# XCAM Controller Unit (XCU-A)

# Product Specification Notes

## Introduction

XCAM have developed an XCAM Controller Unit (XCU-A) which operates almost any type of e2v Technologies CCD imaging sensor; it is perfect for use for CCD evaluation studies, or used as the basis for a custom CCD camera system.

The controller:

- Drives any e2v Technologies ***CCD*** or ***L3 CCD*** (also referred to as ***EMCCD***)
- Drives 2, 3 or 4 phase CCDs
- Drives ***Swept Charge Devices*** (SCDs)
- Drives other manufacturer's CCDs with interface box; it has been used to drive Kodak and Atmel (now e2v Technologies) CCDs
- Allows complete control of the clock and bias voltages and timings
- Enables operation in unusual operating modes
- Can be fitted with one of a selection of ADC cards each optimised for their application
- Has trigger input and outputs to allow synchronisation with your experiment


**XCAM Controller Unit**

# XCAM Controller Unit (XCU-A)

## Controller Applications and Flexibility

The controller is well-suited to a wide range of uses, but it is particularly popular for use by customers who want to perform CCD evaluation and characterisation studies, and as a basis for the design and manufacture of custom CCD camera systems for science experiments.

The controller's flexibility means that whilst it is often purchased for the evaluation, say, of a particular type of CCD for a specific project, customers then go on to use the controller for evaluation of other CCD types or for other projects in the future.

Some examples of past controller use, which demonstrates this flexibility are:

- CCD evaluation for space science work, characterising the flat-band voltage change of a CCD before and after irradiation
- Driving an e2v Technologies CCD4290 in a custom camera head for a laser plasma experiment
- Driving an L3 (EMCCD) custom sensor for an X-ray experiment at a synchrotron
- Driving an e2v Technologies CCD203-84 CCD in a cryogenic chamber for characterisation studes
- 3 units used to drive 3 e2v Technologies CCD4482 CCDs simultaneously in a custom camera head design for XFEL experiments
- Used to drive an e2v Technologies CCD5710 in an unusual operating mode for analysis of volatile atmospheric constituents


Required items to build a system:

- Controller and associated cables; controller to have 1 CDS card, one interface card, one sequencer card and one bias card
- Either a CCD on a headboard OR a CCD in a camera head; in this XCU-A style system, the headboard or camera head provide local supply decoupling and CCD output amplification, in addition to mechanical interface requirements
- Sequencer code for CCD type
- XCAM application software to facilitate use of controller and enable data visualisation and analysis, OR customers can write their own software using our software developer's manual.

