Hardware Installation Guide

ACQ1014-16-BNC

16 channel, 80MSPS/channel DAQ appliance

Any specifications, drawings or reprints or data furnished to bidder or seller shall remain D–TACQ Solutions Ltd property, shall be kept confidential, shall be used for the purposes of complying with D–TACQ Solutions' requests for quotation or with D–TACQ solutions purchase orders and shall be returned at D–TACQ Solutions request. Patent rights embodied in designs, tools, patterns, drawings, devices, information and equipment supplied by D–TACQ solutions pursuant to this request for quotation or purchase order and exclusive rights for use in reproduction thereof are reserved by D–TACQ Solutions Ltd unless otherwise agreed on purchase order.

1 Overview

Drawing 1: ACQ1014-16-BNC Photograph

ACQ1014-16-BNC is a 1U, 19” rack-mount DAQ appliance, providing

16 channels x 80MSPS input clock rate, 14 bit simultaneous analog inputs on the front panel via BNC connectors.

The front panel also includes trigger TRG and clock CLK/TRG2 BNC inputs. The unit may be operated as follows:

- 16 channels, common CLK, common TRG.
- 2 x 8 channels, common CLK, separate TRG (TRG, TRG2 on front panel)
- 2 x 8 channels, independent internal CLK signals.

1.1 Expansion over multiple boxes.

- On ACQ1014-revA, two boxes may be tied together using the SYNC bus on the rear panel, for total 32 simultaneous channels.
- On ACQ1014-revB, this is extended to four boxes for 64 simultaneous channels.
- To make larger systems, an additional clock expander “CLK-TRG-STAR” provides additional fanout

1.2 Clock Options

- Internal clock, 10..80MHz
- User clock on front panel FPCLK, 1..20MHz. *
- Multibox clock from SYNC bus, 1..20MHz *

* NB: ADC clock range 10..80MHz, must use internal clock multiplier.

1.3 Trigger Options

- Internal SOFT TRG, synchronized over 16 channels.
- User front panel TRG, synchronized over 16 channels.
- User front panel TRG for 8 channels, TRG2 for second 8 channels*
- Multibox TRG from SYNC bus.

** NB: when using TRG, TRG2 user FPCLK is not available.

1.4 Throughput vs Sample Rate

Unit supports 80MHz clock rate, aggregate to local DRAM is 2x800MB/s aggregate rate.

Operating limits:

- 16 channels by 50MSPS direct to DRAM.
- 16 channels, 80MSPS sample rate, decimate-by-2 filter, 2x640 MB/s data rate.
- 8 channels, 80MSPS sample direct to DRAM, 2 x 640MS/s data rate.
- 16 channels by 80MSPS direct to DRAM (future field upgrade).

#CH	*ISR MSPS*	*DEC*	*OSR MSPS*	*DATA MBPS*	*SHOT S*	*Comment*
16	80	2	40	1280	1.0	FIR LP Filter, BW=20MHz
16	50	1	50	1600	0.8	Analog BW limit 40MHz (2V pp) 15MHz (5V pp)
8	80	1	80	1600	1.0	
16	80	8	10	320	4.0	FIR LP Filter, BW=5MHz or less

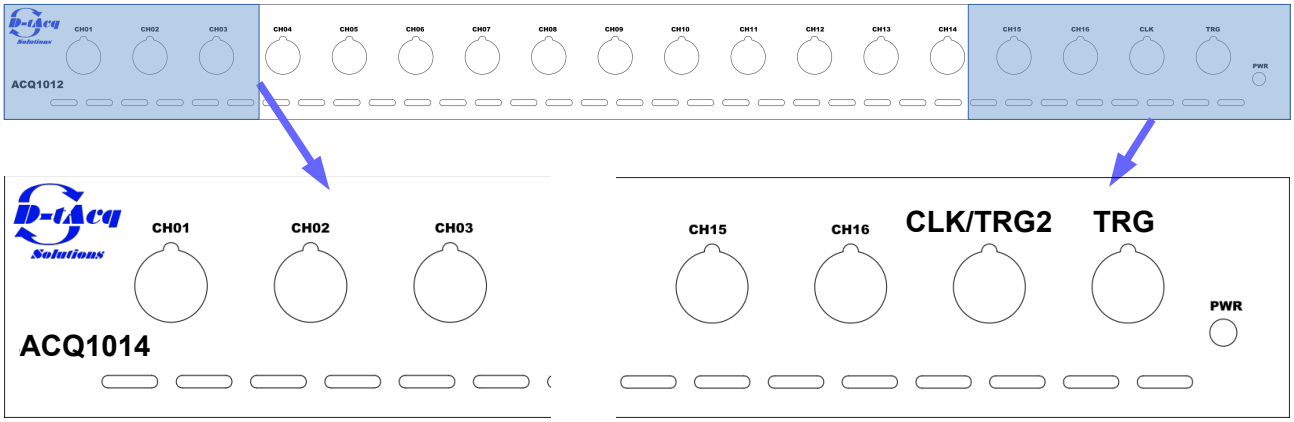
- ISR is Input Sample Rate (Sample Clock),
- DEC is filter decimation factor
- OSR is Output Sample Rate (Sample rate to memory), after decimation.
- SHOT is maximum capture duration in seconds.

2 Variants

ACQ1014 is available in the following configurations.

