CHAPTER 3

CONTROL AND RECEIVING UNIT (CRU)

The substation is the entry point for TWACS communications over the electrical system to and from the meters. It is essential for utility personnel to understand the TWACS substation configuration and architecture in order to install, support, and maintain substation configurations.

<table>
<thead>
<tr>
<th>Personnel</th>
<th>Required</th>
<th>Elective</th>
</tr>
</thead>
<tbody>
<tr>
<td>TNS Operator</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>TWACS Project Manager</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Customer Service Representative Manager</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Billing Personnel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substation and Transmission Engineer</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Meter Technician</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Customer Engineer</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

This chapter overviews the Control and Receiving Unit (CRU).
SCE Component Review

The substation is the point at which the TWACS system interfaces with the electrical distribution system for automatic meter reading (AMR). The utility installs various components at the substation to equip the substation for TWACS AMR.

The following table defines the components and function of the components in the substation.

<table>
<thead>
<tr>
<th>Component Acronym</th>
<th>Component Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRU</td>
<td>Control and Receiving Unit</td>
<td>Responsible for handling communications between TNS and the other substation components.</td>
</tr>
<tr>
<td>OMU</td>
<td>Outbound Modulation Unit</td>
<td>Responsible for outbound communications to the meter.</td>
</tr>
<tr>
<td>MTU</td>
<td>Modulation Transformer Unit</td>
<td>Assists with outbound communications by stepping down voltage for the OMU.</td>
</tr>
<tr>
<td>IPU</td>
<td>Inbound Pickup Unit</td>
<td>Responsible for picking up signals sent from the meters and passing those signals to the CRU components for interpretation.</td>
</tr>
</tbody>
</table>
CRU Overview

The Control and Receiving Unit (CRU) is the heart of communications control at the substation. The CRU controls the communications interface to TNS and the communications interface to components that interact with the meter.

NOTE

An outdoor CRU is shown above. For all CRU variations see the SCE Interconnection guide (Y10246TM). The CRU is shown with IPU termination panels. Other variations of IPU termination panels exist. See the SCE Interconnection guide. The Distribution Panel Assembly (DPA) is located behind the modem assembly and therefore cannot be seen in the picture.

CRU Options

There are three options available for the CRU depending on the requirements of the utility for indoor or outdoor use and space requirements.

<table>
<thead>
<tr>
<th>CRU Option</th>
<th>Can be used for</th>
<th>Available Options</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Outdoor Use</td>
<td>Indoor Use</td>
</tr>
<tr>
<td>Short Outdoor</td>
<td></td>
<td>Fan</td>
</tr>
<tr>
<td>Short Indoor</td>
<td></td>
<td>A/C Heater</td>
</tr>
<tr>
<td>Tall Indoor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

WARNING

Use appropriate electrostatic discharge precautions (wrist strap and ground cord) when handling contents of CRU.

The CRU can be divided into three sections or areas:

- Distribution panel assembly (DPA)
- Modem assembly (MDA)
- Card cage assembly (CCA)
Distribution Panel Assembly (DPA)

The distribution panel assembly (DPA) provides power from the electrical system to the CRU and related peripherals. The DPA contains a surge protected 120VAC power outlet to power the CRU and modem and 120VAC convenience outlet for AC and heater.

The distribution panel assembly has a terminal block for receiving 120 VAC with a line surge suppressor for the voltage. This voltage is fed from somewhere inside the substation. Disconnects are provided on the front side of the panel in the form of AC plug-in socket receptacles. The AC surge suppressor contains one fuse (MDL 7.5) inside the suppressor housing. A green LED on the outside of the housing indicates that the unit is functioning properly. If the LED is off, the unit is NOT providing surge protection, and should be examined.

**WARNING**    Remove all power to surge suppressor before examining or replacing surge suppressor fuses.

**NOTE**    Distribution Panel Assembly shown above is 120 VAC. For a CRU requiring DC voltage please contact DCSI for proper documentation.
**48/125 VDC DPA General**

DCSI can provide a 48/125 VDC DPA for utilities requiring DC power.

**NOTE**  The telco surge suppressor is located on the DC distribution panel as shown. With the AC distribution panel, the telco surge suppressor is located on the modem rack.

The 120 VAC outlet is a convenience for devices such as the modem or other communications device.

