# Kentech Instruments Ltd.

# X-Ray Streak Camera
# SPIDER

Unit 2

Version 3

public version

Last Modified 5 March 2012

PLEASE READ THIS MANUAL CAREFULLY BEFORE USING THE CAMERA.

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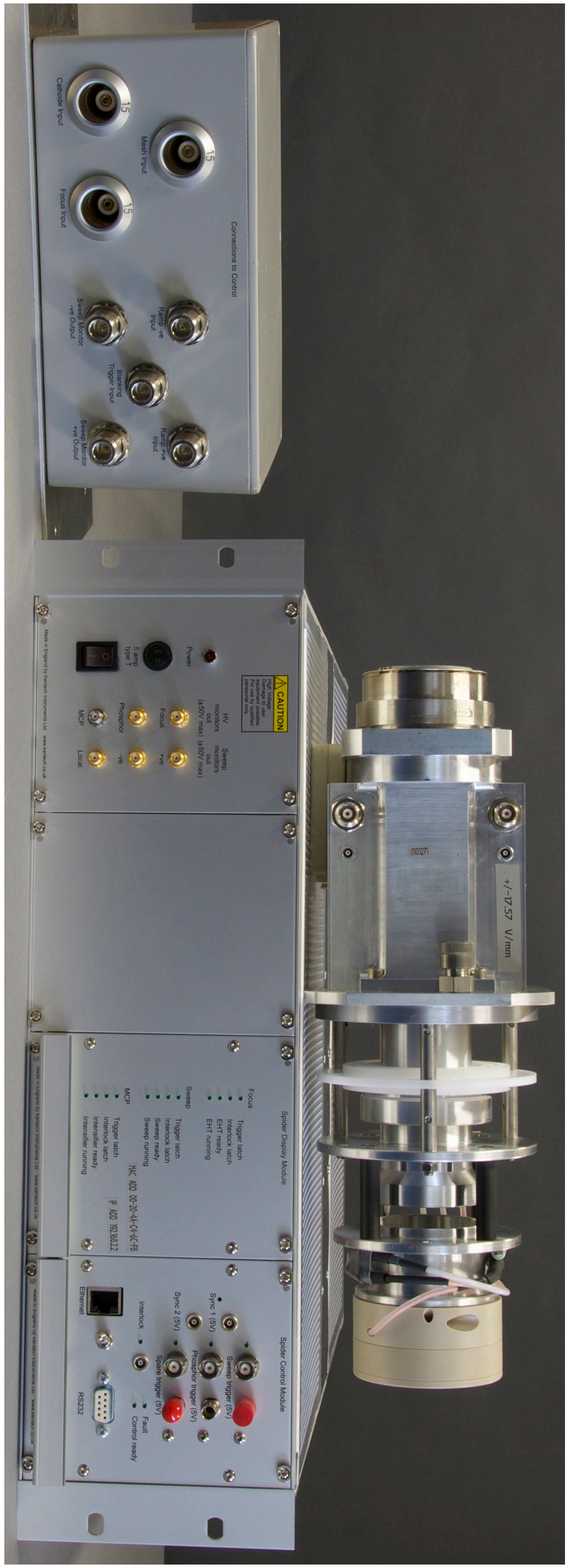


Figure 1 Spider electronics, interface box and streak tube

# 1. DISCLAIMER

This equipment contains high voltage power supplies. Although the continuous current supply capacity is small, careless use could result in electric shock. It is assumed that this highly specialised equipment will only be used by qualified personnel. As this equipment is designed to work over ~50m of cabling the energy stored in the cables can be ~1 joule. In addition the energy stored in the phosphor pulser is similar. Kentech Instruments Ltd. accept no responsibility for any electric shock or injury arising from use or misuse of this equipment. It is the responsibility of the user to exercise care and common sense with this highly versatile equipment.

# 2. ABBREVIATIONS

| | |
|---|---|
| ADC or adc | Analogue to Digital Convertor |
| CPLD | Complex programmable logic device |
| CCD | Charge Coupled Device (camera) |
| cr | carriage return |
| DPCO | Double Pole Change Over |
| dv | desired value |
| EEPROM | Electrically and Erasable Programmable Read Only Memory, non-volatile |
| EHT or eht | Extra High Tension (high voltage) |
| EPLD | Electrically programmable logic device |
| EPROM | Electrically programmable read only memory, non-volatile |
| FET | Field Effect Transistor |
| GXD | Gated X-ray Diagnostic |
| HV | High voltage |
| hw | hardware |
| INT | Intensifier |
| lf | line feed |
| LFC | Large Format Camera, Gated X-ray Imager |
| MAX | A phosphor and MCP combination |
| MCP | Micro Channel Plate |
| MCU | Main Control unit |
| mv | measured value |
| PCD | Photo Conductive Detector |
| PSU or psu | power supply unit |
| RAM | Random access memory, volatile. |
| ro | read only |
| rw | read and write |
| SW | sweep |
| sw | software |
| UCS | Users Control System (to be provided by the user) |
| W/E | Write Enable |
| wo | write only |

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# 3. INTRODUCTION

This manual describes the operation and use of the Spider streak camera and has been updated for use with unit 2 (J1109122). The camera is based upon DISC which is a streak camera, itself based upon our standard Kentech Low magnification tube design. Spider uses the same image tube as DISC but a new set of rack mountable electronics designed to be able to drive the camera from ~ 50m distance. The software control interface uses similar techniques to the DISC and GXD for control of the unit, however, the Spider is a more complex device and the user needs to be aware of the impact of operating from 50m distance from the streak tube. For users not familiar with X-ray Streak cameras or indeed any streak camera, some information may be found at http://www.kentech.co.uk/tut_xrsc.html and http://www.kentech.co.uk/PDF/Slide_show2003.pd

The system comprises the electronics package in a 19 inch rack mount enclosure, an interface box and the streak tube. In addition there is a bulkhead between the interface box and the streak tube.

## 3.1 DIFFERENCES BETWEEN UNITS 1 AND 2

The only differences are small calibration changes and some upgrading of a few PCBs but with no functional changes. The software is identical. Some differences in the absolute delays from trigger time to arrival of a signal on a panel will be found. The focus voltages and sweeps are set up for tube J1109121.

## 3.2 MATTERS ARISING FROM MANUAL V2

Some ambiguities arose from version 2 of the manual and these have been updated in this version. In particular the following have been addressed:

1. Phosphor pulsed mode voltages
2. Interlock state, latch and indicators
3. Sweep bias polarity and ADCs
4. MCP measurables
5. Trip logic
6. Power supply current monitor

## 3.3 SPECIFICATIONS OF THE PACKAGE

| | |
|---|---|
| Streak tube | Low magnification Kentech design |
| Overall tube voltage | -15kV |
| Cathode length | >25mm |
| Cathode to extraction grid spacing | 1 to 5 mm dependent upon spacers and vacuum quality |
| Electron detector | The unit can be fitted with a standard Kentech phosphor or a MAX module. |
| Sweep speeds | The duration of the sweep can be set from ~2ns to ~20ns |
| Power requirements | typically 110 to 240 volts AC at ~ 1 amp |
| Dimensions | 482mm wide (19inch), 540mm deep (plus connectors), 133mm high. |

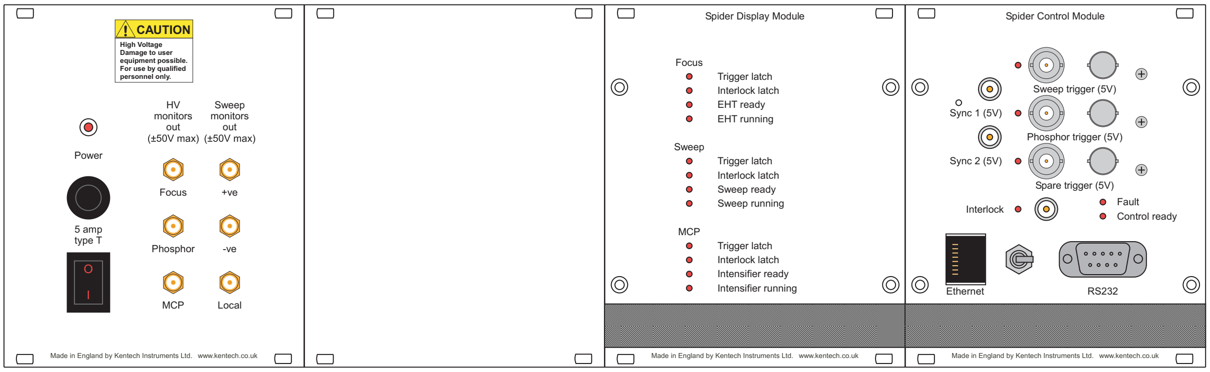



Figure 2 Front Panels

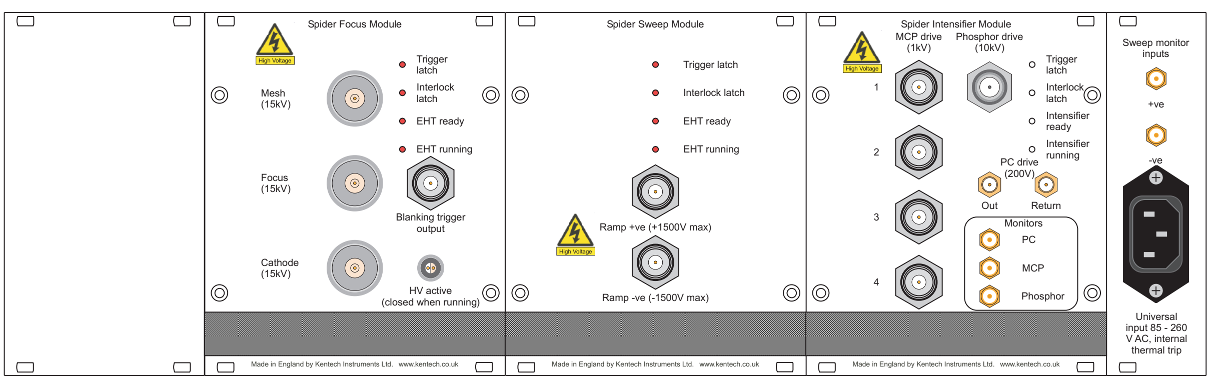



Figure 3 Rear panels

| | |
|---|---|
| Vacuum compatibility | The electronics has **NOT** been designed for operation under vacuum conditions. |
| Sweep bias voltage on each plate | Up to -1kV to +1kV nominal |
| Intensifier Phosphor Voltage | DC 0 to +5kV |
| | Pulsed 0 to +10kV but depends upon capacitive loading. |
| Focus Current trip | User settable through software (0 to 4095) in the range 0 to 8.7$\mu$A. Level 3 command. |
| Maximum repetition rate | Sweep unit >10Hz |
| The blanking and crowbar circuits | are limited by the rate of switch on of the focus voltages. These are ramped up over many seconds. |
| Triggers | Main |
| | Phosphor |
| | Spare |
| Electrical trigger requirements | 5 volts into 50Ω rising in < 5ns for all triggers. |
| Optical triggers | Optical trigger signal input |
| | Wavelength 820-900 nm |
| | Optical power (on) -15dBm (min), +3 dBm (max) |
| | Optical power (off) -30 dBm (max) |
| | Width (50% level) 100 ns (min), 250 ns (max) |
| | Rise time <2 ns |

Each of the three triggers may be either optical or electrical independently. The main trigger triggers the sweep unit. The Intensifier/Max module trigger is triggered from the phosphor trigger. The blanking and crowbar triggers are derived from the main trigger internally.

Connectors:-

| Module | Connector | Function |
|---|---|---|
| Mains Inlet Panel | | |
| | IEC | Mains in |
| | SMA | Sweep Monitor Input +ve |
| | SMA | Sweep Monitor Input -ve |
| Mains Switch Panel | | |
| | BNC | Crowbar Monitor |
| | SMA | Sweep Monitor Out +ve |
| | SMA | Sweep monitor Out -ve |
| | SMA | Sweep Monitor Out Local |
| | SMA | Focus Monitor |

| | | |
|---|---|---|
| | SMA | Phosphor Monitor |
| | SMA | MCP monitor |
| Control module | | |
| | Opto | Sweep Trigger - Opto |
| | Opto | Phosphor Trigger - Opto |
| | Opto | Spare Trigger - Opto |
| | BNC | Sweep Trigger - Digital |
| | BNC | Phosphor Trigger - Digital |
| | BNC | Spare Trigger - Digital |
| | PSA.00.250.NTLC29 | Sync |
| | PSA.00.250.NTLC29 | Sync |
| | PSA.00.250.NTLC29 | Interlock |
| | 9-way D | RS232 |
| | RJ-45 | Ethernet |
| Focus Module | | |
| | ERA.1Y.416.CLL | Focus |
| | ERA.1Y.416.CLL | Mesh |
| | ERA.1Y.416.CLL | Cathode |
| | TNC | Blanking Trigger |
| | ERA.0S.302.CLL | HV Active |
| Sweep Module | | |
| | TNC | Ramp +ve |
| | TNC | Ramp -ve |
| Intensifier Module | | |
| | TNC | MCP Drive 1 |
| | TNC | MCP Drive 2 |
| | TNC | MCP Drive 3 |
| | TNC | MCP Drive 4 |
| | SHV | Phosphor Drive |
| | SMA | Phosphor Monitor |
| | QMA | Photocathode 1 |
| | QMA | Photocathode 2 |

| | |
|---|---|
| SMA | MCP monitor |
| SMA | Photocathode monitor |

Interface Unit (control side)

| | |
|---|---|
| ERA.3Y.415.CTL | Cathode Input |
| ERA.3Y.415.CTL | Mesh input |
| ERA.3Y.415.CTL | Focus Input |
| N Type | Blanking Trigger Input |
| N Type | Sweep Monitor +ve Output |
| N Type | Sweep Monitor -ve Output |
| N Type | Ramp +ve Input |
| N Type | Ramp -ve Input |

Interface Unit (tube side)

| | |
|---|---|
| ERA.3Y.415.CTA | Cathode Output |
| ERA.3Y.415.CTA | Mesh Output |
| ERA.3Y.415.CTA | Focus Output |
| PSA.00.250.NTLC31 | Blanking Trigger Output |
| TNC | Sweep Monitor +ve Input |
| TNC | Sweep Monitor -ve Input |
| TNC | Ramp +ve Output |
| TNC | Ramp -ve Output |

DISC tube

| | |
|---|---|
| modified SMA | Cathode Input |
| modified SMA | Mesh Input |
| modified SMA | Focus Input |
| TNC | Ramp +ve Input |
| TNC | Ramp -ve Input |
| Lemo 00.250 | Sweep Monitor +ve Output |
| Lemo 00.250 | Sweep Monitor -ve Output |

Patch Panel (to be installed by the user)

| | |
|---|---|
| FFA.00.250.CLA.C27 | Blanking trigger |
| FFA.3Y.415.CLAC52 | Photo cathode |
| FFA.3Y.415.CLAC52 | Mesh |

| | |
|---|---|
| FFA.3Y.415.CLAC52 | Focus |
| suggest TNC | Ramp + |
| suggest TNC | Ramp - |
| not defined | Ramp + mon |
| not defined | Ramp - mon |


Figure 4 Panels, Top front, Bottom rear

## 3.4 FUNCTIONALITY

The camera has several modes of operation but the important points to note are the hardware electronic features that are present. Not all of these features are enabled within the software but they could be. There are so many possibilities that it is not practical to include them all. The hardware features include the following:

1 Static focusing for checking that the image of the event onto the cathode is in focus.

2 Camera focusing, for checking that the image of the cathode on the detector is in focus.

3 Flat fielding, for measuring the relative sensitivity of various parts of the detector system. The image of the cathode can be swept slowly across the detector.

4 Sweep modes, apart from a normal sweep mode the sweep can also be run in reduced scan mode so that both start and end finish on the detector. This is useful for timing. Alternatively the bias can be configured so that the start position is on screen but the end position is off screen, (normal sync. mode).

As supplied the reduced scan and sync. modes are accessed by using specific sweep settings (of the 32 available) but none has been set up for reduced scan or Sync. mode. Level 3 software commands see section 8.15 on page 56 will be needed to implement these features.

5 Cathode blanking. The cathode to mesh voltage can be short circuited to blank the camera at the end of the sweep, to stop large electron fluxes entering the camera. This is fairly fast, tens of ns.

6 Crowbarring. The Focus voltages can all be reduced to near zero at the end of a sweep to protect the cathode and mesh from breakdown. This is slower than blanking, ~100$\mu$s. Normally this will also cause the high voltage supplies to turn off which they do in ~1ms. They turn on in ~ 20s. This is intentionally slow to protect the cathode and mesh.

7 Various single or multi-sweep shot modes. Blanking and crowbarring can be linked into the timing sequence. Note that repetitive modes will not work with crowbarring because of the slow turn on of the focus potentials. As supplied the crowbarring and blanking are always linked, either both on or both off. The hardware supports having either one on and the other off as well.

8 Electrical or optical triggering, independently for the phosphor/MCP trigger and the sweep trigger.

9 Image intensification is either by means of a MAX module (not supplied) or an external intensifier (not supplied). The software is set up for use with a MAX module.

For a MAX module the intensifier module supports independently both DC and gated, phosphor and MCP voltages. Only modes with either or both pulsed have been configured.

For an intensifier the cathode can be DC or gated, the phosphor run DC and the MCP in a special fast gate off mode. These modes have not been configured for SPIDER.

10 This package is designed to drive the streak tube over 50m of cabling. The electronics compensates for the cable responses, in particular for the sweep and the MCP gate off signals. Use of cables other than those specified should be avoided.

Whilst in principle the system can do any combination of the various functions listed above, many will need further programming to implement or, in some cases, reprogramming of the four CPLD chips. These are straightforward procedures but need to be done at the factory. A limited amount of software modification may be possible without having the unit returned to the factory.

## 3.5 PULSED PHOSPHOR OPERATION

The phosphor can operate DC or in pulsed mode. In DC mode the voltage is directly selectable with the intensifier mode command. The range of this command is up to 9000 volts but in DC mode it will not exceed 6000. If a DC voltage from 6000 to 9000 is requested the result will be 6000.

In pulsed mode the unit operates as a 2 stage Marx generator and the DC is effectively used twice. The voltage generated is reduced by the charge sharing between the capacitors in the Marx and the capacitance of the load. This load capacitance includes that of the cable. 50m of RG59 (75Ω) cable can be ~ 2.5nF. A result of this is that it is not possible to predict what the phosphor voltage is for an arbitrary load capacitance. However, as estimate is made and in pulsed mode on 50m of RG59 up to around 9kV is possible. The requested voltage should be about right into such a load. The user will have to check this on their particular load arrangements.

## 3.6 INTERLOCK SYSTEM

The interlock is designed to prevent accidental switching on of the system. The interlock requires the central pin of the interlock connector on the front panel of the control module to be short circuited to ground. If the interlock link is broken this will be detected and a latch is set in each of the other modules. The interlock LED on the control panel indicates the current state of the interlock connection. The interlock latch LEDs on each of the other modules indicate the state of the interlock latches in each module.

If the unit is running and the interlock is broken the latches are set in the sweep, intensifier and focus modules and their respective LEDs are illuminated. The control module is also inhibited. All the modules are set to their safe modes. The interlock LED on the control unit is also illuminated. If the interlock connection is remade, the interlock LED on the control unit extinguishes but the interlock latch LEDs on the other modules stay illuminated and all modules remain inhibited. In order to reset the latches and return the unit to operation it is necessary to perform a stop and start.


Figure 5 Front (left) and rear (right) of the interface box.
Front connects to electronics, rear to the streak tube

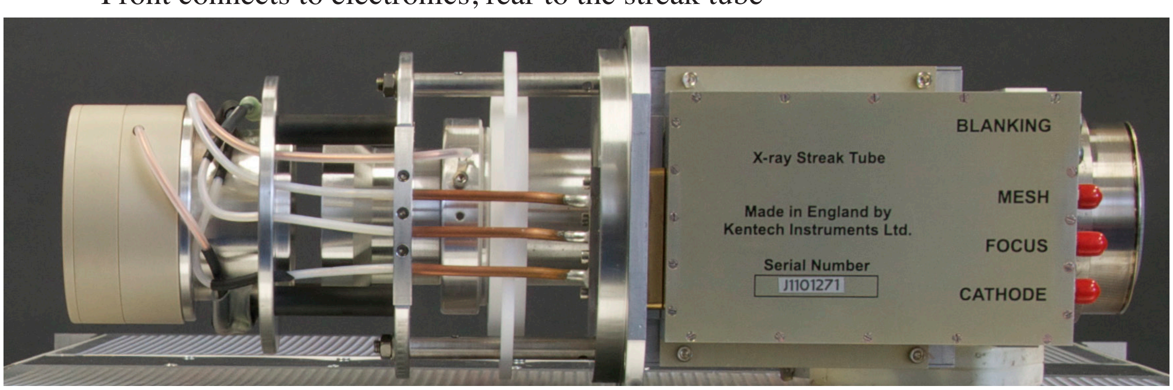



Figure 6 Streak tube fitted with a standard Kentech phosphor


Figure 7 Remove the four M3 screws to loosen the Clamp box. Then lift the clamp box off the three high voltage leads very carefully and without tugging.

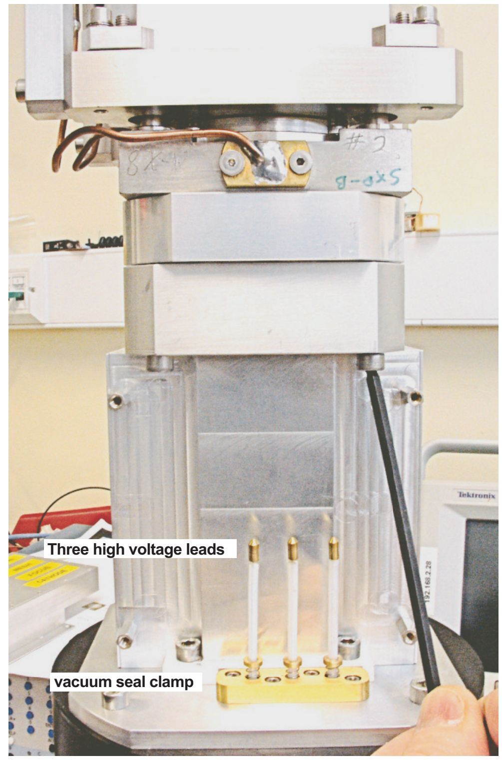



Figure 8 Tighten the four M5 screws to clamp the MAX module

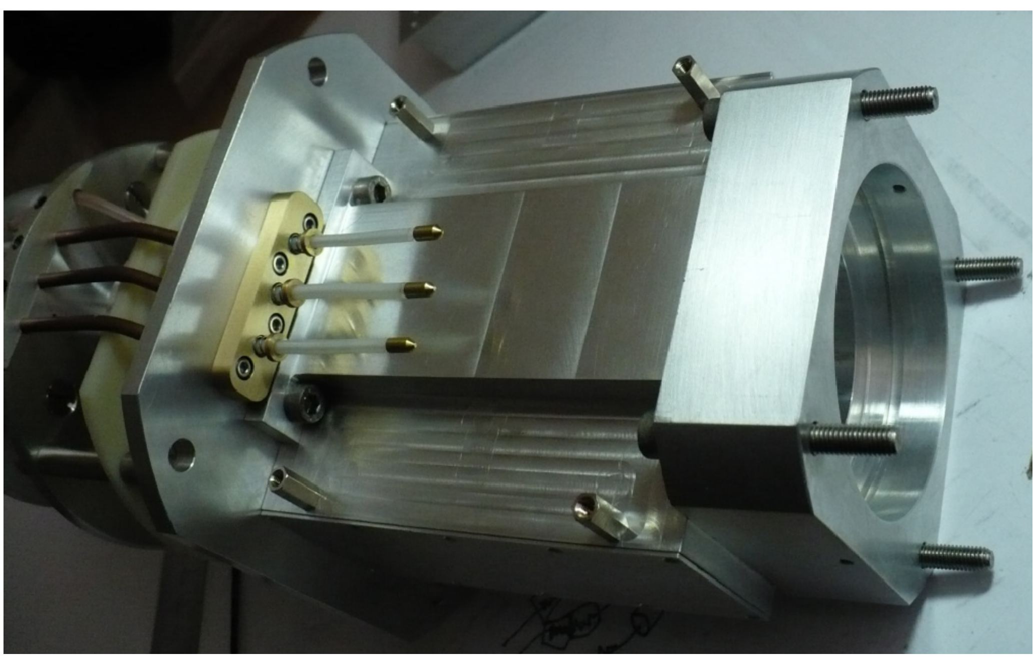


Figure 9 With the Clamp box removed take care not to damage the three high voltage leads or to loose the three washers and springs. Check that the tree brass end connections are in good order and well soldered to the cables. Note that these cables have copper inner conductors and are not as robust as most semirigid cables.

## 3.7 SWEEP BIAS VOLTAGES

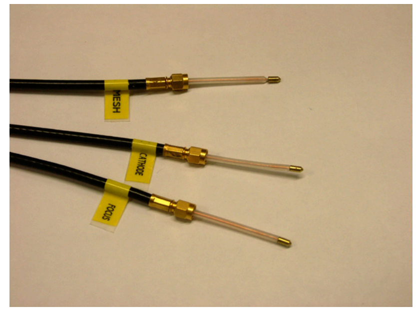



Figure 10 Focus leads. When removing pull gently and carefully

When the system is ready for a shot there is a bias voltage on the sweep plates that holds the image off screen. When the trigger is received the image is swept across the output screen. The voltage at the centre of the sweep plate region is required to be zero for good focus, so the sweep plates are driven with opposing potentials.

The positive ramp requires a negative bias and visa-versa. The bias voltages can be measured with the system and they are called positive bias and negative bias, but each is connected to the ramp of the opposite polarity.

The timing of the image at screen centre depends upon the time the unit is triggered, the sweep speed and the bias voltage. This last parameter affects how far the image has to move to get to screen centre.

To make accurate measurements of the timing during a shot, it is necessary to measure the bias voltages and the ramp waveforms. The ramp monitors do not contain any DC information and so cannot be used to measure the bias voltages.

## 3.8 MCP VOLTAGES

To be able to gate the MCP off quickly it is necessary to drive it from a low impedance source. Spider does this by supplying four 50Ω cables to the MCP. One connection (the top one on the intensifier module) supplies the DC or ON pulse to the MCP. All four connections turn the MCP off and are

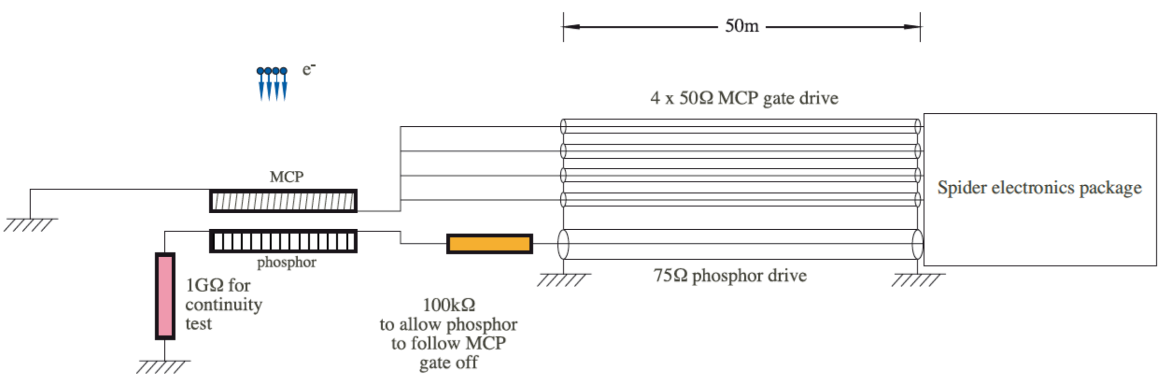



Figure 11 The MAX module should be connected as in this figure. There are four cables for the MCP gate to give the required drive impednence for a 10ns response. The 1GΩ resistor allows the electronics package to check for continuity whilst only drawing a small fraction of the current available in DC mode. The 100kΩ resistor allows the phosphor to track the fall in MCP voltage, i.e. when the MCP output face collapses to ground potential it loses 1kV. The capacitive coupling to the phosphor pulls that down also and the 100kΩ prevents the capacitance from recharging from the 50m of cable. The phosphor supply is turned off at the same time as the MCP is gated off but has a much slower fall time. The resistor keeps the MCP to phosphor capacitance isolated from the cable until the phosphor voltage has also collapsed. The phosphor cable is 75Ω so that the stored charge is kept small, this allows the stored energy in the phosphor pulser to be kept smaller.

capable of doing so in ~ 10ns. To allow the user to check the continuity of all four cables there are voltage monitors on each of the outputs. These should all read the same voltage.

The four voltage monitors all draw some current from the power supply. The current monitor allows for this fairly well and corrects the displayed current so that this is not included in the measurement.

The continuity test should be carried out in DC mode before a shot.

### 3.9 TRIP LOGIC

The various high voltage power supplies have current trips. These protect both the supplies and the various loads. The intensifier and focus potentials all rise slowly and have to charge up significant capacitors (that of the cables). Consequently there can be up to three trip levels for a supply, a "no limit" for use in pulsed mode, a rising limit during DC turn on and a DC limit. Supplies that have no DC mode only need 2 trip levels. The bias supplies have no trips as there is nothing very sensitive and the output impedance is high. The system switches between the trip levels as required. The levels can be reset with level 3 commands, see section 9 on page 58.

### 3.10 POWER SUPPLY CURRENT

Unlike DISC, on which much of Spider is based, there is no power supply current monitor. DISC is powered from a 28 volt DC supply whereas Spider is driven from mains power. There is a self resetting thermal trip in the chassis.

## 4. OVERALL DESCRIPTION

### 4.1 MECHANICS OF THE ELECTRONICS PACKAGE

The electronics package consists of 7 modules in a 19 inch rack, Figure 4 on page 13 a control module (MCU), a sweep (SW) module, an intensifier (INT) module, a high voltage (Focus) module, a display module, a power inlet module and a power control and monitor module. The modular structure allows the easy replacement of one and the ability to screen fully each part of the system to ensure that cross talk is minimised. The hardware can support a second intensifier module in a front panel slot*[1] and a fast blanking module in the free slot adjacent to the focus module. The fast blanking module is currently part of the streak tube but if neutron damage makes it impossible to have it close to the tube an alternative module could be built to fit into the rack. Such a module is likely to have inferior performance in terms of speed but will avoid having to run in a high neutron environment.

### 4.2 THE INTERFACE BOX

The interface box goes between the electronics rack mount unit and the streak tube. It is only connected to the streak tube cabling not to the cabling of the MAX module. It has 8 inputs and 8 outputs. On one side are the inputs for the following:

cathode, mesh, focus, blanking trigger, positive sweep, negative sweep

and outputs for:

positive sweep monitor and negative sweep monitor

The opposite side has inputs for the following:

---

1 *Some factory modifications to the unit are needed to implement this option.*

positive sweep monitor and negative sweep monitor

and outputs for:

cathode, mesh, focus, blanking trigger, positive sweep, negative sweep

The box contains a few passive components. Resistors are placed between the cathode input and output, mesh input and output and focus input and output. In addition there is a ramp balancer which combines the positive and negative sweep inputs, and delivers better balanced sweeps to the two sweep outputs. For information on how the ramp balancer works see www.kentech.co.uk.

## 4.3 MECHANICS OF THE STREAK TUBE

The streak tube is a vacuum component. It should be kept clean, particularly on the surfaces exposed to the vacuum. Wear suitable gloves if possible when working on the streak tube.

The main vacuum interface is about halfway down the tube at the anode. Behind the anode is the drift tube and mounted along side this is the Clamp Box which contains the blanking circuit. The circuit in this box short circuits the cathode and extraction grid when triggered, effectively shuttering the tube. This is a fairly fast circuit, (tens of ns).

The Clamp Box may be removed or partially removed to make fitting of a MAX module easier. See section 5.3 on page 23.

The tube needs to be inserted into a suitably screened enclosure comprising a mu-metal screen and an electrostatic screen. These are not included with the tube but are standard LLNL designed components.

## 4.4 ELECTRICAL CONNECTIONS

### 4.4.1 CONNECTING THE STREAK TUBE

The following needs to be connected to the streak tube:

1 Sweep leads x 2. The sweep will be towards the positive sweep cable. The sweep can be made to go either up or down and in addition the tube can be operated on its side.

2 Sweep monitor leads x 2.

3 Blanking drive lead from the MCU to the “Clamp Box”.

4 Focusing high voltage leads. There are three leads, cathode, mesh and focus. The ends that fit into the streak tube should be treated carefully. Each has a brass contact soldered onto its end, see Figure 10 on page 17. This engages in a spring loaded contact in the clamp box. The leads use SMA clamping screws to hold them in place. If removing these leads **do not pull hard**, undo the SMA nuts and slowly remove the lead. If it catches wriggle it rather than pulling hard.

Note that there are a similar set of connections between the Clamp Box and the streak tube. The tube is supplied with these connected. If the Clamp Box is removed make sure the brass washers and springs on the leads from the streak tube are not lost. Also make sure the leads are not bent significantly.

In the event that one of the brass contacts becomes broken from its cable it is a little hard to repair. These are non magnetic cables and more fragile than standard RG402 cables.

5 The intensifier or MAX module also needs to be connected. There are five leads to go to the Max module. Four go to the MCP and one to the phosphor. The four to the MCP are needed so that it can be turned off quickly, before neutrons from the event under investigation arrive. The four

cables are also monitored for continuity from the electronics to the head and back. The expected fall time of the MCP voltage is <10ns so the cabling near to the head does not have to be super fast. The reverse termination of the cabling makes the voltage waveform overshoot at the MCP. This helps to compensate for the poor high frequency response of the long cabling. The phosphor should have a resistor to ground of ~ 1GΩ capable of withstanding >10kV. This is intended to permit the checking of continuity from the drive electronics to the phosphor, so the resistor should be a separate connection to the phosphor from the gate drive. In addition there needs to be a resistor from the gate drive to the phosphor. This is to allow the phosphor voltage to fall when the MCP is driven off; otherwise the MCP to phosphor voltage will increase. This should be ~ 100kΩ and capable of withstanding >1kV for 10$\mu$s.

### 4.4.2 CONNECTIONS TO THE OUTSIDE WORLD

There are up to 12 leads which connect the unit to the outside world.

**1. Power IEC lead.**

Power is supplied via the rear panel IEC connector but the ON/OFF switch is on the front panel.

**2. Interlock**

The interlock is active low, with a pull up resistor to a 5 volt rail (10k in each of the four active modules, control, intensifier, sweep and focus). A ground connection is provided on the socket also. The software has no means of overriding this hardware interlock but it can sense its state.

**3. RS232**

The RS232 runs at 9600 baud, 8 bit with 1 stop and 1 start bit, no flow control. Normally a regular PC serial port will communicate without difficulty. Only three lines are used in the RS232, TXD, RXD and ground.

**4. Ethernet lead (RJ45)**

The RJ45 Ethernet port is self configuring 10/100Mbits $s^{-1}$. The IP address was set to 192.168.2.2 on units J1011151 and J1109122.

**5. Main trigger Trigger (Sweep)**

The electrical triggers are positive going on the centre pin.

**6. Phosphor Trigger (MCP and Phosphor pre-trigger)**

The electrical triggers are positive going on the centre pin.

**7. Spare Trigger (if needed, currently not used by the software)**

**8. Focus monitor (Cathode DC level, crowbar and fast blanking trigger)**

The focus monitor is a buffered signal from the cathode supply rail. In addition a small fraction of the trigger to the blanking circuit is added in. By monitoring this output the user can see the voltage rise on the cathode following an enable command, the crowbar and also see the timing of the blanking trigger signal.

The buffer is current limited and not designed to drive 50Ω but rather a 10MΩ oscilloscope input. When investigating the blanking trigger a 50Ω termination is more desirable. As the time scale for the cathode voltage is much slower than the blanking signal it is unlikely that the user will monitor both signals unless a dual time-base is used.