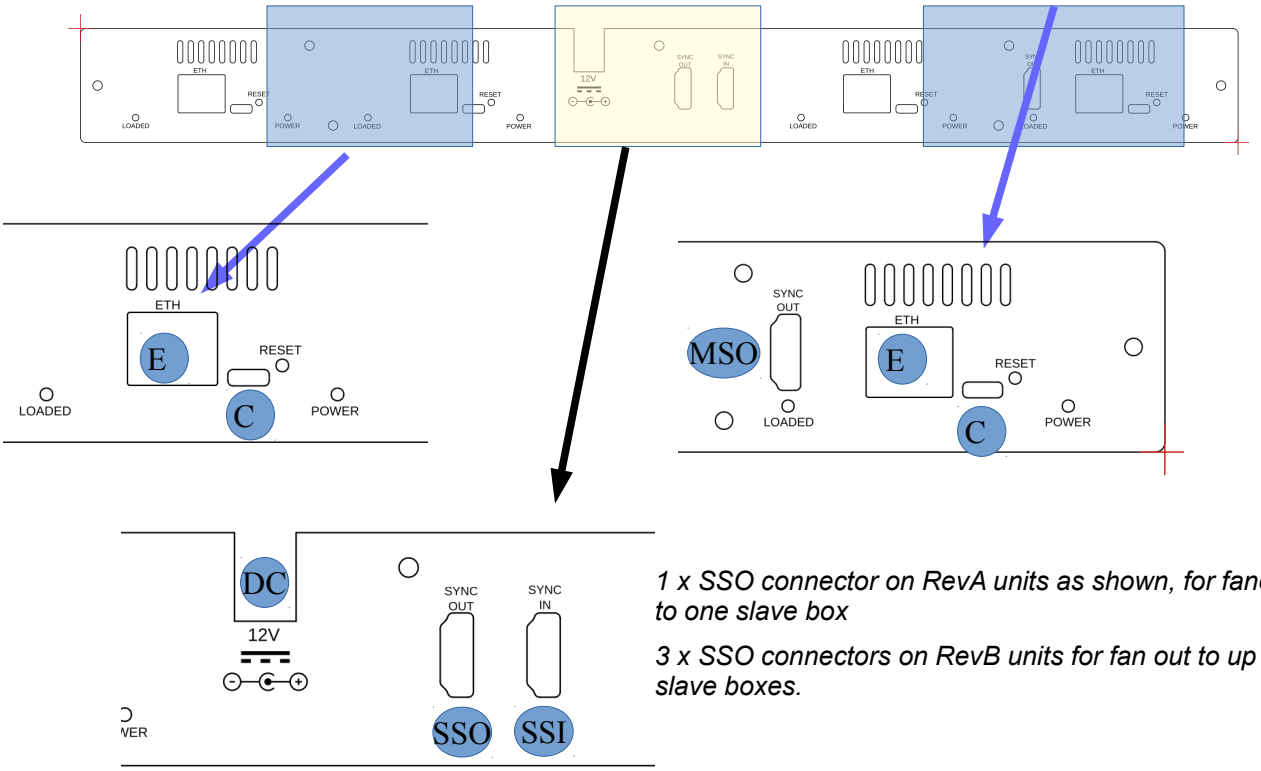
Product Name	*Description*
ACQ1014-16-BNC	16 channels, 80MSPS/channel, BNC front panel
ACQ1014-32-SMA	32 channels, 80MSPS/channel, SMA front panel * * separate installation guide applies.

3 Front Panel



Drawing 2: ACQ10014-16-BNC Front Panel : 18 BNC connectors in 1U

4 Rear Panel



1 x SSO connector on RevA units as shown, for fanout to one slave box

3 x SSO connectors on RevB units for fan out to up to 3 slave boxes.

Drawing 3: ACQ1014-16-BNC Rear Panel

4.1 Rear Panel Ports

4.1.1 Console C

ACQ1001 uses an FTDI FT232 USB-Serial converter for console access via a Micro USB port. Connection is automatic on modern PC's, serial console settings are as follows.

Name	***Setting***
Baud Rate	115200
Data Bits	8, No Parity, 1 Stop, No flow control
Emulator	D-TACQ recommends c-kermit.

4.1.2 Ethernet

The gigabit Ethernet port accepts standard RJ45 connectors. Please be sure to connect BOTH ports. E

4.1.3 Reset

Use a pen or similar object to push the reset button if required.

4.1.4 Power

Power to the entire box is provided by an external 12V regulated DC supply, of minimum output 10W depending on payload. The unit ships with a 45W 12V DC supply, sufficient for any payload combination.

The socket accepts a standard DC barrel connector, centre-positive, 2.5mm internal diameter, 5.5mm external diameter, with length a minimum of 10.5mm.

The power supply's input Earth should be connected to the output 0VD.

4.1.5 LEDs

The rear panel provides extra LEDs for system information.

LED	***Description***	
LOADED	Green	Lights approximately 20s after power-up to indicate FPGA loaded. If unlit after this, check the validity of the SD card image or check the Console for error messages.
POWER	Green	Lit when digital power supplies are all valid.

4.1.6 Sync Bus

D-TACQ provides two Sync Bus connectors allowing multiple units to be chained together. The bus uses standard HDMI cables and has two ports – one input, one output. The pinouts and functionality are described as follows.

In a standalone system, please be sure to connect a short HDMI cable (provided) linking

- Master Sync Out 

to

- Slave Sync In 

- Slave Sync Out 

is only used in multi-box systems

Pin	***Name***	***Description***	
		Output	***Input***
1	Sync	Synchronisation Output	Synchronisation Input
4	Trigger	Trigger Output	Trigger Input
7	GPIO	General Purpose Output. May be switched to an input if desired.	General Purpose Input. May be switched to an output if desired.
10	Clock	Clock Output	Clock Input
15	SCL	I^2C Master Clock Output	I^2C Slave Clock Input
16	SDA	I^2C Master Data	I^2C Slave Data
19	Cable Detect	Allows master to detect the presence of a slave device.	Ground (0VD)
2, 3, 5, 6, 8, 9, 11, 12, 17	GND	Ground (0VD)	
13, 14, 18	NC	Not Connected	

Please be sure to connect the SYNC loopback cable.

4.1.7 Fans

Fan outlets help keep ACQ1014 cool, drawing air across the modules from front to back. Do not cover the fan outlets.

4.1.8 Grounding Points

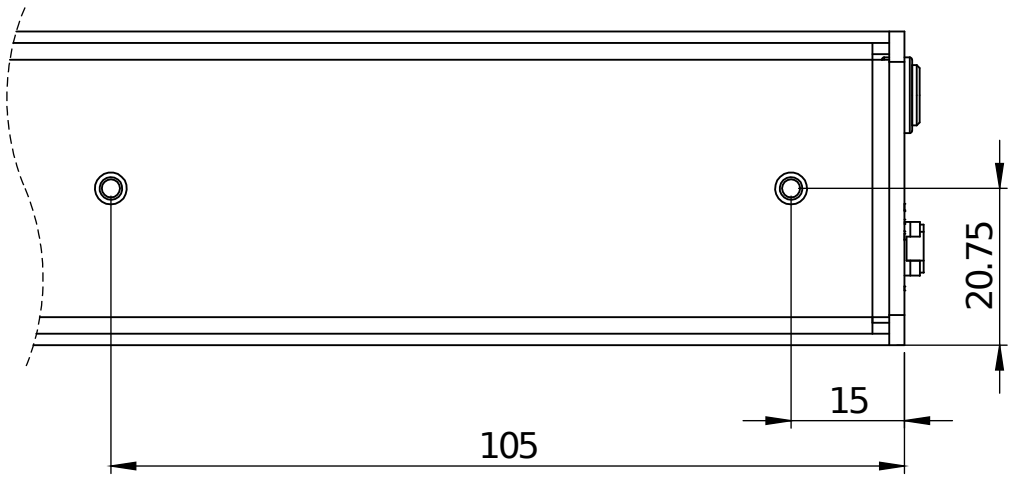
If required, banana plug sockets are provided for both Chassis and 0VD.

5 Analog Characteristics.

Parameter	*Value*	*Comment*
Channels	16	Simultaneous
Max SR	80MHz	Maximum rate to memory, 50MHz. Use 80MHz clock with /2 decimating filter to stream to DRAM at 40MSPS.
Resolution	14 bit	
Input Range	+/-2.5V	Single Ended
Impedance	100K/50R	Soft switched termination
Gain	0..12dB	
Filtering	FIR	24 tap filter in ADC. Additional filters available in FPGA.