**48/125 VDC DPA Fuses, Indicators, and Surge Suppressors**

The following illustration denotes locations of fuses, indicators, and surge suppressors on the DPA.
Modem Assembly (MDA)

The modem assembly (MDA) provides a convenient mounting place for the communications equipment linking the CRU to the Master Station (MS) or Communications Server. The communications equipment plugs into a 25 pin (DB-25) ribbon cable (called the "back" port) on the backplane of the CCA SCPA card in the card cage assembly. The communications equipment may be an asynchronous modem, terminal server, frame relay access device (FRAD) or other asynchronous communications device.

The power connection from the communications equipment plugs in to the distribution panel assembly (DPA) receptacle marked "Power Supply" and is protected by the AC surge protector on the DPA.
Card Cage Assembly (CCA)

The CRU card cage assembly (CCA) contains several cards that perform various functions relating to inbound and outbound communications with the meter and communications with TNS.

**WARNING**

Use appropriate electrostatic discharge precautions (wrist strap and ground cord) when handling contents of CRU

The Card Cage Assembly holds the power supply and controls logic boards for the CRU. The card cage back plane is split into J1 and J2 back planes. Logic boards communicate to each other over the J1 back plane, while inbound electrical signals are brought into the J2 back plane.
The following table lists the CRU cards and the functions each card performs.

<table>
<thead>
<tr>
<th>CRU Card</th>
<th>Component Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPSA</td>
<td>CRU Power Supply Assembly</td>
<td>Power supply for the CCA.</td>
</tr>
<tr>
<td>SCPA</td>
<td>Substation Control Processor Assembly</td>
<td>Interfaces with TNS over a telecommunications link and also interfaces with other CRU components over the CRU backplane.</td>
</tr>
<tr>
<td>OFIA</td>
<td>OMU Fiber-Optics Interface Assembly</td>
<td>Interfaces via fiber optics with the Outbound Modulation Unit for outbound communications.</td>
</tr>
<tr>
<td>CRPA</td>
<td>Correlation Receiver Processor Assembly</td>
<td>Works in conjunction with the CRMA to process inbound information from the IPUs.</td>
</tr>
<tr>
<td>CRMA</td>
<td>Correlation Receiver Multiplexer &amp; Analog Assembly</td>
<td>Transfers the analog inbound signals over copper connections from the IPU to the CRPA. Responsible for digitizing the analog signal from the meter.</td>
</tr>
</tbody>
</table>
CCA Module Detail

The CRU Card Cage Assembly (CCA) contains several modules to handle communications at the substation. This section covers each module in detail.

CRU Power Supply Assembly (CPSA)

The CPSA steps the voltage input, AC/DC service voltage from the DPA down to a regulated +5 VDC that feeds all of the boards in the card cage. (Other voltages used by the boards are developed from the common +5 VDC, when needed.)

The CPSA occupies the left two slots of the card cage. The power connection from the CPSA plugs in to the distribution panel assembly (DPA) receptacle marked "Power Supply" and is protected by the AC surge protector on the DPA. The CPSA board is protected by a Bushman type MDA4 fuse (4 Amps, 250 V), located at position F1, and a Bussman type BK/PCE-5 (5 Amp, 125 VAC, 250 VDC) socket fuse at position F2. (The socket fuse looks like a capacitor, except it is stamped 5A on top.)

**WARNING**

The ON/OFF switch on the CPSA switches the +5 VDC to the card cage logic boards only; it does NOT isolate the AC/DC input voltage from the CPSA. Unplug the CPSA power cord from the DPA before removing or inspecting the CPSA and/or fuses.
Substation Control Processor Assembly (SCPA)

Substation Control Processor Assembly (SCPA) is the hardware platform for the CRU firmware. The firmware running on the SCPA is divided into two functions: the Substation Control Function (SCF) and the TWACS Communication Function (TCF).

Substation Control Function

The Substation Control Function (SCF) program running on the SCPA communicates with the Master Station, directs the overall operation of the SCE, and maintains equipment and status tables. The SCF communicates with the TCF portion of the program to direct the overall operation of the SCE. It also maintains several files and logs for historical review of past events.

TWACS Communication Function

The TWACS Communication Function (TCF) functional division controls TWACS communications. It receives direction from and reports results and/or status to the SCF portion of the program. The TCF communicates with Outbound Modulation Units (OMUs) to transmit outbound TWACS messages, and with the Inbound Receiver Function (IRF) to receive inbound messages.