# XCAM Controller Unit (XCU-A)

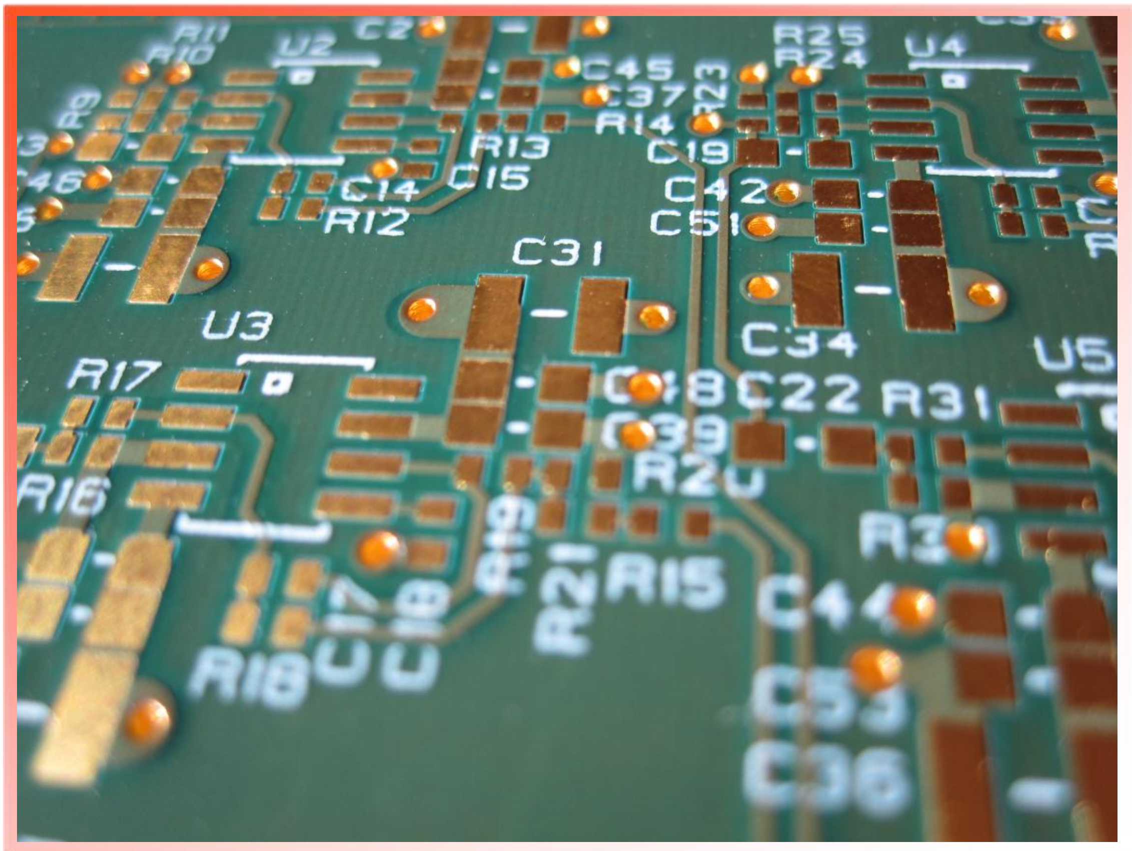
## Controller Construction and Operation

The controller comprises 4 cards together with power supply and power management in a robust housing. The 4 cards are the ADC card, the Interface card, the Sequencer card and the Bias card, and these are described each in turn below:

### ADC card (CDS card)

The ADC card is the card which takes the CCD output and measures the charge in each pixel and converts it to a digital number. This card type is often referred to as the CDS card; CDS is the abbreviation for Correlated Double Sampling, which is a technique that is used to achieve low noise measurements at higher speeds. Another technique which is also used, is that of the Dual Slope Integrator (DSI), and this is used for achieving close to sensor-limited noise measurements where high speed is not required.

Currently there are two types of CDS card available, and any of these can be inserted into the drive unit and used so that you can choose the optimum for your application at any given time. More than one cannot be used simultaneously.



The options to select from

1. 2 x 1MHz CDS card: this CDS card is of true CDS type and handles 2 CCD output nodes simultaneously, with each one operating at speeds of in excess of 1MHz and with low noise of 7 electrons when using optimised settings.
2. A 4 channel 16 bit DSI card enables the user to operate CCDs which have 4 output nodes, or take the output from 2 x 2 output node CCDs, for example, or to take 4 single outputs. This card operates at speeds of about 100KHz and give sensor-limited noise performance with optimised settings.

**The Interface Card**

The interface card is the card which bi-directionally handles all communication between the drive box and the PC, both for issuing commands to the drive unit eg *grab image*, and for receiving data back to the host PC. This card is available as an USB2 interface card for direct interface to a PC, or as a Cameralink card which is used with a National Instruments data acquisition card in the PC.

Options to select from

1. USB2 Interface Card
2. Cameralink Interface Card (needs National Instruments Data Acquistion card NI1426)

**The Sequencer Card**

The sequencer card is the card which produces the clock waveforms for the CCD. This is achieved by the use of a digital signal processor, which is easily reprogrammed, and this enables the system to be modified to drive alternative CCDs. We do not support user-reprogramming of the DSP, but instead provide sequencer codes for any supported CCD. New sequencer codes will be provided on request, but XCAM may require the loan of an engineering grade CCD, if no CCD of that type exists at XCAM for set-up and optimisation of the sequencer code. This sequencer currently operates CCDs at pixel rates of up to about 2-3 MHz depending on the device type and other restrictions. There may be other options available in the future

The options to select from

1. 2MHz Sequencer Card

# XCAM Controller Unit (XCU-A)

## The Bias Card

The bias card generates the clock voltages, which are then modulated by the sequencer card, and the CCD output FET bias voltages. Currently bias voltages are suitable for all e2v Technologies CCDs but can also operate other CCD types by providing the relative voltages required; please enquire for further detail.