6 Mounting Options

There are several different mounting options for ACQ1014. The cases can be mounted on their own via integrated fixing points – shown in the below images, referenced to the bottom and front panels. Alternatively, different options may be attached to D-TACQ's 19” mounting bracket.



Drawing 4: Mounting Points for Rack Case

7 Quickstart

1. Store the default root login credentials shipped with the box for future reference.
2. Mount chassis with clear airflow front to back
3. For setup, connect USB consoles (only needed if IP address not known)
4. Connect 2 x Ethernet RJ45 cables to a 1000T switch on the site Ethernet.
5. Connect DC12V and power of at wall jack.
6. If the consoles are connected, this will provide a commentary on the boot process (60s).
7. The units are set to acquire their ip-address using DHCP. Assuming that the user has access to the DHCP server, it's easy to arrange for the ACQ to get an ip-address and for the user to know what it is. Failing that, there is a fallback address: 192.168.0.serial-number.
8. To set a static ip-address, log in on the console and set as per 4GUG.
9. From a computer on the same subnet, check that you can see the embedded web pages at port 80, and that you can connect to the box using ssh.
10. To control the box using the D-TACQ GUI, install cs-studio, add our OPI project and connect. Press STREAM and view live data on trigger (external or, select soft trigger).
11. A production system may use the GUI, or it may be entirely scripted, or a mix of both. User's choice.

7.1 GUI Setup

cs-studio is based on the eclipse environment. This allows a flexible interface, with pre-defined opi screens dockable N,S,E,W.

- Project: contains the OPI (Operator Interface) screens, use as read-only code
- Workspace: contains site specific setup, including choice of UUT and OPI layout.
- UUT: Unit Under Test, the ACQ digitizer appliance(s)

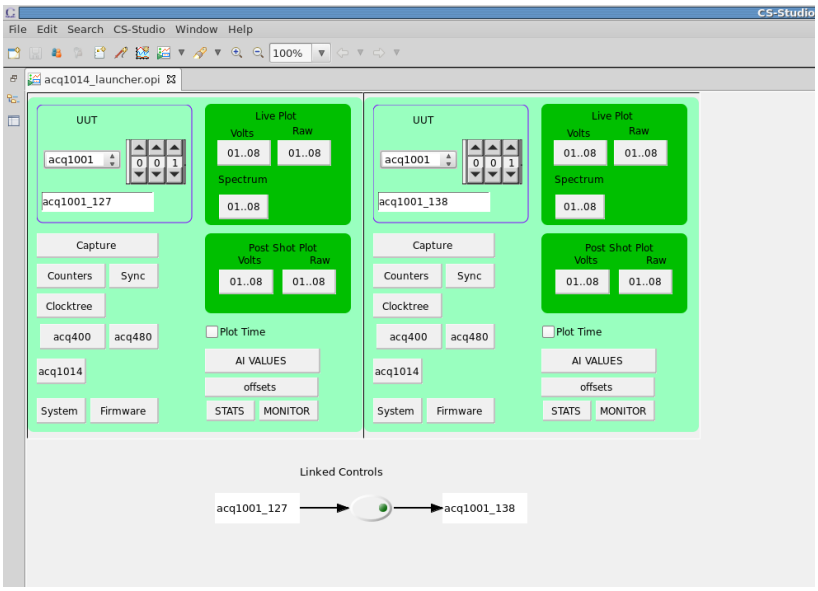
On a site with one UUT, there will be One Project, One Workspace, One UUT

On a site with many UUT's, there's still only one Project, but it may be convenient to run multiple GUI's, each with its own Workspace, UUT and settings.

Ideally, D-TACQ will supply both the Project and a pre-configured Workspace with a suitable layout. The layouts below assume this. If the workspace is not available, it's easy enough for a user to configure his own layout by launching OPI's from the “launcher”, then dragging and docking to get the desired layout. This is very quick with practise. Please see “Starting the UI from Scratch”.

7.2 Initial View, Launcher Only

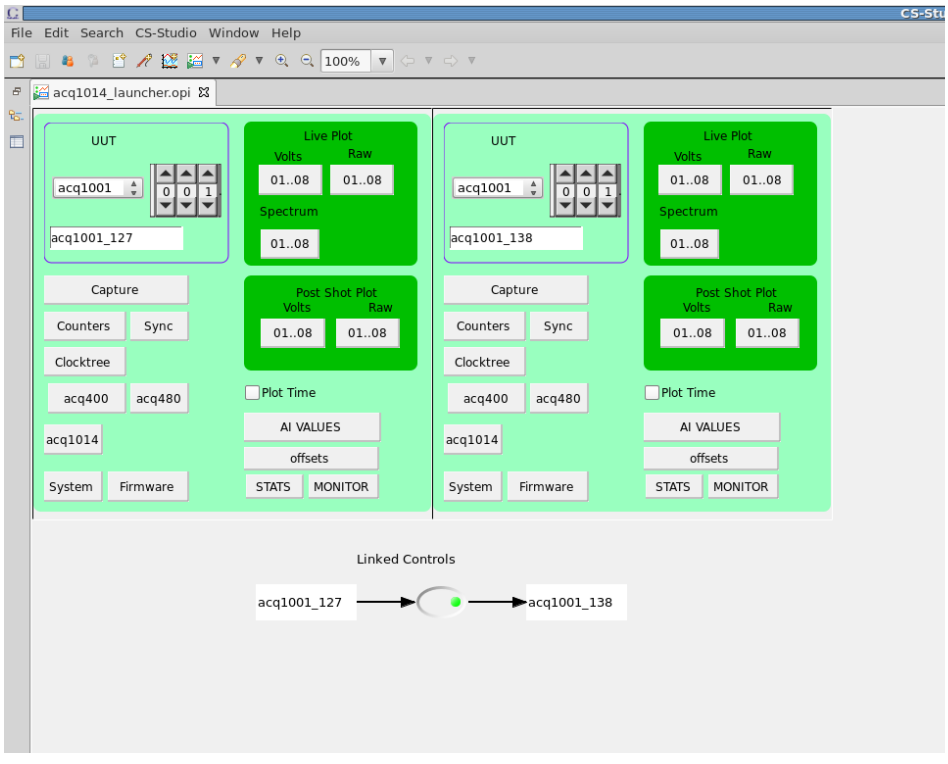
- ACQ1014 Launcher is provided for use with ACQ1014, two UUT's
- It's pre-programmed with UUTLEFT and UUTRIGHT, ID's for left and right digitizers.



7.2.1 Linked controls are recommended.

Press the “Linked Controls” button.

Linked controls means that setting a control on UUTLEFT is mirrored to UUTRIGHT. This saves time and avoids errors. However, if it's required to make different settings, uncheck to break the link.