The SCPA contains a 68000 or 68010 microprocessor program memory, table memory (256 Kilobytes), data memory (512 Kilobytes), dual port memory (250 Kilobytes), interval timer, four serial communication ports, VMEbus control functions, and a real-time clock. Front panel indicators and controls consist of twelve LEDs, two 16-position rotary switches, and one momentary action toggle switch. Front panel connectors consist of three 9-pin (DB-9) subminiature serial port connectors.

Drop IDs and Substation IDs

The TWACS system uses the Drop ID and Substation ID to uniquely identify substations. The utility configures the DROP ID on the substation hardware by changing the panel dials on the faceplate of the SCPA card in each CRU. TNS uses the Drop ID as a common link to the SCPA card.

<table>
<thead>
<tr>
<th>ID</th>
<th>Defined in TNS</th>
<th>Defined in SCE</th>
<th>SCE Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drop ID</td>
<td>Yes</td>
<td>Yes</td>
<td>SCPA front panel dials</td>
</tr>
<tr>
<td>Substation ID</td>
<td>Yes</td>
<td>No</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

The utility uses the SUBSTATION ID with the DROP ID to guarantee a substation's uniqueness in SCE identification across the utility's TWACS network.
Facts about Drop IDs and Substation IDs

The following list will help the participant better understand the difference between the Drop ID and the Substation ID:

- Drop IDs are configured in both the SCPA hardware and TNS.
- The substation does not know its Substation ID.
- The Drop ID in TNS must match the SCPA dial pad.
- The SCPA dial pad Drop ID is in hexadecimal.
- The TNS Drop ID is in decimal, and the TNS Operator must convert the dial pad hex number to decimal for TNS entry.
- If the Drop ID does not match the dial pad, the substation will not communicate with TNS.
- The Drop ID can be from 1 to 254 (hex 01-FE), but TNS does not verify the Drop ID field is within the valid range.
- The Drop ID must be unique within each Communication Server.
- The TNS Operator can assign the same Drop ID used to identify a substation on one Communication Server, to a substation residing on another Communication Server, provided the Substation ID is different on the two substations.
- The Substation ID can be from 1 to 999.
- The TNS Operator can change the Substation ID to whatever the TNS Operator desires without impacting communications with the substation.
- If possible, the utility should keep the Drop ID and the Substation ID the same.

SCPA Front Panel Indicators:

**RUN:** The top LED indicator is the RUN LED. It is toggled by the operating software as it progresses through the normal program cycle. Its normal appearance is to blink in a random manner.

**COM:** The second LED from the top is the communications LED. It indicates activity on the Master Station communications port. It should be noted that with the synchronous protocol used by the CRU, this LED will normally be blinking at a high rate even when there are no messages being sent or received. This is due to the fact that there is always a clock signal on the transmit and receive data lines. This gives the appearance that the LED is always on. If the LED is observed closely, messages are discernible and
appear as a short duration blinking of the LED that otherwise appears to be constantly on.

**STATUS**: Immediately below the communications LED is a group of eight LED's used by the software to indicate various status conditions of interest. These LEDs are used mostly during software development.

**FAIL**: This LED, located just below the Drop ID switches, indicates a failure of the SCPA board to pass one or more of its self-test diagnostics. When this LED is on, the system Fail LED will also be on. This is the normal condition at power-up, or at any other time the system has been reset for any reason. After all self-tests have passed, this LED will be turned off.

**SYS FAIL**: The System Fail LED, located just below the Fail LED, is turned on any time one of the boards in VMEbus card cage is indicating a failure to the system controller board (SCPA). If this LED is on, an examination of the boards in the card cage will reveal one or more boards that have their Fail LED turned on. This is the normal condition at power-up or at any other time the system has been reset for any reason. This condition will generally remain until all boards have passed self-diagnostics, at which time all boards should have turned off their individual fail LEDs and the system fail LED should also be turned off.

**Front Panel Controls:**

**DROP ID (MSD and LSD)**: Two 16-position rotary switches are used to set the Drop ID of the CRU. They are set to the hexadecimal representation of the Drop ID and may be set to any combination from 01 to FE (1 to 254 decimal), with the upper switch being the most significant digit (MSD) and the lower switch being the least significant digit (LSD). Appendix C of the SCE Start-up Manual (Y10251TM) shows a decimal to hexadecimal conversion chart. All substations must have a unique Drop ID.