**9. MCP monitor**

The MCP monitor is divided down from the voltage on MCP drive 1. It is designed to drive a 50Ω cable into a 1MΩ oscilloscope. It is reverse terminated. In this way it can be used for both DC and pulsed measurements without the need for a broadband amplifier. The attenuation ratio is 200:1 when used like this, so the maximum voltage output is ~5 volts. This attenuation is for both the pulse and DC. If used to drive a 50Ω oscilloscope input the DC monitoring division ratio is ~2 $10^6$:1. The pulse on the MCP will appear differentiated with a time constant of ~2$\mu$s.

**10. Phosphor monitor**

The phosphor monitor is AC coupled and so is only suitable for looking at the pulsed voltage. If run DC the voltage should be monitored via the software. When in pulsed mode the pulse voltage is divided by 10000 and fed via 48Ω to the output connector. When run into a 1MΩ oscilloscope input the division ratio is 10,000:1. If run into a 50Ω termination the output will be differentiated with a time constant of ~ 4 x $10^{-8}$.

**11. Sweep monitor local**

This is a simple resistive divider taken from the circuit before the ramps are split into an equal but opposite pair. It also is AC coupled and does not contain any bias voltage information.

**12. Sweep monitor positive**

The sweep monitors are fed from the sweep plates to the rear of the electronics unit and then plumbed through to the front panel. Alternatively the user can just monitor the signals directly from the streak tube. We are unable to supply the actual waveforms from these because this will depend upon the installation and cables used.

The sweep monitor signals are divided down from the sweep plate voltages. They are resistively divided down but AC coupled; consequently they will not monitor the bias voltages which should be obtained from the software.

**13. Sweep monitor negative**

As Sweep monitor positive but from the other plate.

**14. Sync.1 output**

This indicates the time the phosphor and MCP is triggered on.

**15. Sync.2 output**

The rising edge corresponds to the sweep trigger and the falling edge to the blanking, crowbar, MCP-off and phosphor triggers, see Figure 35 on page 70 through Figure 38 on page 71.

## 4.5 RUNNING THE ELECTRONICS

The electronics is designed to be rack mounted in a standard 19 inch rack. The total power consumption is < 216 watts. There are no fans on the unit so a reasonable amount of space should be left for natural convection around the unit. There are thermal sensors in the unit which can be monitored via the software. Temperature stability is desirable because of the timing sensitive aspects of the electronics. In addition there is one self resetting thermal switch which will shutdown the unit if the temperature gets very high (chassis above 70°C). This is unlikely to be activated under normal conditions.

## 4.6 POWERING UP OF THE ELECTRONICS

On power up the LEDs in each module are flashed and then the unit awaits commands from the UCS. It does not send information to the UCS unless requested to do so. The unit may appear unresponsive but it will respond to valid commands.

## 4.7 LEDs

Each module has LEDs on its panel to indicate its status. The LEDs on the panels fitted to the rear of the unit are reflected in the display module on the front of the unit. The indications are as follows:

| Main unit | Control unit | Focus unit | Sweep unit | Intensifier unit |
|---|---|---|---|---|
| Power | Sweep trigger | Trigger latch | Trigger latch | Trigger latch |
| | Phosphor trigger | Interlock latch | Interlock latch | Interlock latch |
| | Spare trigger | EHT ready | EHT ready | Intensifier ready |
| | Interlock | EHT running | EHT running | Intensifier running |
| | Fault | | | |
| | Control ready | | | |

Note: EHT = HV, see Abbreviations on page 3

In addition the display module mirrors the states of LEDs on the rear panel.

## 4.8 THERMISTOR POSITIONS

The thermistors are labelled r1 through r5 for use by the software. These correspond to 5 thermistors, 2 in the MCU, 2 in the Sweep unit, 0 in the intensifier module and 1 in the Focus module.

The item being monitored is as below:

r1 Focus DC DC converters (thermistor on heatsink covering 3 DC DC converters)

r2 Sweep unit high voltage PSU

r3 Sweep unit Sweep FET

r4 IC7 in control unit (DC DC power supply)

r5 IC10 in control unit (DC DC power supply) MAIN CONTROL UNIT

The MCU contains the interface to the outside world, the $\mu$Processor, the high voltage blanking trigger pulse and the trigger routing.

# 5. FITTING THE MAX MODULE TO THE STREAK TUBE

The MAX module (not supplied) is fitted into the rear end of the streak tube. It contains an MCP and phosphor. These are driven by the electronics package, (intensifier module).

The MAX module is designed to seal with an “O” ring in the end of the MAX module. When the streak tube is used with a phosphor the seal is made with a Wilson seal in the wall of the drift tube. This “O” ring should be removed (if present) when the MAX module is installed.

In order to fit the MAX module it is no longer necessary to remove the Clamp box (as it was in DISC tubes) but it may make things easier.

## 5.1 FITTING THE MAX MODULE

If the tube has a blanking piece fitted over the rear end of the drift tube, remove this and retain as a future transit cover. Check that the "O" ring is fitted to the end of the MAX module and that the mating surface is clean. Check also that the there is no "O" ring in the groove inside the streak tube, this is for use with a standard Kentech Phosphor and is not needed for a MAX module. Lower the MAX module into the drift tube. Fit four M5 screws through the back flange of the streak tube and tighten into the MAX module.

## 5.2 FITTING OR REPLACING THE MAX MODULE MOUNT SCREWS

If it is necessary to replace either of the two screws on the right side of the streak tube that screw into the MAX module, it may be necessary to move the sweep connections out of the way.

Remove the nuts on the outside of the connectors and partially push the connector into the sweep connection box. This will give access to the screws and allow replacement. The connectors may then be pulled out of the sweep connection box and the nuts refitted. The connectors have anti-rotation flats and the nuts can easily be done up tightly without twisting the cables fitted to their rear. It is not necessary to remove the cover from the sweep connection box as the TNC connectors are in D shaped holes.

## 5.3 REMOVAL OF THE CLAMP BOX

Remove the three high voltage focus leads if fitted. The clamp box is attached with four M3 screws. Remove these (see figure Figure 7) and then gently ease off the Clamp box to reveal the three high voltage leads that go into the streak tube. Do not tug on the clamp box if it catches during removal. Just gently wriggle it until it slides off the three leads. Make sure not to lose the washers and springs on the high voltage leads.

## 5.4 REPLACING THE CLAMP BOX

Gently ease the Clamp box down over the three high voltage leads until the gap between it and the brass vacuum seal clamp is zero. Then refit the four M3 screws that hold the clamp box in place. Refit the three focus leads as required.

# 6. STREAK CAMERA OPERATION

This section describes the general use of the X-ray streak camera. It assumes that the system is assembled as above and that the user has full control of the software, see section 8

The tube fits into a DIM assembly. The vacuum seal is made on the grounded anode of the electron lens.

## 6.1 VACUUM REQUIREMENTS

The camera can only be used under a reasonable vacuum. The camera is not pumped but relies on the vacuum of the chamber it is connected to, to pump the tube. Care should be taken not to slow the pumping rate significantly with apertures and filters etc. For normal use with a phosphor the pressure should be below $10^{-4}$mBarr. For thin cathode to grid (mesh) spacers (under 2mm) pump to under $10^{-5}$mBarr. If using a MAX module pump to under $10^{-5}$mBarr. The tube has been tested down to ~3 x $10^{-6}$mBarr.

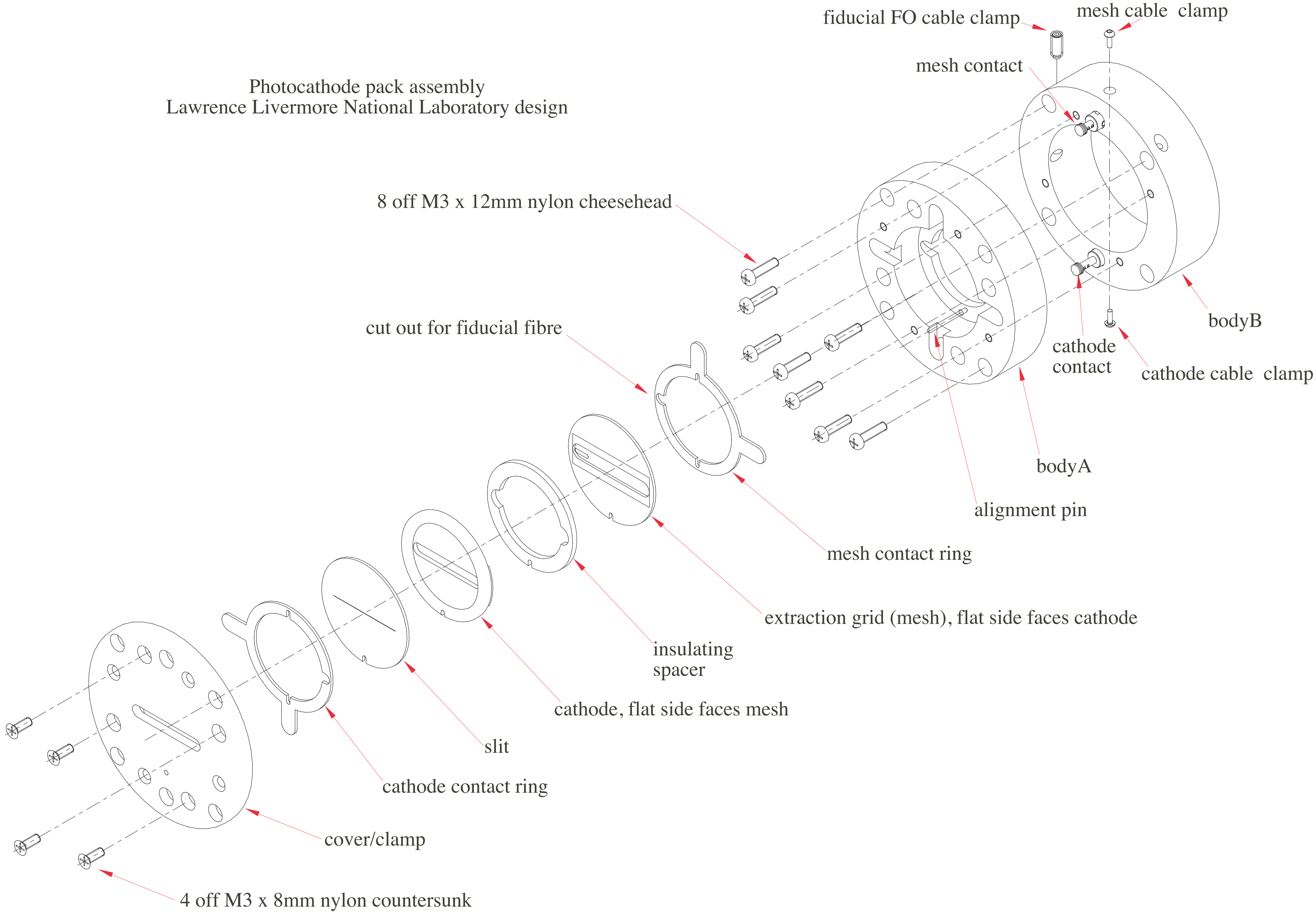



Figure 12 Cathode/mesh assembly

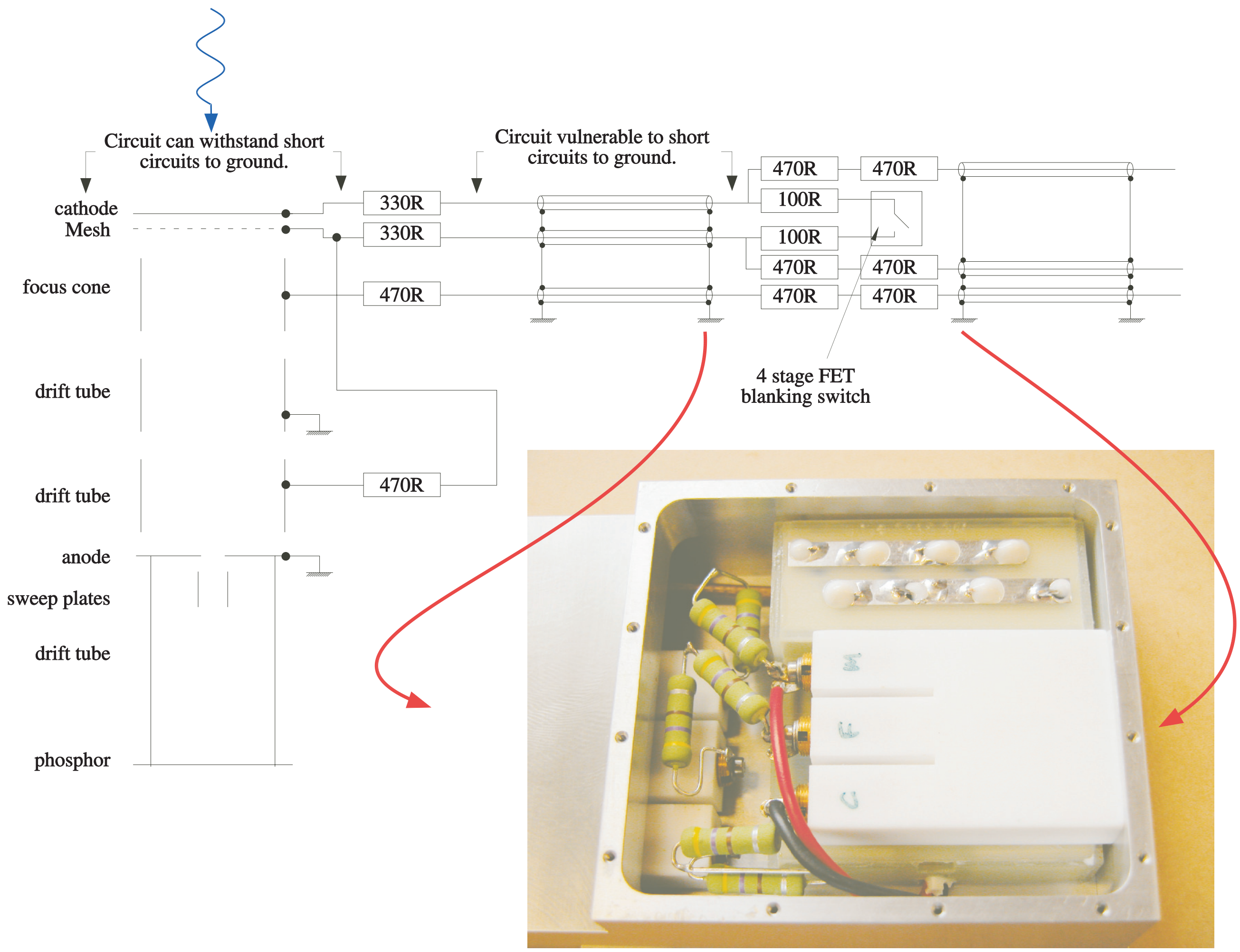



Figure 13 Tube wiring and Clamp Box

## 6.2 PRINCIPAL OF OPERATION

The X–rays to be investigated are incident on the photocathode and produce photoelectrons. The photoelectrons are imaged by the focusing electrodes, passing through the hole in the anode and form an image on the phosphor/MAX module at the end of the streak tube. With a slit in front of the photocathode an image of the slit is formed on the phosphor. This image is swept across the phosphor by a ramp potential applied to deflection plates situated just beyond the anode hole. Position along the photocathode is magnified nominally by a factor of ~1.2 onto the phosphor. The direction normal to this corresponds to time. There is an image inversion in the electron optics.

## 6.3 THE ELECTRON OPTIC FOCUSING

Before the high voltage focusing supply is switched on the vacuum chamber must be at a suitably low pressure, see section 6.1 In order to obtain higher time resolution it will become necessary to increase the extraction field to >30kVcm$^{-1}$ and under these conditions we recommend that the pressure be below 10$^{-5}$ mBarr. The extraction field is adjusted by changing the spacer between the cathode and the extraction grid. If the unit is used at too high a pressure electrical breakdown may occur which can damage the cathode, mesh or MAX module. The voltages applied to the focusing electrodes are given in the data section 12. The cathode is nominally at -15kV and users should be aware not to place metallic objects near to the front end of the camera.

The focusing power supply is set to produce these voltages during the factory test of the camera, (see data section 8), however, these tests should be repeated if a MAX module is fitted as the distance from the cathode to the electron detector will be different.

Focusing is achieved most easily with the camera unswept and a resolution cathode used in place of a normal one. This cathode is then illuminated with UV and the image of it focused on the detector (phosphor or MAX module). The software has a mode of operation for doing this.

The cathode should be set to ~15kV and then the focus and mesh potentials adjusted for good focus. It is also necessary that the cross-over point be near the anode and sweep plates. By looking at the vignetting of the image of the cathode it is possible to see roughly when this condition is met. The other method is to check that the magnification near the tube axis is close to 1.2 and that the image is in focus. This combination will automatically put the cross-over in the right place.

The software allows a voltage increment to be added to the existing voltage, the increment can be made negative to reduce the voltage. The camera is supplied with a software interface intended to be controlled through the UCS. If it is necessary to control the camera with a terminal then the unit can be placed into debug mode. In this mode focusing can be performed without the UCS.

Note that any new focus voltages that are set as above will be lost when the power is cycled unless a "saveuser" command is issued. This will place the new data into EEPROM for use at the next power up. The factory settings are also available if necessary, see section 8.13 on page 51.

## 6.4 CORONA

On our standard X-ray streak cameras the electron lens electrodes are fed from a high impedance source. The result is that although the overall voltage is stabilised, corona from an electrode can affect significantly the voltage on the electrode leading to a possible defocus.

On the SPIDER tube the requirement to blank and crowbar the electrodes means that the source impedance is significantly lower. Also each electrode is individually stabilised. This has the failure mode that if one electrode is grounded the relative voltage to another is high. There are zener diodes between the lens elements to help protect the cathode and mesh. In addition there is a current trip that will shut down all three voltages. Current leakage via corona can be compensated for up to the current limit level.

## 6.5 CATHODE BLANKING

The unit is fitted with the option of cathode blanking. This is achieved by short circuiting the cathode and mesh potentials with a high voltage switch. The switch is located in the "Clamp Box" attached to the side of the drift tube, see figure Figure 7

The clamp box contains four high voltage FETs that are triggered by a signal from the control unit.

The trigger signal is sent at the end of the sweep. One of the set up parameters for a sweep is the delay for the blanking trigger.

*The blanking switch is vulnerable to short circuits that are not current limited. To improve the chances of the switch surviving breakdowns there are series current limiting resistors. However, if there is a breakdown to ground between the switch and the resistors the switch is not protected. It is therefore necessary to be very careful with the insulation between the blanking circuit and the resistors. This is well protected at the time of shipping but if the cathode assembly is changed it is important that careful attention is paid to this issue.*

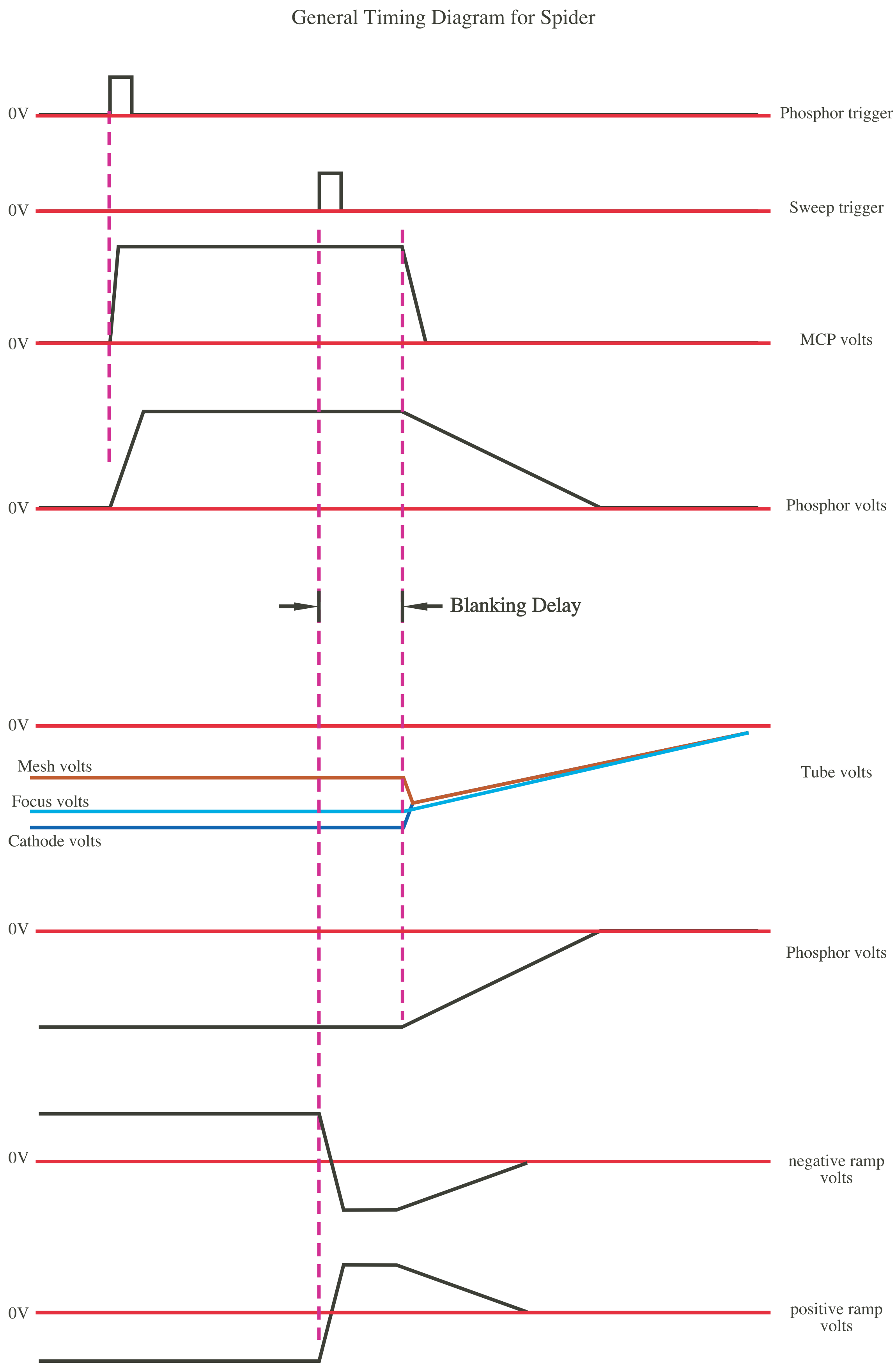



Figure 14 General timing diagram

## 6.6 CROWBAR

The unit is also fitted with a crowbar. This short circuits the three high voltage connections to ground and also turns off the focus unit. Normally this would be used in conjunction with the blanking.

The repetition rate of crowbarring is very slow because the focus supply takes around 10 seconds to come on.

This is designed for single shot use.

## 6.7 SWEEP UNIT

The sweep potentials are supplied by a pair of cables from the electronics package to the streak tube.

These are conformable semirigid cables and somewhat fragile although flexible. Replacement of them with identical length semirigid ones once the units have been fixed in the DIM cart would seem a good idea. See figure Figure 54 for specifications.

The sweep unit provides bias voltages as well as the ramp voltages to deflect the image. The bias voltage sets the start position of the sweep. It also sets the operation point of the ramp. The bias voltages for 11 sweeps have been preset to the optimum values for best sweep linearity. The system is capable of storing up to 32 sweep settings.

The sweep unit has several modes of operation, see 8.15.1 on page 56. These enable the user to do the following:

i nothing

ii normal sweep

iii normal sweep with modified start position for timing

iv short sweep for timing (both start and end points should be visible on screen

v flat fielding, a slow sweep for calibrating the area sensitivity of the CCD camera.

Sweep monitors are provided. A fraction of the sweep signal to each plate is available to monitor the sweep signal. This is intended to be routed back through the sweep unit to the front panel. The connections between the front panel of the sweep unit and the sweep monitor outputs on the streak tube determine which. The sweep can be made to run in either direction by swapping the sweep leads around. Time will run from the negative to positive sweep connection.

## 6.8 MAGNETIC FIELDS

The electron optics are prone to image displacement under the influence of stray magnetic fields. To remove this effect a mumetal screen, which fits around the spool tube may be needed. The user is to provide this.

NOTE

The use of screws of magnetic materials in or near the photocathode assembly can give rise to image displacement. If it is necessary to replace screws ensure that they are of unplated brass or nonmagnetic stainless steel. The use of nickel (magnetic) plated brass screws has not been found to cause problems but we would advise against it. Similarly the residual magnetic field from stainless steel screws generated in the screw manufacturing process has not been found to be a problem.

The screws clamping the cathode snout should be of nylon. The cables carrying the focus potentials to the electrostatic lens have copper inner conductors.

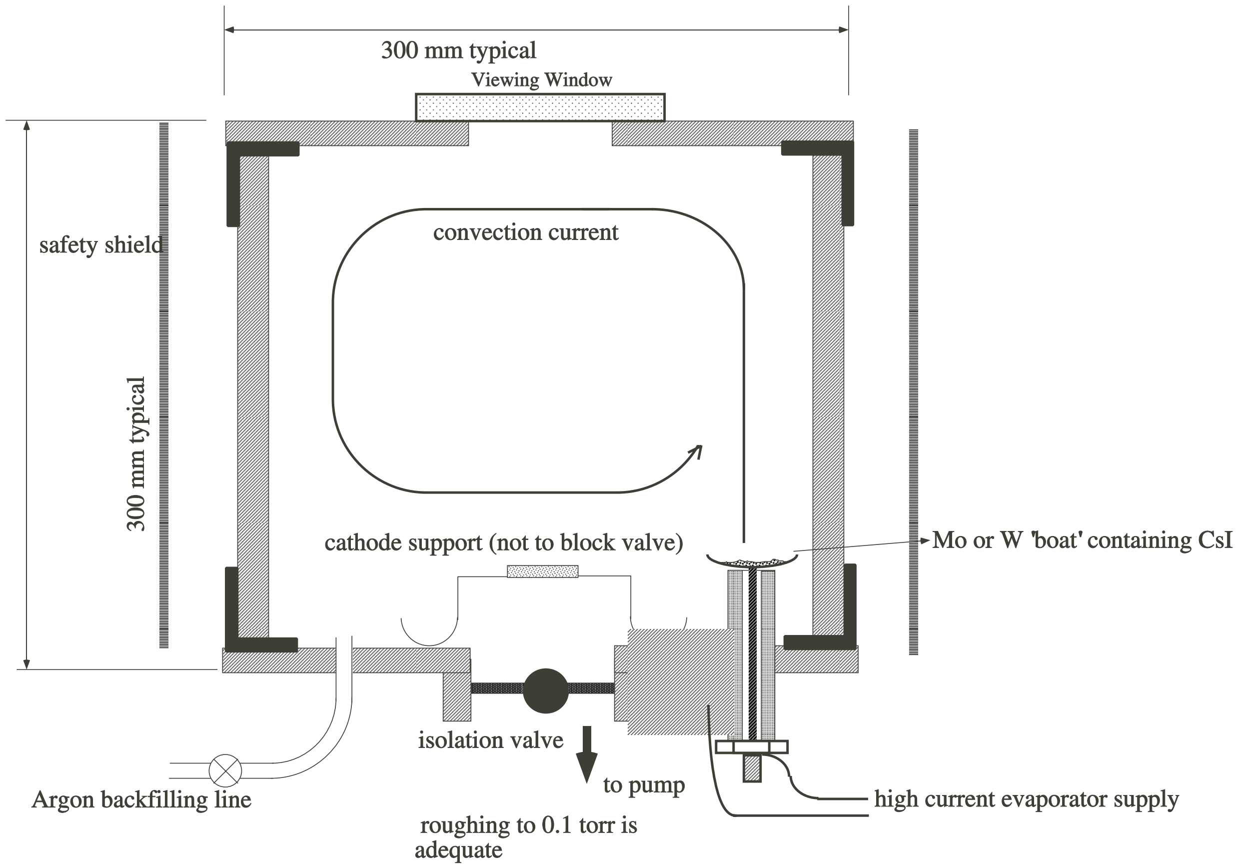



Figure 15 Low Density cathode manufacture

## 6.9 CATHODE AND MESH ASSEMBLY

Cathodes and meshes are very expensive. Considerable care should be exercised when fitting them.

Salt cathodes should be kept either under vacuum or in an inert dry atmosphere. They should spend as little time as possible in a normal atmosphere. If a cathode that has been exposed to the atmosphere for a long time is fitted it may later desorb gas that can compromise the voltage hold off between the cathode and mesh. Salt cathodes will also lose their sensitivity in atmospheric conditions. Foam salt cathodes are somewhat hardier than solid density ones. Gold cathodes are much more stable in normal atmospheric conditions and only good mechanical care is needed.

CsI foam cathodes have proven the most sensitive. KI cathodes have the best time resolution. Other materials that are used are KBr and Au.

Cathodes are usually made on a substrate. This will absorb x-rays and affect the spectral response of the unit beyond that of the cathode material. Consideration of the substrate needs to be given to determine the overall detector response. The web site at Lawrence Berkeley Laboratory is a very useful tool for calculating substrate effects.

The system has been provided with a LLNL designed photocathode holder assembly. A suitable cathode and mesh (available from the Luxel Corporation) need to be inserted before the camera can be used.

The instructions that follow refer to components shown in Figure 12 on page 24. The cathode pack allows the cathode and mesh assembly to be mounted in a holder that is then fitted to the image tube. This allows the user to have several packs available for quick exchange. The LLNL design used here is not their latest.

The cathode and mesh are fitted inside the cathode pack which consists of the cover, cathode contact ring, time resolving slit, cathode, spacer, mesh, mesh contact ring and body A.

It is important that the components are in the correct order and orientation as shown in Figure 12 on page 24. The flat surfaces of the cathode and mesh should be facing each other. Four countersunk nylon M3 screws hold the pack together. This is then mated with body B which is attached to the streak tube. Four nylon cheese head screws fix the pack to body B.

Make sure the pack is fitted to body B in the correct orientation as shown.

If a fiducial system is fitted to the streak tube make sure that the tip of the fibre optic does no protrude too much or it will pierce the cathode and or mesh.

The time resolving slits provided are made from brass. This may not be the optimum material. Also if the incident radiation is angled to the slit it may be necessary to cut the slit at an angle to the surface normal. The user should consider the application carefully and have an appropriate slit made if the general purpose ones supplied are unsuitable. The slit width should normally be wide enough that the static image of it is smaller than the time resolution on the output screen.

## 6.10 INITIAL POWER-UP OF THE STREAK TUBE

It is necessary for the interlock to be set before the focus voltages can be turned on. It is intended that this be connected to relay contacts on a vacuum gauge. The focusing supply must not be turned on if the pressure is higher than $10^{-4}$ torr. At extraction fields greater than ~15kVcm$^{-1}$ (3 mm spacer) it may be necessary to obtain a better pressure. We recommend that the camera first be timed and set up with a low extraction field (3mm spacer between the cathode and mesh). Once the system is operating satisfactorily at this field the spacer can be reduced and the vacuum improved. Note that the pressure in the cathode to mesh gap is what is important, not that at some distance from the cathode.

When the power is first applied a small breakdown will usually occur as a result of absorbed gas released under the influence of high electric fields. The normal procedure, after the vacuum chamber has been evacuated, is to turn the camera on with the intensifier removed while watching the phosphor in semidarkness. At the first application of power there will probably be a slight flash of light. The focusing voltages should be switched on and off a few times, such that no light is visible on the phosphor. It may be necessary to wait for the pressure to improve before this test is passed. This test is only required once after venting the vacuum chamber. Note that the focus voltages are set up to come on slowly. This has been found to help with breakdown problems. EHT ready LED, on the focus unit, will come on once the voltages are up to the normal values. This state can also be interrogated from the UCS.

It is not a good idea to leave the camera powered up for long periods while waiting for shots as an unexpected rise in the chamber pressure due to accidental venting or possibly pump failure could result in destruction of the cathode and/or the mesh.

## 6.11 PROCEDURE FOR TIMING THE STREAK CAMERA

Spider requires either one or two trigger inputs. For normal use the detector phosphor and MCP need to be pretriggered by about 20 to 60$\mu$s and then the sweep should be triggered near the event time. In other modes the phosphor and MCP can be run in DC mode, in which case only the sweep needs to be triggered. Figure 14 on page 27 shows the timing of the various signals

In general the sweep trigger signal should be timed so that it coincides with the X–ray signal on the photocathode, with allowance made for:

(i) the flight time of electrons from the cathode to the sweep plates (approximately 1.7ns)

(ii) the time delay from triggering the sweep unit to the image reaching the middle of the screen. This time depends only a little (much more on DISC at slow speeds) on the sweep speed in use, see Table 1 on page 74. As Spider operates over ~50m cables between the electronics and the streak tube careful timing between the relative arrival time of the sweep ramp and the event generated photoelectrons at the sweep plates and needs to be done.

(iii) the flight time of photons from the plasma to the cathode

(iv) the relative timing of the electrical trigger and the start of the event at the target.

Alternatively timing can be performed in the usual manner, i.e. time up in a “Sync.” mode and then switch to the “OPERATE” mode. On Spider there are up to 32 possible sweep conditions, 11 have been set up as normal sweeps and some should be set up to be of the “Sync.” type, i.e. either with the sweep start on screen or with reduced scan so that both sweep start and finish are on screen. Both will be of use. Existing sweep tables can be used, edited for reduced bias (sync mode) or reduced bias and sweep length (whole sweep on screen) and then saved as a new configuration. This will require level 3 commands, see 8.15 on page 56

The camera deflection sensitivity is ~18V/mm. For the sweep to start on screen the bias voltage needs to be ~ 300 volts, the exact figure for the edge of the screen will depend upon the size of the CCD sensitive area.

### 6.11.1 TIMING IN SYNC MODE

In “Sync.” mode the image starts at on screen at the edge. If the image does not sweep, i.e. it remains in the static untriggered position, then the trigger arrived after the event and the trigger delay must be reduced. Alternatively, if no image is seen on the screen then the trigger arrived too early and the image was swept off screen before the event. In this case the trigger delay should be increased. With this procedure a binary search for the event can be made, but beware of bad shots or other mishaps that can lead one down a false trail in the binary search. Go back and check old positions occasionally as not seeing the image can be caused by a lack of intensifier trigger or no focus voltage, also a stationary image can be caused by a loss of sweep signal.

### 6.11.2 TIMING WITH REDUCED SCAN MODE

With the reduced sweep mode the ambiguities caused by lost triggers are overcome. One should always see a signal. If the trigger comes early the image will be at the far end of sweep, if too late at the start of sweep position. Once the timing is about right in reduced scan mode, switch to a sync. mode.

### 6.11.3 MOVING FROM SYNC TO OPERATE MODES

In sync. mode once the timing is found it should be adjusted to put the swept image on the far side of the streak (away from the start) and then the sweep mode should be reset to a operate mode. If the image disappears then it must be off screen on the start side and the trigger should be made a little earlier; little means small compared to the expected total ramp duration.

### 6.11.4 CHANGING SWEEP SPEED

On Spider the sweep range is quite small making cross timing of different sweep speeds quite easy. The delay may be changed as the sweep speed is changed according to Table 1 on page 74.

## 6.12 TESTS

The electron optics may be tested with either a DC X–ray source or a DC UV source, such as a mercury vapour lamp with quartz envelope. However, for optimum focus, the wavelength should match that to be used in the experiment. A suitable test pattern may be needed. We can supply cathodes made onto resolution charts to do this. [Dynamic de-focusing effects are unlikely to be an issue on Spider due to the relatively slow sweep speeds.]

The camera must be operated in a vacuum so the user must provide a suitable pumping system. The vacuum requirement is a pressure of not more than $10^{-4}$ torr. A suitable window and cathode must be provided for UV use. (Kentech can advise on the supply of such a cathode, being either 10nm gold or 100nm aluminium on a quartz substrate) and a UV mercury vapour lamp, which will operate in the vacuum chamber. Alternatively a more powerful lamp may be imaged through a quartz window onto the cathode.

A typical mercury vapour lamp operating 200 mm from the cathode will give a bright image on an intensifier in contact with the phosphor. With suitable cathodes and reduced lamp to cathode spacing, it is possible to obtain moderately bright images without an intensifier. Remember that the cathode is at -15kV and that the lamp is probably grounded. In normal (swept or short exposure) operation an intensifier should always be used in order to maintain a low electron current in the tube and still obtain a recordable image. It is possible to melt the cathode with some types of UV lamp. Also the UV output from UV lamps usually increases significantly as they warm up. UV light emitting diodes are coming onto the market and may also be suitable. We have not yet tested any.