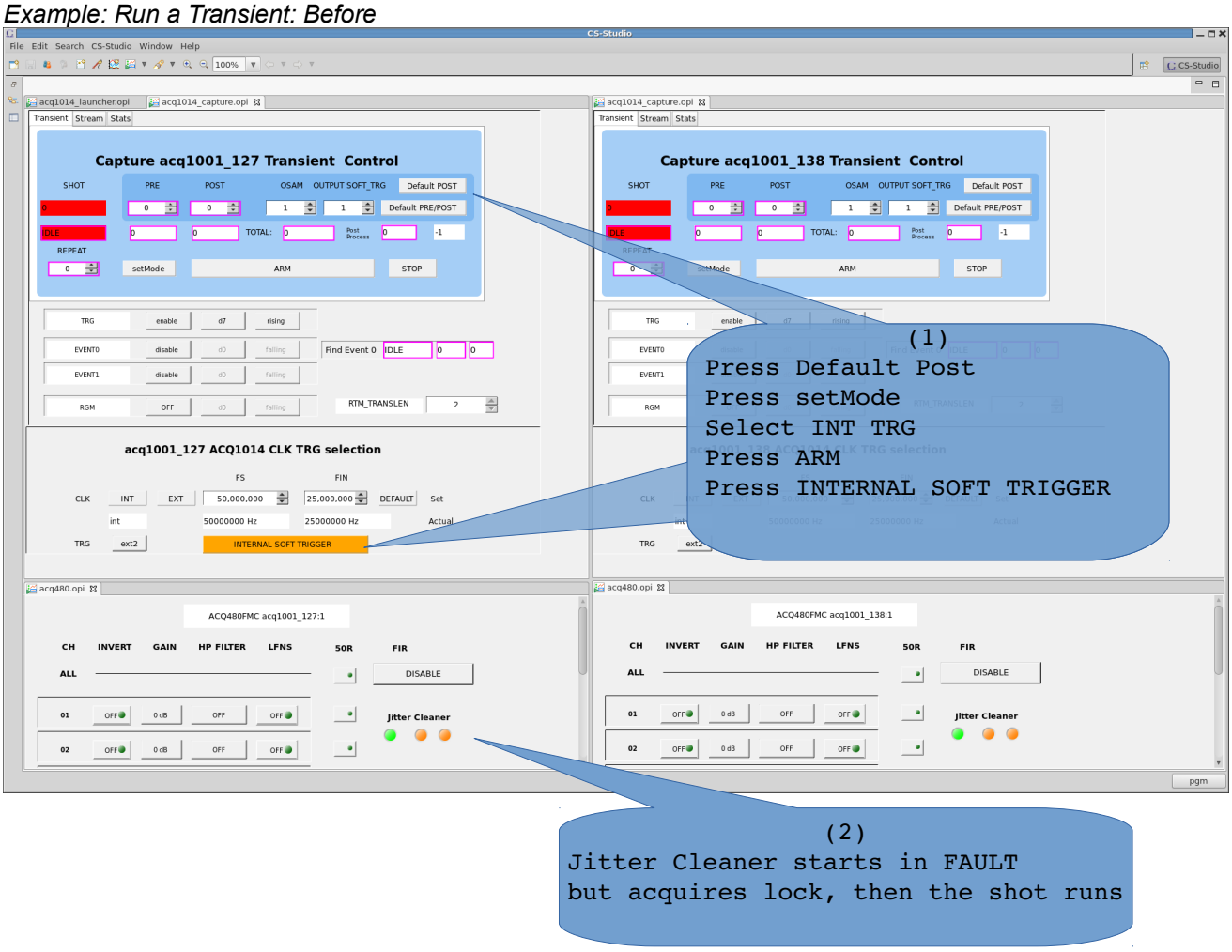
7.2.2 Launch OPI's as required

Pressing a single OPI launch button, will launch two OPI screens, one for UUTLEFT and one for UUTRIGHT. The screens appear in a tabbed manner, drag to split Left and Right on screen.

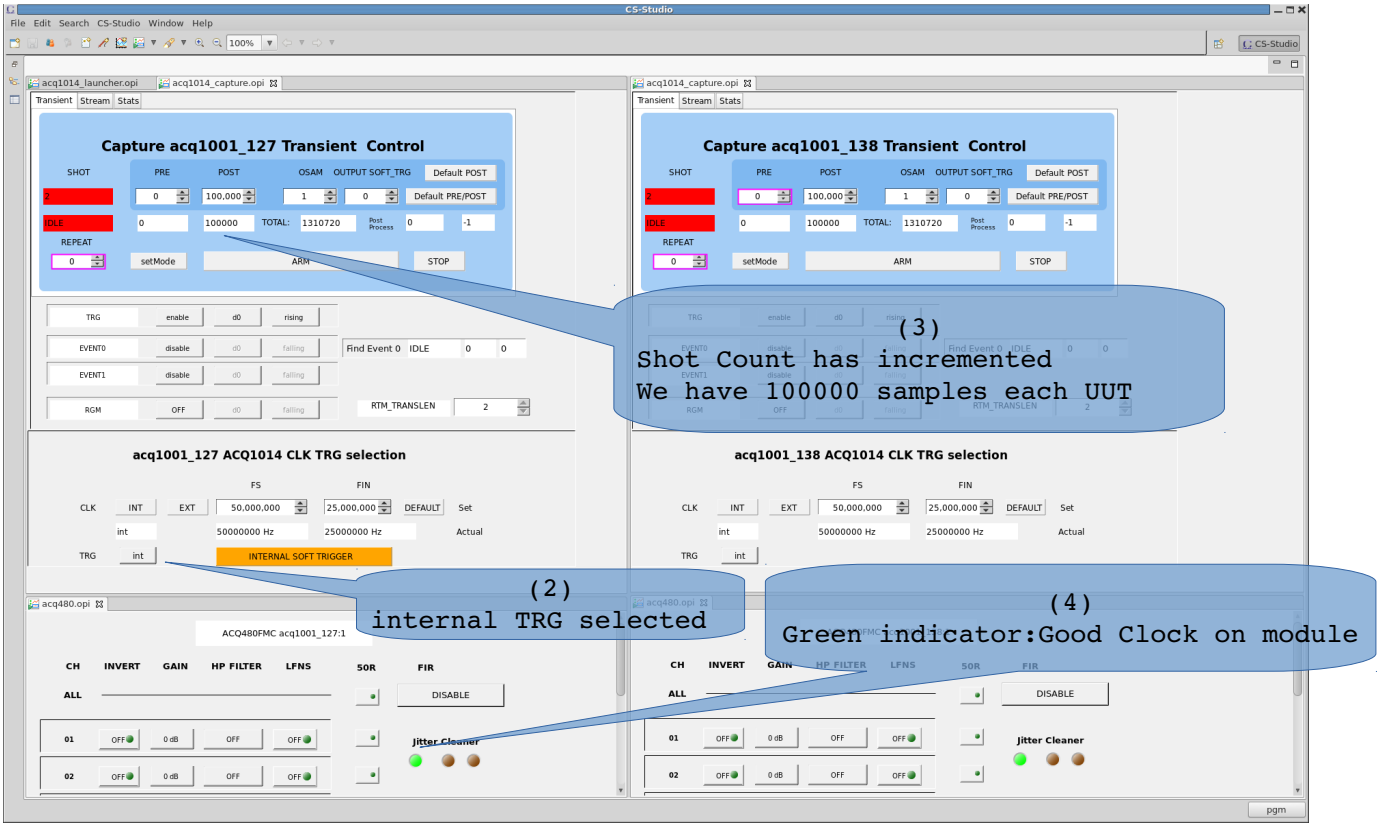
Start with the CAPTURE screen:

- press CAPTURE, drag the UUTRIGHT opi to dock at the right hand side.
- select SITE=1 and press ACQ480, dock to lower edge of the screen.

