Using the Agilent X-Series Signal Generator AUX I/O Port

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1.0 Introduction

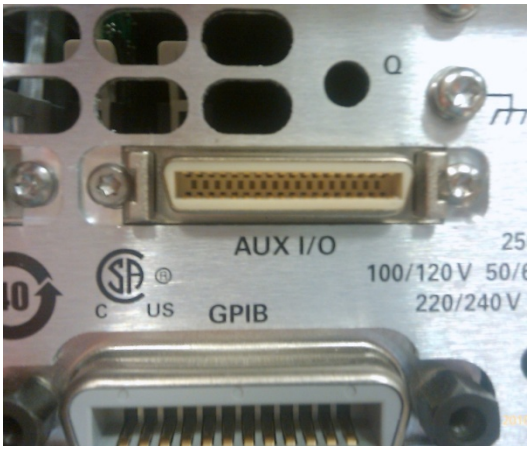
The Agilent X-Series signal generator includes an Auxiliary Input/Output port (AUX I/O) to enable interfacing with external equipment. This port enables the Agilent equipment to send and/or receive supplementary or auxiliary signaling information. This information is non-RF related signaling such as:

- Output Markers from Arbitrary waveform playback sent to external equipment to trigger or respond to waveform changes.
- Output of signals to an external device from real-time generation personalities. Signals such as frame markers, pulse-per-second, even-second, and so on may be supported depending on the signal generation personality (CDMA, 3GPP, GNSS, LTE, etc.).
- Input signals from external devices under test that cause the Agilent equipment to modify characteristics of a signal being generated. These may vary from one signal generation personality to another.
    - Changing output power (power control loop testing)
    - Advancing or delaying timing (timing advance loop testing)
    - HARQ ACK/NAK delivery (HARQ process loop testing)
    - Format specific test triggers such as 3GPP Compressed Mode

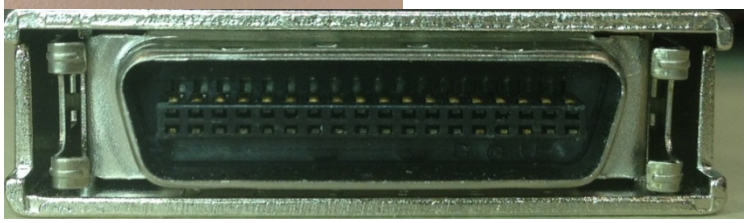
The objective of this document is to provide an overall operation description of auxiliary signaling with X-Series signal generators. The specific functions controllable by auxiliary signaling vary significantly from one real-time signal generation personality to another. These personality and format specific details are described in the documentation for each real-time signal generation personality. Please refer to these additional documents for additional personality and format specific details.

2.0 Physical Connection Details

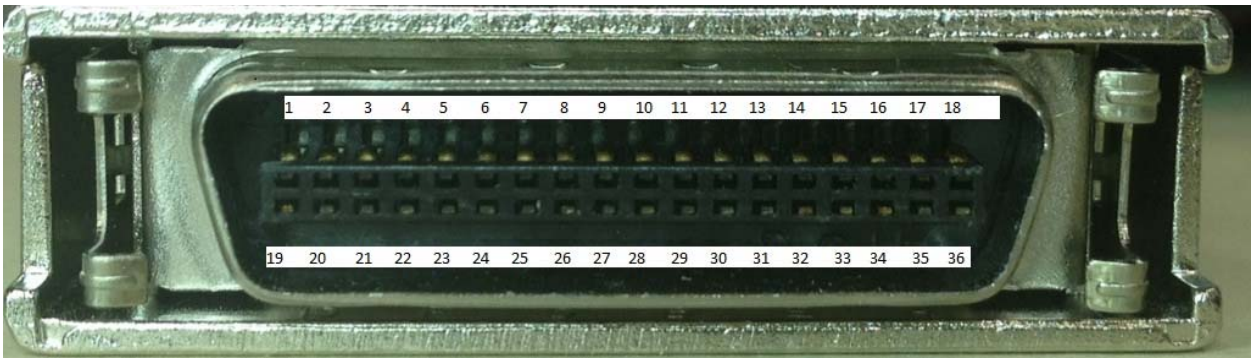
The AUX I/O connector is found on the rear panel of the N5182B instrument, just above the GPIB connector. As shown in the picture below, the port is labeled “AUX I/O”.



