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1 Introduction

The 4409 digital audio synchronising delay combines the features of a sample rate synchroniser/converter with preset audio delay in two independent stages.

The delay stage can delay digital audio from 0 up to 31 video frames. Up to four buffered delay outputs are provided.

The synchroniser or SRC stage, provided by the 5288 plug-in module, provides four buffered outputs. The SRC can synchronise non-synchronous digital audio when locked to an AES11 reference. It will also sample rate convert from any valid digital audio signal in the range 32kHz to 54kHz to the output sample clock rate set by the external reference.

The 5288 module also features an on-board gain control, remote fader option and a programmable automatic fade facility. Audio modify features include channel swap, either channel to both output channels and digital silence.

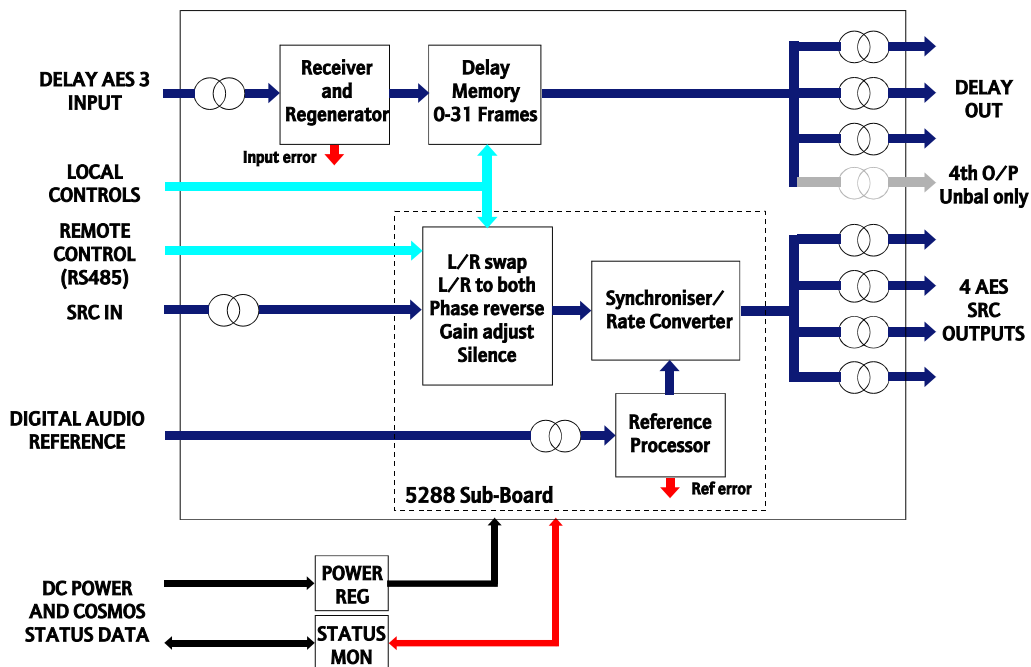
Remote control of gain and fader response is available through a dedicated RS485 serial port. This is not available through the Pro-Bel COSMOS status monitoring system.

If both delay and sample rate conversion or audio modify features are required, one of the delay outputs can be connected to the SRC stage.

The 4409 may be used in the 1050 3U and 1051 1U ICON modular product rackframes with a choice of balanced or unbalanced rear connectors.

Characteristics of the 4409 are:

- four audio modify/synchronised outputs
- up to four regenerated and delayed outputs
- balanced (AES3) and unbalanced (AES3- id) inputs
- AES11 reference input
- variable preset delay from 0 to 31 video frames
- sample rate conversion from 32 to 54Khz to AES reference sample rate
- gain control 0dB to -12dB
- jumper selectable audio modify facilities (L-both, R-both, L/R swap and digital silence)
- RS485 serial control (four wire and two wire) of gain and fader response
- automatic fade to or from silence in 0,1,2,4 or 8 seconds under serial control
- compatible with Pro-Bel COSMOS status monitoring

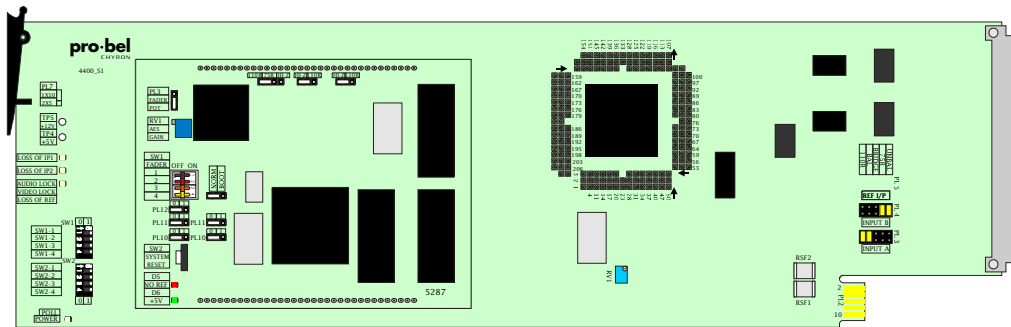


The 4409 digital audio synchronising delay

NOTE: One DELAY output can be connected to the SRC input when both delay and sample rate conversion or audio modify is required.