**NOTE** If the Drop ID is changed at these switches while the system is running, the CRU must undergo a cold restart before the new ID will be recognized. Such a restart should be performed by turning the CPSA OFF and then ON.

**RESET**: A momentary action toggle switch that is used to manually reset the CRU logic. This should only be done when there is a perceived problem in the CRU logic. The SCPA reset should only be used when the substation is offline in TNS. The action of this switch is enabled by the presence of a shorting jumper between pins A2-B2 of Jumper Block JB14.

**NOTE** When the SCPA reset is performed, all memory in the SCPA is lost. If the SCPA reset is performed when the substation is online and transmitting information, errors will likely occur in TNS that will cause data loss.
Front Panel Connectors:

**SYNC (J1):** Allows communication with a Substation Test Set (STS). See Appendix E of the SCE Start-up Manual (Y10251TM) for STS information.

**ASYNC1 (J2):** Allows communication with a monitor device.

**ASYNC2 (J3):** A spare synchronous communications port. It is not currently used for any CRU function.

Normally the CRU communicates with the Master Station through the modem connection coming into the SCPA through a connector on the VME bus J2 backplane. When an STS is connected to the SCPA front panel port, Connector J1, the program senses the connection and will automatically switch communications to the STS port. When the STS cable is removed, the CRU must undergo a cold restart for communications to switch back to the modem port. Such a restart can be performed by toggling the reset toggle switch or by turning off the CPSA.
**Correlation Receiver Processor Assembly (CRPA)**

The CRPA applies digital signal processing techniques to the inbound TWACS signal. This technology provides advanced signal acquisition capability and adaptability. The CRPA is a master/servant device that resides on the VMEbus. It receives commands from, and responds to, the SCPA. It controls a Correlation Receiver Multiplexer Assembly (CRMA) assigned to it by the SCPA TCF logic, and acquires TWACS inbound messages to support the CRU function.

The CRPA contains a 32-bit DSP processor (TMS320C30), high speed static RAM program memory (72k x 31 bits), standard EPROM program memory (64k x 32 bits), EEPROM data memory (128k 16 bits), dual-port memory (128k x 16 bits), 2 standard serial communications ports, 2 high-speed serial communications ports, an interval timer, and customized interrupt capabilities that uniquely support its role in the Inbound Receiver Function (IRF).

Front panel indicators consist of 14 LEDs. Front panel controls consist of 1 reset toggle switch. Front panel connectors consist of 3 (DB-9) subminiature connectors.

The firmware program running on the CRPA is the Inbound Receiver Function (IRF).

**Front Panel Indicators**

**RUN:** Green LED indicates that the CRPA processor is functioning. It will normally blink at a rate of about 1 Hz. During inbound acquisition the blink rate is reduced to approximately 0.2 Hz.

**FAIL:** Red LED (normally off) indicates that a fatal error condition was detected during inbound communication, which caused inbound detection to be aborted. Conditions which can cause this LED to illuminate include:

- Zero-cross failure
- End of Message failure
- A/D hardware failure

**FP ERROR:** Red LED (normally off) Indicates that a non fatal error condition was detected during inbound. Currently, the only condition which can cause this indicator to turn on is a zero cross error.

**XMIT:** Red LED (normally off) Begins blinking immediately after the receiver has received the setup for inbound command. Continues blinking until the OMU has completed signaling outbound.
**RCV**: Yellow LED (normally off) Begins blinking as soon as outbound is complete. Continues blinking until inbound is complete.

**STATUS/ZCSEL**: This row of eight green LEDs is used for different purposes at different times:

CRMA Select: When the CRPA is first set up for inbound, one STATUS/ZCSEL LED will be ON to indicate which CRMA has been selected (e.g. 1 through 4).

Inbound Signal Strength: After outbound is complete, the inbound strength for one inbound channel will be displayed using the STATUS/ZCDEL LEDs. The signal strength is displayed in a logarithmic scale. Normally, when inbound communication is occurring, six or seven LEDs will be ON indicating that the inbound signal strength is greater than 400. If the RCE is not responding, only two or three LEDs will be ON, indicating signal strength of less than 30.

RCE Response Status: At the completion of an inbound acquisition, the STATUS/ZCDEL LEDs will indicate the RCE response status for one of the inbound channels. The number of LEDs ON indicates the quality of the inbound. All eight LEDs ON indicates that the inbound was very clean. Only one LED ON indicates that the inbound signal was very noisy and that the receiver was barely able to decode it.