The focus potentials are changed with level 2 software commands, see section 8.13 on page 51.

With the DC source, the focusing supply and the intensifier (if used), switched on, the focus should be set for optimum image quality. The two potentials are interdependent and the optimum image quality is obtained by iterating between the two settings. The cathode voltage should first be checked to be –15kV. Then a best image should be found by adjusting the mesh potential and then the focus voltage should be changed slightly. The mesh voltage should be again set for a best image and the image compared with that obtained with the previous focus setting. The greatest effect of the focus voltage will be on those parts of the image furthest from the axis. The focus should be chosen to give the best edge image quality while always maintaining the mesh potential at a best image position. The position of the crossover should also be close to the hole in the anode. If it is not vignetting will occur. This is obvious when focusing the camera. Note that vignetting can occur if the crossover is either too far or too near the cathode. A suitable mid position must be found and this will be with the cross over roughly at the anode. This will ensure that the cross over is near the sweep plate assembly.

If DC tests are performed with a CCD readout system it is important that the exposure is maintained at a constant time for image comparison. It may be advisable to trigger the intensifier also or it can be used DC.

Stray magnetic fields may displace the image slightly. A Mumetal ® screen may be adequate to remove this. Otherwise the magnetic field will have to be eliminated.

## 6.13 POSSIBLE FAULTS

### 6.13.1 NO DC IMAGE

Focusing unit not on or vacuum interlock not set.

Insensitive cathode.

Bad connections to cathode/mesh assembly.

Short circuit between mesh and cathode.

Breakdown of high voltage feed (this should result in the focus unit tripping out).

### 6.13.2 BAD FOCUS.

Poor connections to cathode/mesh.

Old/damaged cathode.

Poorly mated high voltage connector.

Fault in bias/sweep supply. (Confirm by disconnecting the sweep circuit completely, which should restore focus).

Focus voltages have drifted (unlikely).

Photocathode and mesh not normal to camera axis.

Image is due to x-rays going straight through the tube and exciting the phosphor. Check that no image is present with the focusing unit switched off. If necessary block the direct X-ray path.

### 6.13.3 NO STREAKED IMAGE.

Intensifier triggering at wrong time, possibly from noise.

CCD camera triggering at the wrong time.

Sweep unit triggering at wrong time from noise.

Sweep feeds incorrectly connected.

Inadequate trigger signal causing jitter.

### 6.13.4 SPURIOUS BLOBS OF LIGHT.

Breakdown in chamber.

Pressure too high. Check vacuum and perform initial power up test.

Breakdown on shot. Plasma or target debris getting into electron optics. Is front of re-entrant vessel adequately screened? It is wise to restrict the front aperture as much as possible and cover the X–ray line of sight with as thick a filter as will transmit the desired X–rays. Use the blanking and crowbarring options.

### 6.13.5 REDUCED SWEEP SPEED COMBINED WITH POSSIBLE LOSS OF FOCUS

Bad connection of one sweep lead. This reduces applied voltage ramp but also fails to a maintain zero potential in drift tube, hence affecting the focus.

### 6.13.6 JITTER PRESENT IN IMAGE.

Inadequate or irreproducible trigger signal. The electronics has a jitter of about 20ps rms. It is necessary to provide a good and stable trigger source for the electronics. This may well not be easy but is left to the user. Kentech can advise about solutions to trigger problems but the subject is too wide for a discussion here.

N.B. Poor connections to the mesh or cathode will often result in an apparent drift in the focusing as the electrodes charge up.

# 7. CATHODES

The cathode materials normally recommended for X–ray use are cæsium iodide and gold but for high time resolution the energy spread from these is too great. We recommend the use of potassium bromide or potassium iodide. It has also been noted that low density cæsium iodide cathodes exhibit a tail in the emission after illumination with a very short pulse. Consequently we recommend solid density cathodes for high time resolution. As these have a very limited lifetime the user will have to be able to recoat the cathodes supplied regularly or be extremely careful about their exposure to anything but a clean vacuum.

TRANSFER THE CATHODES IF SUPPLIED TO AN EVACUATED DESICCATOR AS SOON AS POSSIBLE AFTER RECEIPT OF THE CAMERA

## 7.1 CATHODE MANUFACTURE

The most sensitive cathodes we have used are low density cæsium iodide. This material is made by thermal evaporation in a background atmosphere of argon. The cathode is in the form of a foam, with a structure scale length of a few microns. The voids in the material allow electrons to escape from a greater depth. Furthermore the presence of a large electric field in the material causes a cascading effect, resulting in a small amount of gain. Ironically the low density material, with a very large effective surface area, is most tolerant of atmospheric water vapour. We believe this is because the absorbed water is quickly lost under vacuum, as a result of the large surface area. Low density cathodes are, however, not very mechanically robust.

A suitable “recipe” for the production of such cathodes is to evaporate approximately 1-2ccs of powdered cæsium iodide in a background of 5 mBarr of argon. The layout of the deposition chamber should be roughly as shown in figure Figure 15. The cæsium iodide is carried in the form of a smoke by convection currents in the background gas. A very uniform cathode can be made by rotating the substrate during the deposition.

# 8. DISC SOFTWARE INTERFACE

## 8.1 VERSIONS

The software is based upon that used in DISC but has been modified for use with SPIDER.

Revision 0.0 12th. July 2011

## 8.2 CAUTIONS

1. There is no software based internal thermal shutdown, the 5 temperature sensors must be regularly checked by the UCS and the SPIDER control unit should be shutdown if temperatures become excessive. It is assumed that the unit will be mounted on a heat sink.
2. There is a overall shutdown of the control unit based upon a self-resetting thermal trip
3. SPIDER will accept a wide range of desired voltage settings for the intensifier system. It is the users' responsibility to ensure that the various voltage settings are compatible with the specific intensifier used. The use of the wrong voltages may destroy the intensifier/ MAX module.

## 8.3 COMMAND LEVELS

There are currently three command levels. Level 1 is for general use. Level 2 for setting up by experienced users. Level 3 for more fundamental setting up, recalibration, etc. by expert users who are thoroughly familiar with the device.

Level 3 commands are not covered by this manual. Contact Kentech Instruments Ltd. for details if required.

## 8.4 INTRODUCTION

The SPIDER software provides a comprehensive set of commands using a robust protocol similar to the DISC.

SPIDER uses a Forth operating system similar to the DISC and GXD which is flashed into the H8 processor ROM. It will not be possible to reflash the processor without dismantling the control unit to make a hardware link.

The program in the SPIDER is stored in a serial EEPROM on the $I^2C$ bus which will is read into RAM and executed at power up. The program EEPROM is write protected by a momentary push button. It is possible to download upgraded software in the form of Forth source code to SPIDER but it is recommended that this is done off line using a PC or Mac. The push button is accessible at the front panel of the control module, through a small hole to the left of the Sync. 1 output. A small rod is needed to activate the switch, the shank of a 2mm drill works fine.

Calibration data are stored in a further serial EEPROM. This is write protected by the same momentary push button as the program memory. Again it is recommended that any modifications are done off line.

A further EEPROM contains non-volatile user data which is not write protected. This data consists primarily of cathode, mesh and focus voltages and trigger mode definitions. Changing the user data is a level 2 or engineering procedure. Level 2 commands are covered by this manual, see Level 2 Engineering Commands on page 51.

Other operation settings such as camera mode and sweep number are stored in volatile memory. These settings are lost after power up must be downloaded and checked for each shot using Level 1 operational commands.

## 8.5 ARCHITECTURE

The SPIDER electronics hardware consists of 4 modules, these are:-

| *Module* | *Module no.* |
|---|---|
| Control | 0 |
| Focus | 1 |
| Sweep | 2 |
| Intensifier | 3 |

For software purposes SPIDER system is subdivided into the Camera system consisting of modules 0 through 2 and the Intensifier system consisting of module 3.

Each system has a RUN and a STOP state, and each has a number of operating modes.

Note that there is no PCD supply in SPIDER.

## 8.6 INTENSIFIER SYSTEM

The intensifier is controlled at level 1 by sending values for 5 operational variables and switching the unit between RUN and STOP states. Operational variables are always reset on power up, i.e. they are volatile data. The intensifier will always power up into a STOP condition.

Note that the intensifier system can be in the RUN state but not operational because of an interlock or shutdown (i.e. one shot latch tripped) condition.

### 8.6.1 INTENSIFIER MODES

| *Mode#* | *Intensifier Mode* |
|---|---|
| 0 | Inhibit |
| 1 | MAX module, pulsed, no shutdown (i.e. repetitive, but the trigger LEDs do latch) |
| 2 | MAX module, pulsed with shutdown (i.e. single shot) |
| 3 | MAX module, dc operation, no shutdown |
| 4 | MAX module, dc operation with shutdown<br>(i.e. DC voltages removed on receipt of a trigger pulse) |
| 5 | not used |
| 6 | not used |

### 8.6.2 INTENSIFIER OPERATIONAL VARIABLES

| | |
|---|---|
| Vphosphor | Amplitude of the pulsed or the DC voltage to be applied to the phosphor |
| Vmcp | Amplitude of the pulsed or the DC voltage to be applied to the MCP. |
| Vpcd | Not used on SPIDER |
| PCwidth | Not used on SPIDER |
| Intensifier Mode | A number defining the operating mode 8.6.1 on page 37. |

Pulse widths for the MCP and phosphor are determined by a combination of the following:

7. Time of Phosphor trigger
8. Time of main trigger
9. Setting of the blanking delay

In pulsed mode the phosphor and MCP are switched on when the phosphor trigger is received. They are switched off at a time equal to the main trigger time plus the blanking delay time (set in software). A time-out is set for the off time. If this is exceeded they are switched off anyway. This means that they will be switched off even of no main trigger is received.

Note that the software is only configured to drive the MCP and Phosphor either both in DC mode or both in pulsed, not one in each mode.

## 8.7 CAMERA SYSTEM

The camera system is controlled at level 1 by sending values for 3 operational variables and switching the unit between RUN and STOP states. Operational variables are always reset on power up, i.e. they are volatile data. The camera will always power up into a STOP condition.

### 8.7.1 CAMERA MODES

| *Mode#* | *Camera modes* |
|---|---|
| 0 | Inhibit |
| 1 | Focus/Flat field |
| 2 | Repetitive with no blanking (but the trigger LEDs do latch) |
| 3 | Single [set up to include crowbar and blanking] |
| 4 | User1 |
| 5 | User2 |
| 6 | User3 |
| 7 | User4 |

### 8.7.2 CAMERA OPERATIONAL VARIABLES

| | |
|---|---|
| Sweep# | A number selecting a set of sweep data |
| Trigger Mode | A number defining the trigger configuration. |
| Camera Mode | A number defining the operating mode as above. |

#### 8.7.2.1 SWEEP#

The sweep data is stored in write protected calibration EEPROM. This can be edited off line using level 3 commands.

11 sweeps (0 through 10) have been preconfigured in the calibration EEPROM in the sweep table. See Table 1 on page 74.

#### 8.7.2.2 TRIGGER MODE

The trigger mode is a set of data controlling the selection of electrical or optical inputs and the trigger sources for the various modules. Trigger modes can be edited and created using the level 2 commands below. There are 4 trigger modes preconfigured in the calibration EEPROM. Up to 8 modes can be configured with level 2 commands. The trigger modes are copied into RAM at power up. If modes are edited or created they will be lost at power down unless they have been saved into the user EEPROM using the level 2 commands provided.

There are 3 potential trigger inputs, Sweep, Phosphor and Spare. Each can be driven from an optical or an electrical signal. Each trigger mode contains 3 flags to control this.

Sweep trig optical?
Phosphor trig optical?
Spare trig optical?

Flag set/true (i.e. = -1) means the input is optical, reset/false (=0) means electrical.

SPIDER differs from DISC in that the source of the trigger signals used for the sweep, the intensifier module, the crowbar and cathode blanking are fixed. The Phosphor and MCP-on pulse circuits are triggered from the Phosphor trigger input.

The MCP-off pulse circuit, blanking pulser and crowbar are driven from the main trigger via a programmable delay called the Blanking Delay. This is a separate delay channel in SPIDER and controlled with its own command.

The sweep is always triggered by the sweep trigger input. In DISC the trigger delay to the hold up circuit was equal to the blanking delay but the sweep lengths could be up to 100ns long. In SPIDER these delays are separate, the hold up delay is handled by the sweep table but is the same for all sweeps and set to a minimum for sweeps up to 20ns (the slowest that has been set up). The blanking delay is adjustable and needs to be set up once the length (in time) of the sweep, blanking trigger and Intensifier leads is known. Internal delay cables already set the outputs of these three signals (sweep, blanking trigger and MCP-off) to be approximately synchronous at the rear panel of SPIDER. The phosphor pulse is slow and its timing is not critical. The edge speed for the blanking and MCP-off processes are ~ 10ns. The photo electrons take about 7ns to get from the cathode to the MCP input. Some fine tweaking of the delay may be necessary for optimum performance. There is provision inside SPIDER to add cables to the trigger inputs of the sweep and the fast blanking trigger circuit; currently not to the MCP-off trigger delay (without cutting cables). See General timing diagram on page 27.

The Main trigger is a low jitter signal that is buffered and fed to the Sweep module. The other two trigger inputs are fed to the CPLD where they can be routed to various places. The CPLD also detects the main trigger so that it can use it as an input to the blanking delay.

#### 8.7.2.3 PRE-CONFIGURED TRIGGER MODES

Four trigger modes are pre-configured:

| Mode | Sweep source | Intensifier Source |
|---|---|---|
| 0 | Electrical | Electrical |
| 1 | Optical | Optical |
| 2 | Optical | Electrical |
| 3 | Electrical | Optical |

### 8.7.3 USER VARIABLES

User variables include the trigger mode table and the cathode, mesh and focus voltage settings.

Commands are provided to edit all these variables. Note that any changes will be lost unless they are saved into the user EEPROM using the level 2 commands provided.

The EEPROM containing non-volatile user data is ***not*** write protected and can be corrupted or overwritten with inappropriate values. A command is provided to overwrite the user variables in RAM with the factory defaults.

Commands are provided to allow the changing of the cathode, mesh and focus voltages with the camera in the ON state in focus mode to assist with focusing. To avoid tripping the focus supply it is necessary that any step changes are small and the software limits them to 50V.

In addition there are some level 3 commands that can be used for camera focusing. These turn off the current trip and allow quick changing of values and flipping between the mesh and cathode voltages. These are used when focusing the camera on a continuous or high repetition rate source.

## 8.8 MODULE CONFIGURATIONS

Each module will have a number of operating configurations. It is not necessary to manipulate these directly as they are controlled and selected by the intensifier and camera operating modes.

Control module configurations

| | |
|---|---|
| 0 | Inhibit |
| 1 | Static |
| 2 | Swept no blanking |
| 3 | Swept with blanking |
| 4 | Swept no blanking single sweep |
| 5 | Swept with blanking single sweep |

Focus module configurations

| | |
|---|---|
| 0 | Inhibit |
| 1 | Run no crowbar |
| 2 | Run with crowbar |

Sweep module configurations

| | |
|---|---|
| 0 | Inhibit |
| 1 | Run normal |
| 2 | Bias only |

## 8.9 THE PROTOCOL

This is the protocol used for in situ control using the level 1 operation and level 2 engineering commands below. Level 3 expert commands require the use of a terminal emulator program on a PC or Mac and are not covered by this manual. Level 3 commands can use level 1 and 2 commands but also include many commands that do not adhere to the protocol.

The protocol is very similar to that used on DISC and GXD.

SPIDER will generate responses to valid commands and will not generate any unsolicited output. Invalid commands will be ignored. All commands and response will be in ASCII characters. Commands *are* case sensitive.

In the interest of simplicity all commands are parsed by SPIDER using the Forth interpreter, so the parameters need to be delimited by spaces and the command line will be terminated by carriage return and line feed characters. The Forth interpreter will not recognise commands other than those defined in the command set.

SPIDER will not echo command characters as they are received, no output will be generated until a valid command is recognised. When a valid command is recognised, SPIDER will output a response.

Responses are preceded with a cr and lf, then an ASCII { character and end with an ASCII }. The response will be delimited into fields by an ASCII ; character. The first field in the response will be a repeat of the command. If the command cannot be completed SPIDER will return an error code in the second field. The possible error codes are:-

?stack - the command interpreter has detected a wrong stack depth error, i.e. the wrong

number of parameters have been received.

?param - the command interpreter has detected an out of range parameter

After any error, the command is not executed, the stack is cleared and no values are returned other than the error code. Following a stack error, the stack is cleared than dummy parameters (generally -1 or 65536) are added for the purpose of formatting the response only.

All status commands expect and deliver data as decimal numbers and all numeric data should be

decimal, no decimal points or other punctuation is to be used.

For example

1) To set up camera in mode 2 ( repetitive mode) using trigger mode 0 (default electrical trigger) and sweep# 5, the command would be

0 5 2 !c_mod

and the response would be

{0 5 2 !c_mod;-1}

2) as above but with a missing parameter

0 2 !c_mod

and the response would be:-

{-1 -1 -1 !c_mod;?stack}

The command interpreter detects the wrong stack depth, corrects this by clearing the stack and adding some dummy parameters then flags the error. No execution will result.

3) as above with invalid parameter

0  500  2 !c_mod

and the response would be:-

{0  500  2 !c_mod ;?param}

Again no execution will result.

### 8.9.1 COMMANDS

It is intended that level 1 commands should be sufficient for routine use of SPIDER, these are non-expert commands.

Explanatory notes:-

1) In Forth terminology a @ character implies a fetch or read operation, a ! character implies a store or write operation.

2) For returned parameters, true = -1, false = 0.

## 8.10 LEVEL 1 OPERATIONAL COMMANDS

Note that level 1 and 2 commands have names as well as formats. If using a level 1 or 2 command within a word definition at level 3 it is best to use the name rather than the format. The name used as a level 3 command will return values onto the stack in the order specified so that the first item to be read on the stack is the last item the function sends. The use of the name at levels 1 or 2 will result in the command being ignored as they are not part of the level 1 and 2 protocol. Using level 1 or 2 commands at level 3 inside loops does not work reliably, names should always be used in such circumstances.

Changes from DISC commands are shown in red.

### 8.10.1 INTENSIFIER SYSTEM

| | |
|---|---|
| **Name** | **!intmode** |
| Explanation | write intensifier system mode |
| **Format** | **p1 p2 p3 p4 p5 i_!mod** |
| parameter 1 | p1 = not used |
| parameter 2 | p2 = mcp voltage, range 0 to 900 volts |
| parameter 3 | p3 = phosphor voltage, range 0 to 9000 volts |
| parameter 4 | p4 = not used |
| parameter 5 | p5 = intensifier mode, range 1 to 6 [modes 5 & 6 not used] |
| returned value 1 | r1 = command completed?, true or false |
| Notes | This command will execute only if intensifier system is in STOP state<br>r1 = false implies system in RUN state.<br>Do not forget to set a cam mode |

| *Mode#* | *Intensifier modes* |
|---|---|
| 0 | Inhibit |
| 1 | MAX module, pulsed, no shutdown (i.e. repetitive, but the trigger LEDs do latch) |
| 2 | MAX module, pulsed with shutdown (i.e. single shot) |
| 3 | MAX module, dc operation, no shutdown |
| 4 | MAX module, dc operation with shutdown<br>(i.e. DC voltages removed on receipt of a trigger pulse) |

| | |
|---|---|
| **Name** | **@intmode** |
| Explanation | read intensifier system mode |
| **Format** | **i_@mod** |
| returned value 1 | r1 = not used |
| returned value 2 | r2 = mcp voltage |
| returned value 3 | r3 = phosphor voltage |
| returned value 4 | r4 = not used |
| returned value 2 | r5 = intensifier mode |
| Notes | returns values set with !intmode, not measured voltages |

| | |
|---|---|
| **Name** | **intrun** |
| Explanation | put intensifier system into RUN state |
| **Format** | **i_run** |
| returned value 1 | r1 = command completed?, true or false |
| Notes | This command will execute only if intensifier system is in STOP state |

r1 = false implies system in RUN state
After executing an intrun (i_run) command there is a 10 second built in delay before the intensifier/MAX module becomes operational. The operational state can be checked with the @intstatus (i_@sts) command.

| | |
|---|---|
| **Name** | **intstop** |
| Explanation | put intensifier system into STOP state |
| **Format** | **i_stp** |
| returned value 1 | r1 = command completed?, true or false |
| Notes | will execute only if intensifier system is in the RUN state<br>r1 = false implies the system is in the STOP state<br>After executing intstop wait for the intensifier to stop running before changing any intensifier parameters. Look at the intensifier status [@intstatus] parameter r1. This will remain in the true state until the voltages have collapsed, this takes longer than on DISC as the long cables have to be discharged. |

| | |
|---|---|
| **Name** | **intarm** |
| Explanation | reset intensifier trigger latch |
| **Format** | **i_arm** |
| Notes | This currently only resets intensifier trigger latch. There is no inhibit of the intensifier by the latch. |

| | |
|---|---|
| **Name** | **@intadcs** |
| Explanation | read intensifier system adcs |
| **Format** | **i_@adc** |
| returned value 1 | r1 = not used |
| returned value 2 | r2 = mcp voltage from adc |
| returned value 3 | r3 = phosphor voltage from adc |
| returned value 4 | r4 = phosphor PSU voltage from adc |
| Note | returns are measured values |

| | |
|---|---|
| **Name** | **@intmcpadcs** |
| Explanation | read intensifier system mcp adcs |
| **Format** | **i_@madc** |
| returned value 1 | r1 = mcp1 voltage from adc |
| returned value 2 | r2 = mcp2 voltage from adc |
| returned value 3 | r3 = mcp3 voltage from adc |
| returned value 4 | r4 = mcp4 voltage from adc |

| | |
|---|---|
| **Name** | **@intiadcs** |
| Explanation | read intensifier system current adcs |
| **Format** | **i_@iadc** |
| returned value 1 | r1 = mcp current in $\mu$A |
| returned value 2 | r2 = phosphor current in $\mu$A |
| returned value 3 | r3 = not used |
| returned value 4 | r4 = not used |

| | |
|---|---|
| **Name** | **@intstatus** |
| Explanation | read intensifier system status |
| **Format** | **i_@sts** |
| returned value 1 | r1 = int_go?, true/false |
| returned value 1 | r2 = intrunning?, true/false |
| returned value 2 | r3 = intshutdown?, true/false |
| returned value 3 | r4 = intinterlock?, true/false |
| Notes | operational intensifier system requires int_go? = true<br>int_go? is true if and only if:-<br>intrunning? = true<br>intshutdown? = false<br>intintlk? = false<br>Phosphor current trip? = false<br>MCP current trip? = false<br>intensifier voltages stable (i.e. not in soft start or stop phase) |

| | |
|---|---|
| **Name** | **@inttripstatus** |
| Explanation | read intensifier system trip status |
| **Format** | **i_@tsts** |
| returned value 1 | r1 = Phosphor current trip?, true/false |
| returned value 1 | r2 = MCP current trip?, true/false |
| returned value 2 | r3 = not used |
| returned value 3 | r4 = not used |

## 8.11 CAMERA SYSTEM

| | |
|---|---|
| **Name** | **!cammode** |
| Explanation | write camera system mode |
| **Format** | **p1 p2 p3 c_!mod** |
| parameter 1 | p1 = trigger mode, range 0 to 7 |
| parameter 2 | p2 = sweep#, range 0 to 31 |
| parameter 3 | p3 = camera mode, range 0 to 7 |
| returned value 1 | r1 = command completed?, true or false |
| Note | will execute only if intensifier system is in STOP state |
| | r1 = false implies system in RUN state |

| *Mode#* | *Camera modes* |
|---|---|
| 0 | Inhibit |
| 1 | Focus/Flat field |
| 2 | Repetitive with no blanking (but the trigger LEDs do latch) |
| 3 | Single [set up to include crowbar and blanking] |
| 4 | User1 |
| 5 | User2 |
| *6* | *User3* |
| 7 | User4 |

| *Mode* | *Sweep source* | *Intensifier Source* |
|---|---|---|
| 0 | Electrical | Electrical |
| 1 | Optical | Optical |
| 2 | Optical | Electrical |
| 3 | Electrical | Optical |

| | |
|---|---|
| **Name** | **@cammode** |
| Explanation | read camera system mode |
| **Format** | **c_@mod** |
| returned value 1 | r1 = trigger mode |
| **returned value 2** | **r2 = sweep#** |
| returned value 3 | r3 = camera mode |
| Notes | returns values set with !cammode, not measured voltages |

| | |
|---|---|
| **Name** | **camrun** |
| Explanation | put camera system into RUN state |
| **Format** | **c_run** |
| returned value 1 | r1 = command completed?, true or false |
| Notes | will execute only if camera system is in STOP state |
| | r1 = false implies system in RUN state |

| | |
|---|---|
| **Name** | **camstop** |
| Explanation | put camera system into STOP state |
| **Format** | **c_stp** |
| returned value 1 | r1 = command completed?, true or false |
| Notes | will execute only if camera system is in RUN state |
| | r1 = false implies system in STOP state |

| | |
|---|---|
| **Name** | **@camtubeadcs** |
| Explanation | read camera system tube voltage adcs |
| **Format** | **c_@tua** |
| returned value 1 | r1 = cathode voltage |
| returned value 2 | r2 = mesh voltage |
| returned value 3 | r3 = focus voltage |
| returned value 4 | r4 = +bias voltage |
| Note | returns are measured values<br>r4 is included for compatibility with DISC software but both bias voltages are available under @cambiasadcs, both are needed for accurate sweep timing information. |

| | |
|---|---|
| **Name** | **@cambiasadcs** |
| Explanation | read camera sweep bias voltage adcs |
| **Format** | **c_@bia** |
| returned value 1 | r1 = +bias voltage |
| returned value 2 | r2 = -bias voltage |
| returned value 3 | r3 = not used |
| returned value 4 | r4 = not used |
| Notes | returns are measured values |

| | |
|---|---|
| **Name** | **@camtempadcs** |
| Explanation | read camera system temperature adcs |
| **Format** | **c_@tea** |
| returned value 1 | r1 = focus module temperature °C |
| returned value 2 | r2 = Sweep 1 temperature °C |
| returned value 3 | r3 = Sweep 2 temperature °C |
| returned value 4 | r4 = Control module 1 temperature °C |
| returned value 5 | r5 = Control module 2 temperature °C |
| Notes | returns are measured values |

| | |
|---|---|
| **Name** | **@campoweradcs** |
| Explanation | read camera system power supply adcs |
| **Format** | **c_@psa** |
| returned value 1 | r1 = not used |
| returned value 2 | r2 = not used |
| Notes | returns are measured values<br>Command not used in SPIDER |

| | |
|---|---|
| **Name** | **@camstatus** |
| Explanation | read camera system status |
| **Format** | **c_@sts** |
| returned value 1 | r1 = cam_go?, true/false |
| returned value 2 | r2 = HV running?, true/false |
| returned value 3 | r3 = sweep running?, true/false |
| returned value 4 | r4 = control running?, true/false |
| returned value 5 | r5 = HV shutdown?, true/false |

| | |
|---|---|
| returned value 6 | r6 = HV tripped?, true/false |
| returned value 7 | r7 = HV interlock fail?, true/false |
| returned value 8 | r8 = control armed?, true/false |
| Notes | An operational camera system requires |

| | | |
|---|---|---|
| r1 | cam_go? | = true |

camgo? is true if and only if the following are as listed:-

| | | |
|---|---|---|
| r2 | eht running? | = true |
| r3 | sweep running? | = true |
| r4 | control running? | = true |
| r5 | HV shutdown? | = false |
| r6 | HV tripped? | = false |
| r7 | HV interlock? | = false |
| r8 | control armed? | = true |

HV voltage stable (i.e. soft start completed)

**Name** **camarm**

Explanation arm control/sweep module/focus module.

**Format** **c_arm**

this arms the control/sweep unit and resets trigger latches.
Generally after a shot in single mode it is necessary to restart the Focus module using a camstop and camrun sequence.
During testing of the fast blanking, camarm can be used to reset the single shot latch. In the factory programmed modes the single shot trips the single shot latch and prevents further triggers as well as shutting down the focus module. In repetitive mode the fast blanking is not triggered. Camarm can be used to enable the fast blanking again without having to wait for the focus voltages to rise again.
The user can program other modes that, for example, allow fast blanking in repetitive mode but no crowbarring. Crowbarring will always shut down the focus unit.

## 8.12 CAMERA AND INTENSIFIER COMBINED

| | |
|---|---|
| **Name** | **arm** |
| Explanation | arm system |
| **Format** | **s_arm** |
| | this arms the control/sweep unit and resets trigger latches. Generally after a shot in single mode it is necessary to restart the eht (HV) power supply module using a stop and run sequence. See notes under camarm. |

| | |
|---|---|
| **Name** | **@trigstatus** |
| Explanation | read trigger latch status |
| **Format** | **s_@tst** |
| returned value 1 | r1 = T1 input triggered?, true/false |
| returned value 2 | r2 = T2 input triggered?, true/false (input not configured on Spider) |
| returned value 3 | r3 = Main input triggered?, true/false |
| returned value 4 | r4 = HV module triggered?, true/false |
| returned value 5 | r5 = INT module triggered?, true/false |
| returned value 6 | r6 = SWp module triggered?, true/false |
| Notes | The triggered flags reflect the state of latches on the relevant trigger inputs. Triggered flag set indicates only a signal at the input, does not confirm any pulse at the module outputs. These latches are not reset by a stop and run sequence, reset using arm. |

| | |
|---|---|
| **Name** | **@healthstatus** |
| Explanation | read health status |
| **Format** | **s_@hst** |
| returned value 1 | r1 = focus module found, true/false |
| returned value 2 | r2 = intensifier module found, true/false |
| returned value 3 | r3 = sweep module found, true/false |
| Notes | Returns the results of the power up hardware tests. A true value indicates the relevant module was found. A false value indicates a problem with the $I^2C$ connectors or other hardware fault. |

| | |
|---|---|
| **Name** | **@sysstatus** |
| Explanation | read system status |
| **Format** | **s_@sst** |
| returned value 1 | r1 = ?sysgo, true/false |
| returned value 2 | r2 = ?camgo, true/false |
| returned value 3 | r3 = ?intgo, true/false |
| Notes | Returns the state of the system go flag. Sysgo = true implies the system is ready for the next shot. This is the logical AND of the camera and intensifier go flags. |

| | |
|---|---|
| **Name** | **run** |
| Explanation | put combined system into RUN state |
| **Format** | **s_run** |

| | |
|---|---|
| returned value 1 | r1 = command completed?, true or false |
| Notes | r1 = false implies the camera and/or the intensifier system was already in RUN state. Will leave both camera and intensifier in RUN state regardless. |

| | |
|---|---|
| **Name** | **stop** |
| Explanation | put camera system into STOP state |
| **Format** | **s_stp** |
| returned value 1 | r1 = command completed?, true or false |
| Notes | r1 = false implies the camera and/or the intensifier system was already in STOP state. |

| | |
|---|---|
| **Name** | **safe** |
| Explanation | Puts both the camera and intensifier into the STOP state regardless of their current state. |
| **Format** | **safe** |
| Notes | Use this command in preference to stop if you are unsure of the state of the systems. |

| | |
|---|---|
| **Name** | **@version#** |
| Explanation | read software version no. |
| **Format** | **s_@ver** |
| returned value 1 | r1 = version number, currently 0. |

| | |
|---|---|
| **Name** | **@serial#** |
| Explanation | read serial no. |
| **Format** | **s_@ser** |
| returned value 1 | r1 = serial number |

## 8.13 LEVEL 2 ENGINEERING COMMANDS

| | |
|---|---|
| **Name** | **@camuservolts** |
| Explanation | read camera system user voltage settings |
| **Format** | **c_@usv** |
| returned value 1 | r1 = cathode voltage |
| returned value 2 | r2 = mesh voltage |
| returned value 3 | r3 = focus voltage |
| Notes | returns set values, not measured values |

| | |
|---|---|
| **Name** | **camfocus** |
| Explanation | setup camera focus condition |
| **Format** | **p1 c_foc** |
| parameter 1 | p1 = bias voltage for focus |
| returned value 1 | r1 = command completed?, true or false |
| Notes | will execute only in focus/flat field mode<br>r1 = false return implies system in the wrong mode or in STOP state<br>Execute a C_run before using this command. |

| | |
|---|---|
| **Name** | **camflatarm** |
| Explanation | Arm the camera system in flat field mode |
| **Format** | **p1 c_fla** |
| parameter 1 | p1 = voltage increment per step for flat field |
| returned value 1 | r1 = estimated time in ms for complete flat field |
| returned value 2 | r2 = command completed?, true or false |
| Notes | will execute only in focus/flat field mode false return implies system in the wrong mode or in STOP state restores sweep bias to flat field start condition |

| | |
|---|---|
| **Name** | **camflattrig** |
| Explanation | Trigger the camera system in flat field mode |
| **Format** | **c_flt** |
| returned value 1 | sweep bias voltage on termination |
| returned value 2 | r2 = command completed?, true or false |
| Notes | will execute only in focus/flat field mode false return implies system in the wrong mode or in STOP state This command will sent a return value for several seconds until the flat field sweep has terminated. It will terminate prematurely if any further serial character is received. |

| | |
|---|---|
| **Name** | **incvcathode** |
| Explanation | add an increment to the cathode voltage |
| **Format** | **p1 c_ivc** |
| parameter 1 | p1 = voltage increment, range +/-50V |
| returned value 1 | revised cathode voltage setting |
| returned value 2 | r2 = command completed?, true or false |
| Notes | will execute only in focus/flat field mode<br>false return implies system in the wrong mode or in STOP state |

| | |
|---|---|
| | Changes only the RAM value, will be lost on power up unless saved |

| | |
|---|---|
| **Name** | **incvfocus** |
| Explanation | add an increment to the focus voltage |
| **Format** | **p1 c_ivf** |
| parameter 1 | p1 = voltage increment, range +/-50V |
| returned value 1 | revised focus voltage setting |
| returned value 2 | r2 = command completed?, true or false |
| Notes | will execute only in focus/flat field mode |
| | false return implies system in the wrong mode or in STOP state |
| | Changes only the RAM value, will be lost on power up unless saved |

| | |
|---|---|
| **Name** | **incvmesh** |
| Explanation | add an increment to the mesh voltage |
| **Format** | **p1 c_ivm** |
| parameter 1 | p1 = voltage increment, range +/-50V |
| returned value 1 | revised mesh voltage setting |
| returned value 2 | r2 = command completed?, true or false |
| Notes | will execute only in focus/flat field mode |
| | false return implies system in the wrong mode or in STOP state |
| | Changes only the RAM value, will be lost on power up unless saved |

| | |
|---|---|
| **Name** | **!trigmode** |
| Explanation | store settings to a trigger mode |
| **Format** | **p1 p2 p3 p4 p5 p6 p7 s_!tgm** |
| parameter 1 | p1 = Sweep trigger optical?, true/false |
| parameter 2 | p2 = Phosphor trigger optical?, true/false |
| parameter 3 | p3 = Spare trigger optical?, true/false |
| parameter 4 | p4 = not used |
| parameter 5 | p5 = not used |
| parameter 6 | p6 = not used |
| parameter 7 | p7 = trigmode, range 0 to 7 |
| Note | Use this command to set up new trigger configurations. |
| | Changes only the RAM value, will be lost on power up unless saved with a saveuser command |
| | The spare trigger is not configured for use on SPIDER |
| | Trigger modes are used by !cammode |

| | |
|---|---|
| **Name** | **@trigmode** |
| Explanation | read settings from a trigger mode |
| **Format** | **p1 s_@tgm** |
| parameter 1 | p1 = trigmode, range 0 to 7 |
| returned value 1 | r1 = Main trig optical?, true/false |
| returned value 2 | r2 = T1 trig optical?, true/false |
| returned value 3 | r3 = T2 trig optical?, true/false |
| returned value 4 | r4 = Intensifier trig source, range 0 to 3 |

returned value 5 r5 = Crowbar trig source, range 0 to 3
returned value 6 r6 = Spare trig source, range 0 to 3

**Name** **saveuser**
Explanation save user data to EEPROM
**Format** **s_sus**

**Name** **restoreuser**
Explanation read user data from EEPROM into ram
**Format** **s_rus**

**Name** **defaultuser**
Explanation read factory user data from calibration EEPROM into ram
**Format** **s_dus**
Changes only the RAM value, will be lost on power up unless saved

**Name** **!blankdelay**
Explanation store user blanking delay
**Format** **p1 c_!bl**
parameter 1 p1 = delay, range 0 to 63
Changes only the RAM value, will be lost on power up unless saved with a saveuser command

**Name** **@blankdelay**
Explanation read user blanking delay
**Format** **c_@bl**
returned value 1 r1 = delay, range 0 to 63

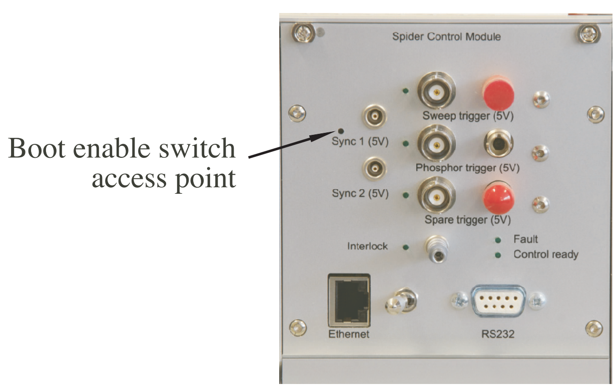



Figure 16 The boot enable access hole is located on the top of the control unit

## 8.14 CONTROL EXAMPLES

1) Repetitive

| | |
|---|---|
| 0 5 2 !c_mod {cr} | |
| | set up camera in mode 2 ( repetitive mode) using trigger mode 0 ( default electrical trigger) and sweep# 5, |
| { 0 5 2 !c_mod; -1} | executed ok |
| 0 450 3000 0 3 !i_mod {cr} | |
| | set up intensifier in mode 3 ( dc operation)<br>450v on mcp<br>0 v on pcd not used in SPIDER<br>3000v on phosphor |
| {0 450 3000 0 3 !i_mod; -1} | |
| | executed ok |
| c_run | Camera to RUN state |
| {c_run;-1} | executed ok |
| i_run | Intensifier to RUN state |
| {i_run: -1} | executed ok |

Wait till ready for shot then

| | |
|---|---|
| c_@sts | camera status check |
| {c_@sts; -1,-1,-1,-1,0,0,0,-1} | |
| | (camera is go, volts and modes look good)<br>(-1 = true) |
| i_@sts | intensifier status shot check |
| { i_@sts; -1,-1,0,0} | |
| | intensifier is go, volts and mode look good |

Do shot

Going to be a long time till next one so

| | |
|---|---|
| c_stp | Camera to STOP state |
| {c_stp;-1} | executed ok |

| | |
|---|---|
| i_stp | Intensifier to STOP state |
| {i_stp: -1} | executed ok |

Nearly ready for next shot so back to RUN

| | |
|---|---|
| c_run | Camera to RUN state |
| {c_run;-1} | executed ok |
| i_run | Intensifier to RUN state |
| {i_run: -1} | executed ok |

Wait till ready then

| | |
|---|---|
| c_@sts | camera status check |
| {c_@sts; -1,-1,-1,-1,0,0,0,-1} | (camera is go, volts and modes look good)<br>(-1 = true) |
| i_@sts | intensifier status shot check |
| { i_@sts; -1,-1,0,0} | intensifier is go, volts and mode look good |

## 8.15 LEVEL 3 COMMANDS

Level 3 commands enable one to reconfigure many things and override safety features, etc. They permit controlling trip levels, setting up sweep and trigger parameters. These commands will not normally be accessed via the UCS but with a terminal programme such as Hyperterminal, Terminal (available from Kentech) or a Forth terminal programme (for use with Macs). A few details are given here for the setting of sweep configurations and changing the focus supply trip levels.