2 Installation

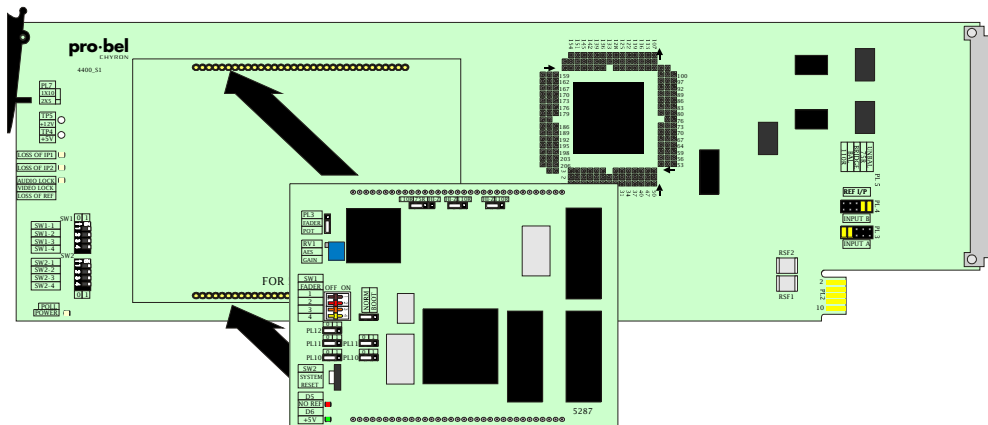
The 4409 digital audio synchronising delay fits in the 1050 3U and 1051 1U ICON modular product rackframes. It is used with either the K4409-2B 20mm rear panel for balanced digital audio I/O or the K4409-3U 30mm rear panel for unbalanced digital audio I/O.



The 4409 digital audio synchronising delay with the 5288 sub-module

The 4409 is supplied with the 5288 sub-module fitted at the factory. In the unlikely event that the sub-module needs to be removed and refitted proceed as follows:

- ease the sub-module out of its header sockets using gentle leverage under the top and bottom connectors
- refit by gently pushing the connectors into the PCB headers
- observe the correct sub-module orientation as shown

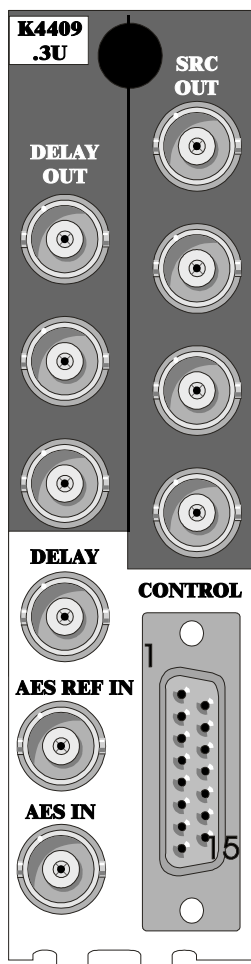


Re-fitting the 5288 sub-module

For module and rear connector installation please refer to the appropriate ICON rackframe section of the manual.

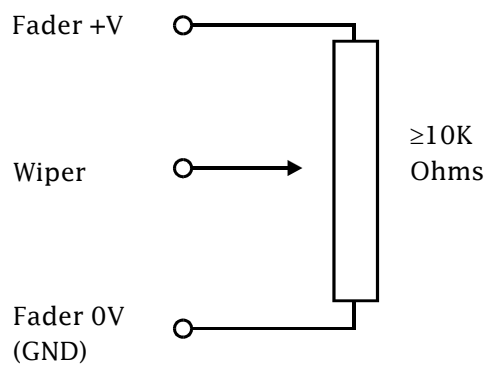
2.1 Signal I/O

The K4409-3U panel is equipped with BNC connectors for unbalanced digital audio, whilst the K4409-2B panel is equipped with a 25 way 'D' type connector for balanced digital audio. Both panels have a 15 way 'D' connector for control and AES reference input. Only three DELAY outputs are available when using the K4409-3U rear connector.



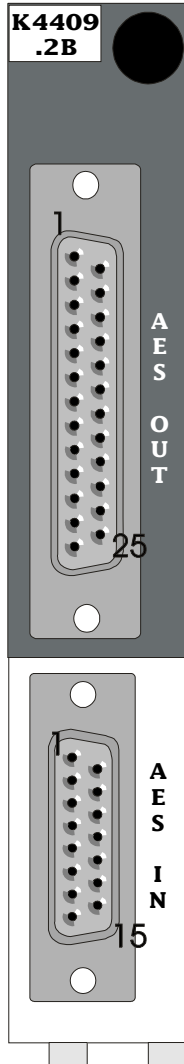
The K4409-3U rear panel for unbalanced I/O

External fader



Control Pin outs			
Pin	Function	Pin	Function
1	TX+	9	TX-
2	GND	10	RX+
3	RX-	11	GND
4	FADER +V	12	FADER WIPER
5	GND	13	*
6	*	14	GND
7	*	15	*
8	GND		

*INTERNAL CONNECTION - DO NOT USE



The K4409-2B rear panel for balanced I/O

Signal I/O (K4409-2B)			
Pin	Function	Pin	Function
1	SRC O/P1-	14	DELAY O/P1-
2	SRC O/P1+	15	DELAY O/P1+
3	GND	16	GND
4	SRC O/P2-	17	DELAY O/P2-
5	SRC O/P2+	18	DELAY O/P2+
6	AES REF IN-	19	N/C
7	AES REF IN+	20	N/C
8	GND	21	DELAY O/P3-
9	SRC O/P3-	22	DELAY O/P3+
10	SRC O/P3+	23	GND
11	GND	24	DELAY O/P4-
12	SRC O/P4-	25	DELAY O/P4+
13	SRC O/P4+		

