SUMMARY

This bulletin provides information for the installation of 900MHz spread spectrum radio scheme for Direct Transfer Trip (DTT) between two existing substations.

AFFECTED DOCUMENT

Transmission Interconnection Handbook, Appendix F

TARGET AUDIENCE

System protection, substation test, and telecommunication personnel

WHAT YOU NEED TO KNOW

1 General Information

1.1 DTT schemes for PG&E’s transmission grid require highly dependable communication circuits between substation facilities or 3rd-party locations, and traditionally utilize 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 DS-0 circuits completely.

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

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 scheme utilizes encryption to ensure cyber security.

2 Initial Test and Deployment

2.1 Two SEL-3031 radios were initially tested in an exceptionally harsh 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.
Direct Transfer Trip 900MHz Radio Scheme

3 Spread Spectrum Limitations

900MHz Spread Spectrum is unlicensed:

- Requires line of sight for successful transmission, (e.g. no buildings, hills or large trees in communication path).
- "Point to Point" only with no repeater devices allowed.
- Available “hop” frequencies may be limited by interference from other electromagnetic emissions resulting in degradation of signal over time.
- Radiated antenna power (EIRP) is FCC limited to +36 dBm for the 900 MHz ISM band.

4 Procedures for Installing Spread Spectrum Scheme

4.1 Feasibility

1. PERFORM a path study to determine the viability of the communication path.
   a. A path analysis report must be provided by Product Specialist to provide predicted levels of performance. The analysis takes into account the terrain profile and certain RF factors that could potentially affect the path. Ideally, the path study should show at least 60% of the first Fresnel zone being clear of all obstacles.

2. A field survey must be performed 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 rack mount with encryption, MM fiber and ST connectors: 30310R233XX
      (2) 125/230 volt AC/DC rack mount with encryption, MM fiber and ST connectors: 30310R433XX
   b. Two SEL-2411 I/O modules; (must have ring terminations, as compression terminations are not allowed). Select from the following based on DC power supply requirements:
      (1) 125 VDC/VAC rack mount, 4 digital I/O, Single 10/100 base Ethernet, fiber multimode ST: 241101A1A0X0X0X1130;
Direct Transfer Trip 900MHz Radio Scheme

(2) 48 VDC/VAC rack mount, 4 digital I/O, Single 10/100 base Ethernet, fiber multimode ST: 241102C1C0X0X0X1130;

(3) 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 dB @ 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: A hoisting grip to assist with installation of coaxial cable and to provide appropriate vertical support (Andrew part number L4SGRIP or equivalent). Grounding kits (Andrew part number SGL4-0681 or equivalent) to be installed outdoors on tower with cold shrink weatherproofing. Coaxial cable support hardware will be dependent on the type of support structure (e.g., steel lattice angle-iron, round pipe member, etc.).

d. Antenna mounting tower (depends upon 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 Polyphasor IS-B50LN-C2 or equivalent.

g. Copper Ground Bus Bar with insulated standoffs such as CPI 10622-10 or equivalent.

h. Multi-mode 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. 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. Hi-gain Yagi antennas are extremely directional. Ensure antennas are correctly aligned with the flashed path.

3. Minimize the length of Heliax or LMR400 cabling and the use of connectors and adapters in the RF circuit in order to minimize losses.

4.4 Installing the Radio Devices

1. General Info: 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.

2. In special cases where the path study indicates signal strength is very marginal, it may be required to mount the radio separate from the SEL 2411 in order to keep the antenna cable length to an absolute minimum. 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. 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. REPEAT same action of 4.4.3

4.5 Wiring the Device Connections

1. Master Location—Appendix 1 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).
Direct Transfer Trip 900MHz Radio Scheme

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

d. Remote Location—see Appendix 2

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

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

e. Transfer trip received

f. transfer trip confirmed

g. Local SEL-2411 trouble alarm

h. Remote trouble alarms

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

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

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 upon installed length and number of adapters used. 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 dB. An RSSI of -82 dB will provide a +15 dBm fade margin.

2. Initially (by default), a SEL-3031 uses channels 1 through 10 (of the 16 channels available).
Direct Transfer Trip 900MHz Radio Scheme

a. POWER UP the radio in service for at least 15 minutes, and CHECK each channel’s availability. Ideally it will be above 98 percent.

b. If any channel is below 98 percent, it indicates interference on that frequency. Add this channel to the “skip list” and try the next available channel (channel 11 through 16). Select the ten channels that on average provide the highest available percent availability.

NOTE

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

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

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. Also 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, then no additional maintenance is required. Any value above 90 percent should ensure that a DTT will have a 99.99 percent chance of being successfully sent within 26 milliseconds.