### 8.15.1 CHANGING THE SWEEP TABLE

This requires the use of level 3 commands. These are accessed by placing the camera in debug mode. Debug mode does not adhere to the protocol. Debug mode is not suitable for use with the UCS. Debug mode should not be used by anyone who is not familiar with the system and its potential vulnerabilities. In debug mode one is talking to the FORTH operating system using the FORTH language.

If SPIDER is powered down in debug mode it will power back up in the same mode.

+debug changes to debug mode
[this is the only command accepted by the protocol that is not part of it]

-debug changes back to standard protocol mode

In debug mode forth commands are echoed responded to with ok after any output is sent.

The sweep table is part of the calibration data, this is read from the calibration EEPROM at power up or reset. Any changes will be lost unless it is explicitly saved to EEPROM.

ee!cal saves the current calibration data, including the sweep table, to EEPROM

Note that the calibration EEPROM is write protected and the write enable button must be operated by inserting a small screw driver or similar object (~ 2mm diameter) into the hole on the control unit Figure 16 on page 53.

A good procedure is:-
1) type ee!cal
2) press and hold write enable button
3) press return
4) wait for “ok” prompt
5) release write enable button

The sweep table can hold data for 32 different sweeps, numbered 0 to 31.

Currently defined there are 11 sweeps defined which are shown in Table 1 on page 74

Each sweep entry consists of 12 fields.

The first field “time” is intended to hold the physical sweep speed but is not used at present.

The ramp circuit works by adding several stages together. This gives a degree of arbitrary waveform generation ability that helps when the sweep duration is similar to the round trip time of the cabling. There is a hold up circuit that clamps the deflection to stop retrace.

Unlike DISC the bldel field delay does not control the delay to the fast blanking circuit. This is because the cabling lengths are so long that the blanking circuit timing needs a separate delay control that can easily be set up separately from the sweep lengths. So the “bdel” field is not used. As none of the sweeps is longer than 30ns, the hold field is set to zero for all the 11 sweeps set up for Spider. This fires the hold up circuit as early as possible and in the 11 cases this does not need mre than the intrinsic circuit delay.

There are 12 fields to control the sweep module hardware. The fields do the following things:

| | |
|---|---|
| swp_time | for reference, not used |
| swp_bias | the optimum bias voltage for this sweep speed, measured empirically. |
| swp_hold | delay for firing hold up circuit (0 to 63, 63 = short delay, unlike the level 2 command **!blankdelay**) |
| swp_60v | controls the slope of a stage |
| swp_18v | 0 through 4 controls the delay of a stage |
| swp_diode | if set to true turns on a diode to increase the speed slightly<br>Only used on the fastest sweep. |
| swp_short | Set true if the ramp is to be fully on screen. Can be used for timing but none of the 11 preset Spider speeds is set to use this reduced scan mode. |
| swp_bldel | Not used in Spider. |

The fields can be individually *read* with the following words:-

| Word | Stack effect |
|---|---|
| @swp_time | ( swp# -- n) |
| @swp_bias | ( swp# -- n) |
| @swp_hold | ( swp# -- n) |
| @swp_60v | ( swp# -- n) |
| @swp_18v_0 | ( swp# -- n) |
| @swp_18v_1 | ( swp# -- n) |
| @swp_18v_2 | ( swp# -- n) |
| @swp_18v_3 | ( swp# -- n) |
| @swp_18v_4 | ( swp# -- n) |
| @swp_diode? | ( swp# -- n) |
| @swp_short? | ( swp# -- n) |
| @swp_bldel | ( swp# -- n) |

e.g.

```
3 @swp_bias .
```

Will print the bias field for sweep 3

The fields can be individually *written* with the following words:-

| Word | Stack effect |
|---|---|
| !swp_time | ( n swp# -- ) |
| !swp_bias | ( n swp# -- ) |
| !swp_hold | ( n swp# -- ) |
| swp_60v | ( n swp# -- ) |
| !swp_18v_0 | ( n swp# -- ) |
| !swp_18v_1 | ( n swp# -- ) |
| !swp_18v_2 | ( n swp# -- ) |
| !swp_18v_3 | ( n swp# -- ) |
| !swp_18v_4 | ( n swp# -- ) |

!swp_diode? ( n swp# -- )

!swp_short? ( n swp# -- )

!swp_bldel ( n swp# -- )

e.g.

3500 1 !swp_60v

will set the 60v DAC field for sweep 1 to 3500.

Existing sweeps can be edited by changing individual fields as above, though it is recommended that new sweeps are defined rather than changing existing ones which have been set up to obtain a good linearity.

To set up a new sweep one needs to define all twelve fields.

E.g. if you type or download the following, sweep 16 will be set up similarly to existing sweep 1

```
2000 16 !swp_time
610 16 !swp_bias
false 16 !swp_short?
false 16 !swp_diode?
63 16 !swp_hold
3500 16 !swp_60v
2500 16 !swp_18v_0
2700 16 !swp_18v_1
2300 16 !swp_18v_2
2300 16 !swp_18v_3
2300 16 !swp_18v_4
 0 16 !swp_bldel
```

Note that true is -1, and false is 0, the interface can accept either format.

Once the table is modified it must be save to EEPROM as shown earlier in this section.

# 9. CURRENT TRIPS

Unlike DISC there are current trips on the intensifier supply. The DC trips are automatically set to maximum in pulsed mode. In DC mode the values are stored in variables

| | |
|---|---|
| phrisetrip | controls the trip current during the turn on of the power supplies. |
| phdctrip | controls the trip current in DC mode once the power supplies are at the set voltage. |
| mcprisetrip | controls the trip current during the turn on of the power supplies. |
| mcpdctrip | controls the trip current in DC mode once the power supplies are at the set voltage. |

There is a trip on the focus unit. The trip uses the currents in the mesh, focus and cathode circuits summed together.

There are two settings:-

| | |
|---|---|
| ehtrisetrip | - variable containing the value used during soft start. |
| ehtdctrip | - variable containing the value used after soft start when the eht is steady. |

The values are the numbers output to the dac, range 0 to 4095. They work in inverse logic, higher is more sensitive, lower is less sensitive.

Default settings are:-

3000 for ehtrisetrip

3300 for ehtdctrip

The dctrip is more sensitive. These are the most sensitive values that work reliably on the bench (no tube attached).

They are read with the level 3 commands

ehtrisetrip @ .

ehtdctrip @ .

They can be changed by for example

1234 ehtrisetrip !

2345 ehtdctrip !

Newly entered values will be overwritten at power up or reset unless stored with ee!cal.

**defaultuser** will restore factory defaults to these and all other calibration variables.

# 10. THE SOURCE CODE

The software inside is in two sections:-

The Forth operating system resides in the 128kbyte Flash memory of the Renesas H8S/2148F microprocessor.

The application program resides in an I2C serial EEPROM.

**Forth Operating System**

The Forth operating system uses MPE ROMFORTH. It was produced using the H8/330H and H8S Forth 6 Cross Compiler version 6.2 from:-

MPE Ltd.
133 Hill Lane
Southampton SO15 5AF
UK

Tel +44 2380 631441
Fax +44 2380 339691
http://www.mpeltd.demon.co.uk/

Most of the source code for the Forth development system is proprietary to MPE and we are not allowed to disclose it unless the user purchases a licence for the Forth 6 Cross Compiler. It is not easy or meaningful to supply our modifications to the MPE code without also supplying sections of the original code. However, it is possible to change the application program without changing the Forth operating system so we consider that this is not strictly necessary and that it is beyond the scope of the current contract.

The Forth 6 Cross Compiler generates an image file from the source code which is then put into flash memory. A copy of the GXD image file called “CPU2148.IMG” is supplied on CD. The image file can be transferred to the flash memory on the Renesas H8S/2148F using the “Flash Development Toolkit” which is available from Renesas Technology www.renesas.com. This should be necessary only if the H8S/2148F chip fails and is replaced with a new unprogrammed item.

## 11. CATHODE PACK

The unit is supplied with a user supplied cathode pack rather than the standard Kentech one.

This facilitates easy removal of the cathode and mesh and also integrates with a fibre optic fiducial system.

## 12. TUBE DATA

Deflection sensitivity +&-

18.9$Vmm^{-1}$ J0902271-1

18.0$Vmm^{-1}$ J0902271-2

17.4$Vmm^{-1}$ J1101271

18.0 $Vmm^{-1}$ J1109122

Focus potentials when focused with no MAX module, just a plain phosphor.

These are the potentials in volts measured with the built in monitor.

focus V 11450

mesh V 10779

cathode V 14992

## 13. SWEEP DATA

In Table 1 on page 74 the delays to screen centre w.r.t. speed 0 are shown as well as the total screen duration on a 40 mm detector and sweep speeds.

# 14. WAVEFORMS

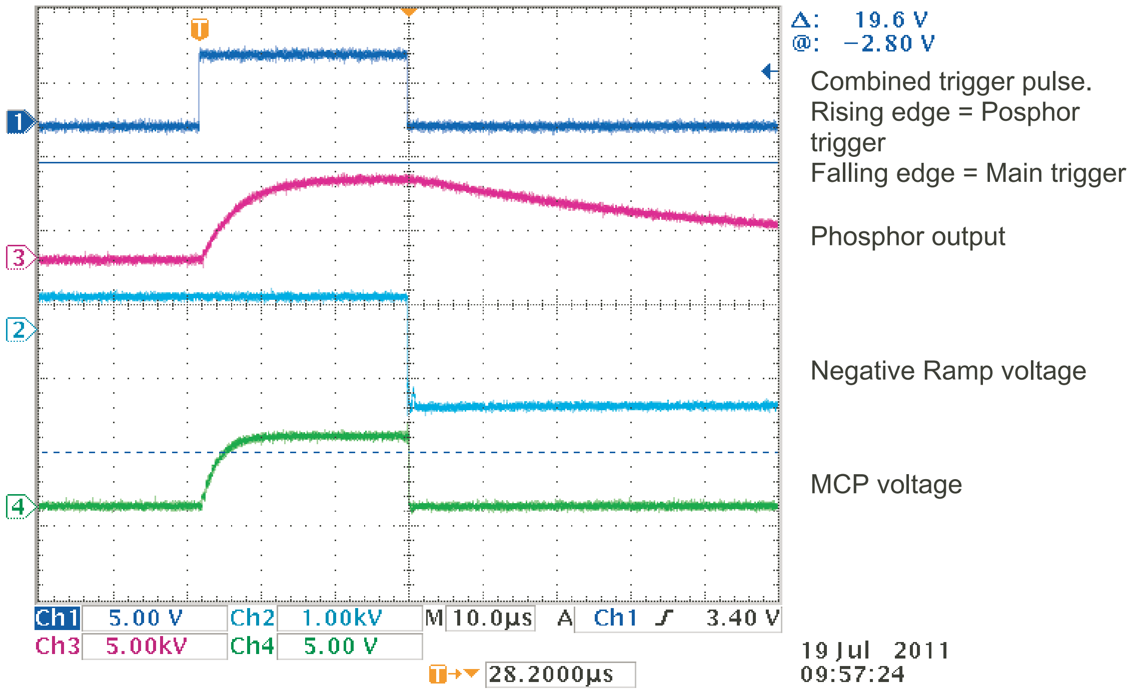



Figure 17 Timing diagram showing the phosphor, sweep and MCP timings.

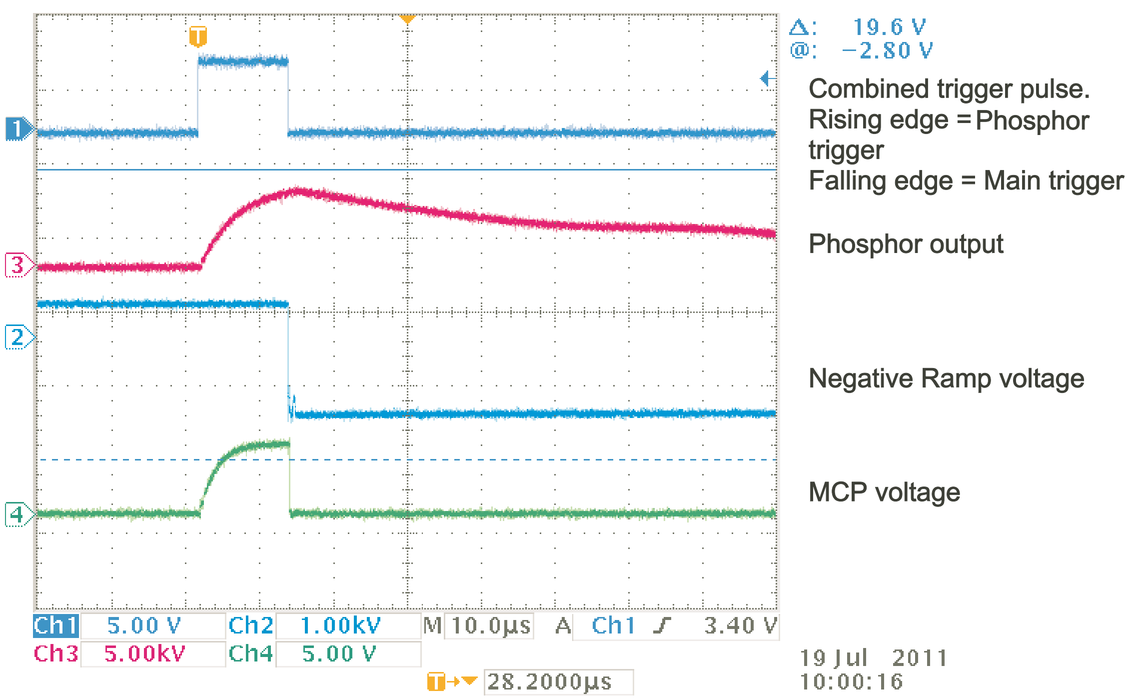



Figure 18 As Figure 17 but with sweep delay reduced to 12$\mu$s after phosphor trigger

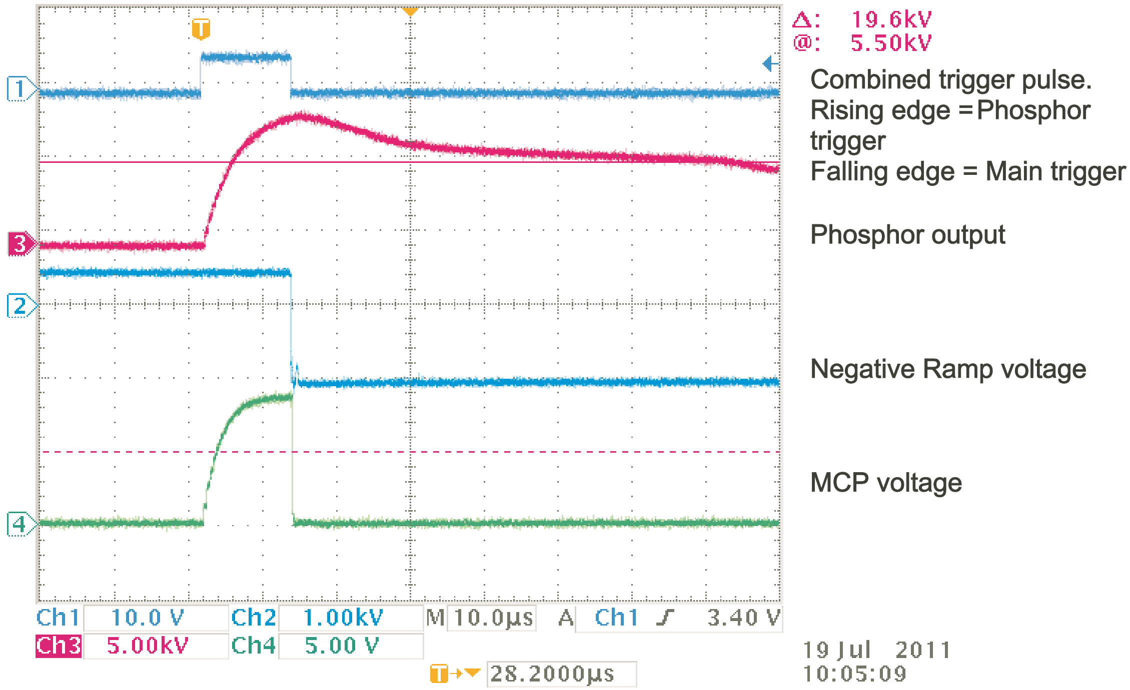



Figure 19 As Figure 18 but with maximum phosphor and MCP amplitude.

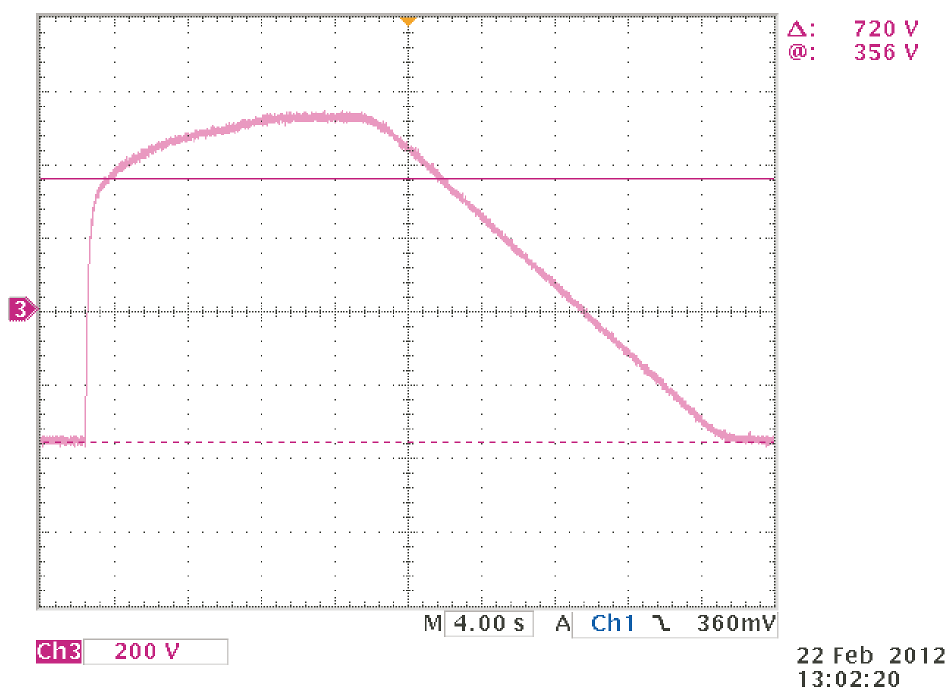



Figure 20 The phosphor waveform during a flat field scan with 2V/increment.

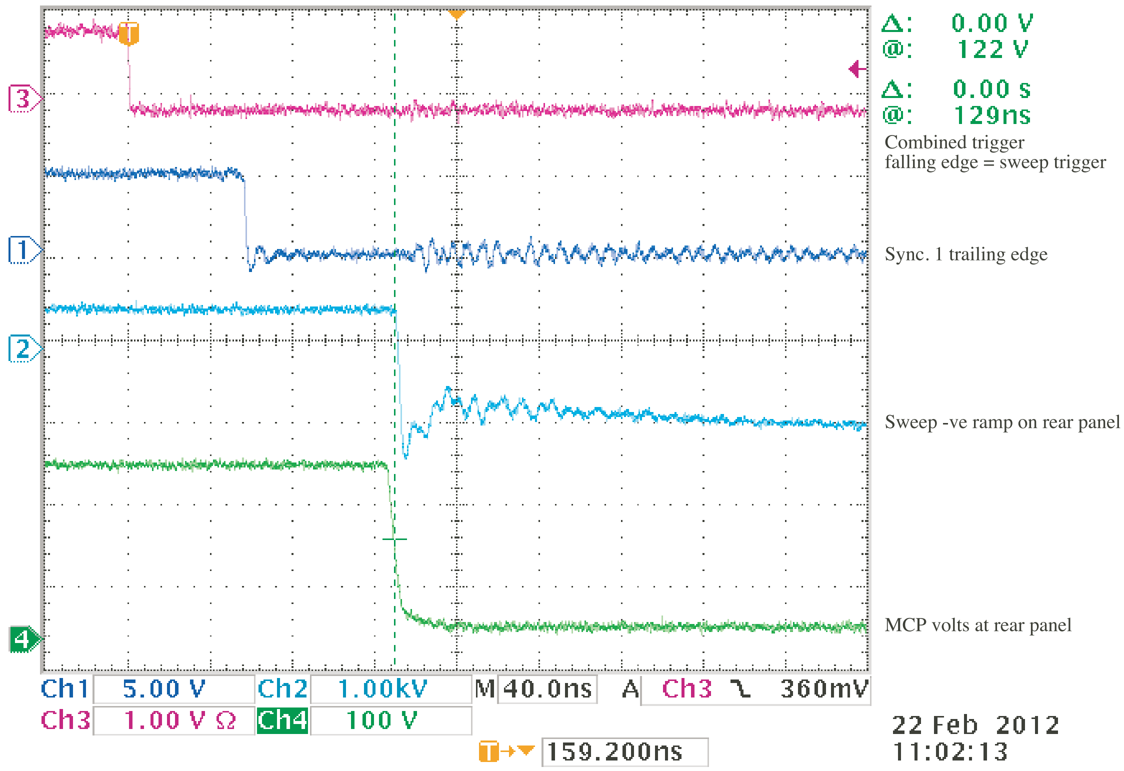



Figure 21 Blanking delay set to zero.