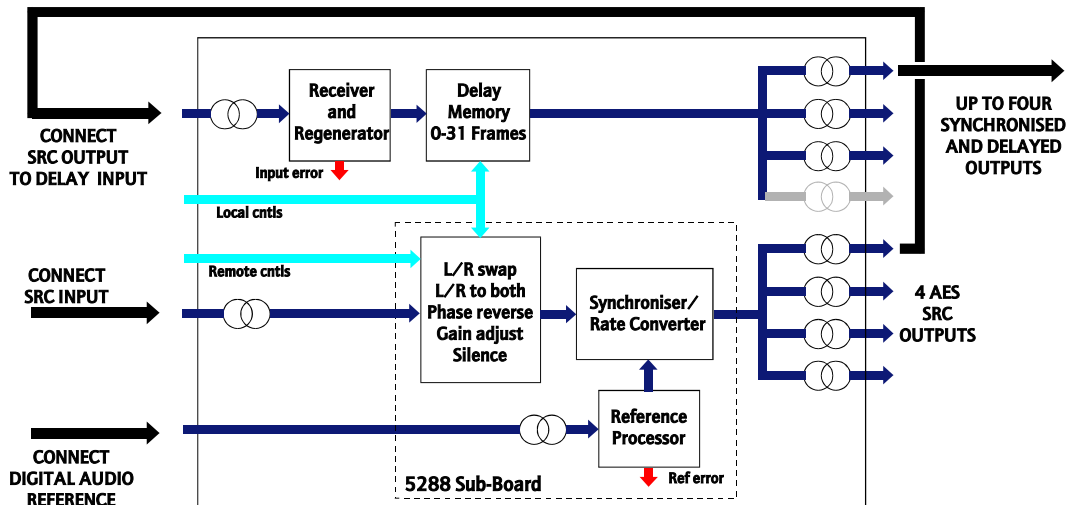
Control Pin outs			
Pin	Function	Pin	Function
1	TX+	9	TX-
2	GND	10	RX+
3	RX-	11	GND
4	FADER +V	12	FADER WIPER
5	GND	13	SRC AES I/P+
6	SRC AES I/P-	14	GND
7	DELAY I/P +	15	DELAY I/P -
8	GND		

NOTE: DELAY O/P 4 is ONLY available with the K4409-2B rear panel.

2.2 Cabling the DELAY and SRC stages

To use both the integrated synchroniser and delay features proceed as follows:

- install the 4409 module into a rackframe
- apply an AES signal to the SRC input and an AES reference to the REF input
- use a short cable to connect one of the SRC outputs to the DELAY input
- set the DELAY and audio modify options as required
- the synchronised and delayed output is now available from any of the DELAY outputs



Connecting the SRC and DELAY stages of the 4409

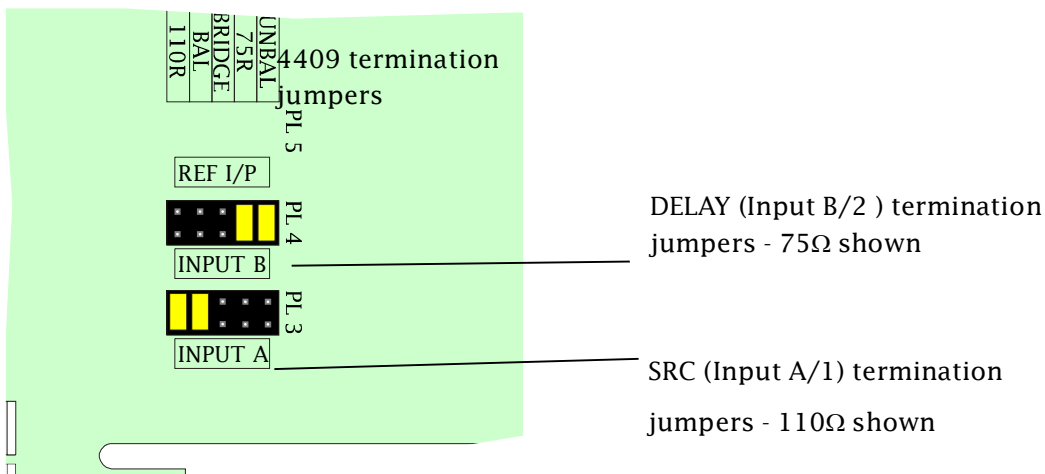
3 Configuration

The 4409 may be configured for different input, reference and RS485 comms termination values and audio modify options. When placed under RS485 remote control, a unique multi-drop address may be selected.