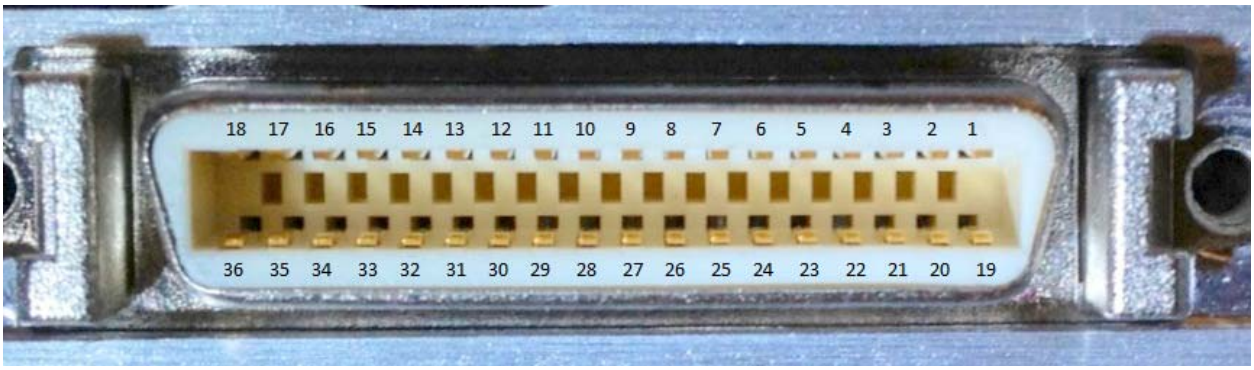
The AUX port for the X-Series signal generator consists of a 36 pin connector: a 3M ® connector, part number N10236-52B2PC.



The mating connector is a 3M ® 10136-3000 wire mount plug (or 3M ® 10136-8000 IDC plug) with a 3M ® 10336 shell.



X-Series AUX I/O Port Physical Pin Assignments
Mating Connector view



X-Series AUX I/O Port Physical Pin Assignments
Rear Panel View

2.1 Connector Pin-outs and Pin Functions

The following table shows the pin definitions for the X-Series signal generator's AUX I/O connector:

Pin #	Pin name	Input Output	Description
1	Marker1	Out	Output marker signal 1 from ARB or Real Time generation, 3.3V
2	Marker2	Out	Output marker signal 2 from ARB or Real Time generation, 3.3V
3	Marker3	Out	Output marker signal 3 from ARB or Real Time generation, 3.3V
4	Marker4	Out	Output marker signal 4 from ARB or Real Time generation, 3.3V
5	User clock	Out	Output clock signal from custom real-time mode
6	AUX strobe	In	AUX I/O VALID signal supplied by external equipment. Can be configured for positive or negative edge
7	10MHz clock	Out	10 MHz reference clock output
8	AUX0	In	AUX Input signal, binary signal, 3.3V
9	AUX1	In	AUX Input signal, binary signal, 3.3V
10	AUX2	In	AUX Input signal, binary signal, 3.3V
11	AUX3	In	AUX Input signal, binary signal, 3.3V
12	AUX4	In	AUX Input signal, binary signal, 3.3V
13	AUX5	In	AUX Input signal, binary signal, 3.3V
14	AUX6	In	AUX Input signal, binary signal, 3.3V
15	AUX7	In	AUX Input signal, binary signal, 3.3V
16	AUX8	In	AUX Input signal, binary signal, 3.3V
17	AUX9	In	AUX Input signal, binary signal, 3.3V
18	AUX10	In	AUX Input signal, binary signal, 3.3V
19	AUX11	In	AUX Input signal, binary signal, 3.3V
20	DCOM/Ground		Ground
21	AUX12	In	AUX Input signal, binary signal, 3.3V
22	DCOM/Ground		Ground
23	AUX13 *custom data in	In *In	AUX Input signal, binary signal, 3.3V
24	DCOM/Ground		Ground
25	AUX14 *custom symbol sync in	In *In	AUX Input signal, binary signal, 3.3V
26	DCOM/Ground		Ground
27	AUX15 *custom burst in	In *In	AUX Input signal, binary signal, 3.3V
28	DCOM/Ground		Ground
29	AUX sample clock *custom data clock in	Out *In	AUX sample clock, 3.3V, indicates AUX0..AUX15 have been sampled
30	DCOM/Ground		Ground
31	*custom event 2	*Out	RT Custom Mode, Custom Event #2 signal
32	DCOM/Ground		Ground
33	*custom data out	*Out	RT Custom Mode, Data Out signal
34	DCOM/Ground		Ground
35	*custom sync out	*Out	RT Custom Mode, Sync Out signal
36	DCOM/Ground		Ground