2. On an annual basis, visually check antennas and cabling for any damage. Log on to each SEL-3031 and check RSSI and channel availability.

   a. If no significant changes and no report of problems, then no additional maintenance is required.

   b. If there are significant changes or report of problems, further corrections need to be made.
5 Operation Functions

5.1 The DTT scheme has several indications and a Trip test feature.
5.2 Substation Transmitting Station

1. Indications:
   a. Trip Sent – Trip was initiated from the substation.
   b. Trip 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. Gen CB CLO – Generation breaker closed
   f. GEN RCO C/I – Generation side DTT cutin.

2. Control:
   a. Test Mode - Push to place in test mode allows for trip to be sent from the transmitting station.
b. Send Trip – Push in conjunction with test Mode push button to send trip to generation site. (Ensure generation is off line or generation site RCO is cutout-out prior to send trip).

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.

(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:

The “Trip Sent” and Trip RDV” LEDS are latched. After a trip event, the “Target Reset” pushbutton needs to be pushed to clear the trip LEDS.

(1) Substation

- Trip Sent – ON
- Trip RCV – ON
- Comm Alarm - Off
- Test Mode – Off
Direct Transfer Trip 900MHz Radio Scheme

- Gen CB Open – ON Generation breaker open
- GEN RCO C/O – Off Generation side DTT cut-in.

(2) 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 cutin.

c. Abnormal Conditions

For SEL 3031 or SEL 2411 equipment issues communications will be interrupted and most cases, which will bring in the “Comm Alarm” LED. If this alarm is received ISTS should be contacted and steps taken to address the loss of DTT for the generation application.

6 Definitions

**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.

**EIRP** - Equivalent Isotropically Radiated Power – maximum directional signal strength as compared to an isotropically radiated signal (with equal signal strength in all directions).

**I/O** - Inputs and Outputs

**RF** - Radio Frequency

**RSSI** - Received Signal Strength Indicator

**SEL** - Schweitzer Engineering Laboratories

**SEL-3031** - Spread Spectrum Radio equipment manufactured by SEL

**SEL-2411** - Remote I/O module manufactured by SEL

**SOE** - Sequence of Events
Direct Transfer Trip 900MHz Radio Scheme

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

**DOCUMENT APPROVER**

Jonathan Sykes, Sr. Manager, System Protection

**DOCUMENT CONTACT**

Mike Jensen, System Protection

Thomas Kruckewitt, ISTS Telecommunications

**INCLUSION PLAN**

The information in this bulletin will be incorporated into the next update of the Transmission Interconnection Handbook (TIH), once the design standards are completed, in support of project design and construction.
Direct Transfer Trip 900MHz Radio Scheme

APPENDIX 1 -- TRANSMITTER WIRING DIAGRAM

Transmit Station

<table>
<thead>
<tr>
<th>IN 101</th>
<th>OUT 304</th>
<th>OUT 301</th>
<th>OUT 302</th>
<th>OUT 303</th>
<th>OUT 102</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trip (TM81)</td>
<td>C07</td>
<td>C01</td>
<td>C03</td>
<td>C05</td>
<td>A05</td>
</tr>
<tr>
<td>Trip RCV (TM82)</td>
<td>C08</td>
<td>C02</td>
<td>C04</td>
<td>C06</td>
<td>A06</td>
</tr>
<tr>
<td>CH FAIL (RBADB)</td>
<td>A07</td>
<td>OUT 103</td>
<td>RLY FAIL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEV FAIL (ISV7T)</td>
<td>OUT 103</td>
<td>RLY FAIL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GEN RCO STATUS (RMB3)</td>
<td>OUT 103</td>
<td>RLY FAIL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRIP RCV (RMB4)</td>
<td>OUT 103</td>
<td>RLY FAIL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GEN CB STATUS (RMB5)</td>
<td>OUT 103</td>
<td>RLY FAIL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GEN SEL DEVICE FAIL (RMB6)</td>
<td>OUT 103</td>
<td>RLY FAIL</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fiber Connection

Spread Spectrum 900Mhz Signal

SCADA Points to RTU
CH Fail/Relay Fail to Annuc.
APPENDIX 2 – RECEIVER WIRING DIAGRAM

Receive Station I/O Table

<table>
<thead>
<tr>
<th>IN 301</th>
<th>GEN RCO STATUS (TMB3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN 302</td>
<td>TRIP RCV (TMB4)</td>
</tr>
<tr>
<td>IN 303</td>
<td>GEN CB STATUS (TMB5)</td>
</tr>
<tr>
<td>IN 304</td>
<td>Spare</td>
</tr>
<tr>
<td>IN 101</td>
<td>GEN SEL 3031 DEV/CH FAIL (TMB7)</td>
</tr>
<tr>
<td>OUT 101</td>
<td>Trip (RMB1)</td>
</tr>
<tr>
<td>OUT 102</td>
<td>Trip RCV (RMB2)</td>
</tr>
<tr>
<td>OUT 103</td>
<td>DEV CH/RLY FAIL (ISV07T)</td>
</tr>
</tbody>
</table>
APPENDIX 3 – RF CHANNEL CONNECTIONS FOR DTT