Trip Sent” AND Trip RDV” LEDS are latched. After a trip event, PUSH the “Target Reset” pushbutton to clear the trip LEDS.

(2) Substation:

- Trip Sent – ON.
- Trip RCV – ON.
- Comm Alarm – Off.
- Test Mode – Off.
- GEN CB Open – ON generation breaker open.
- GEN RCO C/O – Off generation side DTT cut-in.

(3) Generation End:

- Trip RCV – ON.
- Comm Alarm – Off.
- Test Mode – Off.
- Radio Fail – Off SEL 3031 not in failure mode.
- GEN CB Open – ON Generation breaker open.
- GEN RCO C/O – Off Generation side DTT cut-in.

Direct Transfer Trip 900MHz Radio Scheme

5.2 (continued)

c. Abnormal Conditions:

(1) For SEL 3031 OR SEL 2411 equipment issues, communication is interrupted AND in most cases brings in the “Comm Alarm” LED.

(2) IF this alarm is received,

THEN CONTACT information systems technology services (ISTS) personnel AND TAKE steps to address the loss of DTT for the generation application.

END of Instructions

DEFINITIONS

Direct transfer trip (DTT): A communication system wherein a trip signal is transmitted to a remote terminal. The communication media is based on phone lines, radio carrier, fiber optic, or other suitable media. The objective of the system is to provide a high speed (typically less than 8 milliseconds) system for sending the trip signal to the remote terminal.

Equivalent isotropically radiated power (EIRP): maximum directional signal strength as compared to an isotropically radiated signal (with equal signal strength in all directions).

Hop or frequency hopping spread spectrum (FHSS): Frequency-hopping spread spectrum is a method of transmitting radio signals by rapidly changing the carrier frequency among many distinct frequencies occupying a large spectral band. The changes are controlled by a code known to both transmitter and receiver.

SEL - Schweitzer Engineering Laboratories.

Spread Spectrum - A method wherein a signal is given bandwidth gets spread in frequency domain, to minimize interference from other users in the same frequency domain.

IMPLEMENTATION RESPONSIBILITIES

Managers of system protection and IT ensure all system protection, substation test, and telecommunication personnel are trained in this procedure.

GOVERNING DOCUMENT

NA

Direct Transfer Trip 900MHz Radio Scheme

COMPLIANCE REQUIREMENT / REGULATORY COMMITMENT

Records and Information Management:

Information or records generated by this procedure must be managed in accordance with the Enterprise Records and Information (ERIM) program policy, standards and Enterprise Records Retention Schedule (ERRS). Refer to GOV-7101S, "Enterprise Records and Information Management Standard," and related standards. Management of records includes, but is not limited to:

- Integrity
- Storage
- Retention and Disposition
- Classification and Protection

APPENDIX

Appendix 1 – Transmitter Wiring Diagram

Appendix 2 – Receiver Wiring Diagram

Appendix 3 – RF Channel Connections for DTT

DOCUMENT RECISION

This utility procedure cancels and supersedes Utility Bulletin TD-1013B-001, "Direct Transfer Trip 900MHz Radio Scheme" Revision 2, dated 02/23/2016.

DOCUMENT APPROVER

Rama Reddy, Manager

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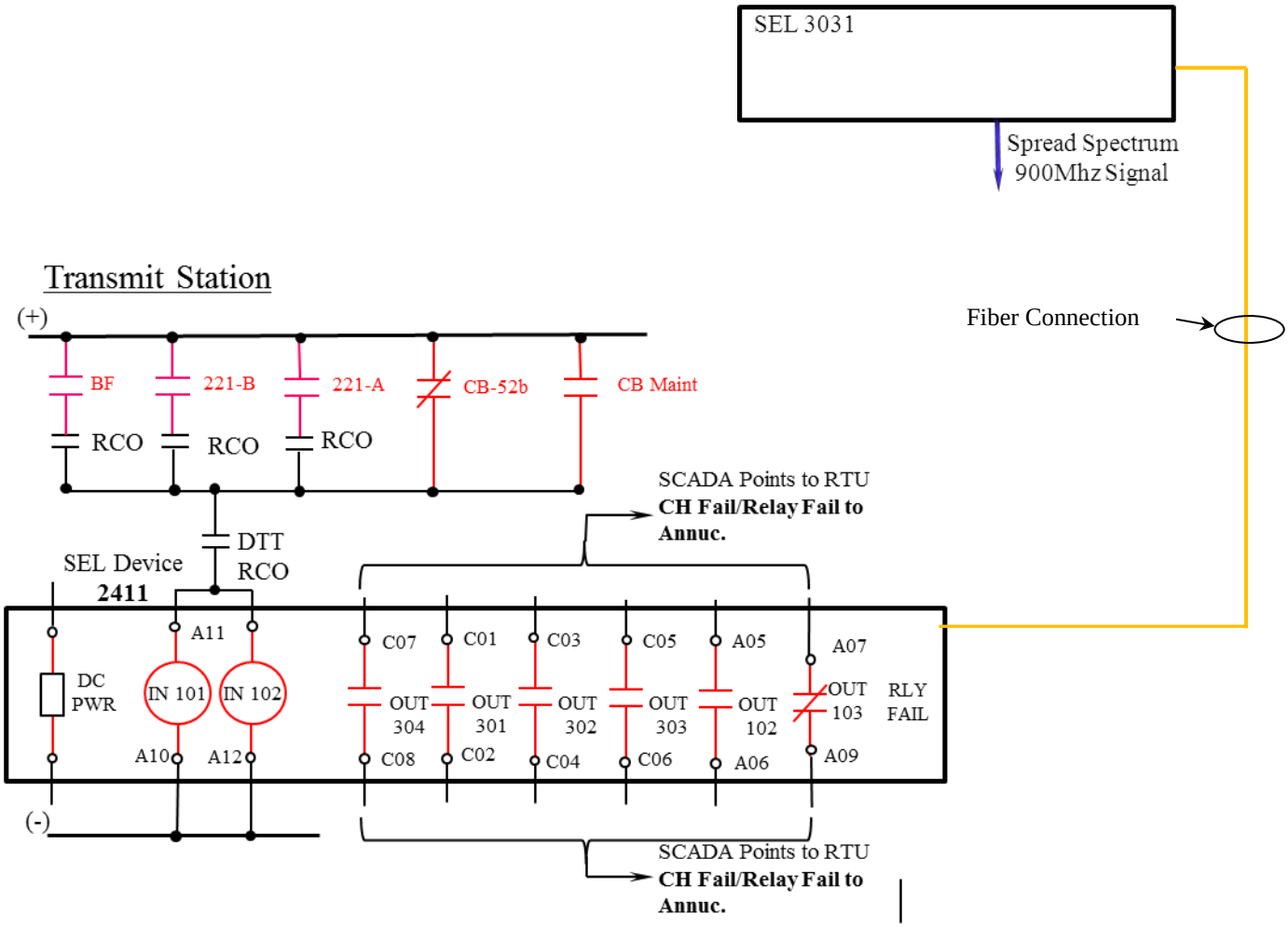
REVISION NOTES