*these signals are available only in the CUSTOM RT mode of the X-Series signal generator
All signals use 3.3V LVTTL signaling

2.2 Voltages and Waveforms

The Auxiliary I/O port supports standard 3.3 volt TTL signaling levels. The signals are diode protected against some weak under voltage and over voltage conditions. Signals support data rates up to 50 MHz with minimum rise and fall times of 3 ns.

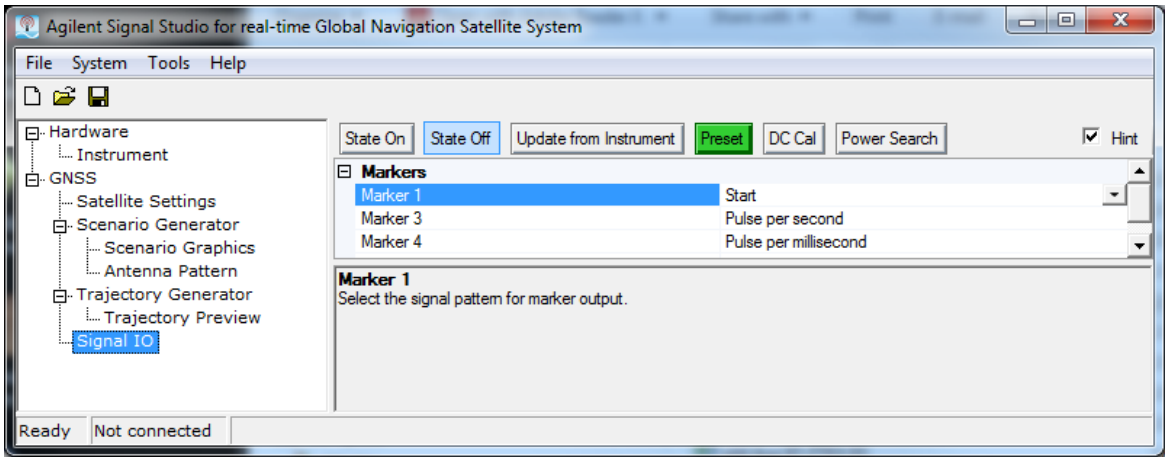
2.3 Signal Descriptions

2.3.1 Output Marker Signals (1..4)

When playing an arbitrary waveform file (MODE: ARB), these output marker signals can be sourced from marker bits placed in the waveform file. You can control the relative placement and width of marker waveforms by placing appropriate markers in the file. Marker routing can be controlled by the instrument to send signals out of the four marker signal outputs on the AUX port. This can be configured using SCPI commands or from the instrument front panel (MODE:ARB).

When playing a real time signal (MODE: Real Time Application), these output marker signals are sourced from the real-time signal generation personality. Each personality will have some selection of signals that can be routed to these output marker signals using SCPI commands or the real-time application Signal Studio control software.