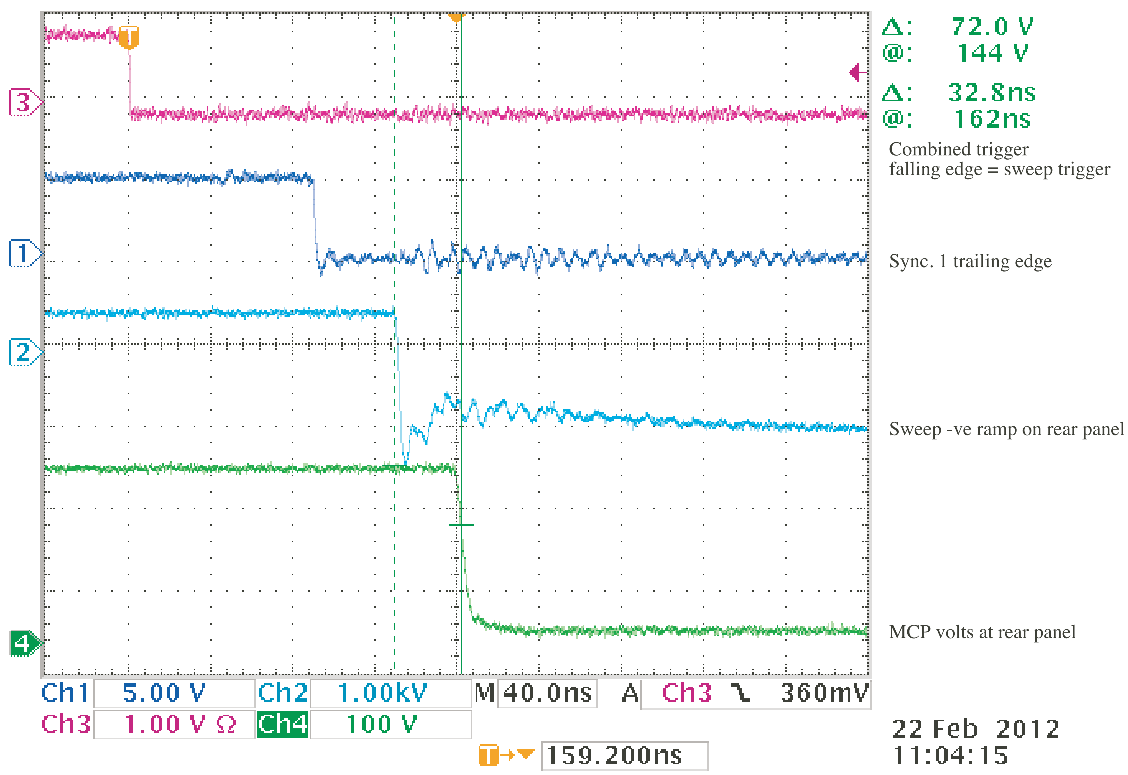



Figure 22 Blanking delay set to 7 = 32.8ns

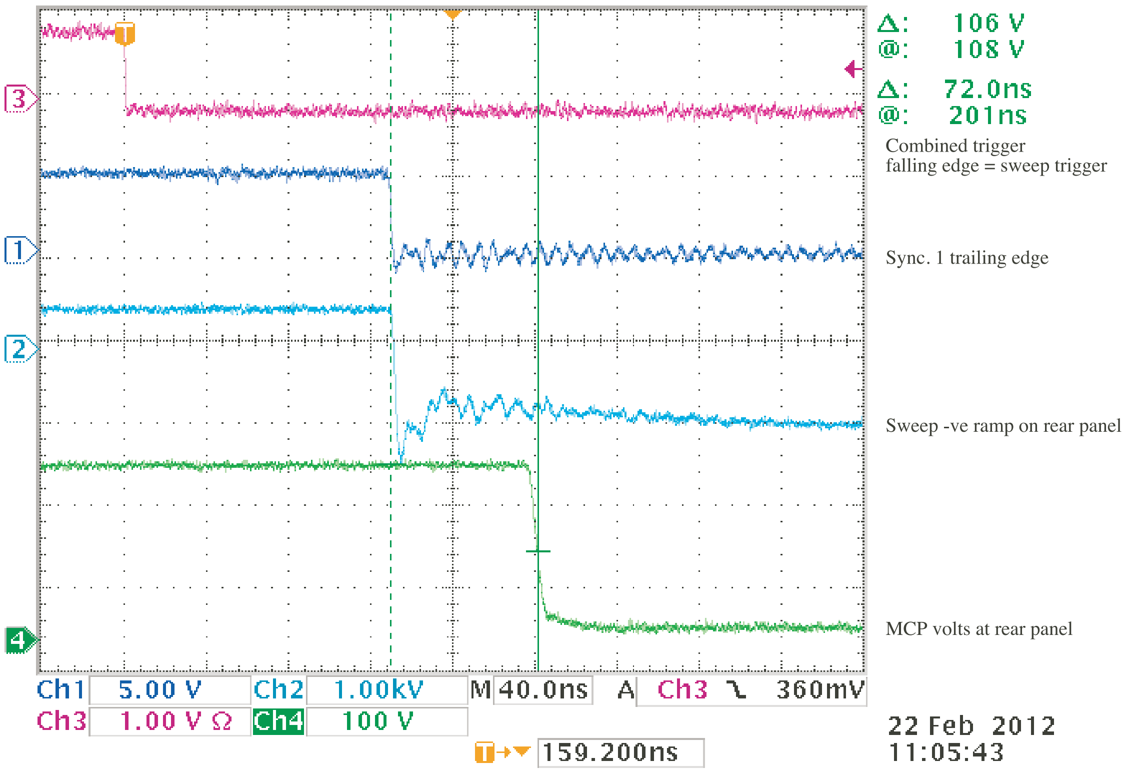



Figure 23 Blanking delay set to 15 = 72ns

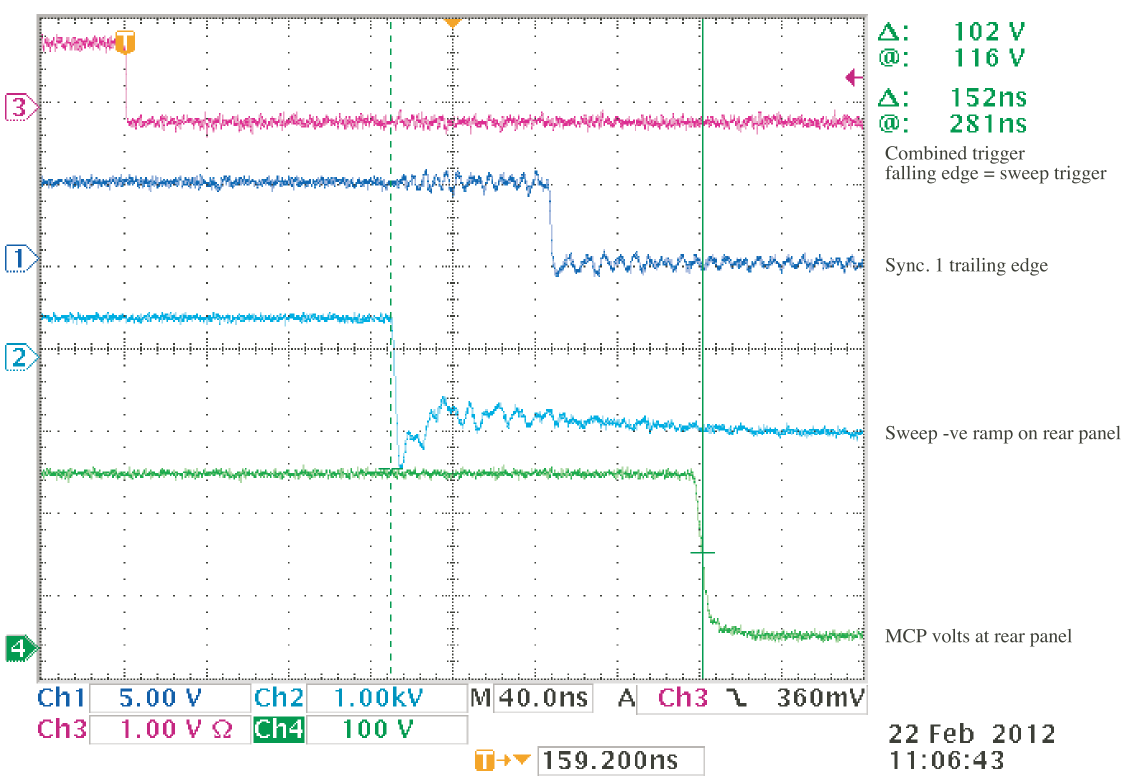



Figure 24 Blanking delay set to 31 = 152ns

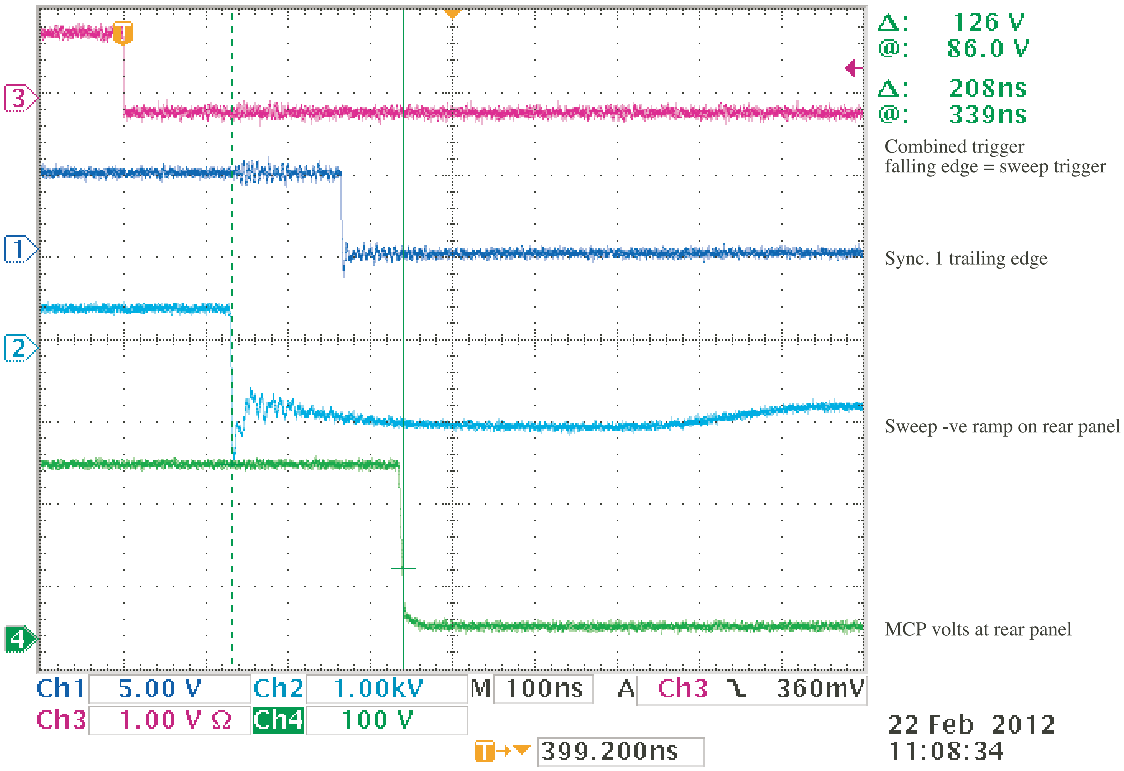



Figure 25 Blanking delay set to 43 = 208ns

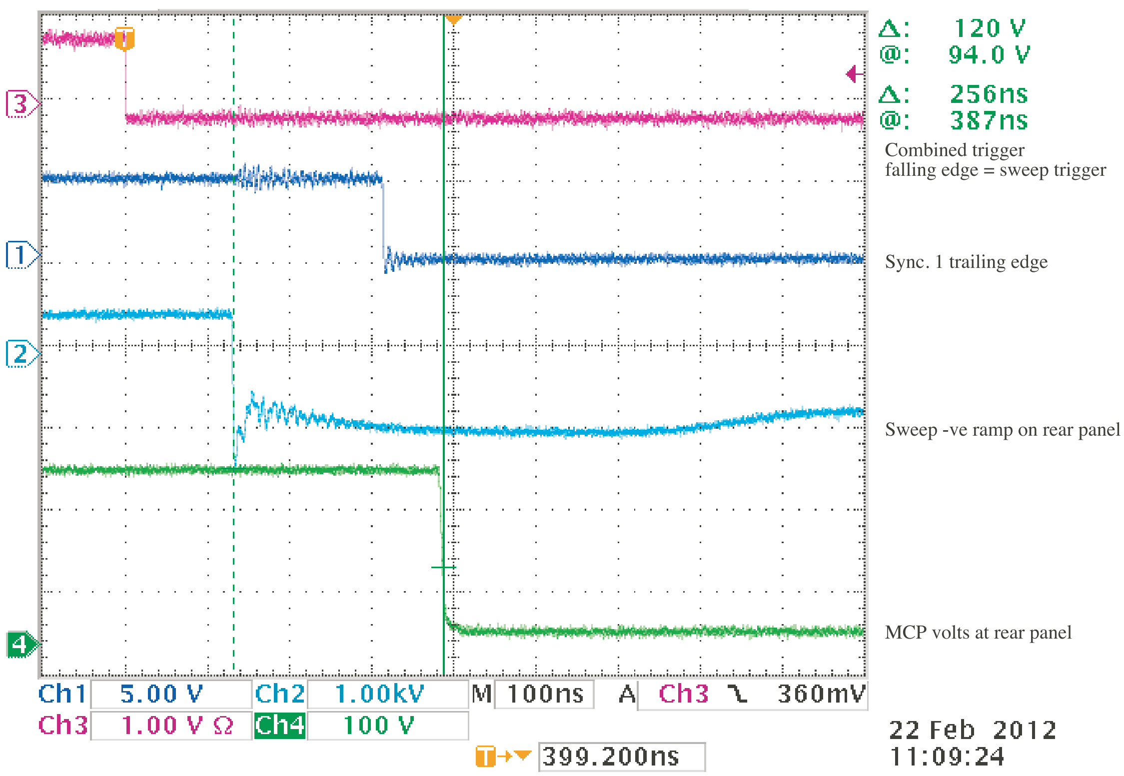



Figure 26 Blanking delay set to 53 256ns

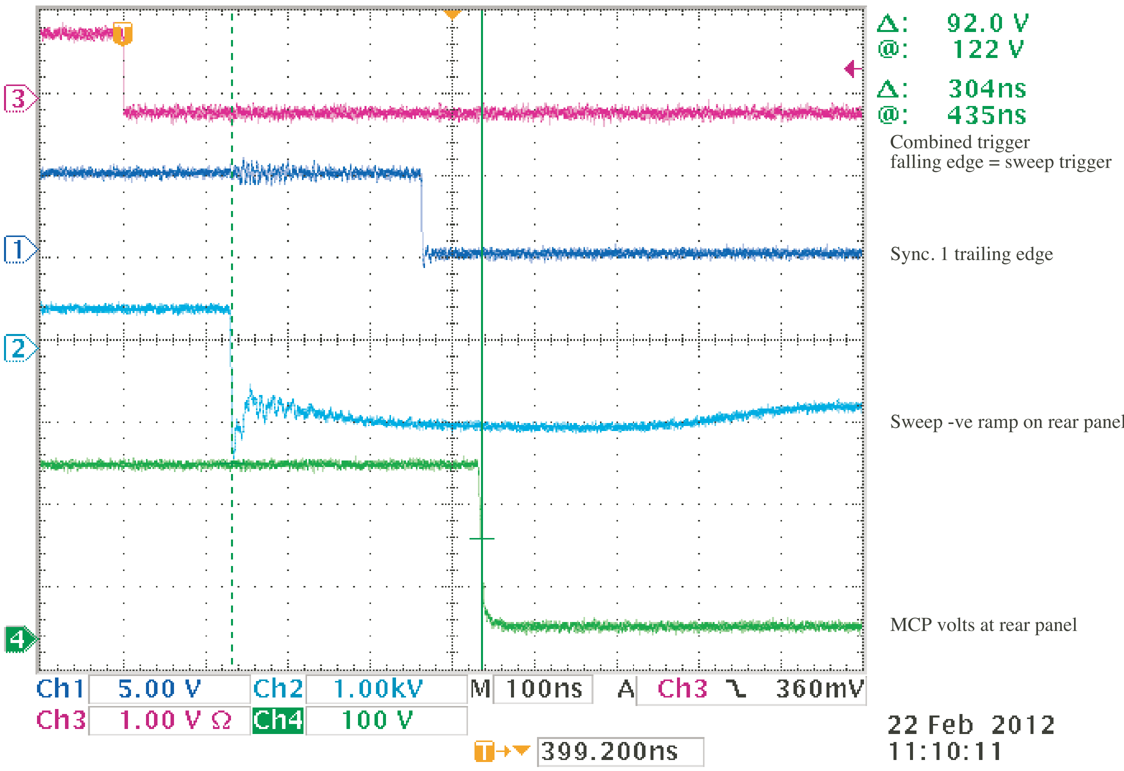



Figure 27 Blanking delay set to 63 304ns

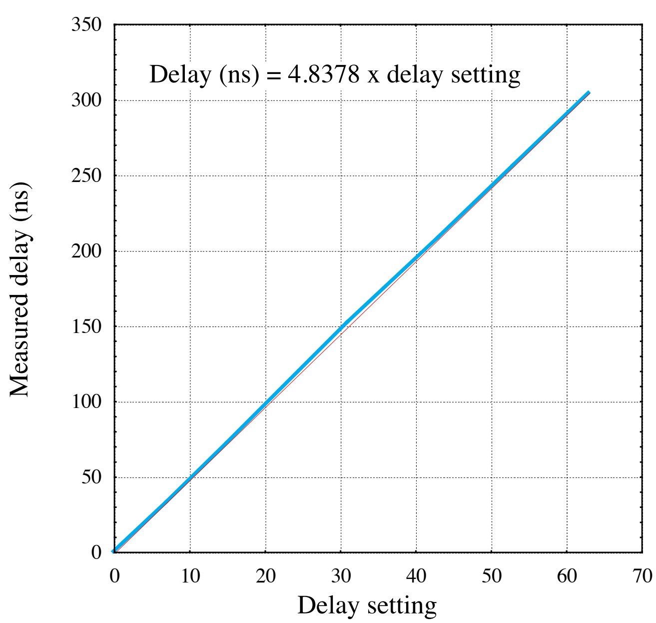



Figure 28 Blanking delay calibration. Delay (ns) = 5 x delay setting

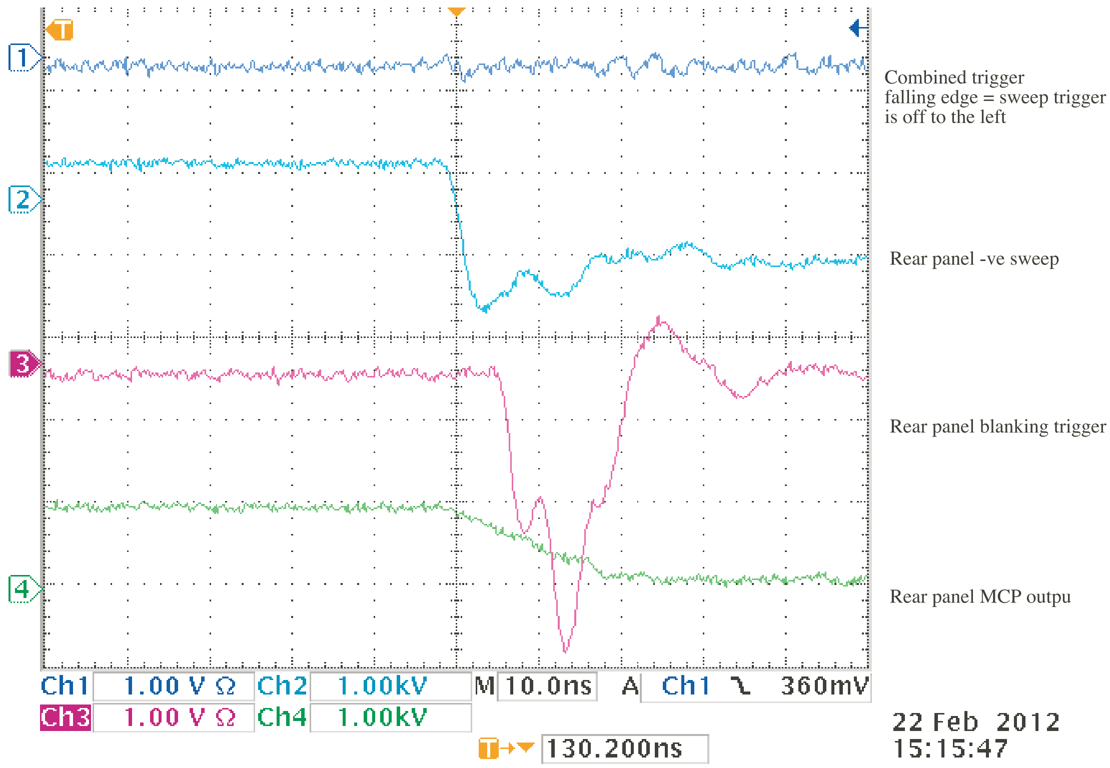



Figure 29 The outputs for fast blanking, sweep and MCP gate-off. Blanking delay set to zero. All have been synchronised at the rear panel by adding cabling delays to the blanking

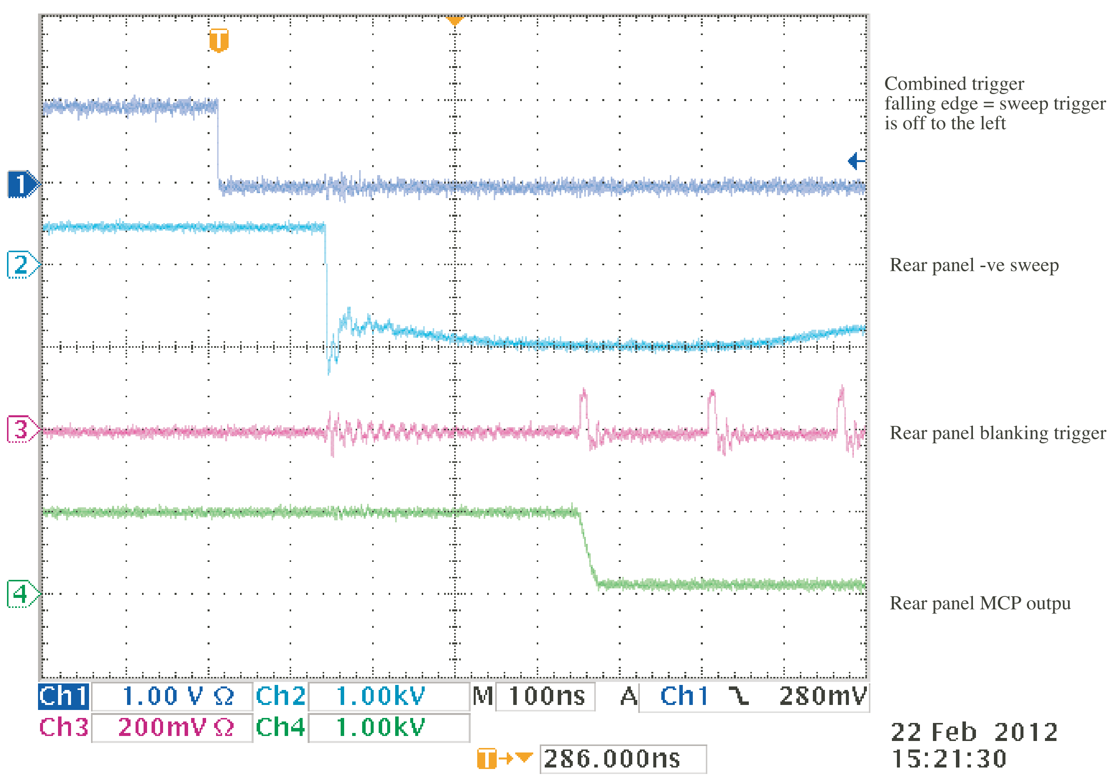



Figure 30 The outputs for fast blanking, with the blanking delay set to 63.
There is noise pickup at the beginning of the blanking trigger from the sweep.

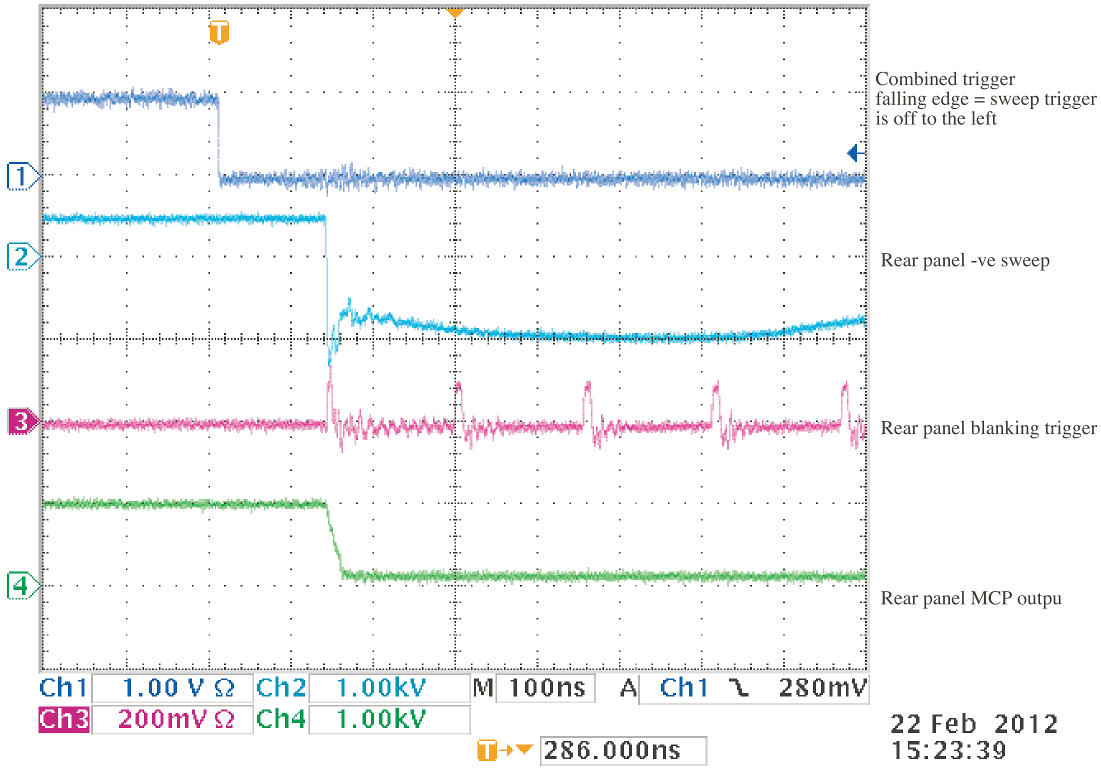



Figure 31 The outputs for fast blanking, sweep and MCP gate-off. Blanking delay set to zero. Slow scan speed

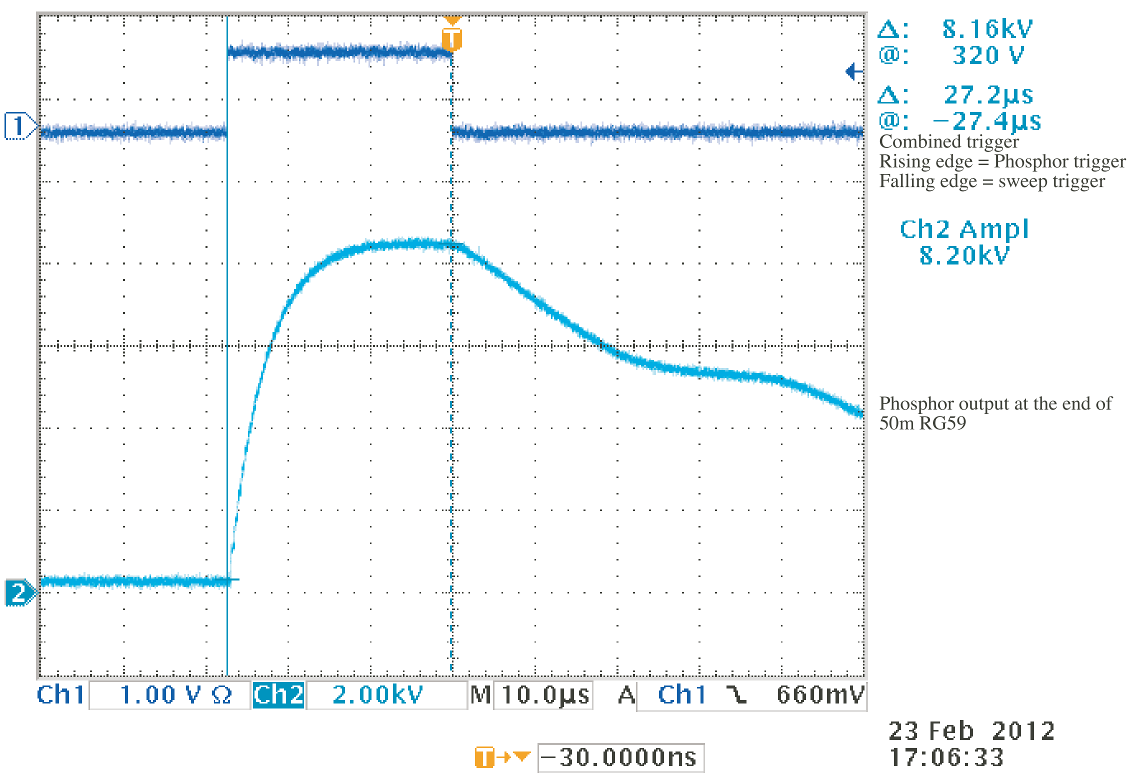



Figure 32 The phosphor pulser timing showing optimum pre-trigger range.
The phosphor should be triggered between 18.2 and 27.2$\mu$s before the sweep.

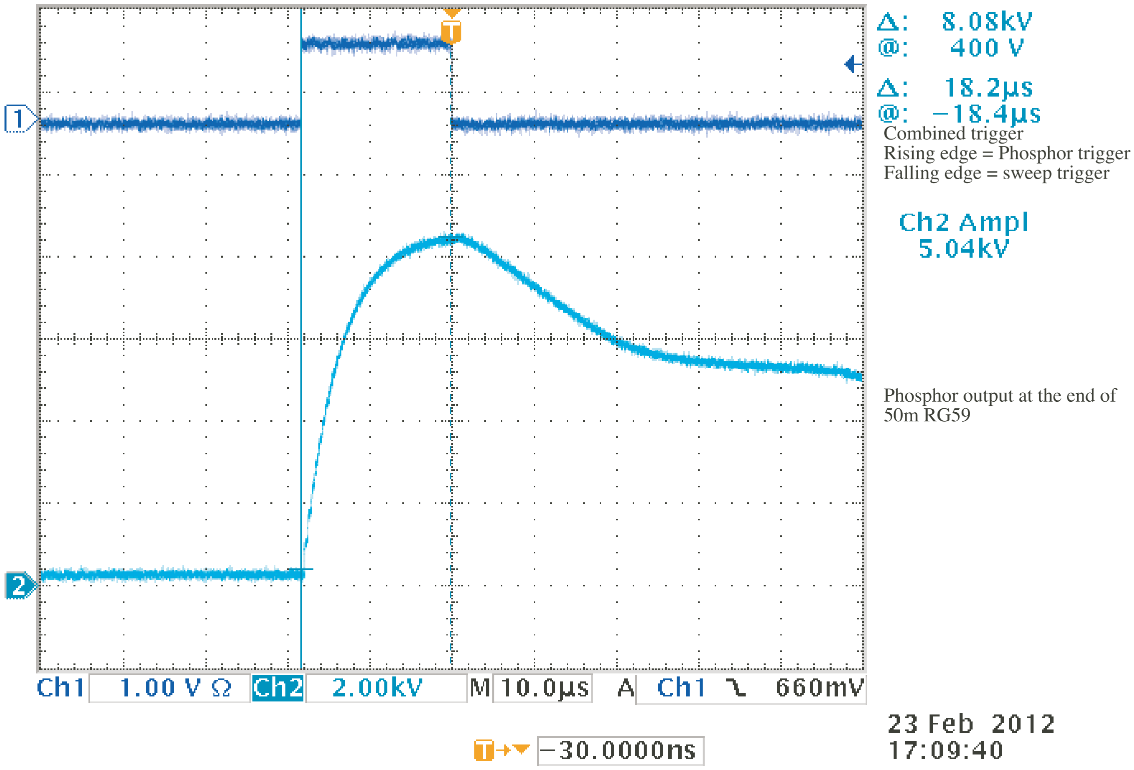



Figure 33 The phosphor pulser timing showing the latest pre-trigger.
The phosphor should be triggered between 18.2 and 27.2$\mu$s before the sweep.

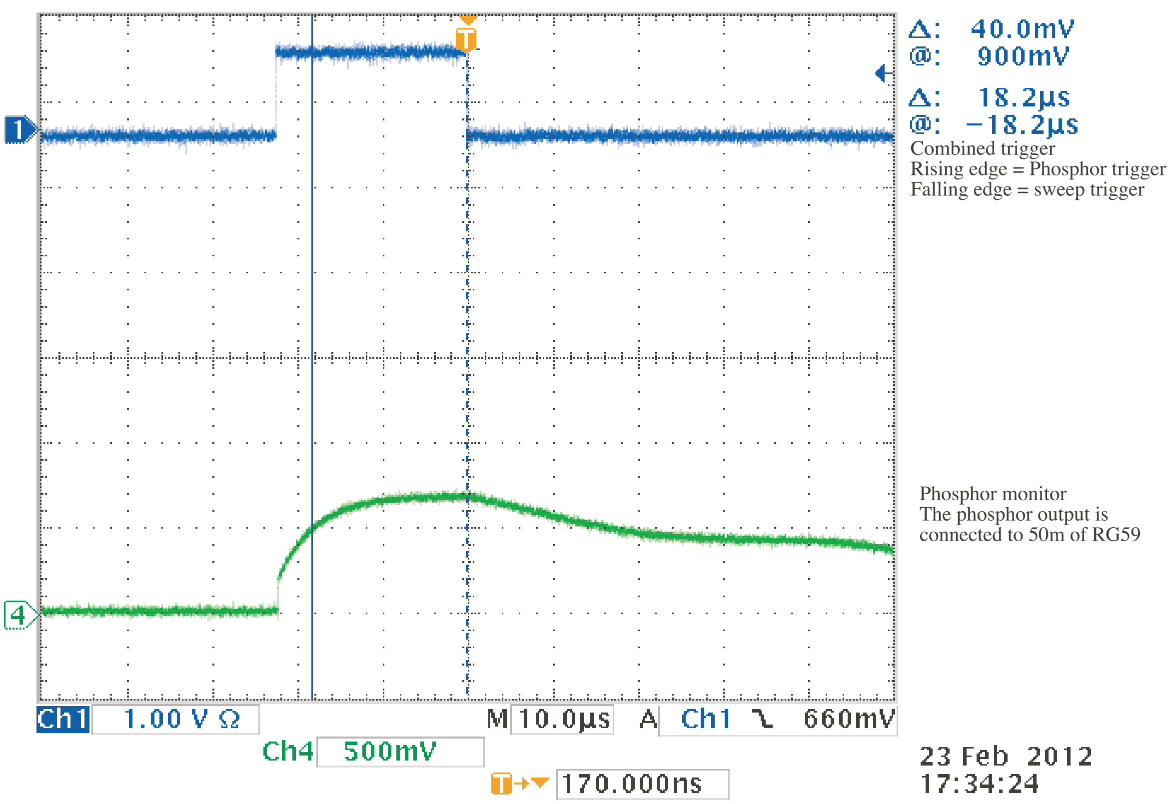



Figure 34 The phosphor monitor output with the phosphor output connected to 50m RG59

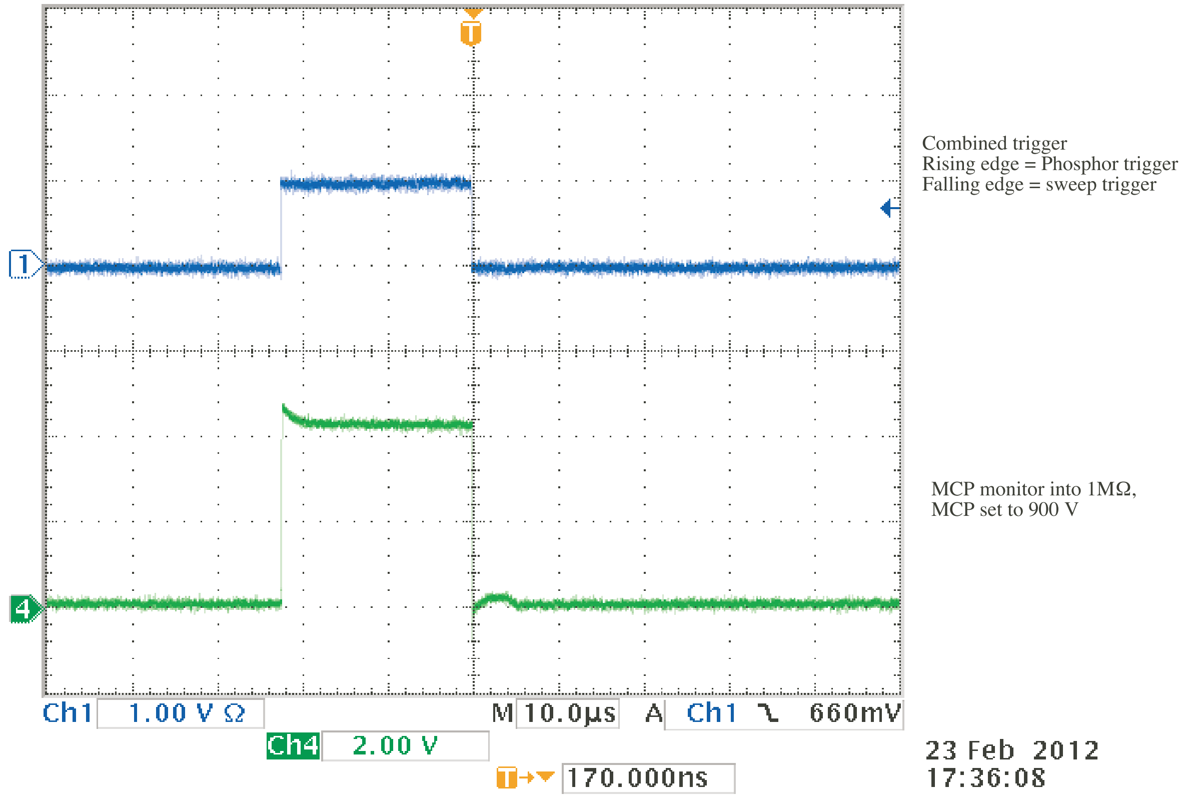



Figure 36 The MCP monitor.

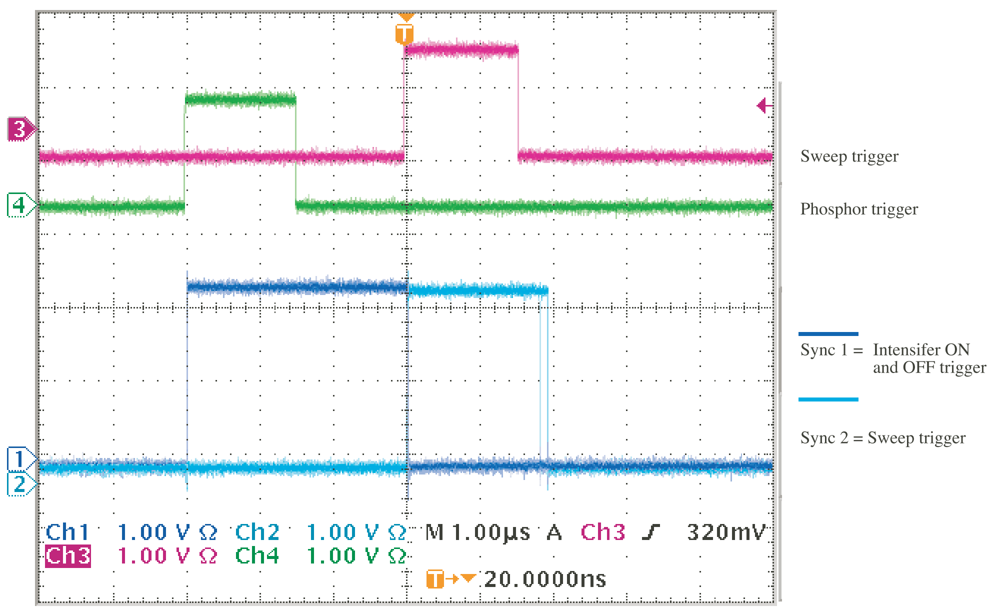



Figure 35 Sync outputs with blanking delay set to zero

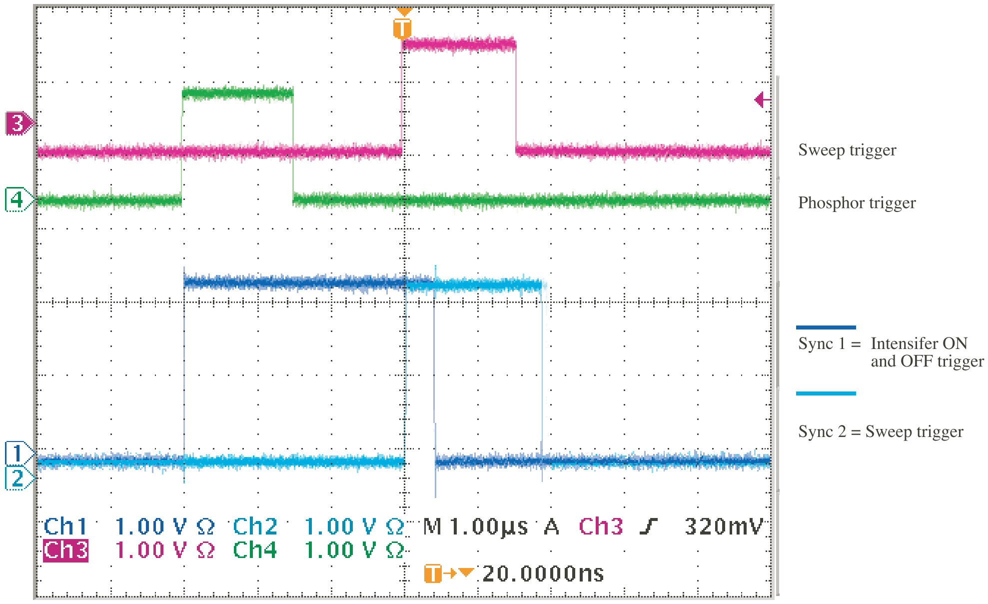



Figure 37 Sync outputs with blanking delay set to 63

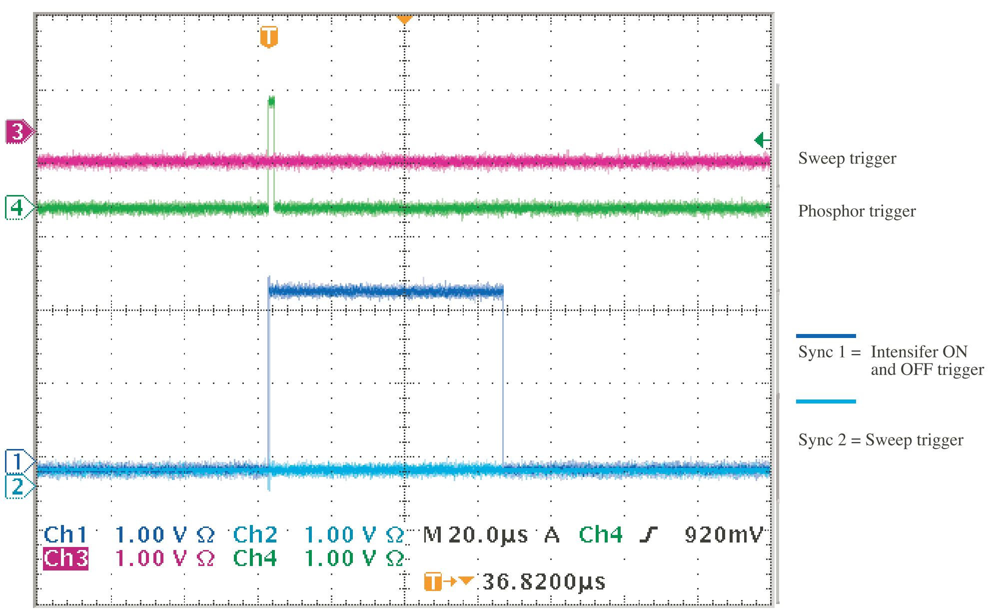



Figure 38 Sync outputs with no main trigger showing time out for the intensifier trigger. Note the 20$\mu$s time base setting compared with 1$\mu$s in Figure 37


Figure 39 Sweep 0 jitter
Range 22.98ps; standard deviation 5.774ps


Figure 40 Sweep 5 jitter
Range 56.54ps; standard deviation 9.133ps


Figure 41 Sweep 10 jitter
Range 228.98ps; standard deviation 29.249ps

Table 1 Sweep speeds and the relative delay to reach screen centre

| Sweep number | Relative delay (ns) | Sweep speed ps $mm^{-1}$ with tube J1109121 [18V$mm^{-1}$] | Sweep length nominal (ns) |
|---|---|---|---|
| 0 | 0.127 | 35.69 | 1.4 |
| 1 | 1.73 | 49.65 | 1.9 |
| 2 | 1.18 | 74.34 | 2.9 |
| 3 | 3.27 | 92.18 | 3.6 |
| 4 | 5.35 | 160.64 | 6.3 |
| 5 | 8.86 | 215.97 | 8.4 |
| 6 | 9.82 | 239.73 | 9.3 |
| 7 | 15.22 | 336.92 | 13 |
| 8 | 15.62 | 404.33 | 15.7 |
| 9 | 20.39 | 540.94 | 21 |
| 10 | 35.07 | 858.82 | 33.5 |

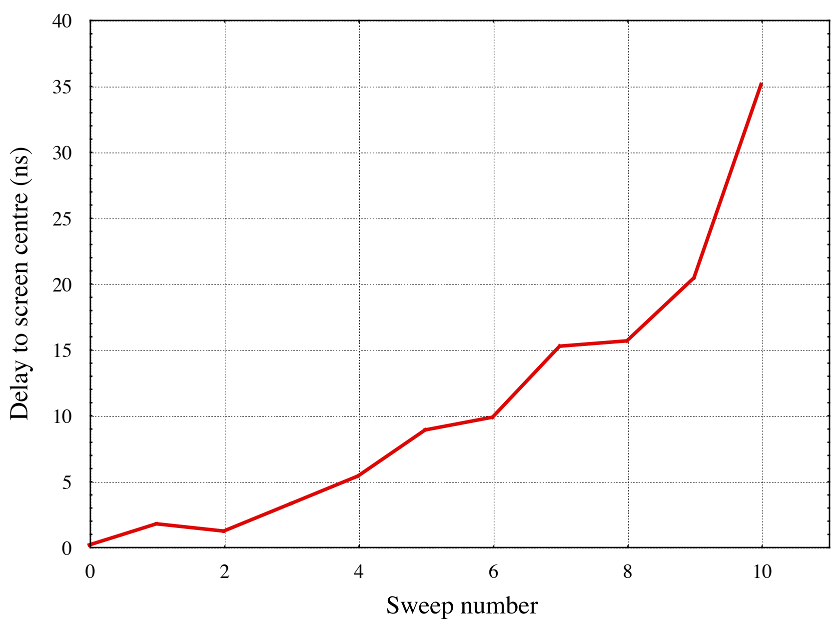



Figure 42 Relative delay of streak at screen centre with respect to sweep speed 0 for streak speeds 1 through 10

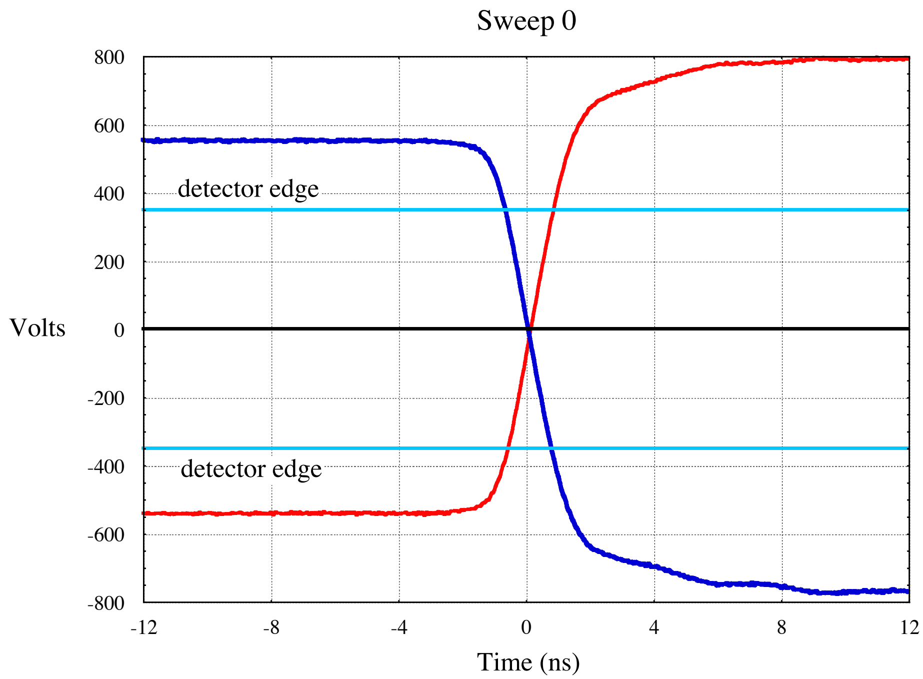



Figure 43 Sweep speed 0 overall shape.