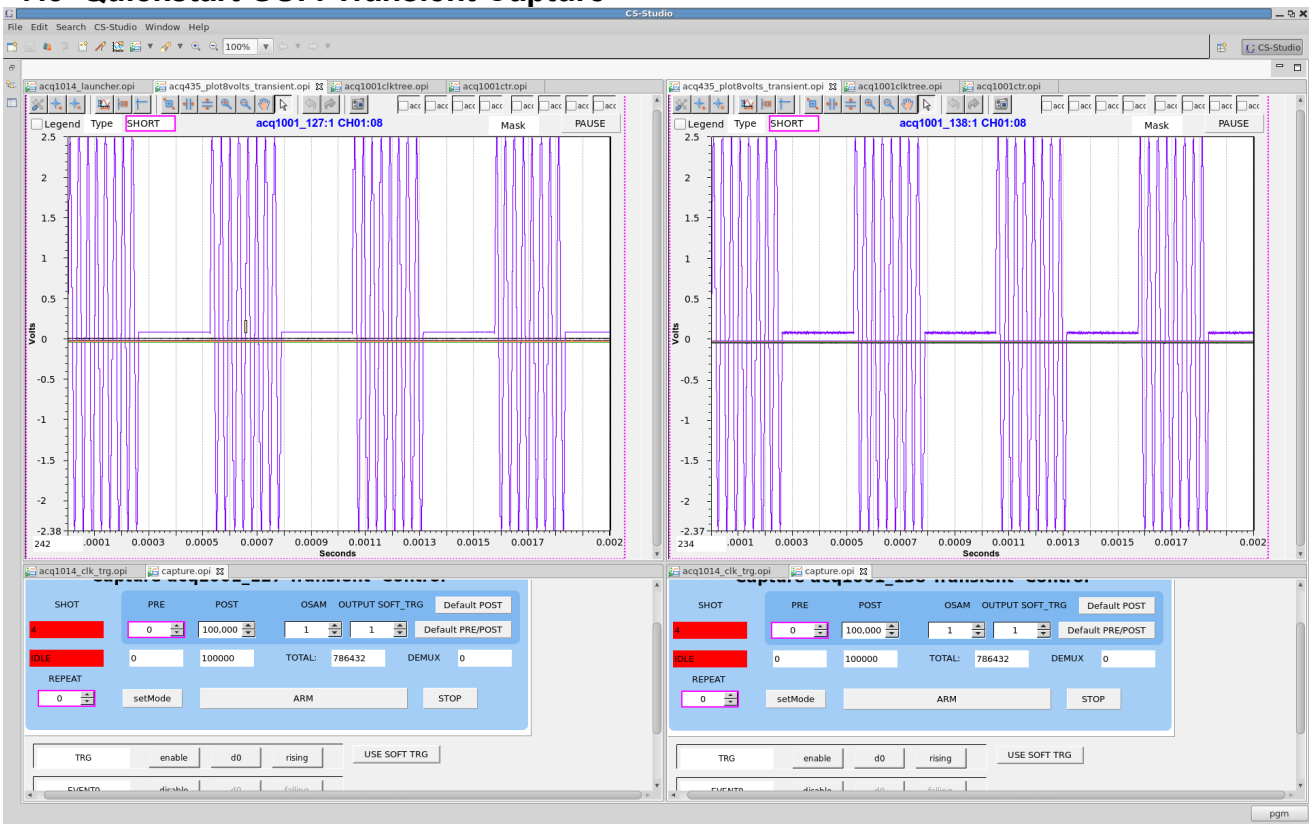
Example: Run a Transient: Before



Example: Run a Transient: After

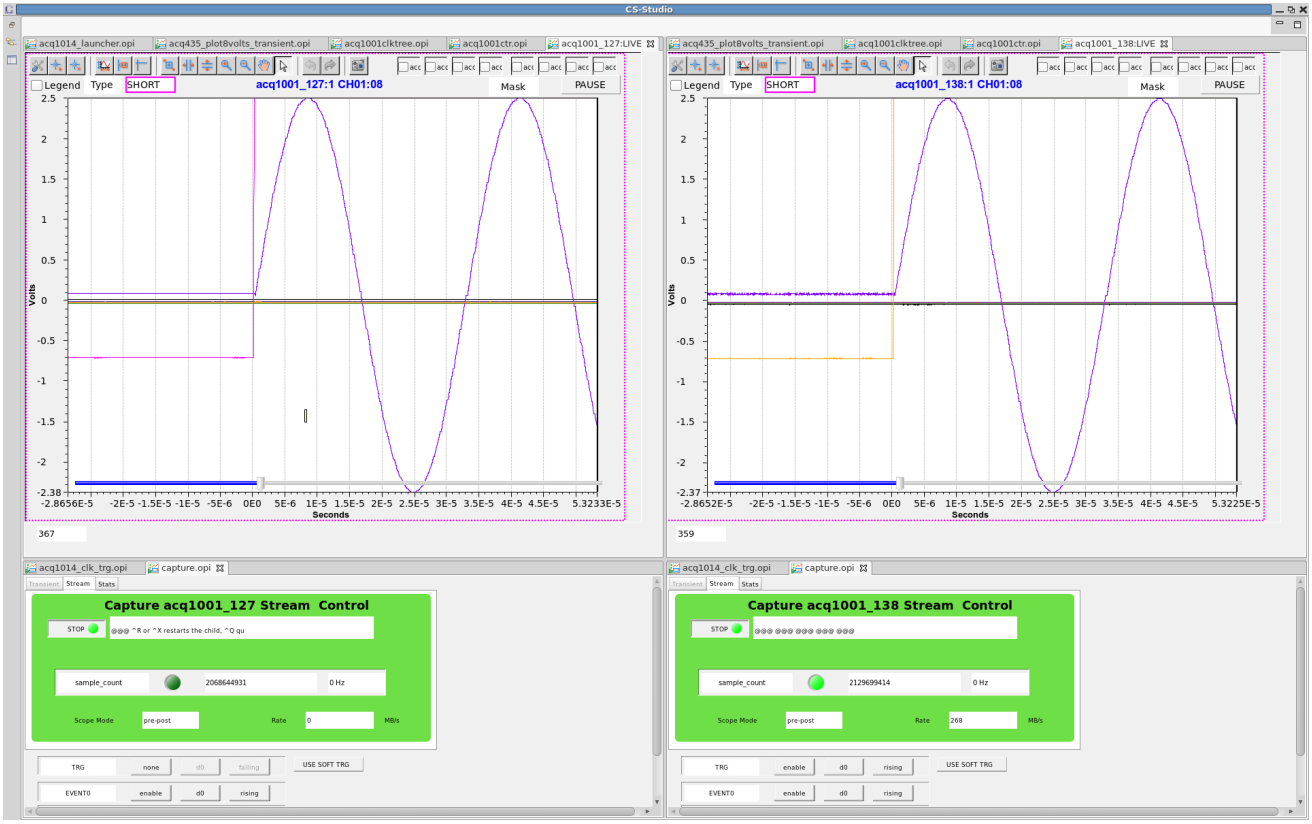


7.3 Quickstart GUI : Transient Capture



7.4 Quickstart GUI Streaming Capture (Live Scope)

- Enable Event0, using input trigger signal, select Rising|Falling
- Press START, display shows a repeating update, synchonized with the trigger.
- A delay cursor allows continuously variable delay
- Event Rising|Falling may be changed in-shot



8 Scripted Control

Anything that can be controlled from the UI can be controlled from a script, either local or remote.

8.1 ACQ1014 Unique commands

It's important to note that ACQ1014 is really 2 x ACQ1001 units, ie two discrete embedded systems, however, they can be configured to work in synchonization. The commands below are intended to be run identically on each unit. The commands are presented on port 4220 for ease of remote control.

acq1014+acq480.init SAMPLE-RATE	boot time initialization
acq1014_is_master	outputs 1 if master sync loopback cable is connected to this unit.
acq1014_select_clk_src {int|ext} {SR} [CR]	configure clocking: int: internal (Rear Panel) clock ext: external (Front Panel) clock (SOLO box only – all SLAVE boxes are clocked from Rear Panel, and hence use the int clock) SR: Sample Rate in Hz CR: [external] clock rate in Hz if known.
acq1014_select_trg_src {int|ext|ext2}	configure triggers Master Box: int:soft trigger ext: Front Panel trigger ext2: Front Panel trigger, TRG2 if slave 8 channels Slave Box : must be int.
acq1014_matched_pair	supervisory script, includes select_trg_src

8.2 acq1014_matched_pair

Complete capture supervisory script, run on each box.

8.2.1 Synopsis

```
[PRE=pre-length] [POST=post-length] acq1014_matched_pair [sig] [edge]
pre-length: 0..25000000 [default 0]
post-length: 0..25000000 [default 25000000]

PRE+POST : not to exceed 30000000

sig:  [int|ext|ext2]  [default:ext]
      int: internal (soft trigger),
      ext: shared trigger on TRG input BNC
      ext2 : split triggers, UUTLEFT is on TRG, UUTRIGHT is on CLK/TRG2

edge: [falling|rising]  [default: rising
```