For example, the Signal Studio for real-time Global Navigation Satellite System software (N7609B) has a control node called *Signal IO* that enables the internal signals to be routed to these markers as shown in the following figure:

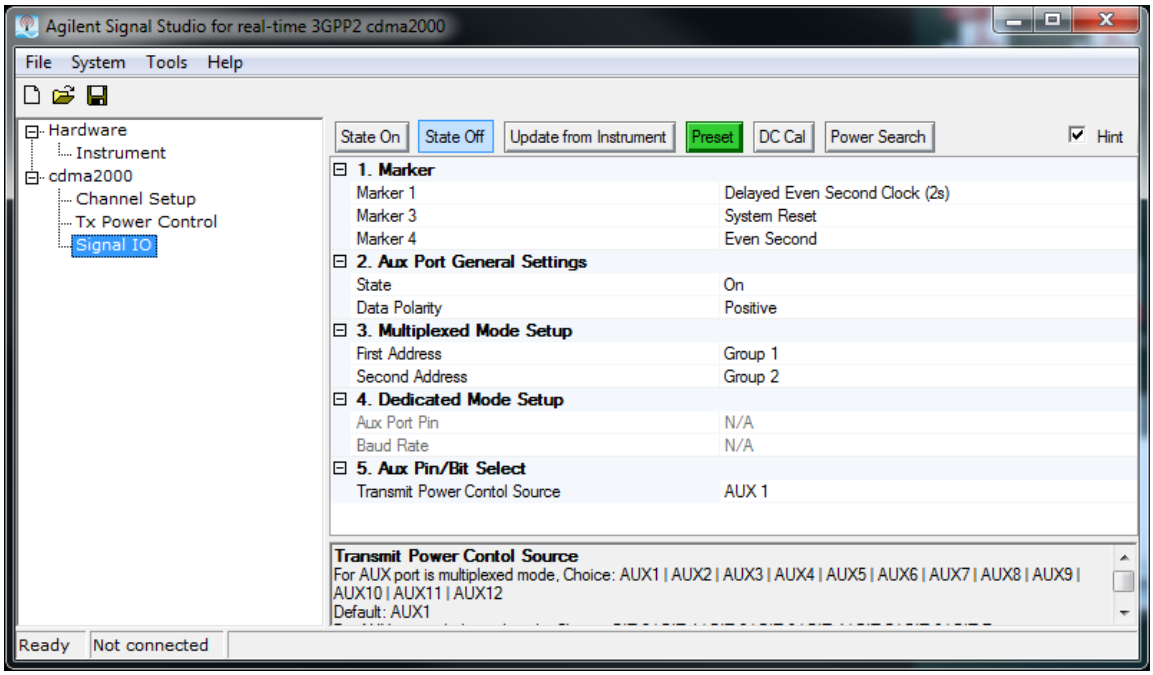


2.3.2 AUX Input Signals

The AUX input signals are used to provide feedback to real time signal generation personalities such as N7601B Signal Studio for real time 3GPP2 CDMA2000 signals.

For the N7601B operation, AUX input signaling can be used to provide power control loop testing. An external signal is connected to the AUX input port and is used to signal a power change for each signal frame.

The AUX input port can be configured under the Signal IO node of the N7601B software as shown in the following figure.



This shows that the AUX I/O port is in *Multiplexed* mode. The key item for this figure is item 5 – Aux Pin/Bit Select. Here you see that the AUX1 pin is selected. This means that the CDMA real time system expects you to supply a power control feedback signal using the AUX1 pin of the AUX I/O connector.

The following describes the AUX port settings shown in the previous figure:

2. Aux Port General Settings

- State: *On* or *Off*. Off means AUX signaling is ignored.
- Data Polarity: *Positive* or *Negative*. Positive means a 3.3 volt signal is interpreted as a '1' and a 0 volt signal is a '0'. Negative selection inverts this so that a 3.3 volt signal is interpreted as '0' and 0 volt signal is interpreted as '1'.

3. Multiplexed Mode Setup

- The AUX port mode can be selected as Multiplexed or Dedicated. In this case, it is selected as Multiplexed.
- For the X-Series, it is not necessary to select any group addresses so these can be left in their default state.