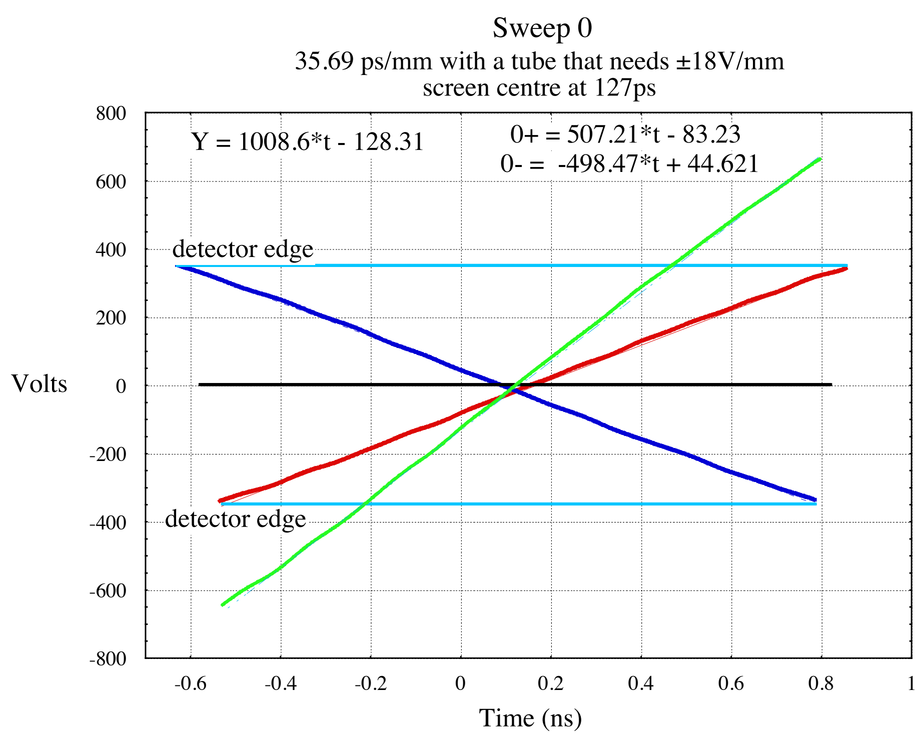



Figure 44 Sweep speed 0 central portion whilst traversing the screen giving 35.69 ps $mm^{-1}$
The green line is the difference of the ramps, i.e. the total deflection voltage and is used to calculate the ramp speed.

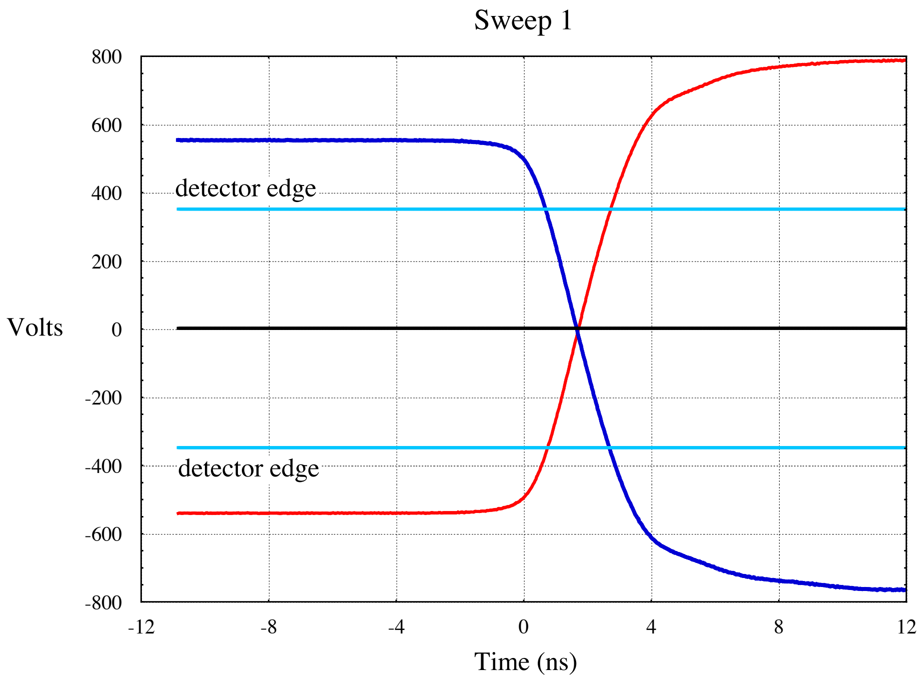



Figure 45 Sweep speed 1 overall shape.

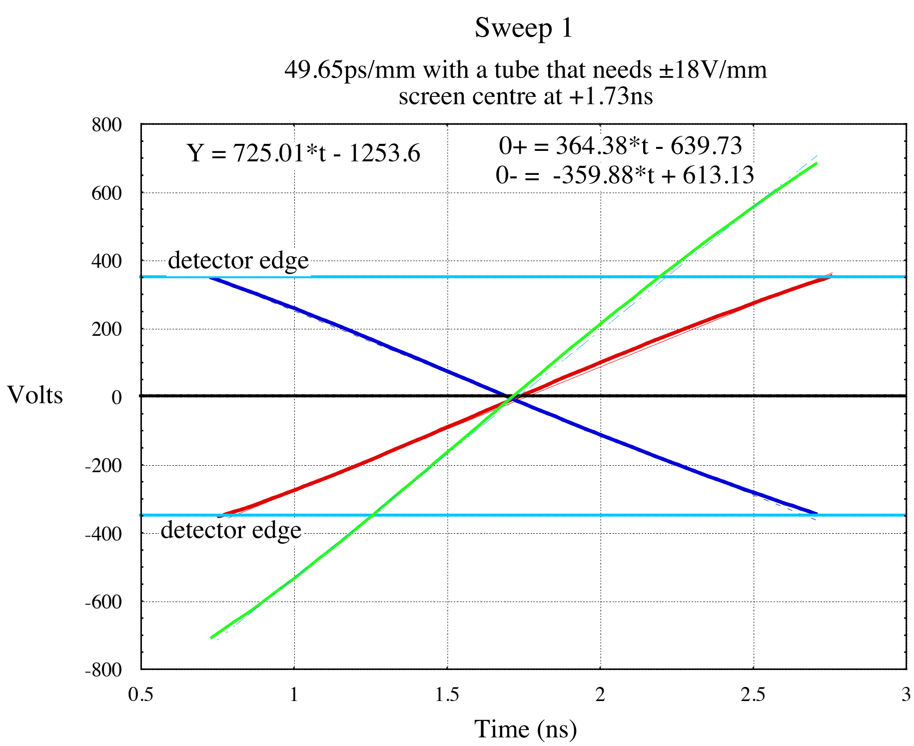



Figure 46 Sweep speed 1 central portion whilst traversing the screen giving 49.65 ps $mm^{-1}$

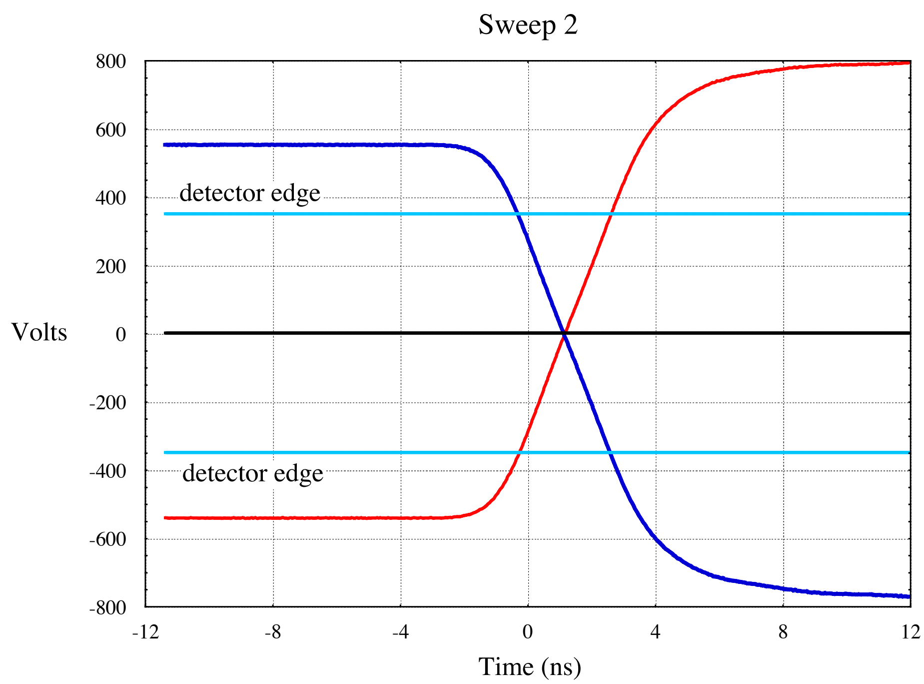



Figure 47 Sweep speed 2 overall shape.

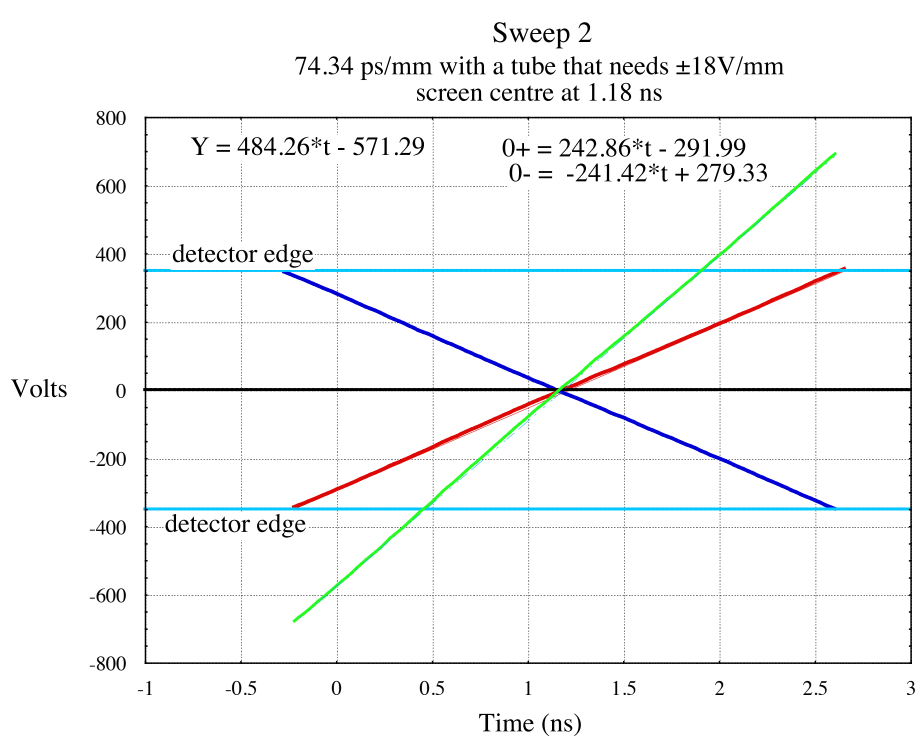



Figure 48 Sweep speed 2 central portion whilst traversing the screen giving 74.34 ps $mm^{-1}$

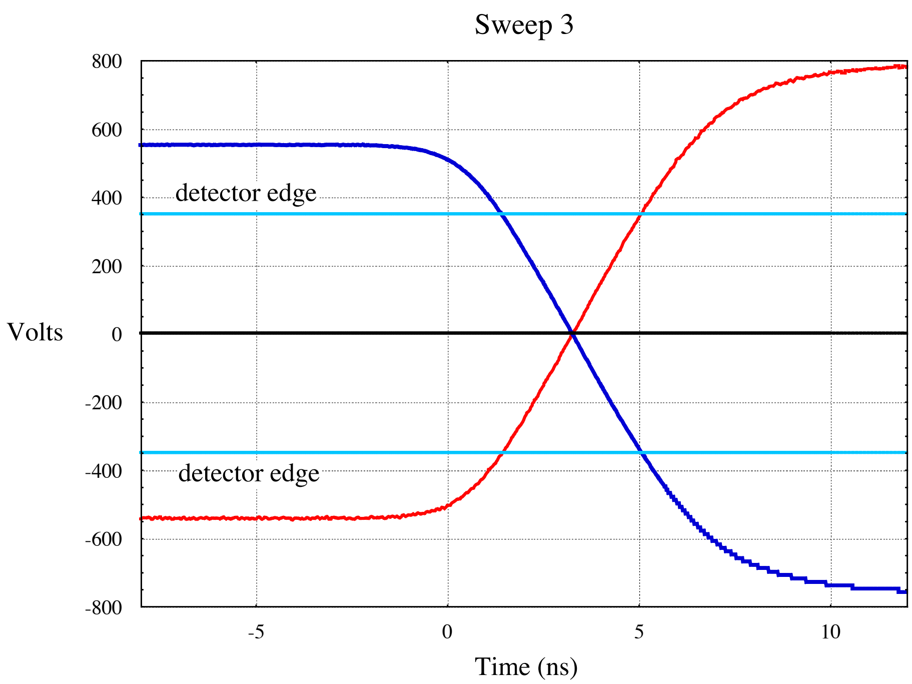



Figure 49 Sweep speed 3 overall shape.

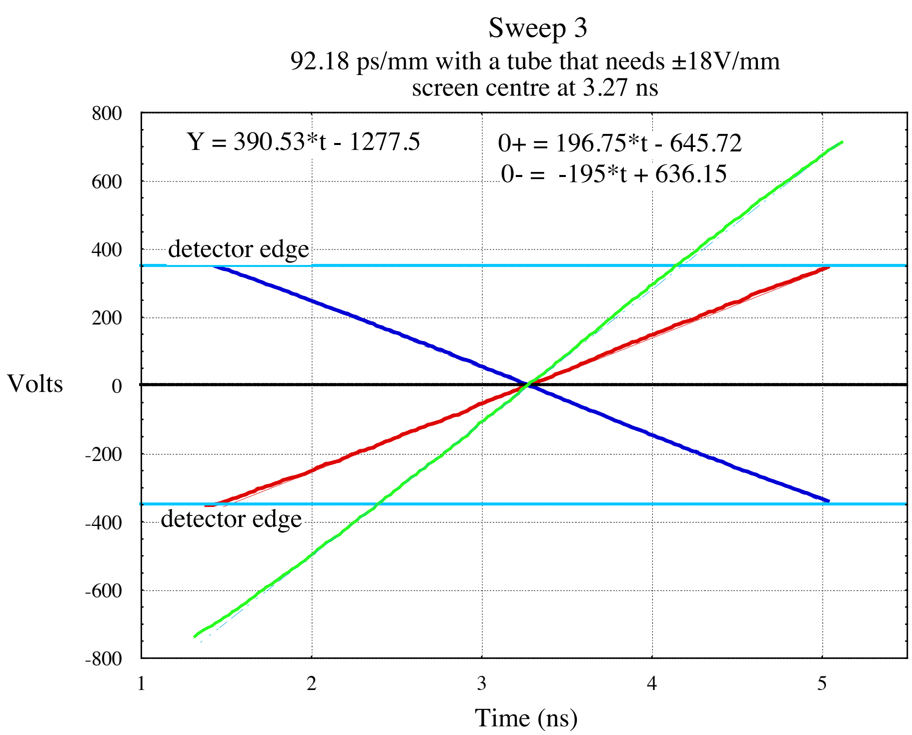



Figure 50 Sweep speed 3 central portion whilst traversing the screen giving 92.18 ps $mm^{-1}$

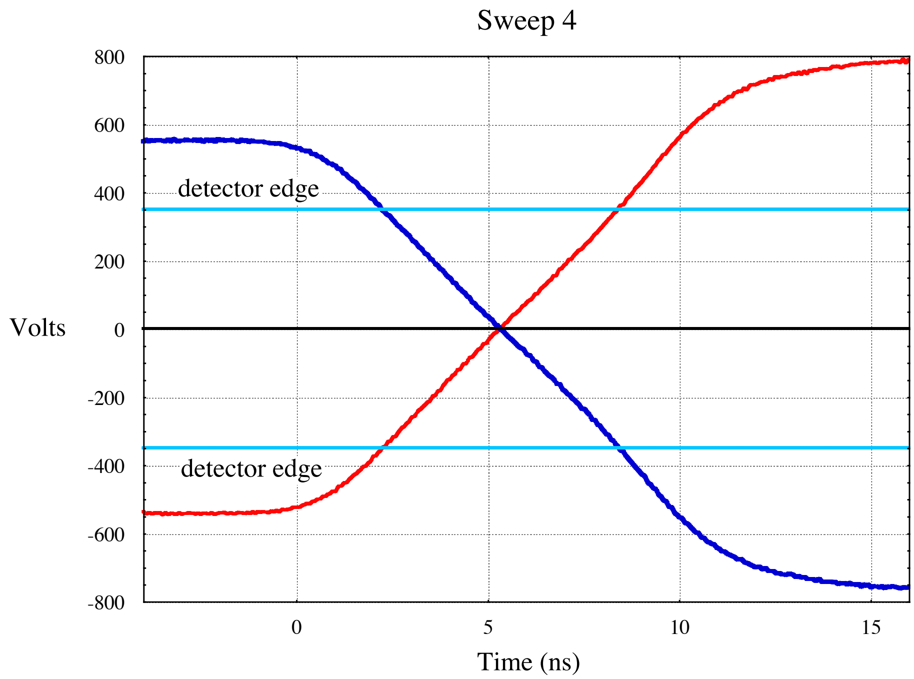



Figure 51 Sweep speed 4 overall shape.

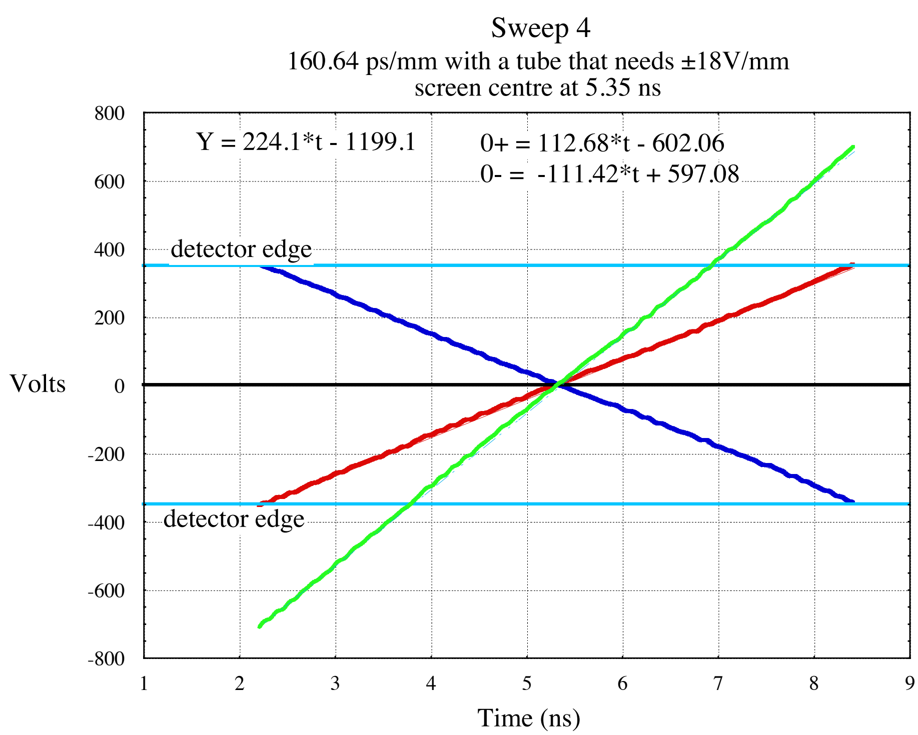



Figure 52 Sweep speed 4 central portion whilst traversing the screen giving 160.64 ps $mm^{-1}$

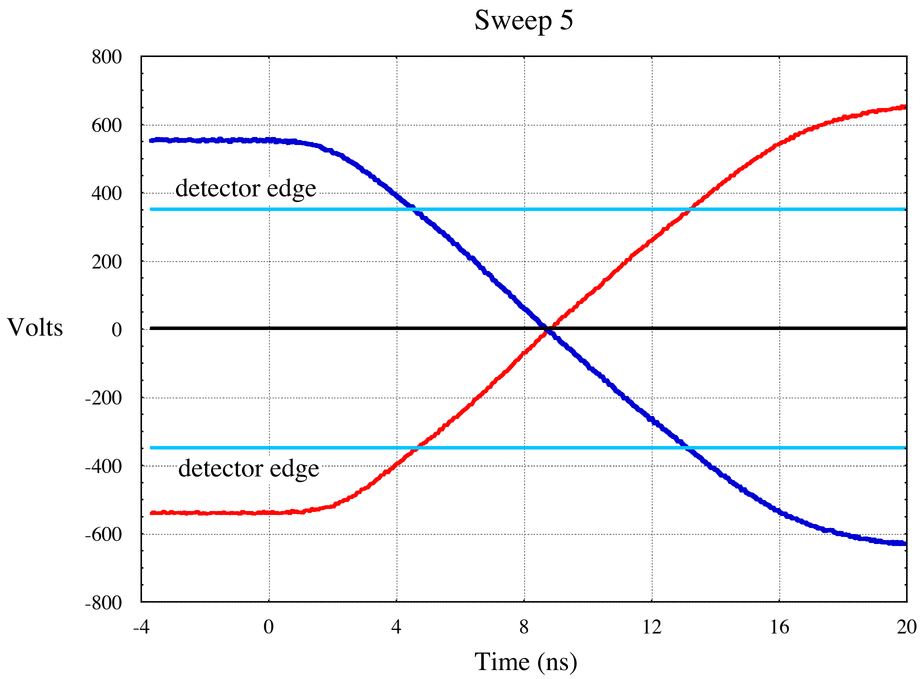



Figure 53 Sweep speed 5 overall shape.

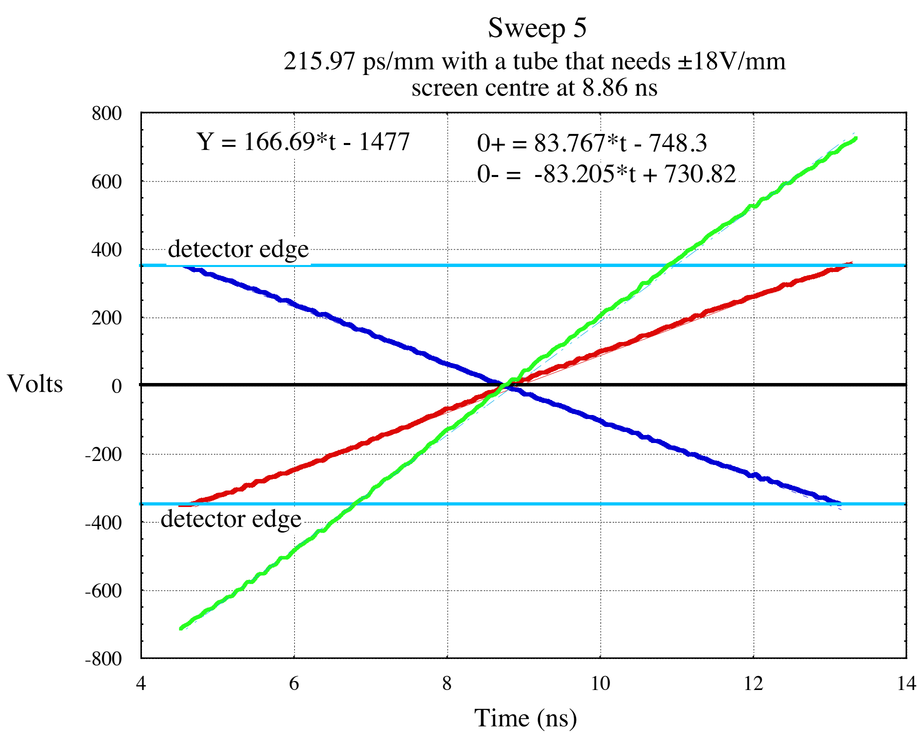



Figure 54 Sweep speed 5 central portion whilst traversing the screen giving 215.97 ps $mm^{-1}$

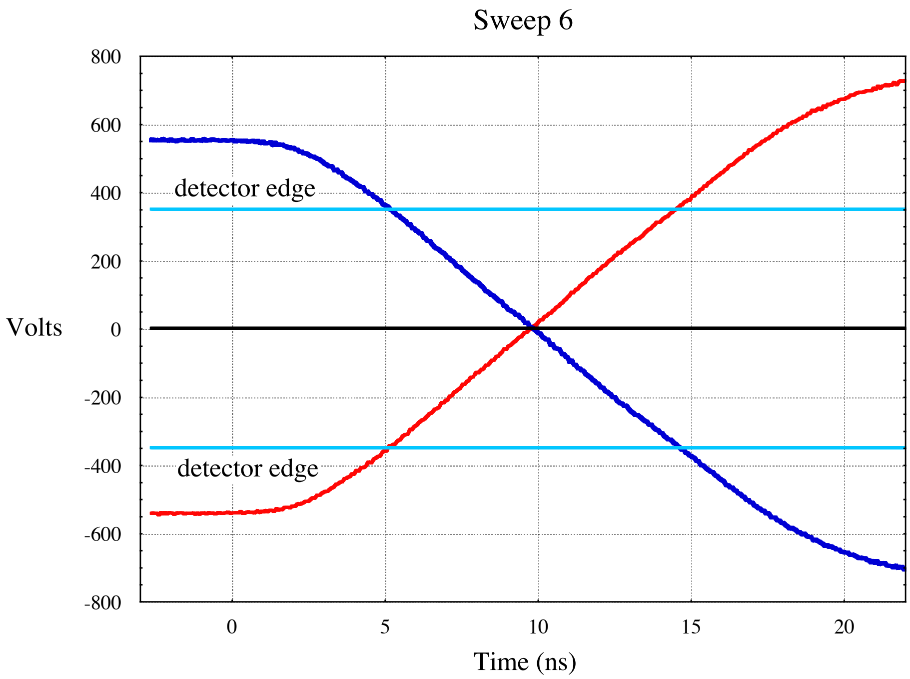



Figure 55 Sweep speed 6 overall shape.

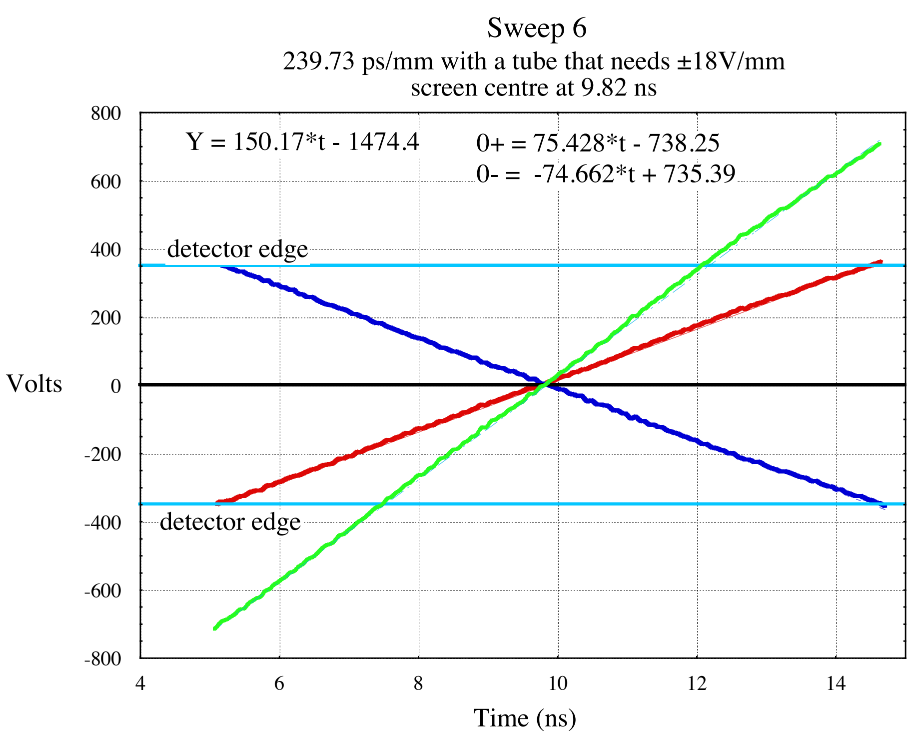



Figure 56 Sweep speed 6 central portion whilst traversing the screen giving 239.73 ps $mm^{-1}$

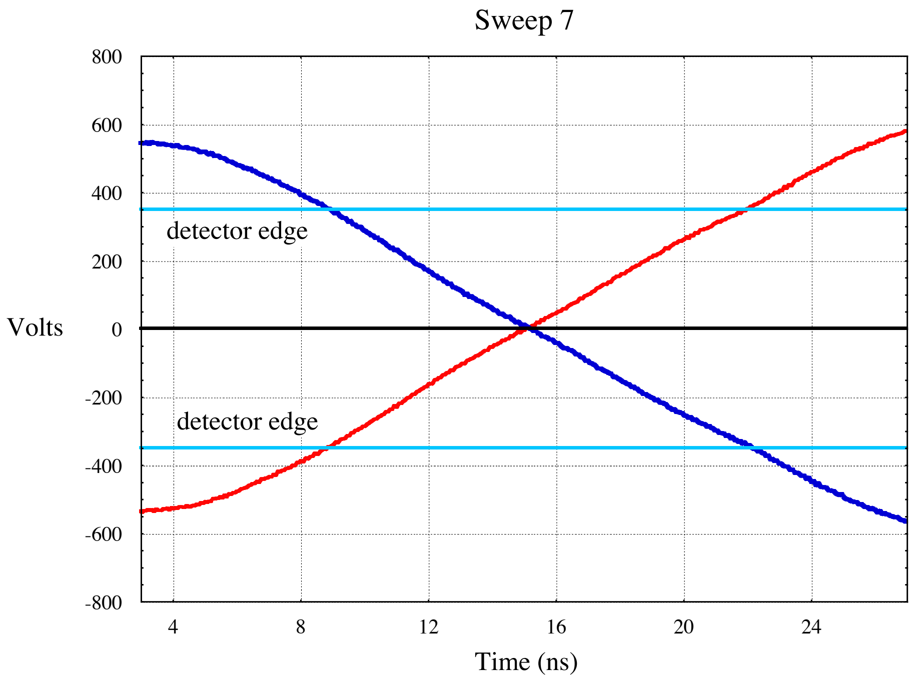



Figure 57 Sweep speed 7 overall shape.

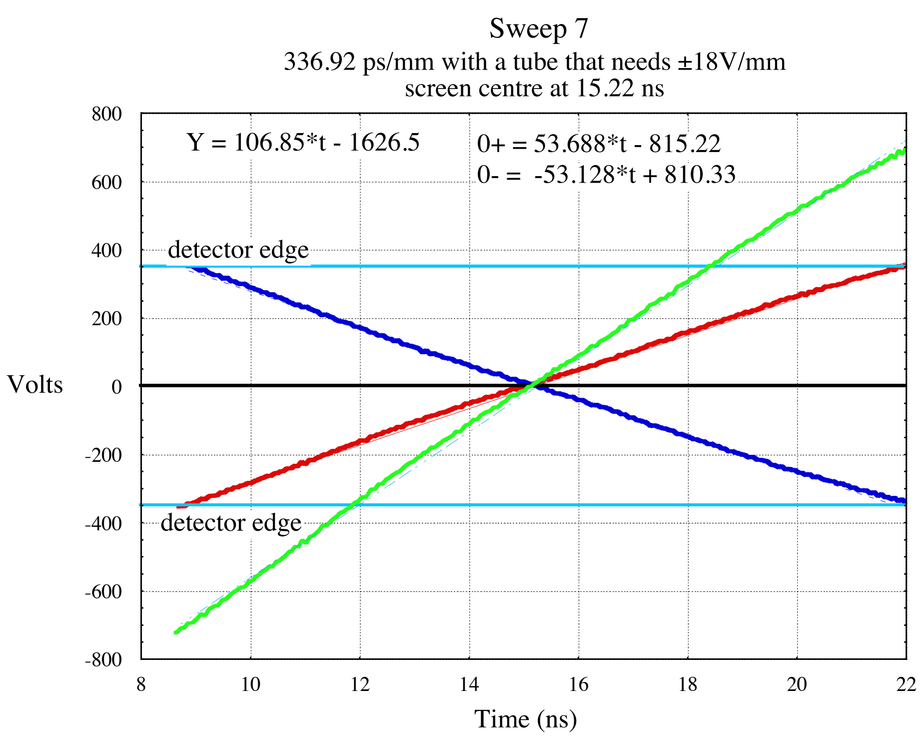



Figure 58 Sweep speed 7 central portion whilst traversing the screen giving 336.92 ps $mm^{-1}$

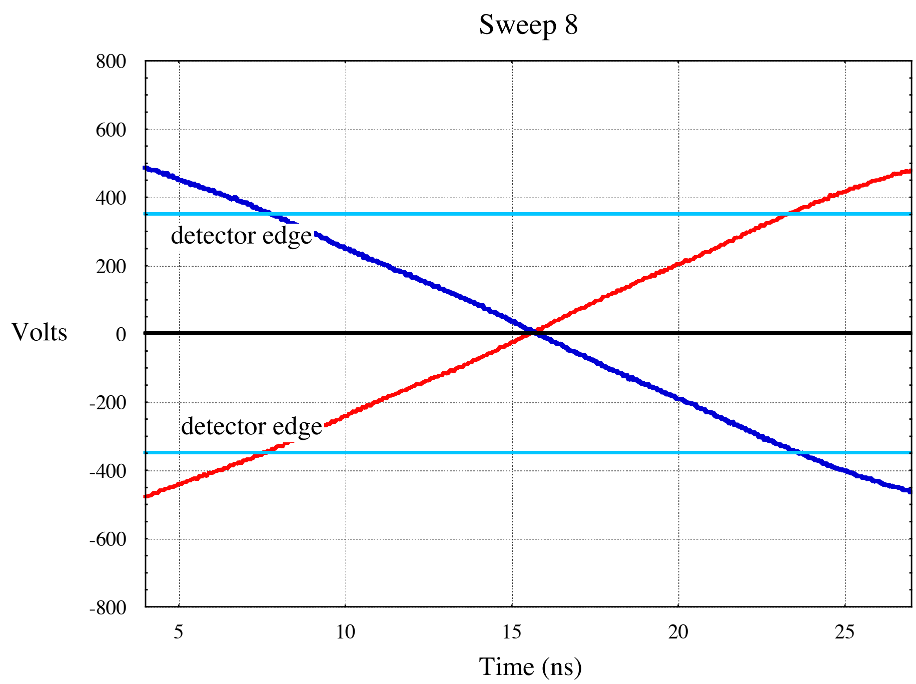



Figure 59 Sweep speed 8 overall shape.