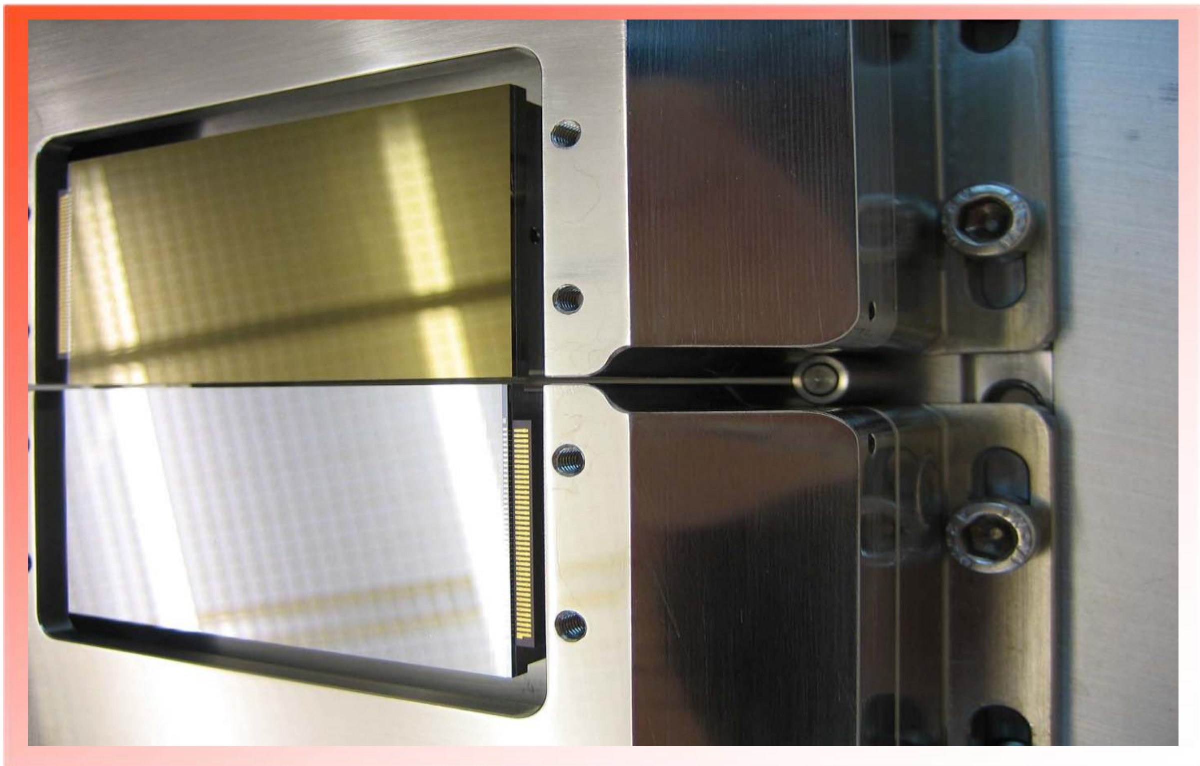
A P channel CCD bias card is in prototype form available to order shortly. Bias cards suitable for operating alternative CCDs may be availble on request.

Options to select from are

1. E2v technologies N channel CCD bias card
2. E2v technologies P channel CCD bias card (available to order shortly)

## Temperature Controller

We anticipate being able to include an integrated temperature controller unit in the future, but for the current time recommend an external stand-alone temperature controller or power supply is recommended for cooling of the device.



## XCAM Controller Software Options

The ***Application User Software Package*** (API) provides users with an easy interface with which to control and communicate with the controller and do simple analysis and data visualisation; please see separate product note which covers the software in more detail.