4. Dedicated Mode Setup

- Because the AUX port mode is selected as Multiplexed, these settings are not active and are shown in gray text.
- If Dedicated mode is selected, these fields are used to select the AUX pin and baud rate of the dedicated connection.
- You can switch between AUX port modes Dedicated and Multiplexed by using the Instrument node on the user interface, by using a SCPI command, or by using the instrument front panel.

5. AUX Pin/Bit Select

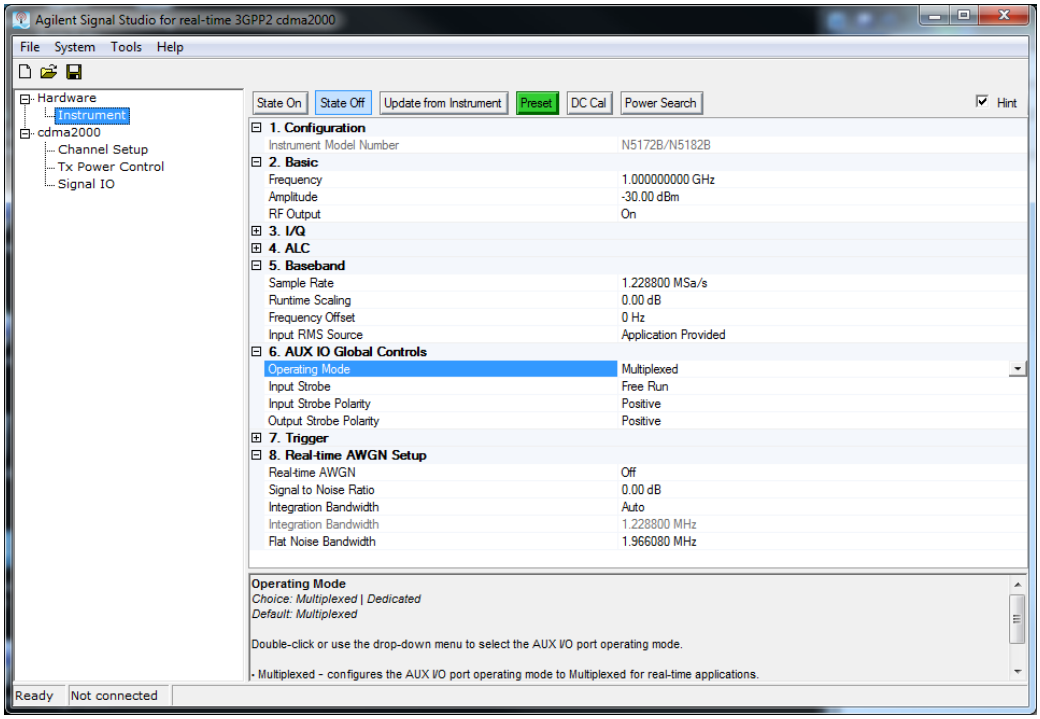
- This enables you to select which AUX pin (AUX0 .. AUX11) will be routed to control the N7601B power control function.

2.3.2.1 Switching AUX Port Modes

The AUX port has a Multiplexed mode and a Dedicated mode. In Multiplexed mode, auxiliary signaling is sent using level-sensitive binary signaling (3.3V LVTTL) connected to one or more AUX port input bits. In Dedicated mode, auxiliary signaling is sent using an RS-232C type serial signal at a specified baud rate to a selected AUX port input bit.

The AUX port mode can be selected on the Instrument node in the user interface, by sending a SCPI command, or by using the instrument front panel.

The following figure shows the AUX port mode selection.



2.3.2.2 AUX IO Global Controls

There are four AUX IO Global controls.