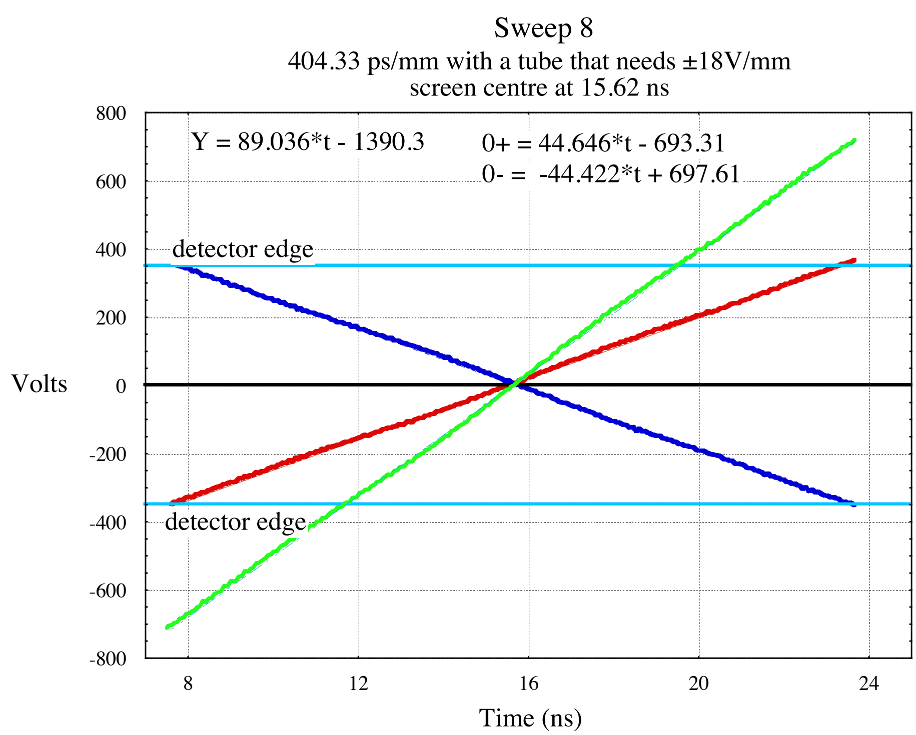



Figure 60 Sweep speed 8 central portion whilst traversing the screen giving 404.33 ps $mm^{-1}$

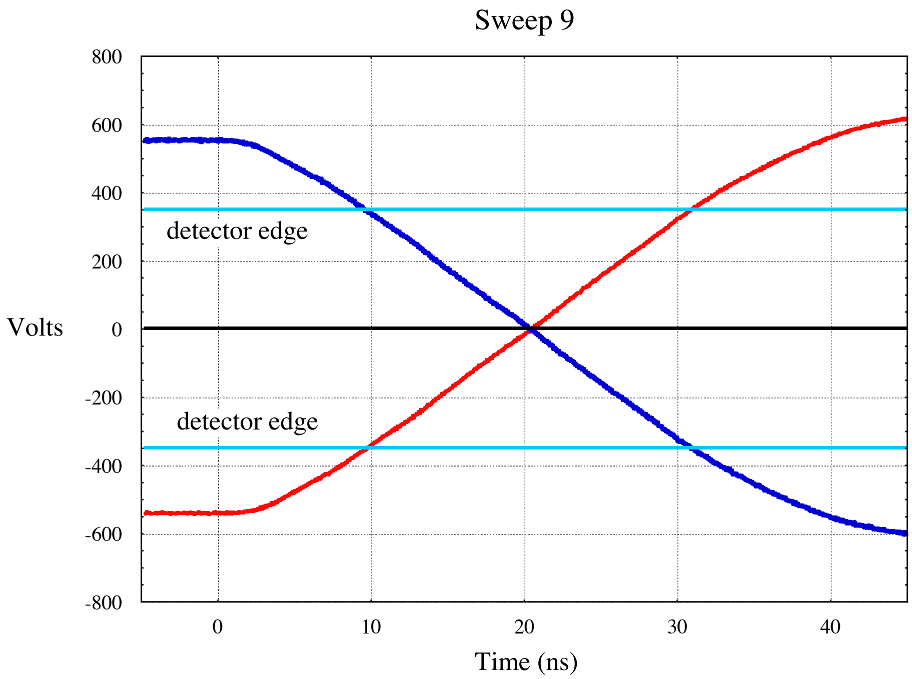



Figure 61 Sweep speed 9 overall shape.

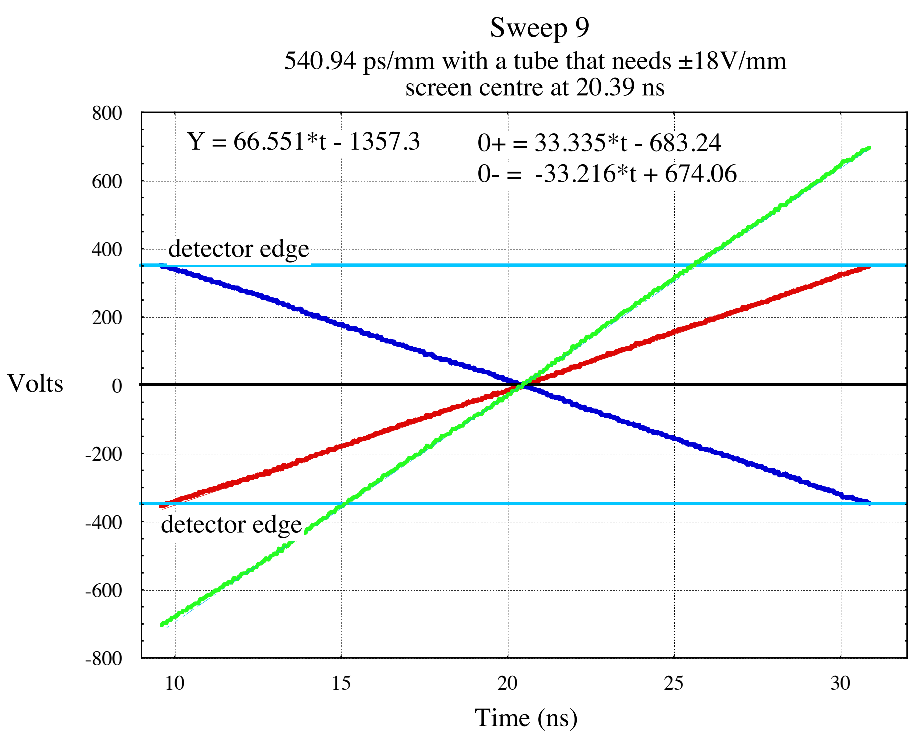



Figure 62 Sweep speed 9 central portion whilst traversing the screen giving 540.94 ps $mm^{-1}$

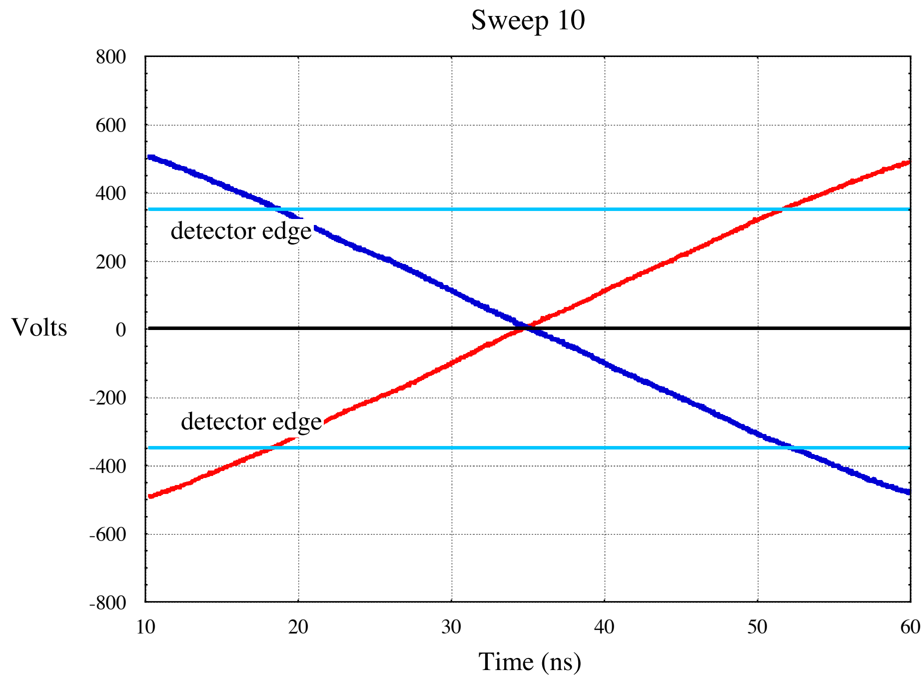



Figure 63    Sweep speed 10 overall shape.

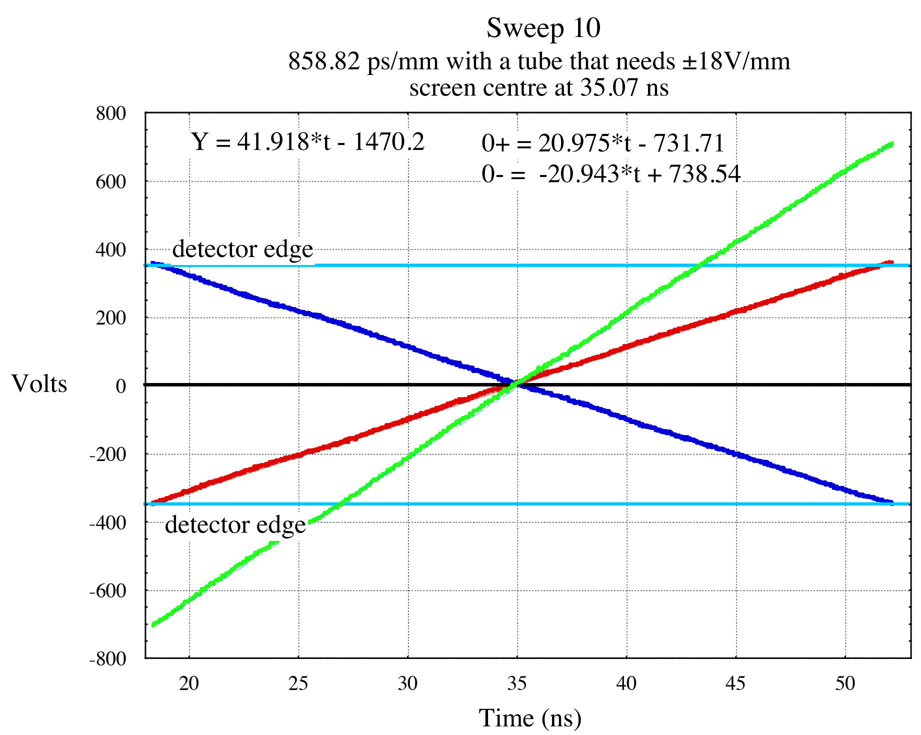



Figure 64    Sweep speed 10 central portion whilst traversing the screen giving 858.82 ps $mm^{-1}$

# 15. RE-ORDERING INFORMATION

The Spider electronics package is 0010-0042 Spider Electronics

This consists of the 19 inch rack mount assembly and the interface box.

The interface box alone is

0060-0032 Spider Interface Unit.

The 19 inch rack assembly consists of the following:

0060-0031 Spider General Assembly

0060-0026 Spider Control Module

0060-0027 Spider Display Module

0060-0028 Spider Focus Module

0060-0029 Spider Sweep Module

0060-0030 Spider Intensifier Module

In addition there is the Spider Tube which is identical to the DISC tube.

0030-0035 DISC streak tube

However, you need to specify also the LLNL photocathode pack option.

In fact the photocathode pack supplied with the Spider order was an old LLNL design as this is what LLNL gave us the drawings to.

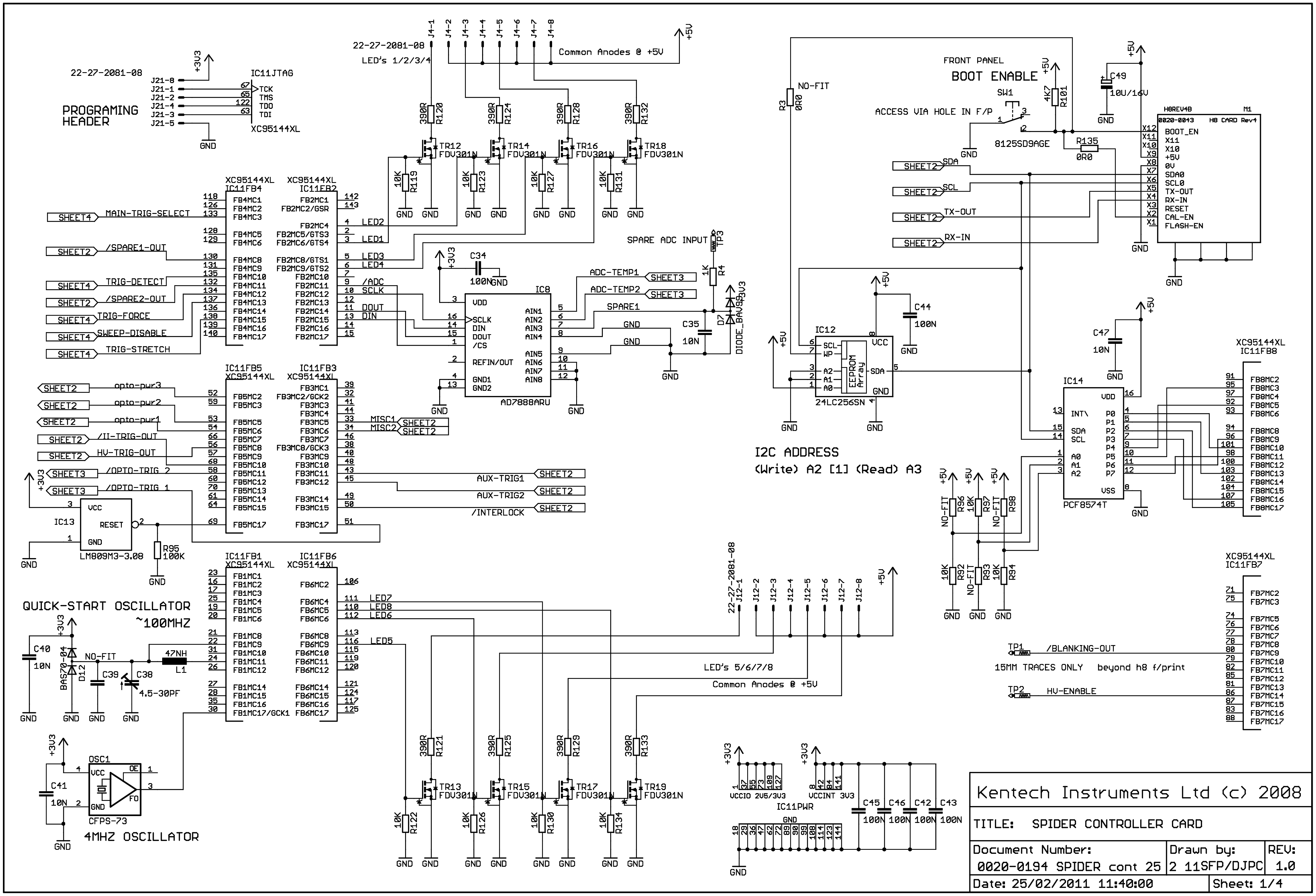
Ladona Willis (of LLNL) told me that there is a newer design so we were probably given the old one in error.

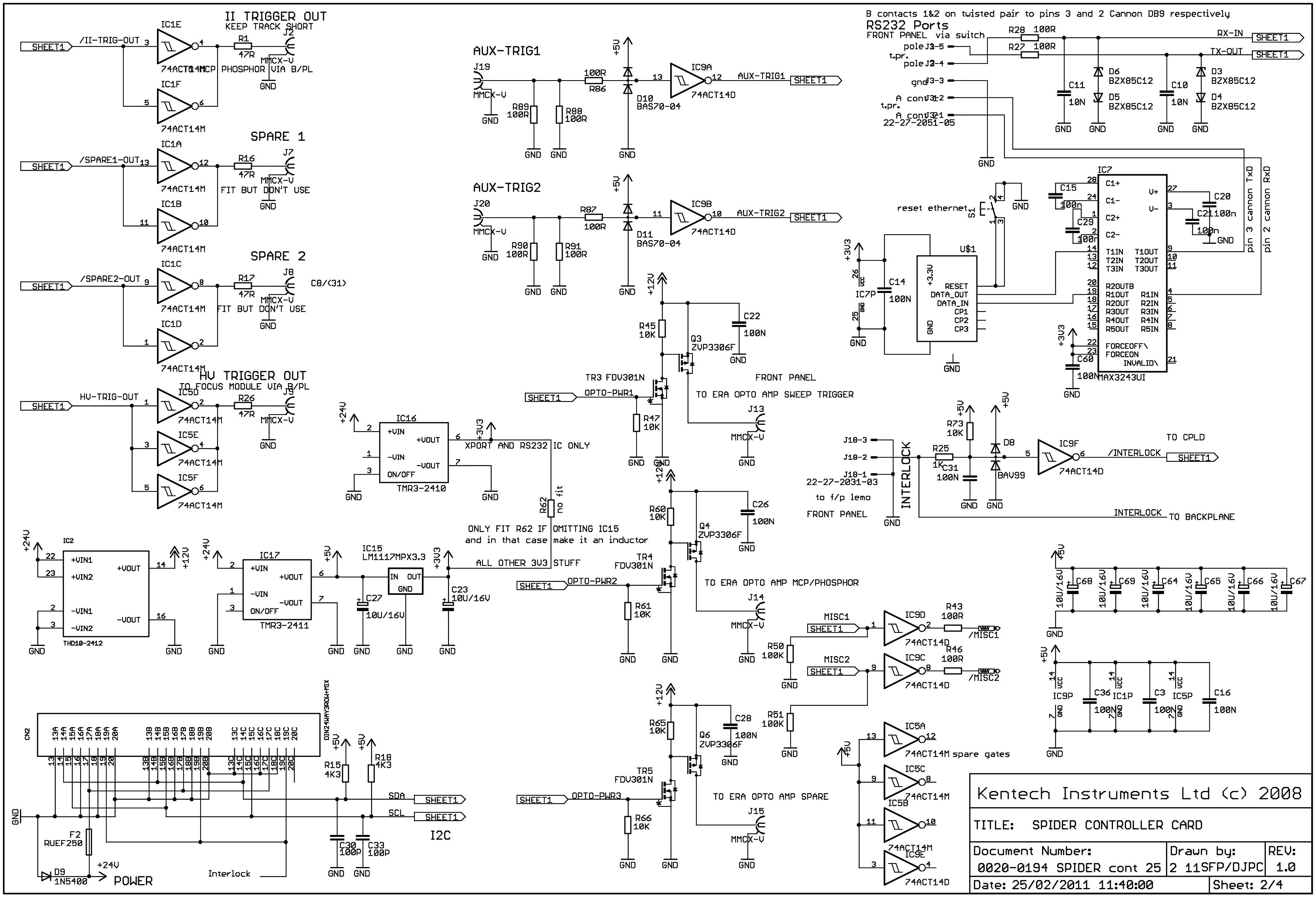
These are our internal assembly numbers.

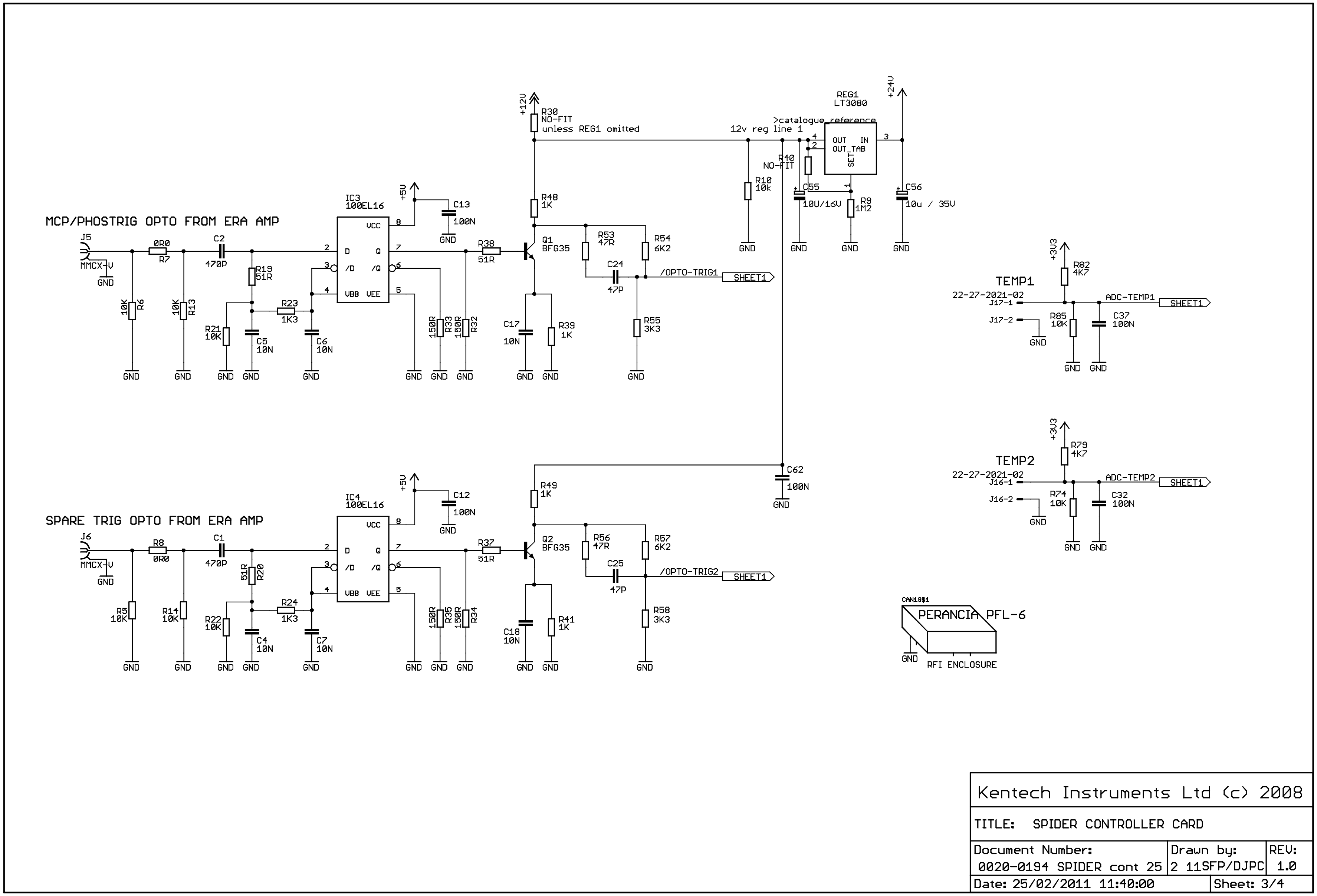
As yet Kentech has not assigned assembly numbers to any of the external cables but I think the LLNL definitions are OK for those.

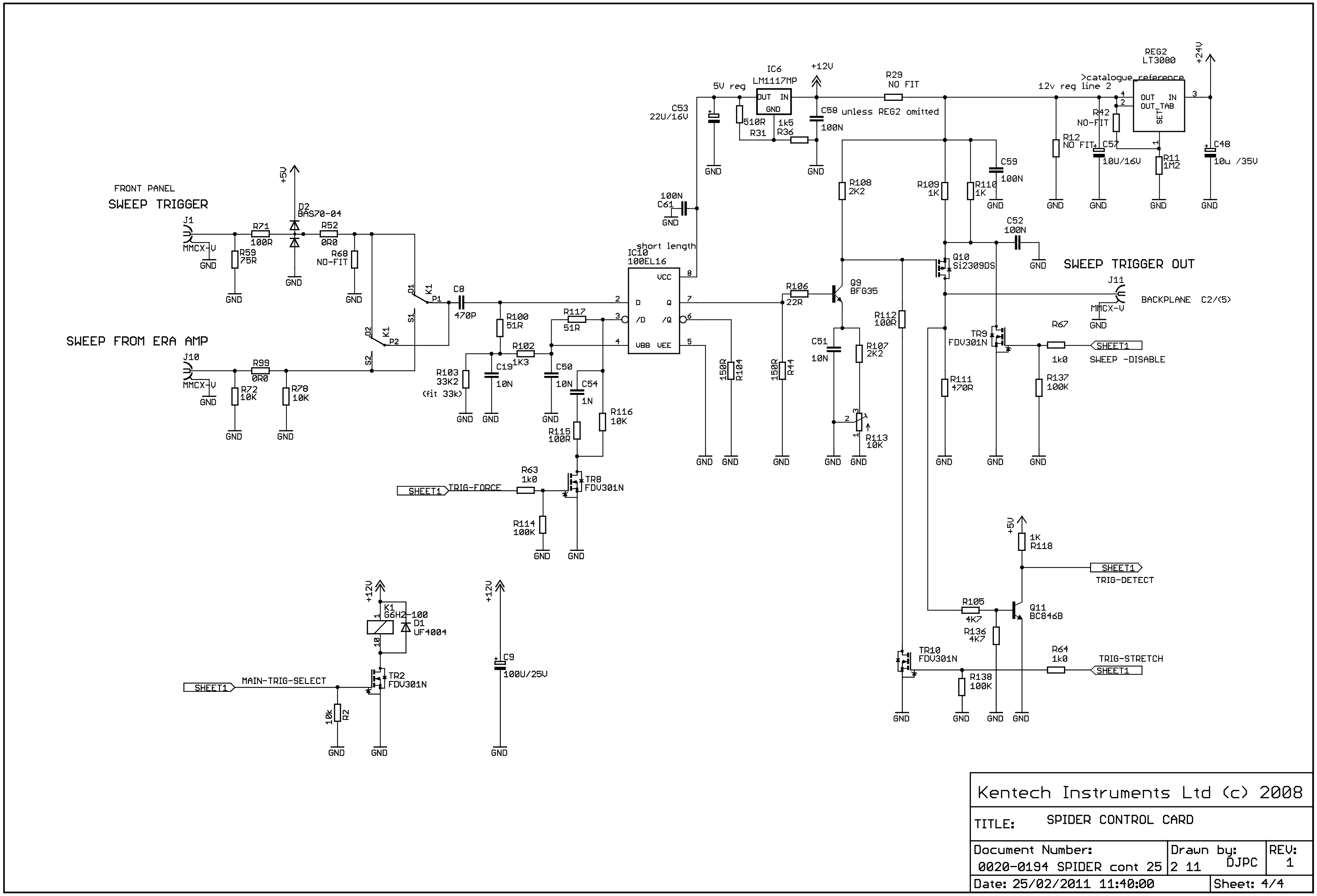
# 16. CIRCUIT DIAGRAMS

## 16.1 CONTROL UNIT


PROGRAMING HEADER
IC11JTAG
XC95144XL
QUICK-START OSCILLATOR ~100MHZ
4MHZ OSCILLATOR
LED's 1/2/3/4
Common Anodes @ +5V
LED's 5/6/7/8
SPARE ADC INPUT
AD7888ARU
FRONT PANEL
BOOT ENABLE
ACCESS VIA HOLE IN F/P
8125SD9AGE
H8 CARD Rev4
I2C ADDRESS
(Write) A2 [1] (Read) A3
24LC256SN
PCF8574T
LM809M3-3.08
CFPS-73
15MM TRACES ONLY beyond h8 f/print
Kentech Instruments Ltd (c) 2008
TITLE: SPIDER CONTROLLER CARD
Document Number: 0020-0194 SPIDER cont 25
Drawn by: 2 11SFP/DJPC
REV: 1.0
Date: 25/02/2011 11:40:00
Sheet: 1/4

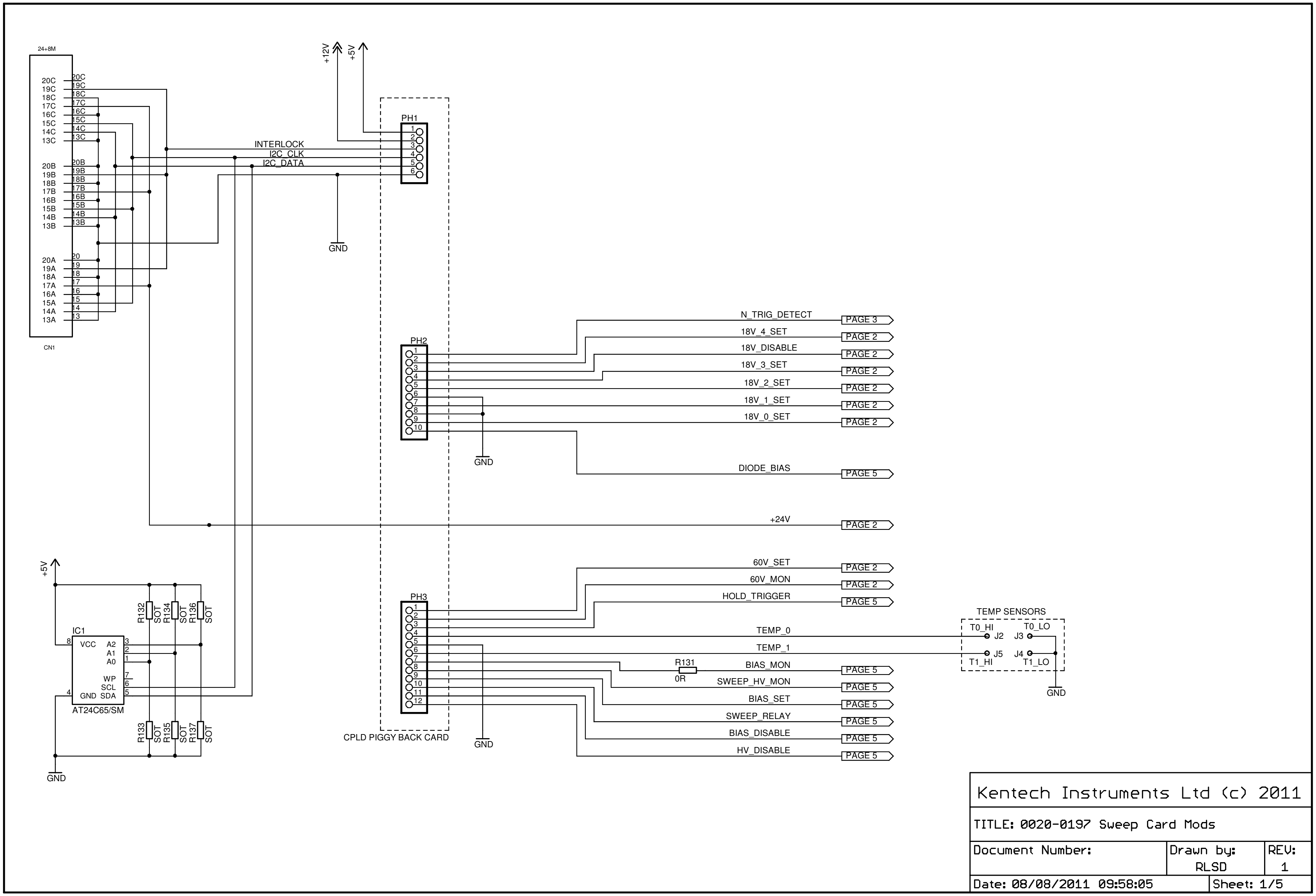

II TRIGGER OUT
KEEP TRACK SHORT
MCP PHOSPHOR VIA B/PL
SPARE 1
FIT BUT DON'T USE
SPARE 2
FIT BUT DON'T USE
HV TRIGGER OUT
TO FOCUS MODULE VIA B/PL
AUX-TRIG1
AUX-TRIG2
B contacts 1&2 on twisted pair to pins 3 and 2 Cannon DB9 respectively
RS232 Ports
FRONT PANEL via switch
RX-IN
TX-OUT
reset ethernet
pin 3 cannon TxD
pin 2 cannon RxD
FRONT PANEL
TO ERA OPTO AMP SWEEP TRIGGER
XPORT AND RS232 IC ONLY
ONLY FIT R62 IF OMITTING IC15
and in that case make it an inductor
ALL OTHER 3V3 STUFF
TO ERA OPTO AMP MCP/PHOSPHOR
TO ERA OPTO AMP SPARE
INTERLOCK
TO CPLD
/INTERLOCK
TO BACKPLANE
to f/p lemo
FRONT PANEL
spare gates
I2C
SDA
SCL
POWER
Interlock
Kentech Instruments Ltd (c) 2008
TITLE: SPIDER CONTROLLER CARD
Document Number: 0020-0194 SPIDER cont 25
Drawn by: 2 11SFP/DJPC
REV: 1.0
Date: 25/02/2011 11:40:00
Sheet: 2/4