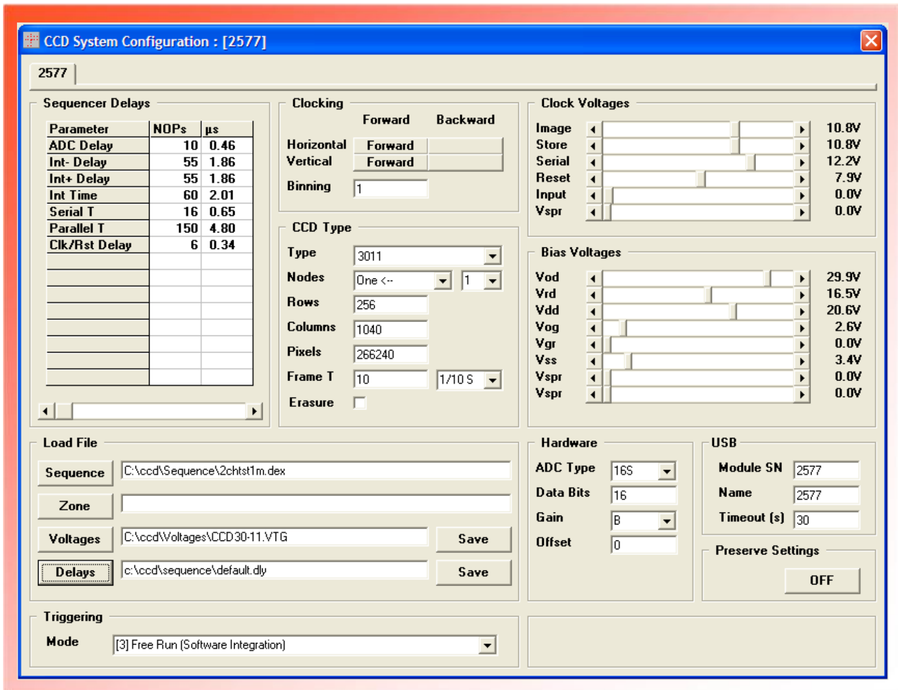
Alternatively, a ***Software Developer's Manual*** is provided for users who would prefer to write or use their own software, calling the XCAM dll files.

Many XCAM Controller users, use programs such as ***Matlab*** to control the drive unit, and a library of code is being developed to assist these users; this code will be made available on request.

The minimum specification for a PC to operate the system is Windows 7, XP Pro or Vista operating system; 2 GHz processor; 2 GB memory minimum; hard drive 100GB minimum; CD drive; 3 USB2 ports.

The controllers can be used to control custom multiple large area CCD camera systems synchronously in master-slave mode operation.

Both hardware and software triggering is possible, of either polarity. Custom triggering schemes are possible allowing seamless integration with experiments can be made produced.



# XCAM Controller Unit (XCU-A)

## Technical Specifications and Details

### Dimensions and Weight

The controller has dimensions of approximately 340mm width, 130mm height and 310mm depth. The weight is 5.6Kg

### Front Panel Connections

The front of the controller has several connections. 4 BNC connectors take up to 4 CCD outputs into the controller; note that the number of CCD outputs that can be used simultaneously depends on the CDS card that is included in the box at the time of operation.

Trigger and Sync BNC connectors are provided: the trigger input allows the user to provide a trigger signal to the box for synchronisation of image acquisition with an experiment; the sync connector is a line sync output which can also be useful for synchronisation.

There is a USB2 connector which allows the bilateral USB2 connection to communicate with the host PC and pass data back to the PC, or a Cameralink MDR connector.

The front 25w D connector supplies all the clock and bias voltages that are required for successful operation of the CCD and the pin designations are given below.

| Pin | Function | Remarks | Range | Pin | Function | Remarks | Range |
|---|---|---|---|---|---|---|---|
| 1 | I1 | Image Clock 1 | 0-15 | 14 | I2 | Image Clock 2 | 0-15 |
| 2 | I3 | Image Clock 3 | 0-15 | 15 | n/c | | |
| 3 | S1 | Store Clock 1 | 0-15 | 16 | S2 | Store Clock 2 | 0-15 |
| 4 | S3 | Store Clock 3 | 0-15 | 17 | DG | Dump Gate | 0-15 |
| 5 | R1 | Serial Clock 1 | 0-15 | 18 | R2 | Serial Clock 2 | 0-15 |
| 6 | R3 | Serial Clock 3 | 0-15 | 19 | n/c | | |
| 7 | PhiR | Reset | 0-15 | 20 | P/A 0V | Preamp 0V | 0V |
| 8 | +15V | Preamp +15V | +15 | 21 | -15V | Preamp -15V | -15V |
| 9 | Vod | V Output Drain | 0-34 | 22 | Vrd | V Reset Drain | 0-30 |
| 10 | Vdd | V Dump Drain | 0-30 | 23 | Vss | V Substrate | 0-30 |
| 11 | Vog | V Output Gate | 0-30 | 24 | n/c | | |
| 12 | Vgrn/c | V Guard Ring | 0-34 | 25 | n/c | | |
| 13 | | | | | | | |