Operating Mode: Select *Multiplexed* or *Dedicated*. These function as previously described.
Input Strobe: Select *Free Run* or *User*. In Free Run mode, the instrument samples the values of the AUX input signals (AUX0..AUX15) according to the instruments internal timing – this happens at about 3.5 MHz. In User mode, you must supply a strobe signal that causes the AUX input signals to be sampled.
Input Strobe Polarity: You can choose *Positive* or *Negative* polarity. With Positive polarity, the AUX input signals are sampled on a rising edge (0V to 3.3V transition) of the pulse you supplied to the AUX strobe (AUX connector pin 6). With Negative polarity, the AUX input signals are sampled on the falling edge of the AUX strobe signal.
Output Strobe Polarity: You can determine when the AUX input signals have been sampled by looking at the AUX sample clock (connector pin 29) signal. If the Output Strobe Polarity is positive, a positive going pulse about 200 ns wide is asserted when the AUX input signals are sampled. If the polarity is negative, the AUX sample clock is a series of negative going pulses about 200 ns wide.

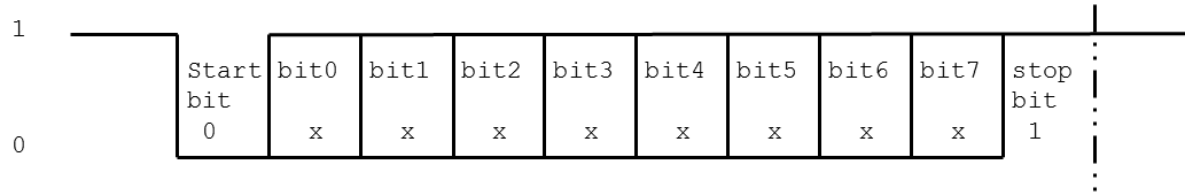
3.0 Operational Modes – AUX Input Signaling

The Auxiliary I/O port is designed to support many different configurations of real-time signal generation personalities running in the X-Series signal generators and to interface with many different configurations of external equipment under test.

For example, consider a configuration where the X-Series is running a CDMA 2000 3GPP2 Uplink signal generation personality. This personality can be configured to accept a power up or power down command from external equipment to enable testing of power control loops in base stations.

Auxiliary signaling can be delivered from external equipment in one of two formats.

- **Multiplexed** –a low-voltage, TTL format: In this case, your equipment generates a binary signal connected to the AUX port in an LV TTL format with 0 volts representing a '0', 3.3 volts representing a '1'.
  If this signal cannot be delivered directly from the external equipment, an inexpensive interface board can be used to connect to external equipment with a USB connection. For example, the USB Bit Whacker (SKU: DEV-00762, www.sparkfun.com) can be used to interface from your external equipment with a USB connection to the AUX I/O port.
- **Dedicated** – a serial format: In this case, your equipment generates a serial-port type connection using an LV TTL RS-232 type protocol. Baud rates from 4800 to 460800 are supported in this format. For this purpose, a device can use any LV TTL line that can generate RS-232 type signals, or some simple USB to RS-232 TTL signaling devices can be used.
  - The serial format is illustrated below. Each signaling transmission consists of an 8 bit character (bits b7 b6 b5 b4 b3 b2 b1 b0, b0 is least-significant bit, b7 is most significant bit). The signaling transmission consists of a start bit '0', followed by the 8 data bits (transmitted LSB first) followed by a stop bit '1'. The bit rate can be one of 4800, 9600, 19200, 38400, 57600, 115200, 230400, or 460800 bits per second.
  - If the polarity is selected as inverted (negative), then the expected signal will be the inverted form (switch '1' and '0' on the left side of the diagram).



Serial Data Transmission Format

Start bit (0), 8 data bits, stop bit (1)

  - If this signal cannot be delivered directly from the external equipment, an inexpensive interface board such as the FT232RL USB to Serial interface board (SKU: BOB-00718, www.sparkfun.com) could be used to interface external equipment with a USB connection to the AUX I/O port.