3.1 Selecting input terminations

The jumpers to select AES input termination are located on the main 4409 module. The available options are explained in the following table:

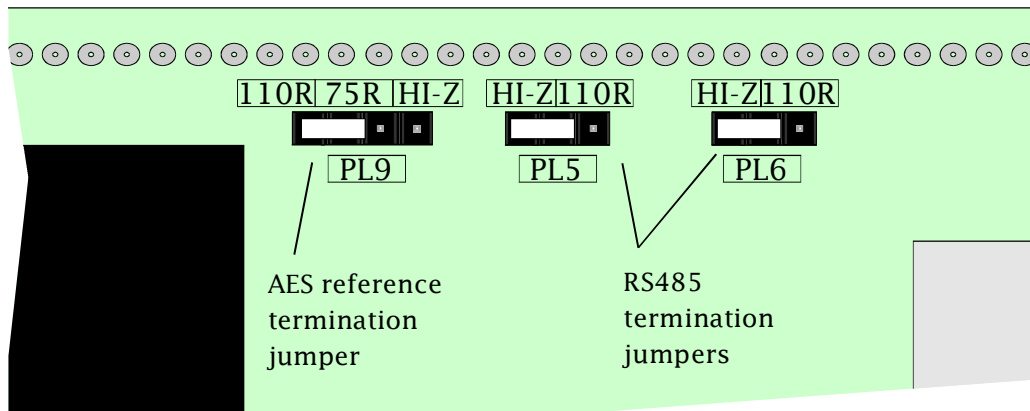
AES input termination modes	
PL3&4 settings (4409)	Description
UNBAL	Use for unbalanced signal - requires K4409-3U rear panel
75R	Use with unbalanced input to terminate signal with 75 Ω
BRIDGE	Selects high impedance termination (Hi-Z)
BAL	Use with balanced input - requires K4409-2B rear panel
110R	Use with balanced inputs to terminate signal with 110Ω



3.2 Selecting the reference termination

The jumper (PL9) to select the AES reference termination values is located on the 5288 sample rate converter sub-module itself. The available selections are as follows:

AES reference termination values	
PL9 settings (5288)	Description
75R	Use with unbalanced input to terminate signal with 75 Ω
HI-Z	Selects high impedance termination (Bridging mode)
110R	Use with balanced inputs to terminate signal with 110Ω



5288 termination jumpers

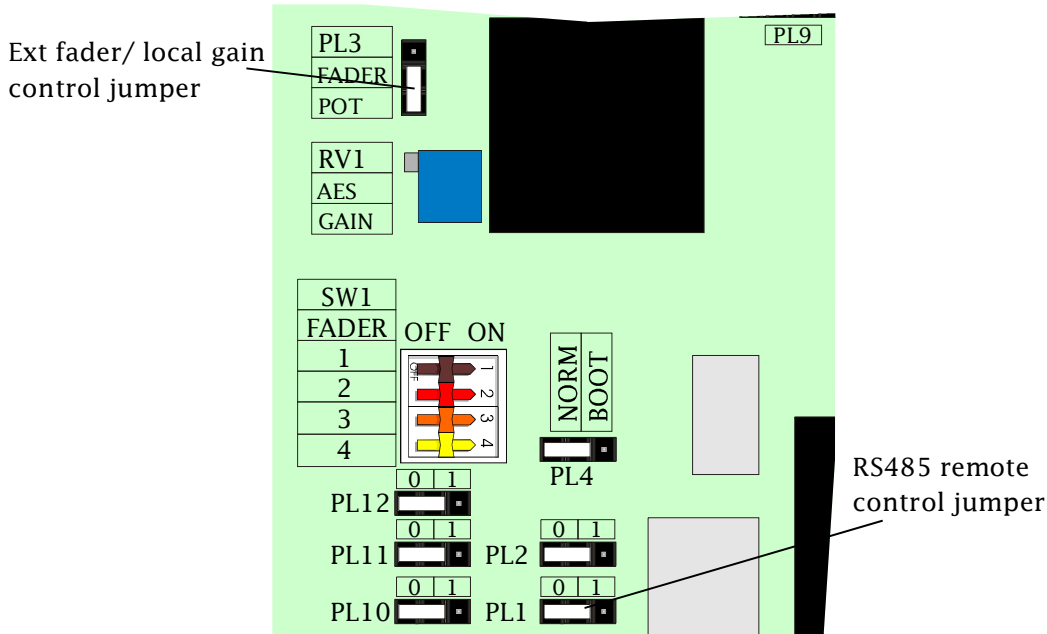
The termination impedance for the RS485 communications ports are set by PL5 (transmitter) and PL6 (receiver) as described in the following table:

RS485 transmit and receive termination values	
PL5&6 settings (5288)	Description
HI-Z	Selects high impedance termination (Bridging mode)
110R	Use with balanced inputs to terminate signal with 110Ω

NOTE: Do not leave the AES reference or RS485 inputs in high impedance without a signal connected to avoid spurious reset spikes.

3.3 Setting local/remote gain modes

The local or RS485 remote gain control is selected by 5288 jumper PL1. Setting PL1 to '0' enables PL3 to select either an external fader or the on-board potentiometer, RV1 to control AES gain.



Local/remote gain and fader control		
PL1	PL3	Mode
0	FADER	Control via external fader
0	POT	Control via on-board potentiometer, RV1
1	X	Control via RS485 comms

NOTE:

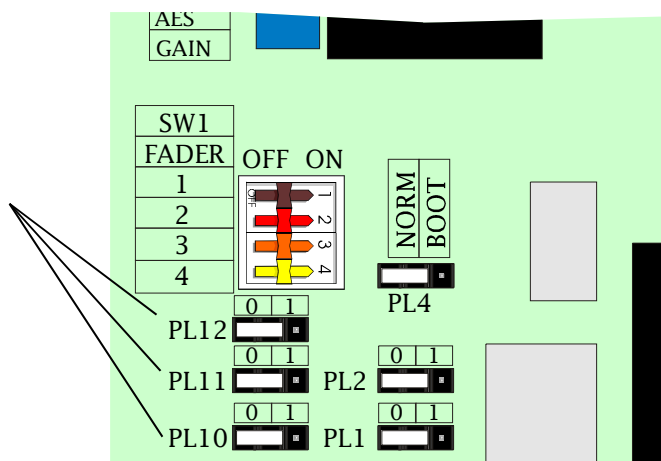
- An external fader ($\geq 10k\Omega$), may be connected to the control port as described in the installation section.
- Setting PL1 to '1' assigns gain/fader control to the RS485 communication protocol.
- X = don't care
- PL4 must be left in the NORM position and PL2 is reserved for future use.