## Back Panel Connections

The back 9wD connector provides additional inputs and outputs for more sophisticated triggering requirements.

| Pin | Function | Remarks |
|---|---|---|
| 1 | +5V o/p | n/a |
| 2 | PF4 - input | n/a |
| 3 | PF6 - input | n/a |
| 4 | PF0 (Sync) - Output | n/a |
| 5 | nc | n/a |
| 6 | Dig GND | n/a |
| 7 | PF5 - Input | n/a |
| 8 | PF7 - Input | n/a |
| 9 | PF1 (Strobe) - Output | n/a |

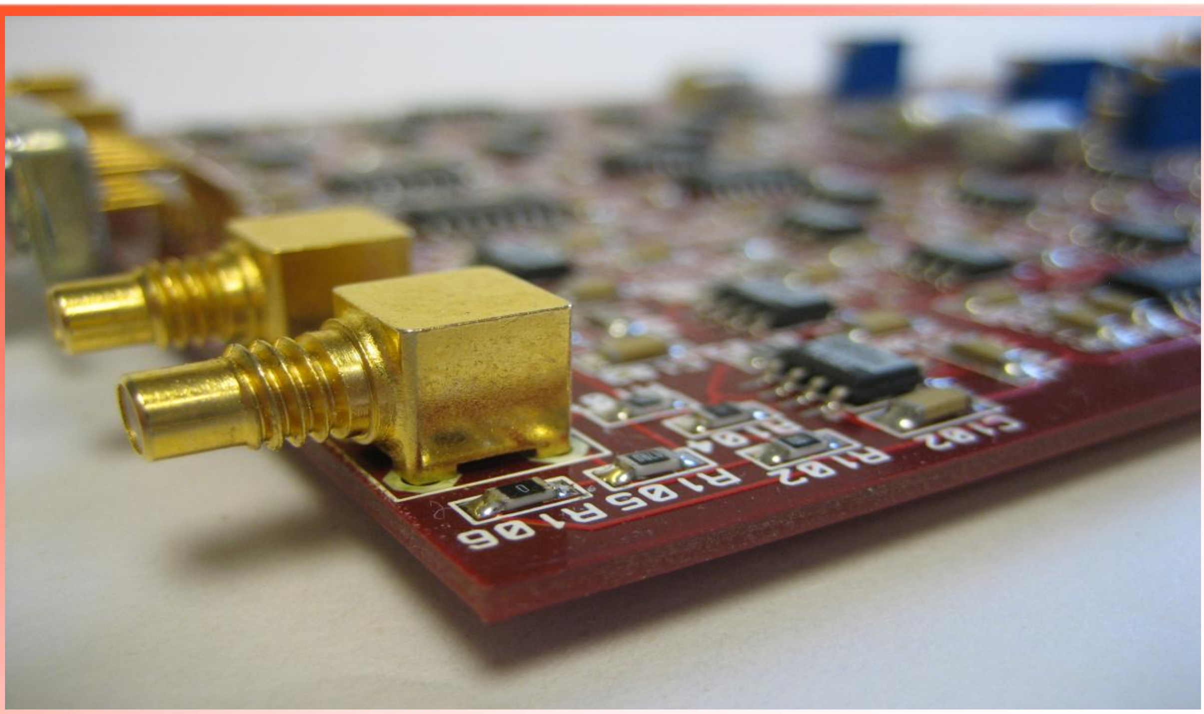
# XCAM Controller Unit (XCU-A)

## Noise performance and Speed of Operation

The current sequencer card can operate at frequencies of approximately 3MHz, although this may be lower depending on the sequencer program that is operating the CCD and various factors such as number of phases of operation of the CCD. The clock frequency of the CCD is usually 16-20MHz, giving the possibility of programming in 33-20ns steps.