8.2.2 Example 1

Command on UUTLEFT:

```
PRE=1000000 POST=25000000 acq1014_matched_pair ext
```

Command on UUTRIGHT

```
POST=1000000 PRE=25000000 acq1014_matched_pair ext
```

Both UUT's trigger on the SAME trigger, UUTLEFT has small PRE, big POST, UUTRIGHT has big PRE, small POST.

After data upload, timeshift and plot (D-TACQ recommends kst2), data is shown to be perfectly aligned.

8.2.3 Example 2

Command on UUTLEFT:

```
PRE=1000000 POST=25000000 acq1014_matched_pair ext2
```

Command on UUTRIGHT

```
POST=1000000 PRE=25000000 acq1014_matched_pair ext2
```

UUTLEFT has small PRE, big POST, triggers on input TRG,

UUTRIGHT has big PRE, small POST, triggers on input CLK/TRG2.

The two triggers were commoned externally, after data upload, timeshift and plot (D-TACQ recommends kst2), data is shown to be aligned.

9 Transient Data Service

9.1 Host-Pull

Post-shot channelized data is available from sockets 53001..53008 / TCP.

Simply connect to the socket and read until done.

9.1.1 Minimal scripted Linux Host-Pull example

```
#!/bin/bash
# host-pull fetch channels [8] to files CH0x

UUT=${1:-acq1001_127}
CMAX=${2:-8}

for ch in $(seq $CMAX); do
        nc -i 1 $UUT 5300$ch > $(printf "CH%02d" $ch) &
done

for ch in $(seq $CMAX); do
        wait
done
```

Above script fetches data to 8 binary files-per-channel. Takes 9s for 25MSamples.

Minimum time is limited by the 1s idle time out on the general purpose NC. A customized client would avoid this.

Easy to plot the data using kst2. Needs this format files-per

```
[pgm@hoy4 ACQ1014_TEST]$ cat format
CH01  RAW   s     1
CH02  RAW   s     1
CH03  RAW   s     1
CH04  RAW   s     1
CH05  RAW   s     1
CH06  RAW   s     1
CH07  RAW   s     1
CH08  RAW   s     1
```

9.2 Target-Push

- EPICS waveform records .. good to maybe 100k Points
- MDSplus Thin Client mdsPutCh – push to MDSplus tree with calibration and time.
- FTP Client - push raw data to remote FTP server
- Samba Client. - push raw data to remote Windows file share.

10 Clock and Sync Options

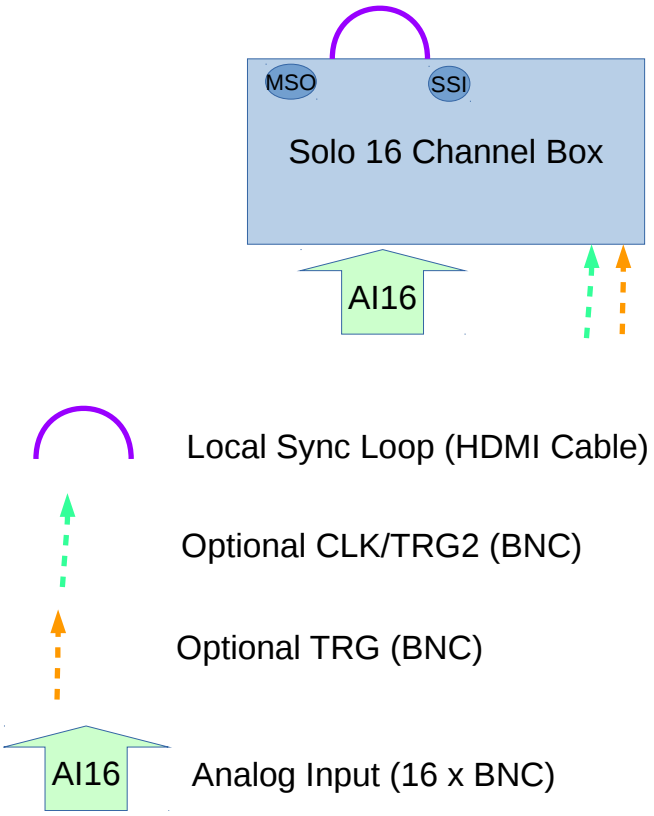
10.1 Single box:

Always connect the clock loopback from MSO to SSI.