3.4 Setting audio modify options

The audio modify features of the module are set with jumpers PL10, 11 and 12 as described in the following table:

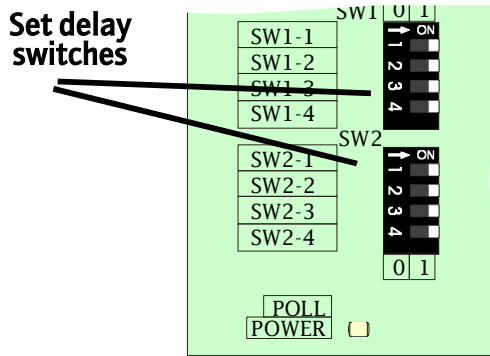
Audio modify options			
Function	PL10	PL11	PL12
Stereo (normal mode - no modify)	1	1	1
Input L - both	0	1	1
Input R - both	1	0	1
L/R swap	0	0	1
Digital silence	1	1	0
Reserved for future use	0	1	0
Reserved for future use	1	0	0
Reserved for future use	0	0	0

Audio modify jumpers



3.5 Selecting the audio delay

The delay of the audio delay path is selected with SW1 and SW2 on the main board as follows:



NOTE:
 Delay is specified in the equivalent of 625/50 video frames, (40ms) and is accurate at 48kHz sampling rate. At other sampling rates, the delay will vary in proportion to the sample period.

Audio delay 0-15 video frames					
	SW1 1	SW1 2	SW1 3	SW1 4	SW2 1
0	OFF	OFF	OFF	OFF	OFF
1	ON	OFF	OFF	OFF	OFF
2	OFF	ON	OFF	OFF	OFF
3	ON	ON	OFF	OFF	OFF
4	OFF	OFF	ON	OFF	OFF
5	ON	OFF	ON	OFF	OFF
6	OFF	ON	ON	OFF	OFF
7	ON	ON	ON	OFF	OFF
8	OFF	OFF	OFF	ON	OFF
9	ON	OFF	OFF	ON	OFF
10	OFF	ON	OFF	ON	OFF
11	ON	ON	OFF	ON	OFF
12	OFF	OFF	ON	ON	OFF
13	ON	OFF	ON	ON	OFF
14	OFF	ON	ON	ON	OFF
15	ON	ON	ON	ON	OFF

Audio delay 16-31 video frames					
	SW1 1	SW1 2	SW1 3	SW1 4	SW2 1
16	OFF	OFF	OFF	OFF	ON
17	ON	OFF	OFF	OFF	ON
18	OFF	ON	OFF	OFF	ON
19	ON	ON	OFF	OFF	ON
20	OFF	OFF	ON	OFF	ON
21	ON	OFF	ON	OFF	ON
22	OFF	ON	ON	OFF	ON
23	ON	ON	ON	OFF	ON
24	OFF	OFF	OFF	ON	ON
25	ON	OFF	OFF	ON	ON
26	OFF	ON	OFF	ON	ON
27	ON	ON	OFF	ON	ON
28	OFF	OFF	ON	ON	ON
29	ON	OFF	ON	ON	ON
30	OFF	ON	ON	ON	ON
31	ON	ON	ON	ON	ON

3.6 Inverting the right hand channel

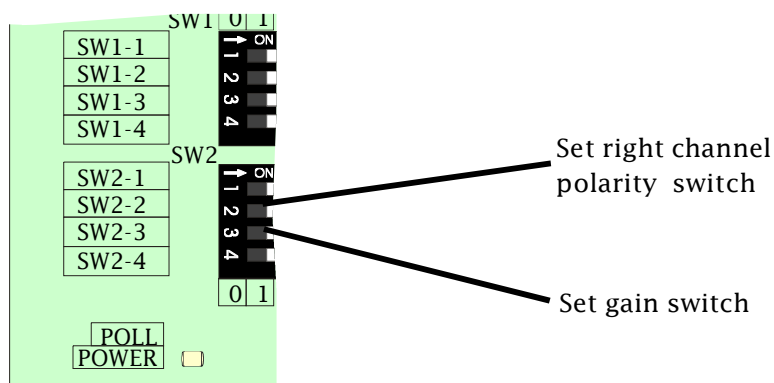
The right hand channel may be inverted with SW2-2 on the main board as follows:

Right hand channel polarity	
SW2-2	Polarity
ON	Invert
OFF	Normal

3.7 Selecting audio gain

The audio gain may be increased by 6dB with SW2-3 on the main board as follows:

Audio gain	
SW2-3	Gain
ON	+ 6dB
OFF	Normal

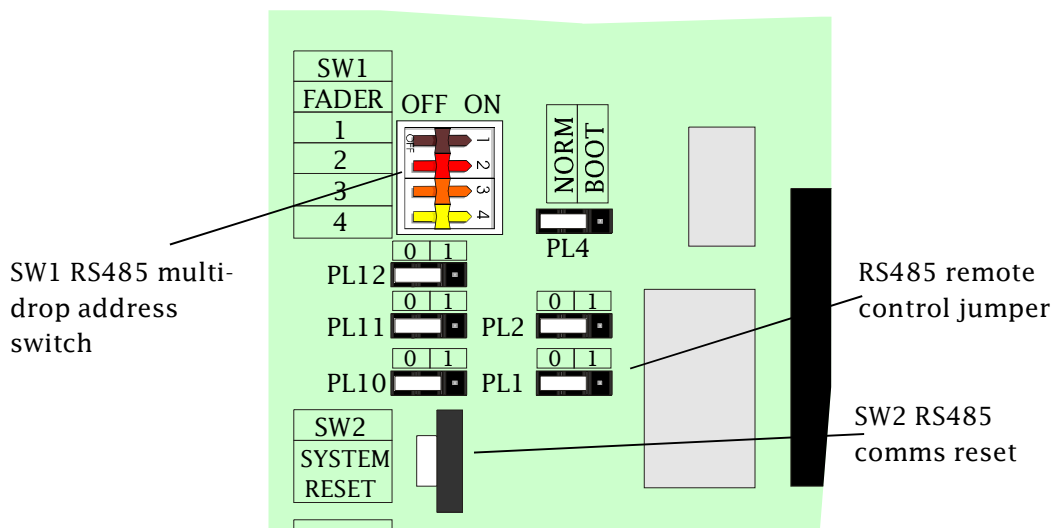


4 RS485 serial control

The RS485 comms control enables up to sixteen 4409 sample rate converter/synchroniser cards to be remotely controlled and monitored.

The RS485 controlling unit may set gain, automatic fades of various rates, reset and monitor the status of each card individually. Gain is automatically restored to 0dB after a power-on reset.

Assign a 4409 module to RS485control by placing PL1 on the 5288 sub-module to the '1' position:



4.1 Setting the multi-drop address

Each module may be assigned a unique multi-drop address using SW1 on the 5288 sub-module, to operate over the RS485 communication protocol as described in the following table:

Multi-drop address, SW1				
Hex address	1	2	3	4
F (15)	1	1	1	1
E (14)	0	1	1	1
D (13)	1	0	1	1
C (12)	0	0	1	1
B (11)	1	1	0	1
A (10)	0	1	0	1
9	1	0	0	1
8	0	0	0	1
7	1	1	1	0
6	0	1	1	0
5	1	0	1	0
4	0	0	1	0
3	1	1	0	0
2	0	1	0	0
1	1	0	0	0
0	0	0	0	0

The reset switch, SW2, initialises the RS485 comms state, (fader at top, gain = 0dB) and resets the AES Digital Signal Processor. The reset button must be pressed after changing the address switch, SW1 to update the multi-drop address memory.

4.2 Electrical parameters

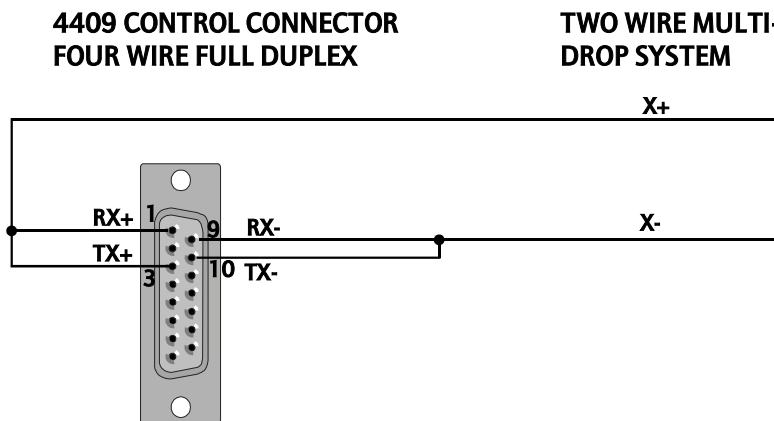
Normal electrical parameters are:

- RS485
- 8 bit data
- one stop
- even parity
- 38.4kbaud

Normal transmitters used must be capable of running in parallel i.e. more than one transmitter enabled, RS485 compatible. The group poll uses this feature.

4.3 Four wire and two wire operation

The 4409 is a full duplex four wire device. However due to the workings of the multi-drop communication protocol where the controller initiates data flows, the 4409 can be used as a two wire device with the following connector modifications:



4.4 The link layer protocol

The general protocol format is:

MD header	Device address	Message
------------------	-----------------------	----------------

- all multi-drop (MD) headers have the top bit set.
- the device address is a single byte in the range 0 to 16.
- all undefined commands have no effect.

Multi-drop headers

The following MD headers may be transmitted to the 4409 by a controller

F3 - Send device data

This is followed by a device address and any command message for the 4409.

F4 - Device data request

This is followed by a device address. The device must respond with a single byte of data. The null response may be sent if no data is ready.

F5 - Group poll

This causes any device with data to transmit a single null character. If more than one device replies the controller may receive an overrun, framing or parity error. The controller interprets any character received or any of the above error conditions as a request to send data by one of the devices.

The multi-drop link layer only packages outgoing messages as all incoming data is of one byte length.

Message layer

After the controller has issued a send device data byte (F3) followed by a device address (hex 01-10), the next byte sent will be a command to that device.