<table>
<thead>
<tr>
<th>STATUS/ZCSEL LEDs</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;3</td>
<td>&gt;8</td>
<td>&gt;20</td>
<td>&gt;54</td>
<td>&gt;148</td>
<td>&gt;403</td>
<td>&gt;1096</td>
<td>&gt;2980</td>
<td></td>
</tr>
</tbody>
</table>

**Front Panel Controls**

**RST**: The manual reset switch is located near the top of the CRPA front panel. This switch is usually disabled in the standard CRU configuration.
**Front Panel Connectors**

- **J1 DCE**: Serial Communications Port Connector

- **J2 DTE**: Serial Communications Port Connector

- **J3 HS Port**: High Speed Serial Communications Port Connector

  These connectors have no user application. They are there for future application and engineering aids only.

**Power Up Diagnostics**

When the utility initially powers up the CRPA, the LEDs are used to indicate the identification number of the self diagnostic test being performed.
Correlation Receiver Multiplexer and Analog Assembly (CRMA)

The CRMA operates under the control of the CRPA board, with its Inbound Receiver Function (IRF) firmware. The CRMA receives control signals from the CRPA and returns response data. There may be 1 to 4 CRMAs in the card cage. Four CRMAs will accommodate 128 IPU input circuits.

The CRMA is a dual function board. It is a multiplexer for the Inbound Pickup Units (IPUs) and does the analog-to-digital (A/D) conversions for inbound signal detection.

The multiplexer function is controlled from the CRPA. Each CRMA has an input capacity of 32 differential input pairs. Each pair of wires represents an IPU input. When an input signal path is selected, only that IPU pair is connected to the A/D converter. The A/D converter is controlled from the CRPA. At the proper time, after the OMU sends its "End of Message" signifying that outbound signaling is complete, the CRPA instructs the CRMA to do A/D conversions on the input voltage signal from the IPU. It is from this digitized data that the inbound responses are decoded.

The cabinet temperature sensor is located on the CRMA board.

The CRMA board is powered from the +5 VDC furnished by the CPSA. To operate the A/D converter the CRMA generates 5 VDC, +15 VDC, and -15 VDC on the board itself.

Front Panel Indicators

RX: This green LED (normally off) will blink when the CRMA is acquiring inbound data.

FAIL: This red LED (normally off) illuminates when a VMEbus error has been detected.

SER I/O: These four green LEDs indicate which CRPA (1 of 4) has control of the board.

ANALOG PWR: These red LEDs are analog power indicators. The LEDs indicate that +5 VDC, 5 VDC, +15 VDC, 15 VDC are present. They do not, however, indicate whether the voltage is or is not correct. The Substation Engineer must use the voltage test points to measure the voltage.

Voltage Test Points

The +15 VDC test point, Analog Ground test point and 15 VDC test point are used to measure voltage. These voltages are not adjustable.
OMU Fiber Optics Interface Assembly (OFIA)

The OFIA is a multiplexer board for communicating with the OMUs. The OFIA receives and transmits messages from the OMUs by fiber optic links connected to the front edge of the board. Each OMU communications link on the board has a Transmit, Receive, and Zc fiber optics port for communicating to an OMU:

- The Transmit fiber carries information to the OMU.
- The Receive fiber carries information from the OMU.
- The Zc fiber carries zero crossing information and the OMU "End of Message" signal from the OMU to the TCF function on the SCPA.

The CRU Card Cage can hold up to three OFIA boards, each of which can connect to four OMUs. The total number of OMUs that a CRU can support is twelve.

The OFIA is under the control of the SCPA TCF function logic. OMU selection is made by the SCF logic and sent to the OFIA which enables the correct OMU port.

Front Panel Indicators

Each OMU port has three (3) LED indicators.

**Tx**: The red Tx LED indicates when the CRU is "Transmitting" to the OMU.

**Rx**: The green Rx LED indicates when the CRU is "Receiving" data from the OMU.

**Zc**: The yellow Zc LED indicates zero crossing and the OMU "End of Message" information when data is being sent to the CRU.

During normal operation, the **Tx** and **Rx** LEDs will blink rapidly and the **Zc** LED will appear to be on. The **Tx** and **Rx** LEDs blink because a constant polling occurs between the TCF function logic and the OMU logic. The OFIA reports any change in the OMU status to the CRU. The zero crossings occur rapidly and cause the **Zc** LED to appear to be constantly on.