Where?	What Changed?
NA	New document.

Direct Transfer Trip 900MHz Radio Scheme

Appendix 1 – Transmitter Wiring Diagram

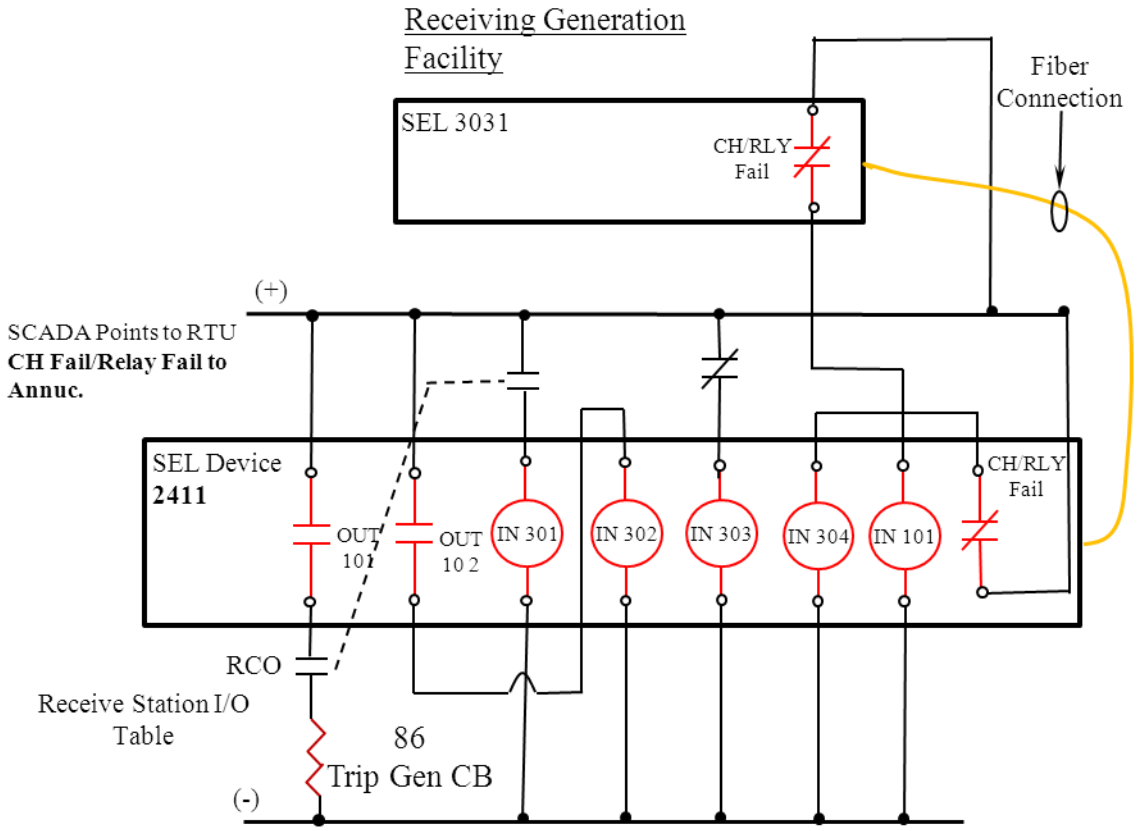


Transmit Station I/O Table

IN 101	Trip (TMB1)
IN 102	Trip RCV (TMB2)
OUT 102	CH FAIL (RBADB)
OUT 103	DEV FAIL (!SV7T)
OUT 301	GEN RCO STATUS (RMB3)
OUT 302	TRIP RCV (RMB4)
OUT 303	GEN CB STATUS (RMB5)
OUT 304	GEN SEL DEVICE FAIL (RMB6)

Direct Transfer Trip 900MHz Radio Scheme

Appendix 2 – Receiver Wiring Diagram



Receive Station I/O Table

IN 301	GEN RCO STATUS (TMB3)
IN 302	TRIP RCV (TMB4)
IN 303	GEN CB STATUS (TMB5)
IN 304	Spare
IN 101	GEN SEL 3031 DEV/CH FAIL (TMB7)
OUT 101	Trip (RMB1)
OUT 102	Trip RCV (RMB2)
OUT 103	DEV CH/RLY FAIL (!SV07T)

Direct Transfer Trip 900MHz Radio Scheme

Appendix 3 – RF Channel Connections for DTT