The controller can send the following commands to the 5288:

- set output level gain**
- byte 1 : 0001HHHH
 - byte 2 : 0000LLLL

This command sets the audio input, output gain, HHHH are the high gain bits, while LLLL are the lower gain bits. Step size is 0.09375 dB per bit.

HHHHLLLL = 00 = -12db minimum gain setting

HHHHLLLL = 80 = 0db unity gain (if greater than 80 gain is set to 0db)

set fade - byte 1 : 0010000D
 - byte 2 : 0SSSSSS

To start an audio fade this command is sent with the parameters D for up (1) or down (0) and SSSSSS for fade rate.

SSSSSS	00 = fade in 0 seconds	Note: These are approximate times
	05 = fade in 1 second	
	0A = fade in 2 seconds	
	14 = fade in 4 seconds	
	28 = fade in 8 seconds	

Other values have no effect.

status request - byte 1 : 00110000

On receiving this command the 4409 will respond by sending 6 bytes of status data as detailed in the following section.

reset - byte 1 : hex FD

Causes the 4409 to reset to the power up condition which is fader at the top and unity gain.

Bytes transmitted

The following data bytes are transmitted by the 4409 after a panel poll from the link layer has been issued by the controller.

fader gain high - 0001HHHH

fader gain low - 0010LLLL

Reports the fader gain status. This is not the audio gain setting but a value corresponding to the fade position at that particular point. These bytes are issued in response to a status request command given from the controller.

HHHHLLLL	00 = fade has reached bottom position
	80 = fade active
	FF = fade has reached top position

NOTE: These bytes are included for compatibility with the CBC 5015 fader protocol.

transition status - 00 11ABCD

These are status bits indicating the current fade action. All bits are active when they are high.

- A = fading down
- B = fading up
- C = fade at bottom
- D = fade at top

No two bits should be on at any time. This byte is issued in response to a status request command and when the fade transition status changes.

AES data status - 01000NOO

The AES bit stream input signal has various status bits which are active when high.

Data error (no input)

Typically, with no audio signal, BIT N will be set high. This byte is issued in response to a status request command and when the AES input status changes.

4.5 Protocol examples

Status request		
Controller	Description	Device response
F5	Group poll	
F3 0A 30	Status request card 10	
F5	Group poll	00
F4 0A	Request data from panel 10	1F
F4 0A		2F
F4 0A		31
F4 0A		44
F4 0A		58
F4 0A		60
F5	Group poll	

Device response 1F, 2F says that the fader gain is fully up. Byte 31 indicates that the fader is at the top position and byte 44 says that no valid AES bit stream data is present at the card inputs. Byte 58 and 60 form together to report the output level gain of 0dB (unity gain).

Note: This is the status of the 4409 after a reset command, on power-up and when the comms reset button is pushed.

Set output level gain		
Controller	Description	Device response
F5	Group poll	
F3 07 18 00	set unity gain on panel 7	
F3 0B 10 00	set -1.2dB gain on panel 11	
F5	Group poll	

No response is issued from the 4409 when the gain is changed.

Set fade		
Controller	Description	Device response
F4 09	Request data from panel 9	FF
F3 09 20 00	Fast fade down for panel 9	
F4 09	Request data from panel 9	32
F3 09 21 05	Fade up in one second	
F4 09	Request data from panel 9	34
F4 09	Request data from panel 9	31

Device response 32 indicates fade at bottom. Byte 34 says that the fader is currently fading up but has not reached the top yet and finally, byte 31 tells the controller that the fade is finished and at the top

5 Status monitoring

The COSMOS frame interface, if fitted, will provide the following information to the COSMOS status monitoring system:

- module present
- I/P 1 (SRC) present
- I/P 2 (DELAY) present
- audio locked
- SW1 status
- SW 2 status
- power OK

In addition, the module is programmed with the following information, which can be read by the status monitoring controller:

- Module type
- Module bar code
- Module issue no

For further details of the Pro-Bel status monitoring system please refer to the COSMOS status monitoring manual.

6 **Trouble shooting**

The green card edge POWER LED is not lit

- check the PSU indicator to confirm that there is power to the frame
- check the resettable fuses protecting the card - do this by removing the power to the card for about 30 seconds then restoring the power
- if necessary, refer to the power supply trouble shooting guide in the appropriate ICON rackframe manual section

There is no output signal

- ensure that the green power LED on the front of the main card is lit
- check that the green +5V LED is lit on the 5288 sub-module
- check that a valid input is connected to the rear panel
- check that the appropriate red LOSS OF INPUT LED is not lit

The output signal is corrupted

- check the quality of the input signal(s)
- if an AES reference is used, check that the green AUDIO LOCK LED is lit and that the red NO-REF LED is not lit on the 5288 sub-module
- check that the appropriate termination has been set

The manual gain control does not work

The incorrect mode may have been selected

- check that jumper PL1 on the sub-module is set to '0'
- press the reset button on the sub-module to change mode if necessary
- ensure that jumper PL4 on the sub-module is set to 'NORM'