Optionally connect your external clock to the front panel CLK input.

Optionally connect the primary trigger TRG

For 2 x 8 channel operation, connect the secondary trigger TRG2.

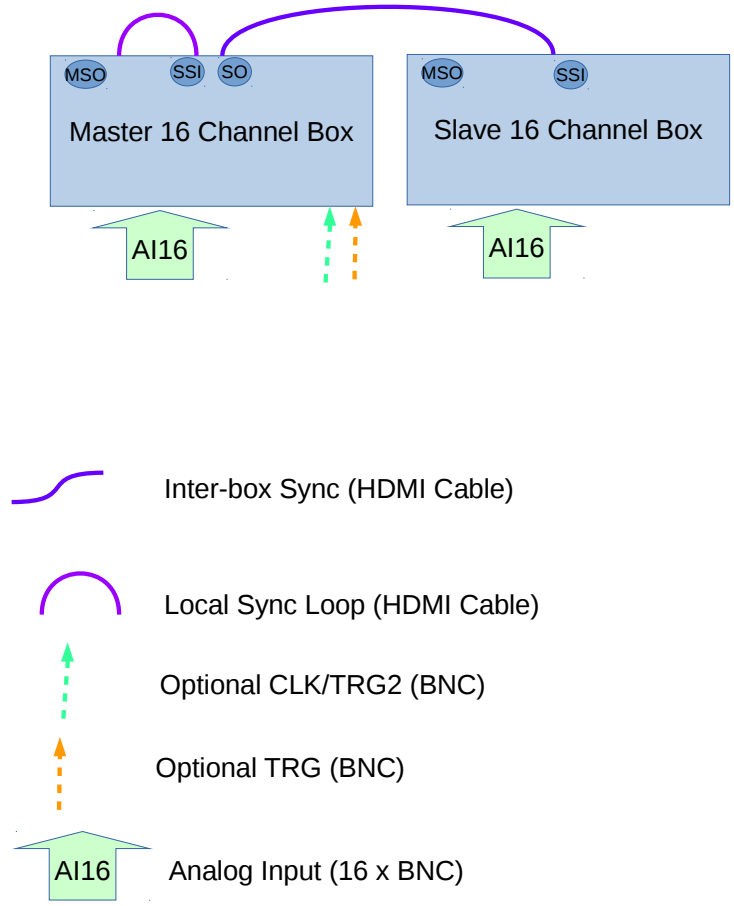


Drawing 5: : Single Box sync, plan view

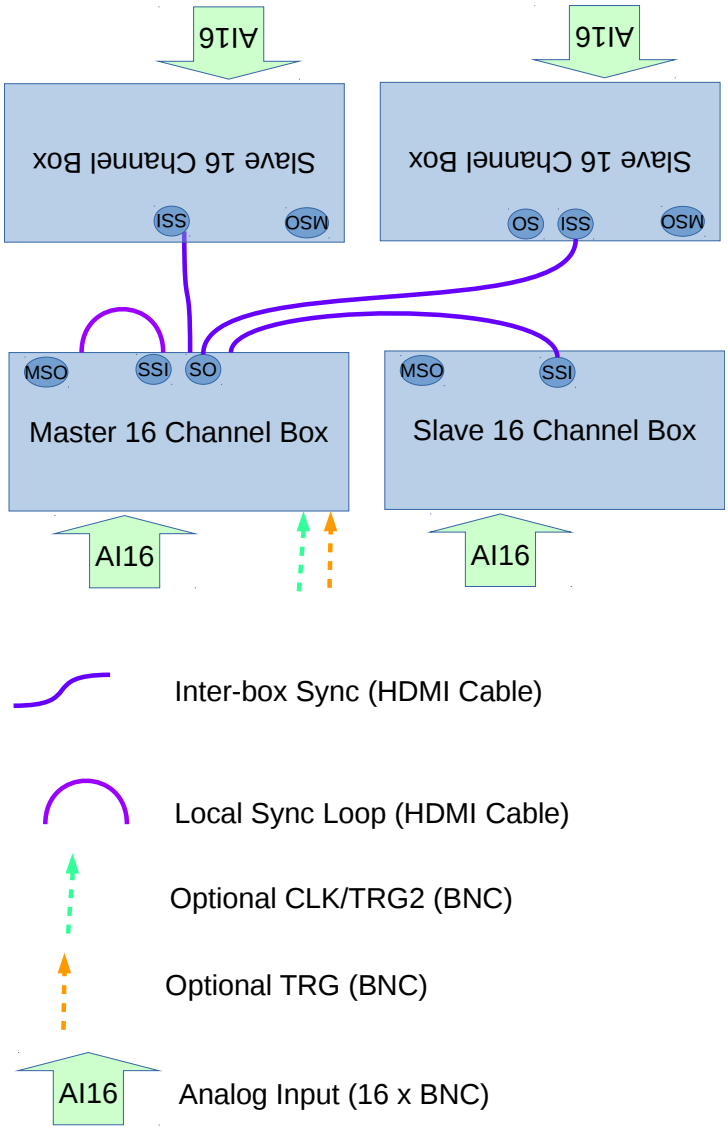
10.2 Multiple box:

Designate one box as the master, and connect as above.

On each slave box, connect an HDMI cable from SYNC OUT in the middle of the master box rear panel to SYNC IN on the slave box. Each slave box will experience a single gate delay or less than 10nsec delay; this is not visible in the sampling system.