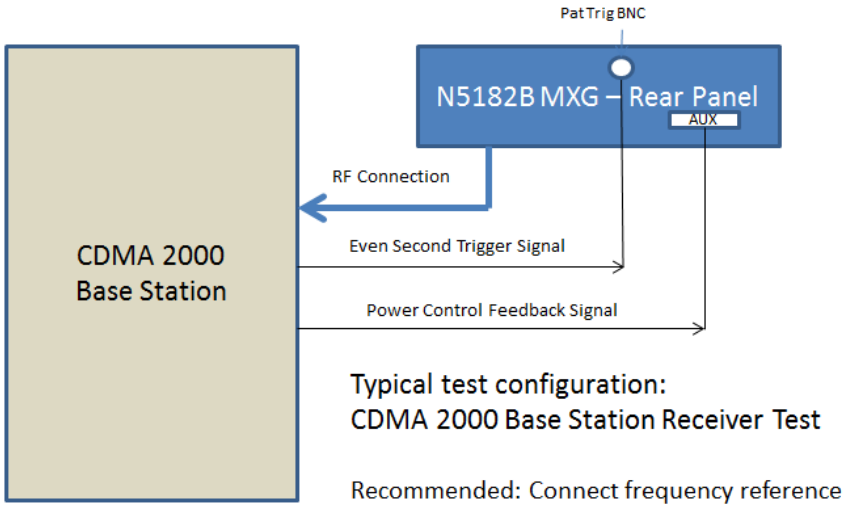
3.1 External Device Signaling Example

Let us again consider the previous CDMA2000 example. In this example, your external equipment must communicate a command to control the X-Series CDMA reverse link transmission power for the next frame. There are two conditions for your equipment to signal –

1. Increase power
2. Decrease power.

The external device must provide a signal each and every frame.

The following diagram shows a typical interconnect diagram with a CDMA2000 base station for making base station receiver tests. In this example, the X-Series RF signal is connected to the input of the base station, an even-second trigger signal is sent from the base station to the X-Series PAT TRIG BNC input (rear panel) (enables X-Series to synchronize its frame timing with the base station), and a power control feedback signal is connected to the AUX port of the X-Series.



In this case, a single binary signal could be used, where a '1' means to increase power and a '0' means to decrease power. Your external equipment would generate an LV TTL signal for each frame. For this configuration, your equipment connection to the X-Series can be as simple as a cable with a single signal wire and a ground connection – for example, connecting the LV TTL signal to pin 8 of the AUX port connector and ground to pin 20.

The signaling format could be selected as Multiplexed or Dedicated over this single line. The X-Series user interface enables selection of the signaling format.

In Multiplexed mode, your external equipment can send a 3.3 volt signal or 0 volt signal each frame to communicate a command to increase or decrease power in the next frame.
In Dedicated mode, your external equipment can send a single character each frame to indicate a command to increase or decrease power in the next frame. You can select any one of the 8 bits of the single character to control the power level in the next frame. In this case, your external equipment would send one serial character each frame.

Note that X-Series AUX pins AUX0 to AUX11 are available for delivering auxiliary commands from 1 to 12 bits in width in Multiplexed mode.

Pins AUX12 to AUX15 are used for addressing in Multiplexed mode. In a typical X-Series example, pins AUX12 to AUX15 are left unconnected. The X-Series reads them as a '1' to indicate an address of 1111 in binary or an address of 15 in decimal. Address 15 (1111) is the default address if AUX12, AUX13, AUX14, and AUX15 are not connected to external signals.

In Dedicated mode, where serial format signaling is used, serial signaling can be connected to any one of the pins AUX0 to AUX11.

3.2 Dedicated Mode

In Dedicated mode, all signaling is delivered in serial format as previously described. Serial command signals can be connected to the AUX0 to AUX11 pins of the AUX I/O connector, and each signal generation unit/group in the generator can be configured to select which AUX pins (AUX0 to AUX11) will be used to receive commands specific to that signal generation unit/group. The serial format transmits 8 bits at a time to the X-Series. These bits can be mapped to auxiliary signaling functions of a real-time signal generation application.

3.3 Multiplexed Mode

In Multiplexed mode, auxiliary commands are delivered as 1 to 12 bit wide commands in LV TTL format. For the X-Series, the recommended configuration is to leave the AUX12 – AUX15 pins unconnected.