The RS485 comms does not work

The incorrect mode or address may have been selected

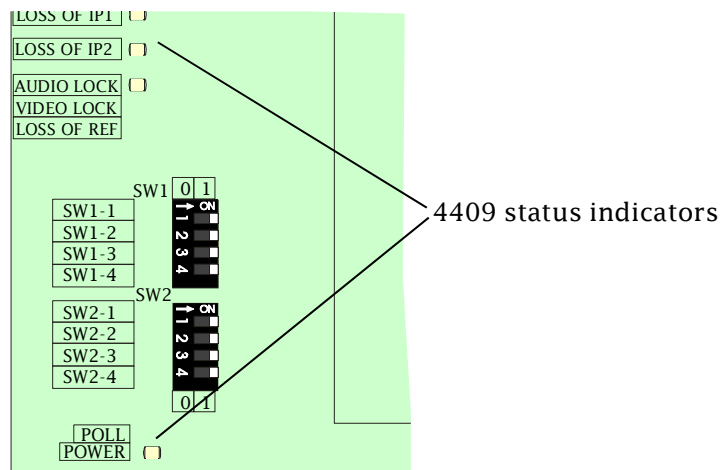
- check that jumper PL1 on the sub-module is set to '1'
- press the reset button on the sub-module to change mode if necessary
- check that the multi-drop address is set correctly
- if the multidrop address needs to be changed, push the reset button afterwards to store the new address

The output signal causes pops and clicks in downstream equipment

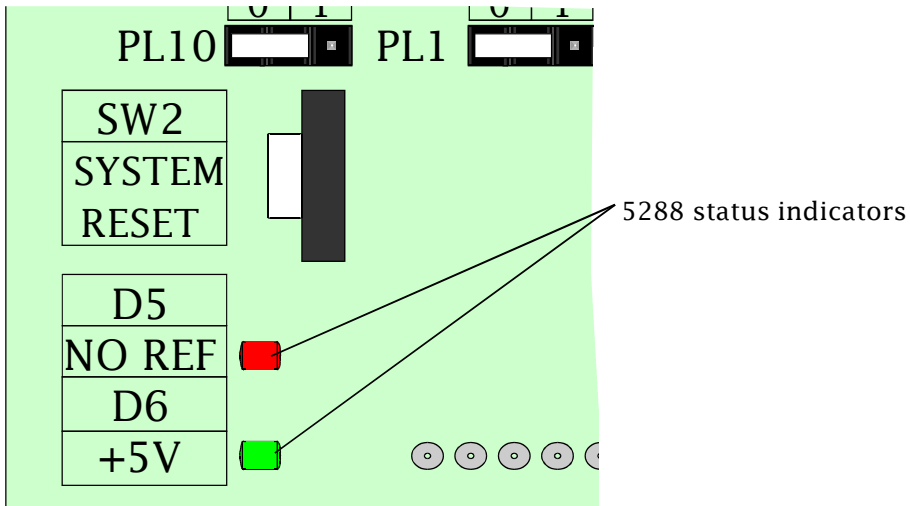
- check that the reference used has the correct phase and frequency as all other digital audio equipment used in the system

Note: It is recommended to employ a common AES11 reference for all digital audio equipment if accurate phasing to station signals is required throughout a facility. The 4409 should meet the timing requirements of AES11 under these conditions.

4409 Status indicators	
LED label	Meaning when lit
LOSS of I/P 1	Lights red when I/P 1 (SRC) is not present or when channel 1 error flag (ERF) is set
LOSS of I/P 2	Lights red when I/P 2 (DELAY) is not present or when channel 2 error flag (ERF) is set
AUDIO LOCK	Lights green to show that the audio clock is locked to AES reference
POWER	Lights green if all voltage rails are present



5288 status indicators	
LED label	Meaning when lit
NO REF	Lights red to show that reference level is too low - check termination value
+5V	Lights green if + 5 volt rail is present



7 Specification

Delay input (signal)

Number and type: 1, balanced, transformer coupled to AES3-1992 or unbalanced to AES3-id including SPDIF

Termination: High, 75Ω or 110Ω

SRC input (signal)

Number and type: 1, balanced, transformer coupled to AES3-1992 or unbalanced to AES3-id including SPDIF

Termination: High, 75Ω or 110Ω

Input (reference)

Number and type: 1, balanced, transformer coupled to AES3-1992 or unbalanced to AES3-id

Termination: High, 75Ω or 110Ω

SRC outputs

Number and type: 4, transformer coupled, balanced to AES3-1992 or unbalanced to AES3-id

Delay outputs

Number and type: 4, transformer coupled, balanced to AES3-1992 or unbalanced to AES3-id
(Only three available with K4409-3U unbalanced rear connector)

SRC Performance

Bitstream integrity: 20 bit audio

Sample rate: 32, 44.1 or 48kHz

Audio modify

Available functions: Variable attenuation from 0 to -12dB
Switchable +6 dB gain
Left channel to both
Right channel to both

Left channel swapped with right channel

Invert right channel

Digital silence

Fader law

Logarithmic, i.e. linear dBs with time

Time specified is from full gain to -60dB

Automatic fades

Fades to or from silence in 0,1,2,4 or 8 seconds
to or from current gain level (0 to -12dB)

Remote control

Number and type:

RS485 @38.4k Baud, 4 or 2 wire duplex
multi-drop bus for gain control, automatic fading
and remote status monitoring, 8 data bits, 1 stop
bit, even parity

Impedance:

Selectable for 110Ω or bridge

Temperature range

Operating:

0° to +40°C

Storage:

-10°C to +70°C

8 **Ordering information**

Part number	Description
ICO-4409-2B00	Digital Audio Synchronising Delay, balanced I/O, 20mm rear panel
ICO-4409-3U00	Digital Audio Synchronising Delay, unbalanced I/O, 30mm rear panel