Noise performance is heavily dependent on the speed of operation, the ADC method, and the CCD chip used. Typical values for noise, together with frequency of operation are given below in the table.

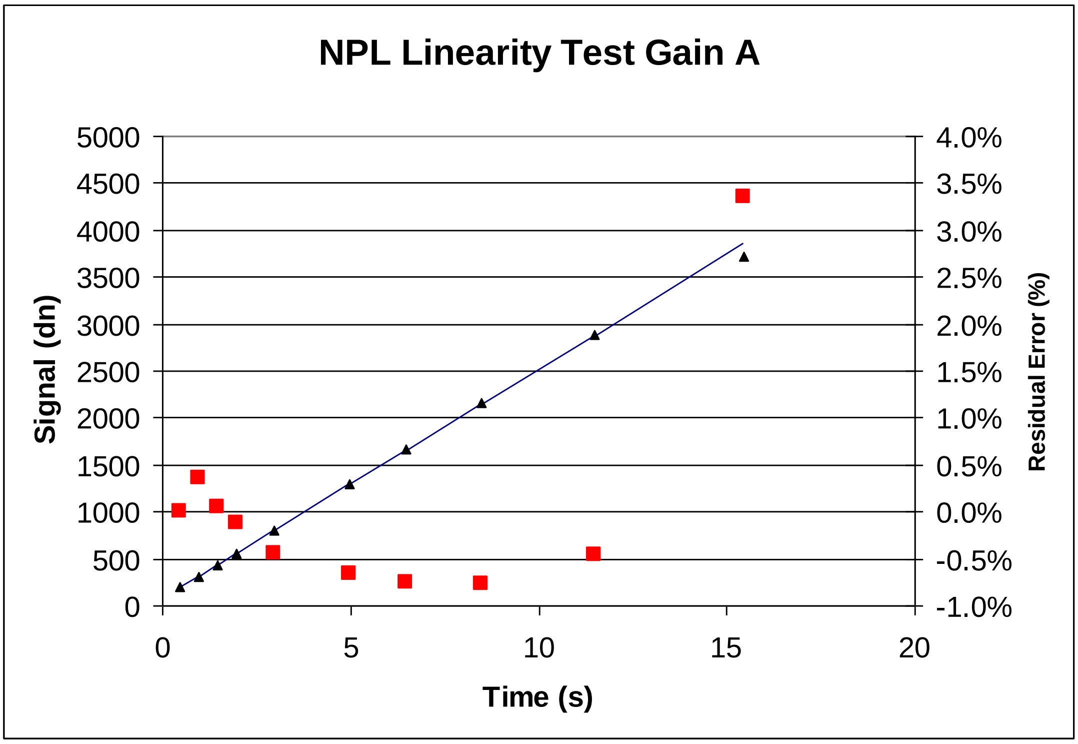
| ADC Card | Speed | Noise |
|---|---|---|
| 1MHz, 2 channel, Correlated Double Sampling | To 2MHz | Approximately 7 electrons (depending on sensor noise) at 1MHz |
| 500KHz, 4 channel, Dual Slope Integrator | To 500KHz | Sensor noise limited if all voltages and timings optimised ~ 2 electrons |



# XCAM Controller Unit (XCU-A)

## Linearity Data

We have measured the linearity of the XCAM system at the UK National Physical Laboratory (NPL), where a stabilized optical light source was used to illuminate the CCD, and the image exposure time increased. The measured results of this experiment are given in the figure below, with the residual error from a linear relationship shown in the red points (scale on the right hand side). This indicates that the linearity of the system is typically <1%, but deviates in the low gain mode for the largest signals approaching the amplifier full signal capacity.





**XCAM Limited**
2 Stone Circle Road
Round Spinney
Northampton
NN3 8RF, UK

Tel: 44 (0)1604 673700
Fax: 44 (0)1604 671584
Web: www.xcam.co.uk
Email: info@xcam.co.uk