Drawing 6: : Two Box sync, plan view

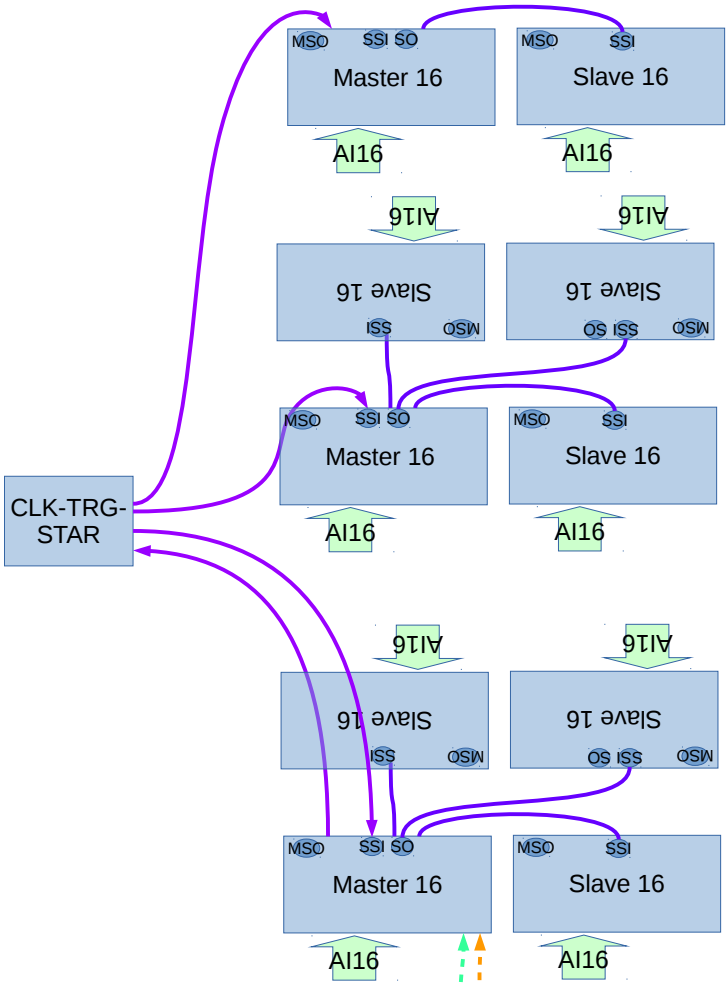


*Drawing 7: : Three/Four Box sync, plan view (*Rev B only)*

10.3 Unlimited fanout with CLK-TRG-STAR accessory.

While it's possible to daisy-chain additional slave boxes, we don't recommend this as the gate delays will add up. D-TACQ provides a clock distribution box for this purpose.

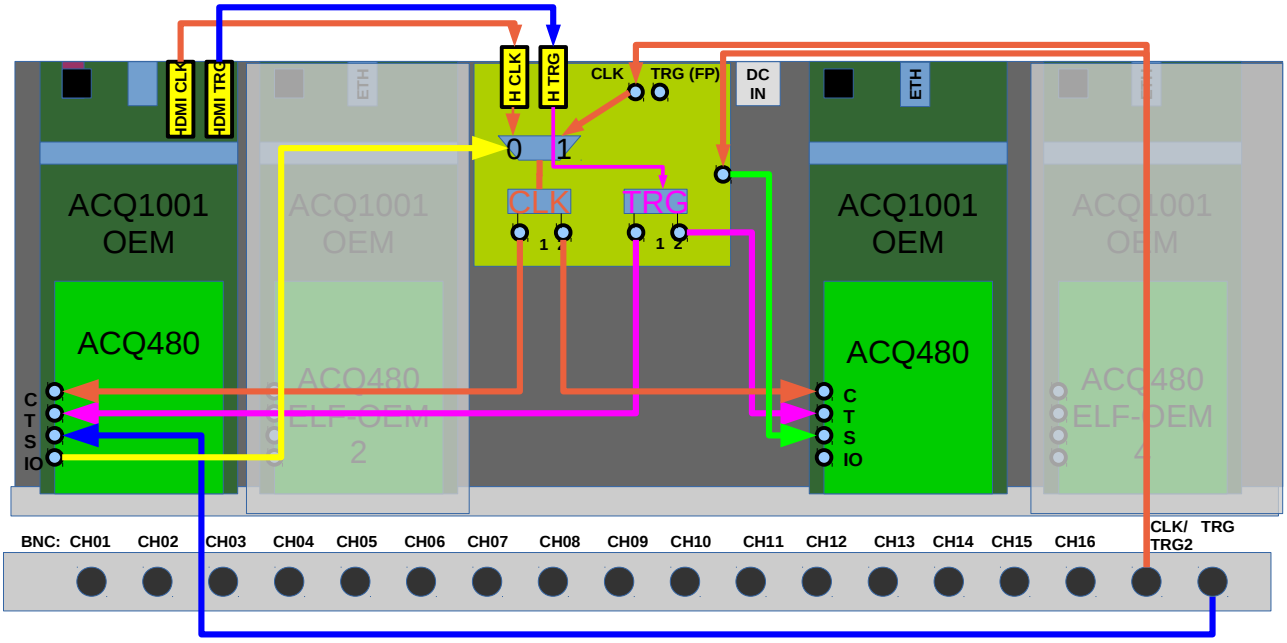
CLK-TRG-STAR provides 1:4 fan out from a master clock, allowing 4 x 64 channels sampling with maximum 1 gate delay variation.



Drawing 8: : Multiple box sync, using CLK-TRG-STAR

10.4 Internal Signal Routing.

Soft_trigger or Front Panel - Selection on SYNC opi Fork CLK in to be used as optional 2nd Trigger



Trigger 1 FP is sampled by 25 MHz clock on MASTER board before being pushed out HDMI to become **global trigger.** Pushed out **d7** of the TRG BUS in System Control Module. Soft_trigger is also is sampled by 25 MHz clock in System Control Module before it hits the TRG BUS(**d1**) and potentially selected as **HDMI TRG**

Global trigger (Soft/Front Panel) resampled on 25 MHz clock in System Control Module. Mapped onto **d0** of TRG BUS in System Control Module.

Optional **Trigger 2** for slave board. Operate as Internal Clock 2x banks of 8CH. Mapped onto **d7** of TRG BUS in System Control Module

IO Selects Rear Panel RP or Front Panel FP CLK

11 Appendix: starting the UI from scratch.

1. Download cs-studio binary eg from :

   https://ics-web.sns.ornl.gov/css/products.html

   https://ics-web.sns.ornl.gov/css/updates/apps/basic-epics-4.1.1-win32.win32.x86_64.zip

   https://ics-web.sns.ornl.gov/css/updates/apps/basic-epics-4.1.1-linux.gtk.x86_64.zip

   https://ics-web.sns.ornl.gov/css/updates/apps/basic-epics-4.1.1-macosx.cocoa.x86_64.zip

2. Download D-TACQ OPI set

   https://github.com/petermilne/ACQ400CSS/

   Store data at PROJECTS/ACQ400/OPI

3. Run cs-studio, create new workspace

   Press “Workbench”

   From Navigator:

   Right Click, New Project, General, Project, Next>

   Uncheck Use default location

   Browse to PROJECTS/ACQ400/OPI/ACQ400 [OK]

   Project Name : type ACQ400

   [FINISH]

4. Specifically for ACQ1014

   Edit | Preferences | CSS Applications | Display | BOY |

   Top OPI's : delete all, enter acq1014_launcher.opi

   [APPLY]

   Opi Runtime

   Macros ADD:

   UUTLEFT <uutleftname eg acq1001_112>

   UUTRIGHT <uutrightname eg acq1001_113>

   [APPLY] [OK]

   File | Restart cs-studio

   From Navigator, double click ACQ1014_launcher.opi. Check that UUT left and right names are correctly set.

12 Changelog

Date	*Rev*	*Section*	*Changes*
20161109	2	8.2,8.3	matched and independent central control
20161111	3	8.2	acq1014_matched_pair command.