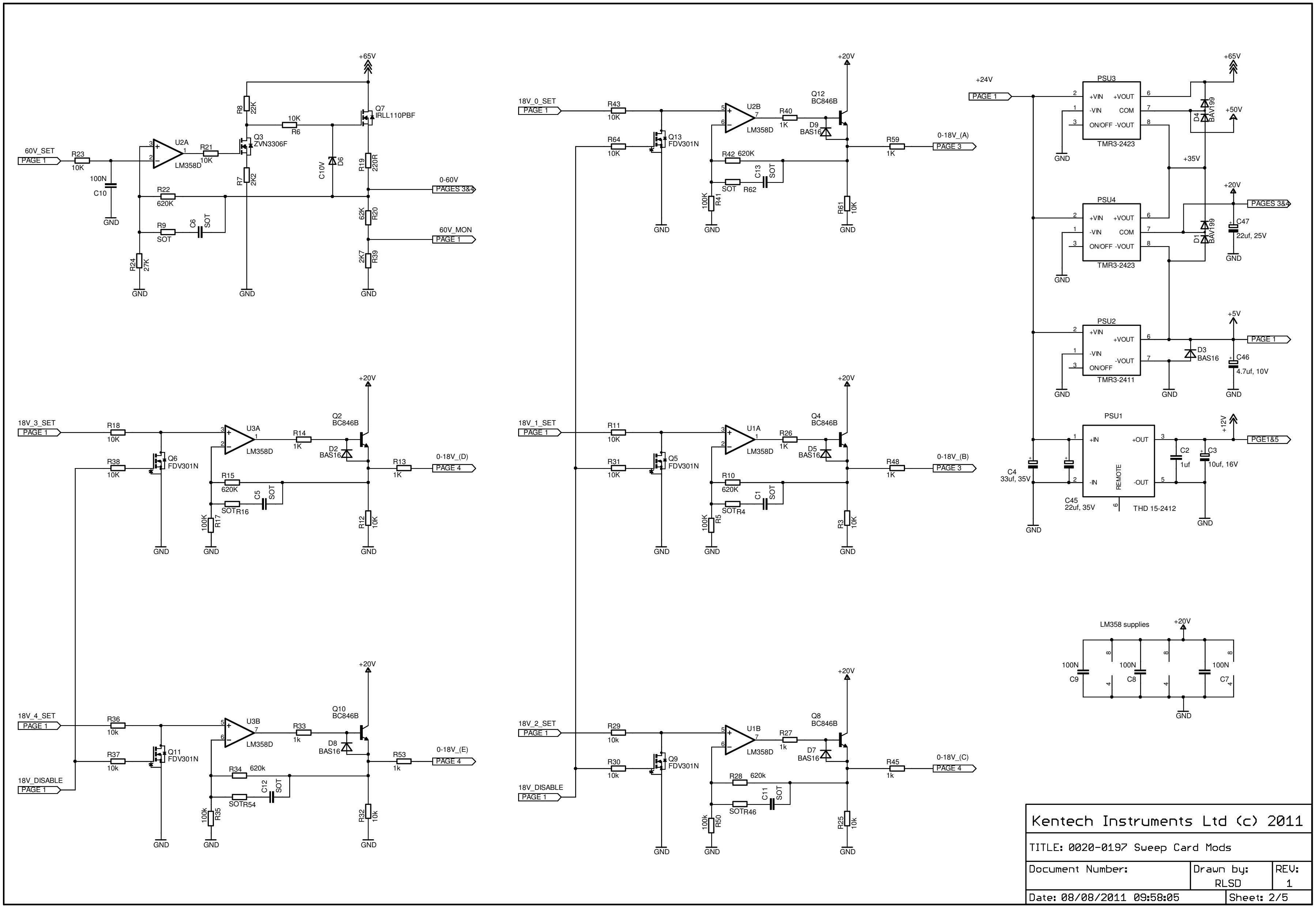

MCP/PHOSTRIG OPTO FROM ERA AMP
SPARE TRIG OPTO FROM ERA AMP
IC3 100EL16
IC4 100EL16
Q1 BFG35
Q2 BFG35
REG1 LT3080
>catalogue_reference
R30 NO-FIT unless REG1 omitted
12v reg line 1
R40 NO-FIT
/OPTO-TRIG1
/OPTO-TRIG2
SHEET1
TEMP1
TEMP2
22-27-2021-02
ADC-TEMP1
ADC-TEMP2
PERANCIA PFL-6
RFI ENCLOSURE
+12V
+24V
+5V
+3V3
GND
Kentech Instruments Ltd (c) 2008
TITLE: SPIDER CONTROLLER CARD
Document Number:
0020-0194 SPIDER cont 25
Drawn by:
2 11SFP/DJPC
REV:
1.0
Date: 25/02/2011 11:40:00
Sheet: 3/4



FRONT PANEL
SWEEP TRIGGER
SWEEP FROM ERA AMP
SWEEP TRIGGER OUT
BACKPLANE C2/(5)
SWEEP -DISABLE
TRIG-FORCE
TRIG-DETECT
TRIG-STRETCH
MAIN-TRIG-SELECT
5V reg
12v reg line 2
unless REG2 omitted
>catalogue reference
short length
IC6 LM1117MP
REG2 LT3080
IC10 100EL16
Q9 BFG35
Q10 SI2309DS
Q11 BC846B
D2 BAS70-04
D1 UF4004
K1 G6H2-100
TR2 FDV301N
TR8 FDV301N
TR9 FDV301N
TR10 FDV301N
Kentech Instruments Ltd (c) 2008
TITLE: SPIDER CONTROL CARD
Document Number: 0020-0194 SPIDER cont 25 2 11
Drawn by: DJPC
REV: 1
Date: 25/02/2011 11:40:00
Sheet: 4/4

## 16.2 SWEEP CARD


24+8M
CN1
+12V
+5V
PH1
INTERLOCK
I2C_CLK
I2C_DATA
GND
PH2
N_TRIG_DETECT
18V_4_SET
18V_DISABLE
18V_3_SET
18V_2_SET
18V_1_SET
18V_0_SET
DIODE_BIAS
+24V
PAGE 3
PAGE 2
PAGE 5
PH3
60V_SET
60V_MON
HOLD_TRIGGER
TEMP_0
TEMP_1
BIAS_MON
SWEEP_HV_MON
BIAS_SET
SWEEP_RELAY
BIAS_DISABLE
HV_DISABLE
R131
0R
TEMP SENSORS
T0_HI
T0_LO
T1_HI
T1_LO
J2
J3
J4
J5
CPLD PIGGY BACK CARD
IC1
VCC
A2
A1
A0
WP
SCL
GND
SDA
AT24C65/SM
R132
R133
R134
R135
R136
R137
SOT
Kentech Instruments Ltd (c) 2011
TITLE: 0020-0197 Sweep Card Mods
Document Number:
Drawn by: RLSD
REV: 1
Date: 08/08/2011 09:58:05
Sheet: 1/5

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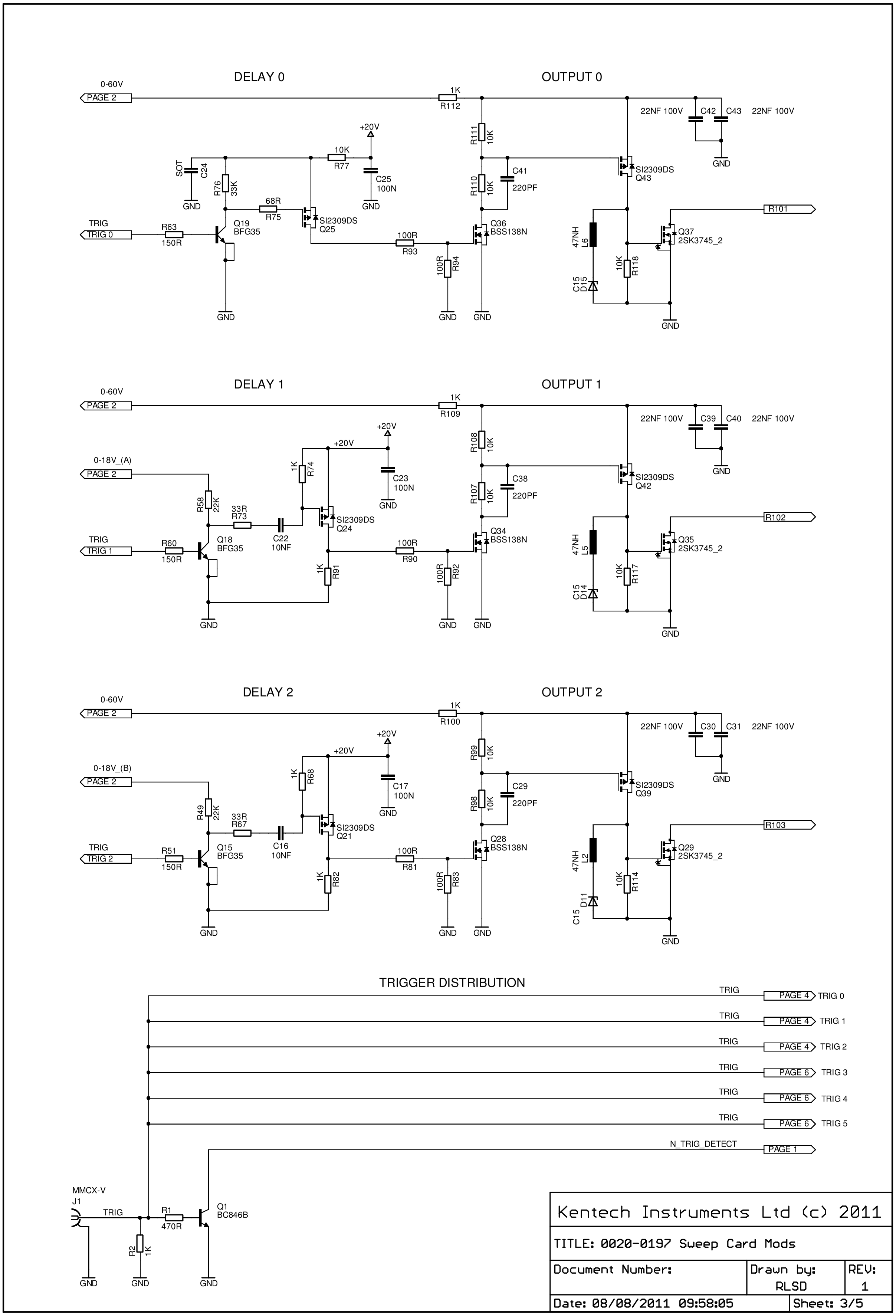


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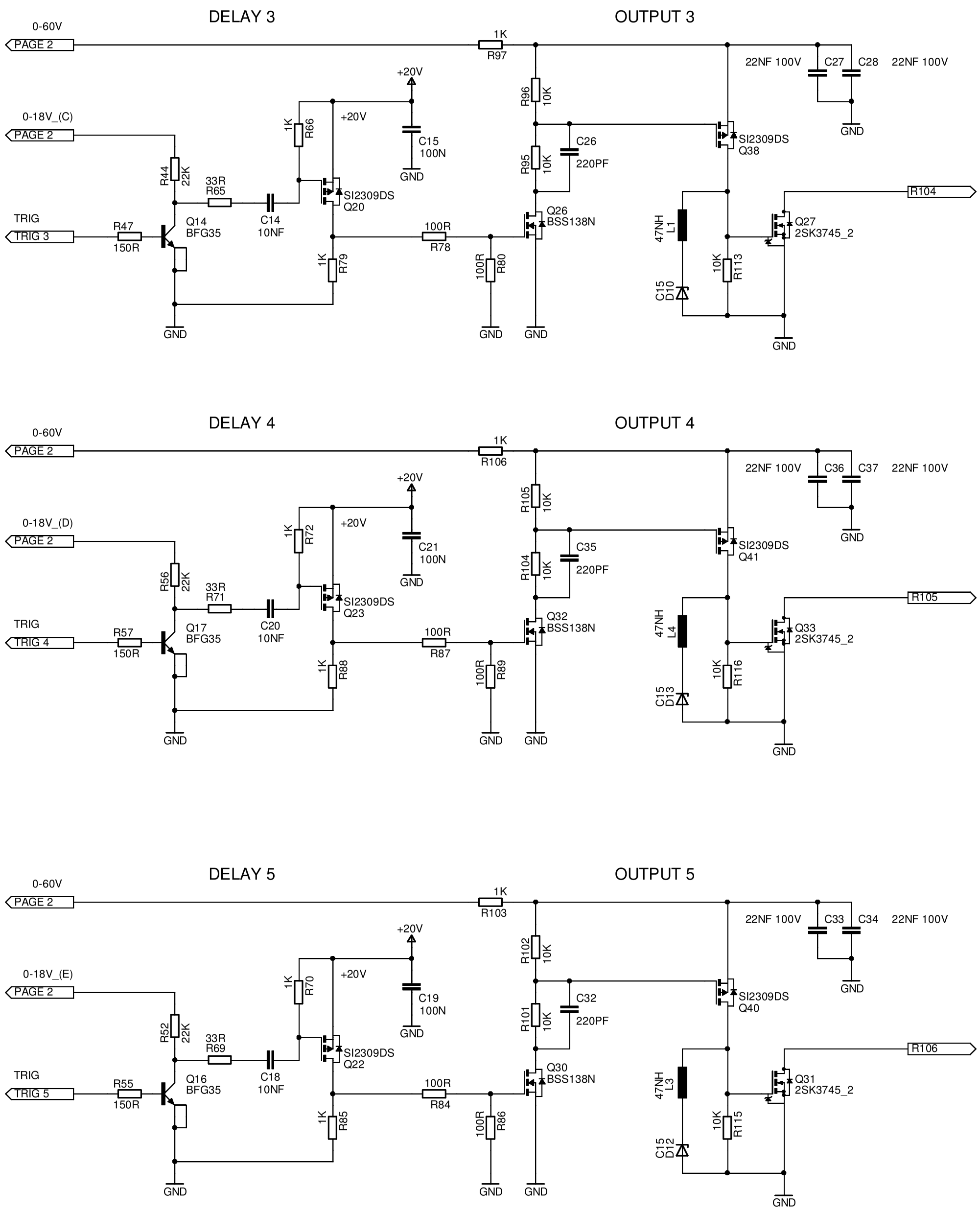
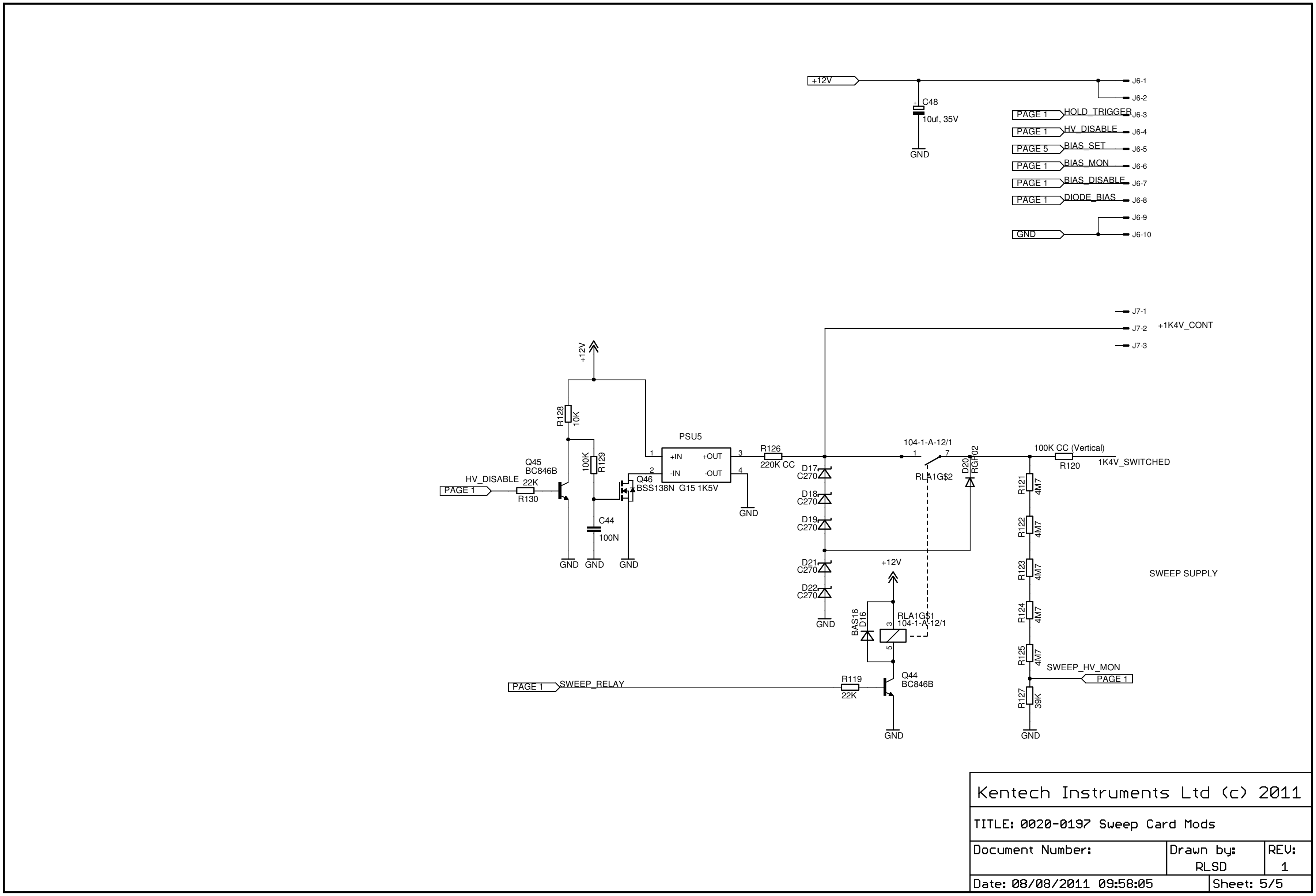



| Kentech Instruments Ltd (c) 2011 | | |
|---|---|---|
| TITLE: 0020-0197 Sweep Card Mods | | |
| Document Number: | Drawn by: RLSD | REV: 1 |
| Date: 08/08/2011 09:58:05 | | Sheet: 4/5 |

08/08/2011 12:13:10 f=0.72 C:\Filing_Cabinet\Eagle Projects\Spider\0020-0197 Sweep Card Mods.sch (Sheet: 4/5)

Kentech Instruments Ltd., Isis Building, Howbery Park, Wallingford, Oxfordshire, OX10 8BA, U.K.
5-3-2012



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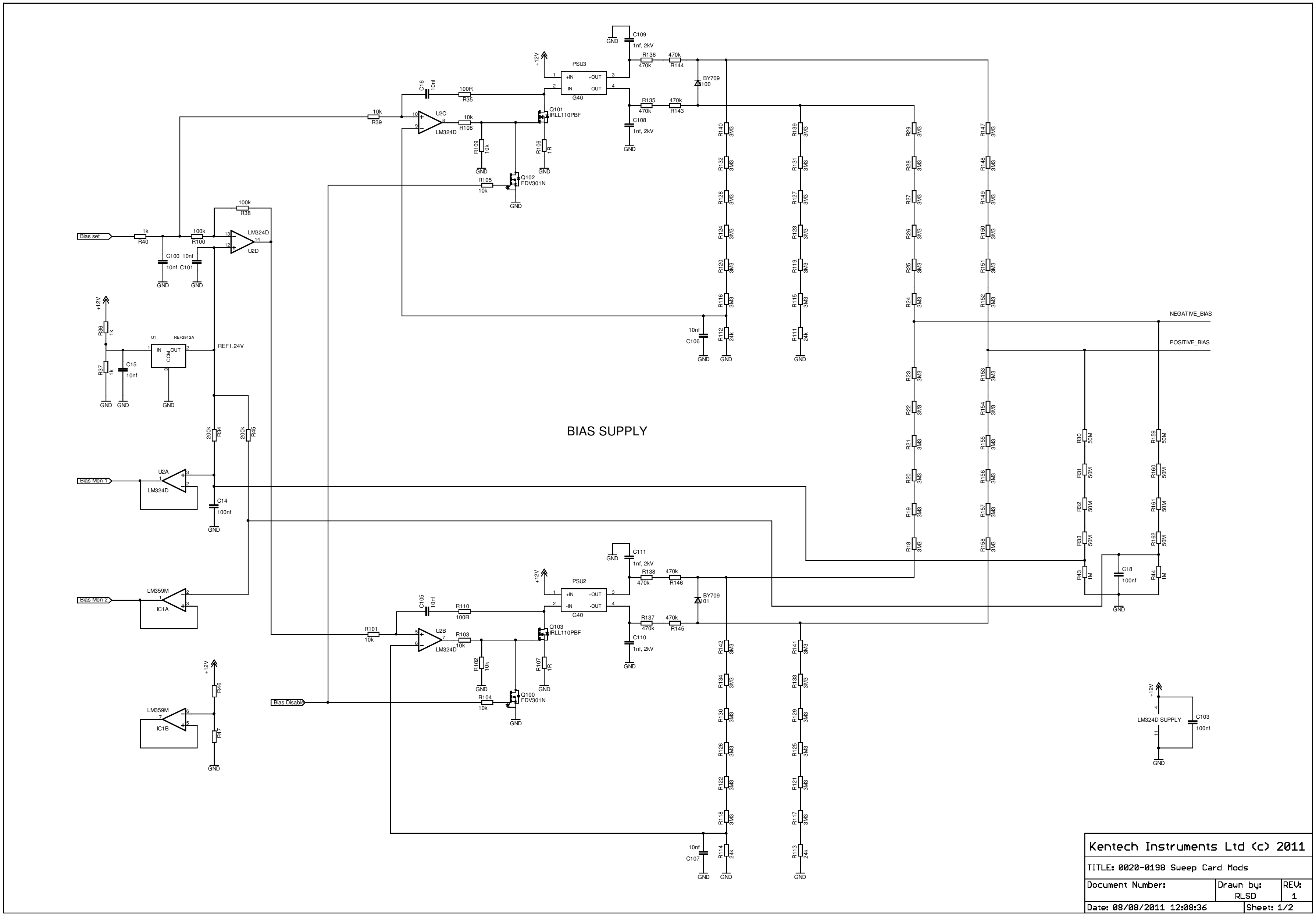


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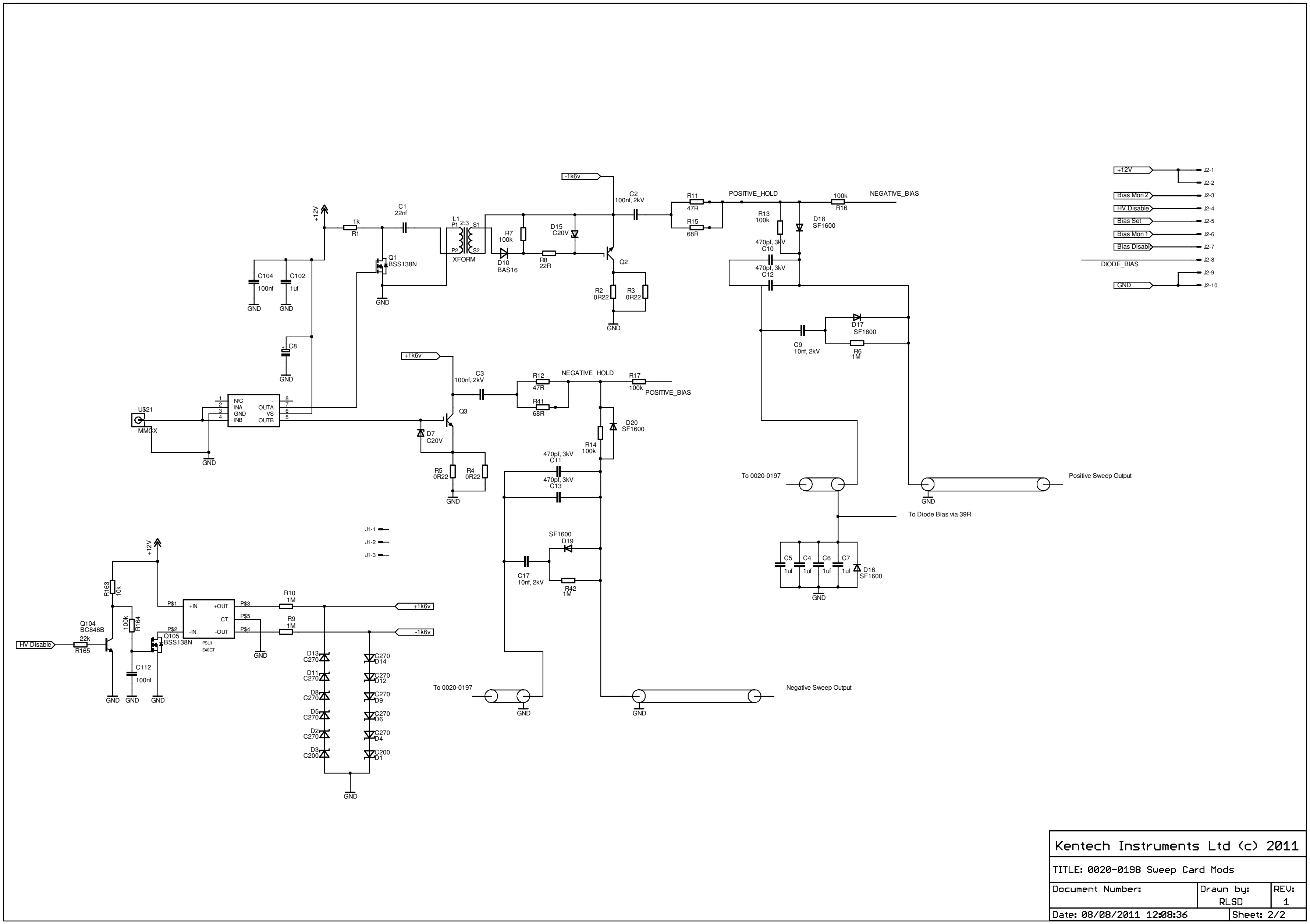
Kentech Instruments Ltd., Isis Building, Howbery Park, Wallingford, Oxfordshire, OX10 8BA, U.K.



5-3-2012

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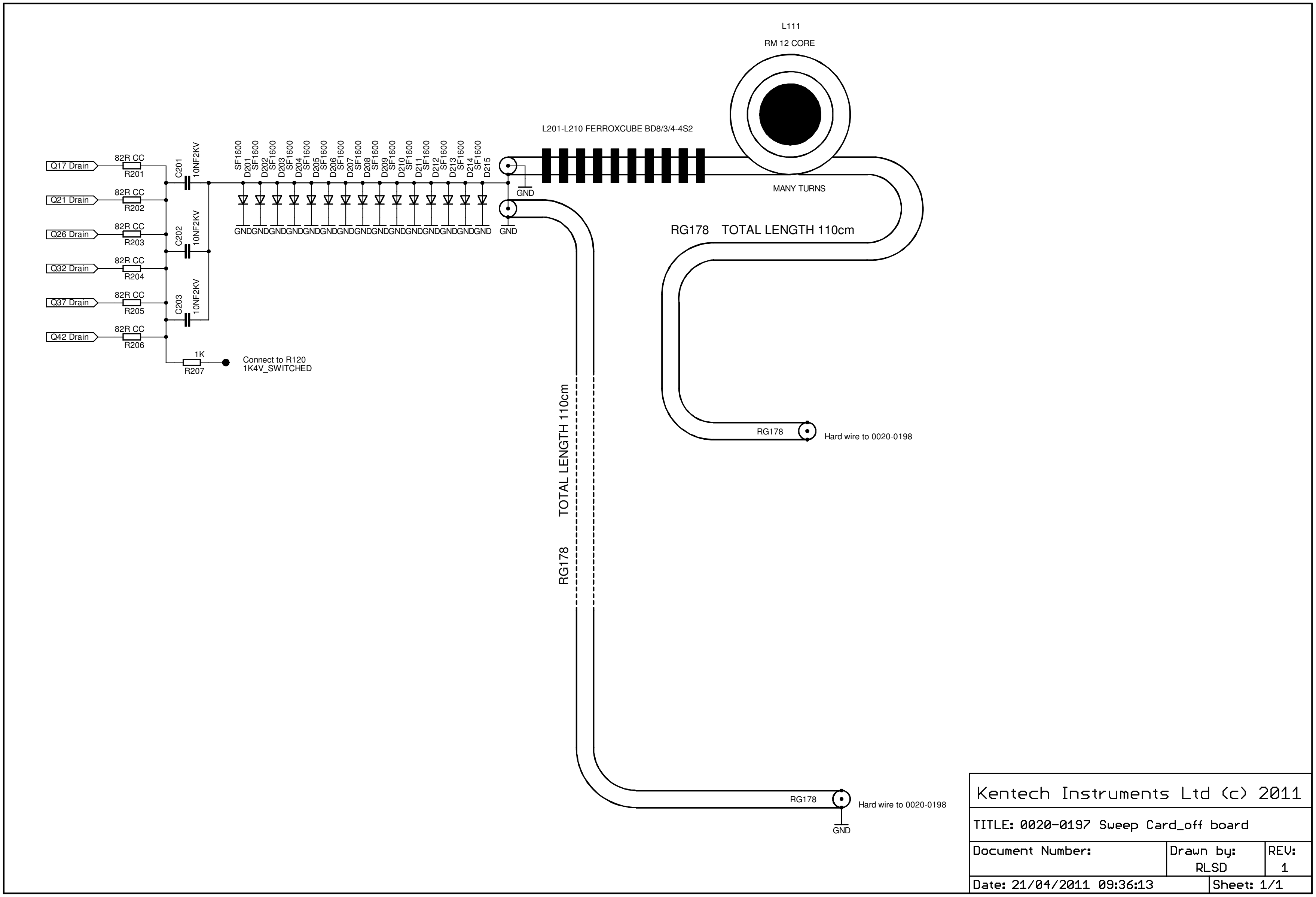
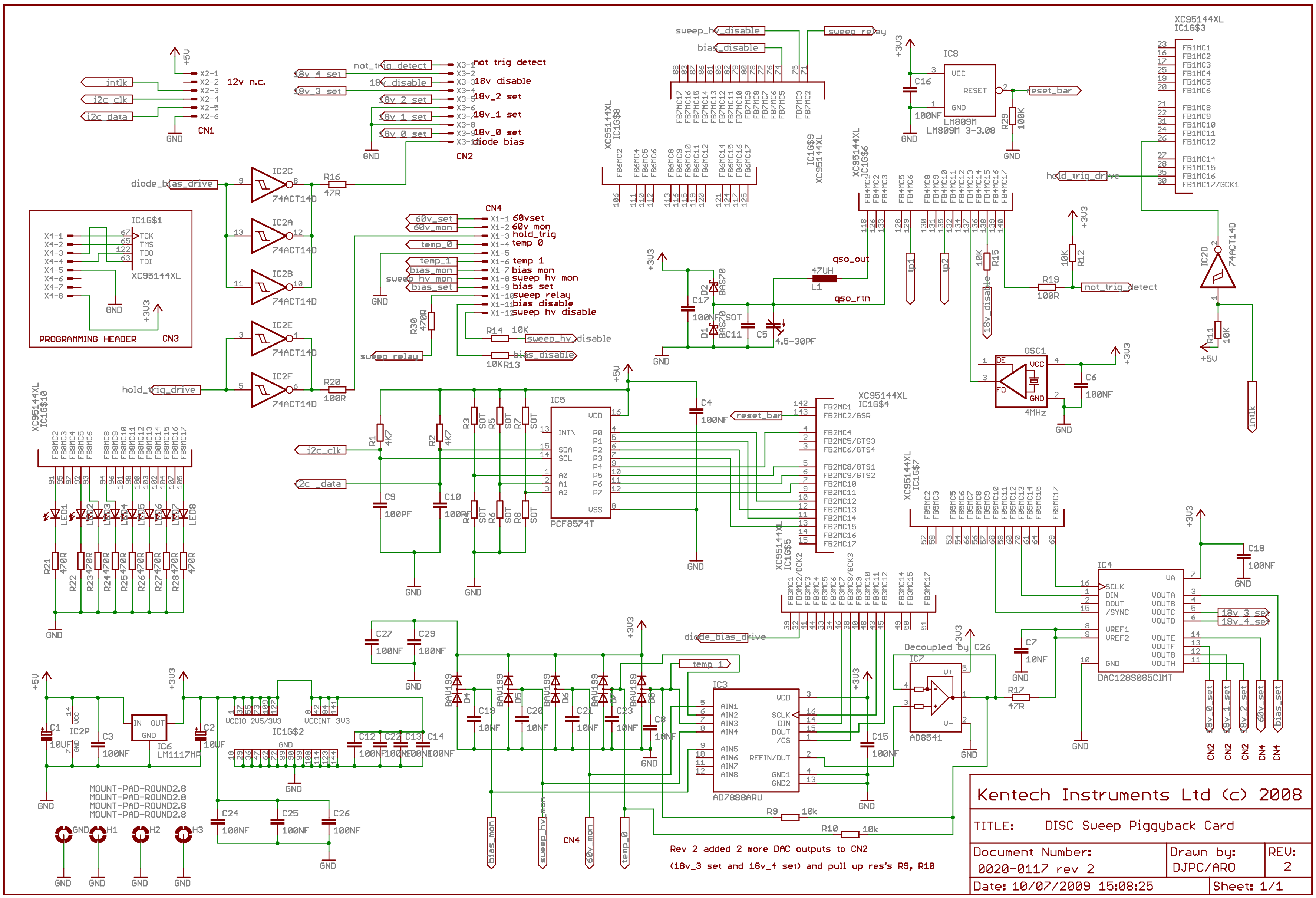

L111
RM 12 CORE
L201-L210 FERROXCUBE BD8/3/4-4S2
MANY TURNS
RG178 TOTAL LENGTH 110cm
Q17 Drain
Q21 Drain
Q26 Drain
Q32 Drain
Q37 Drain
Q42 Drain
82R CC
R201
R202
R203
R204
R205
R206
C201
C202
C203
10NF2KV
1K
R207
Connect to R120
1K4V_SWITCHED
SF1600
D201
D202
D203
D204
D205
D206
D207
D208
D209
D210
D211
D212
D213
D214
D215
GND
TOTAL LENGTH 110cm
RG178
Hard wire to 0020-0198
Kentech Instruments Ltd (c) 2011
TITLE: 0020-0197 Sweep Card_off board
Document Number:
Drawn by: RLSD
REV: 1
Date: 21/04/2011 09:36:13
Sheet: 1/1

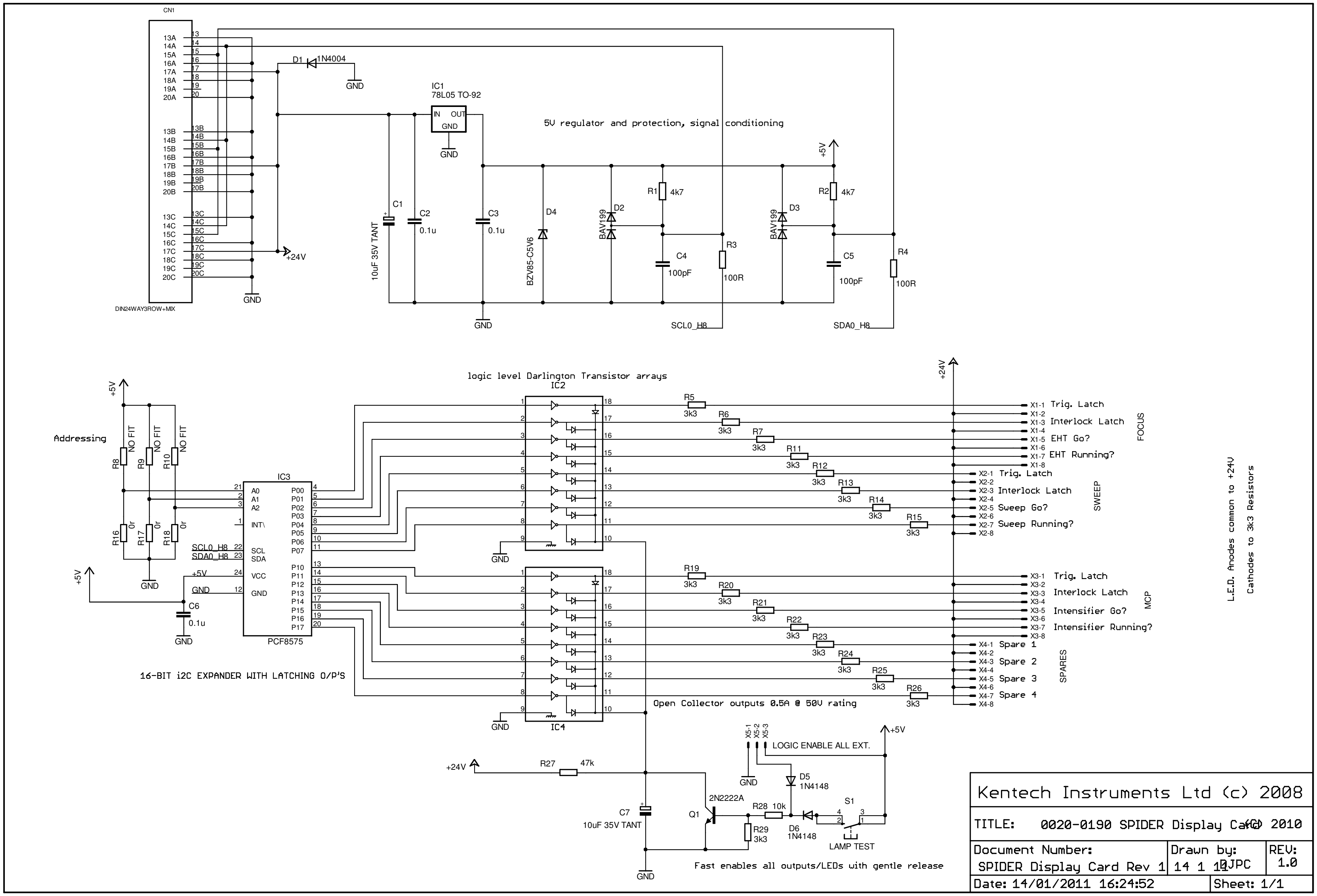
## 16.3 SWEEP PIGGY BACK CARD

Kentech Instruments Ltd., Isis Building, Howbery Park, Wallingford, Oxfordshire, OX10 8BA, U.K.

5-3-2012



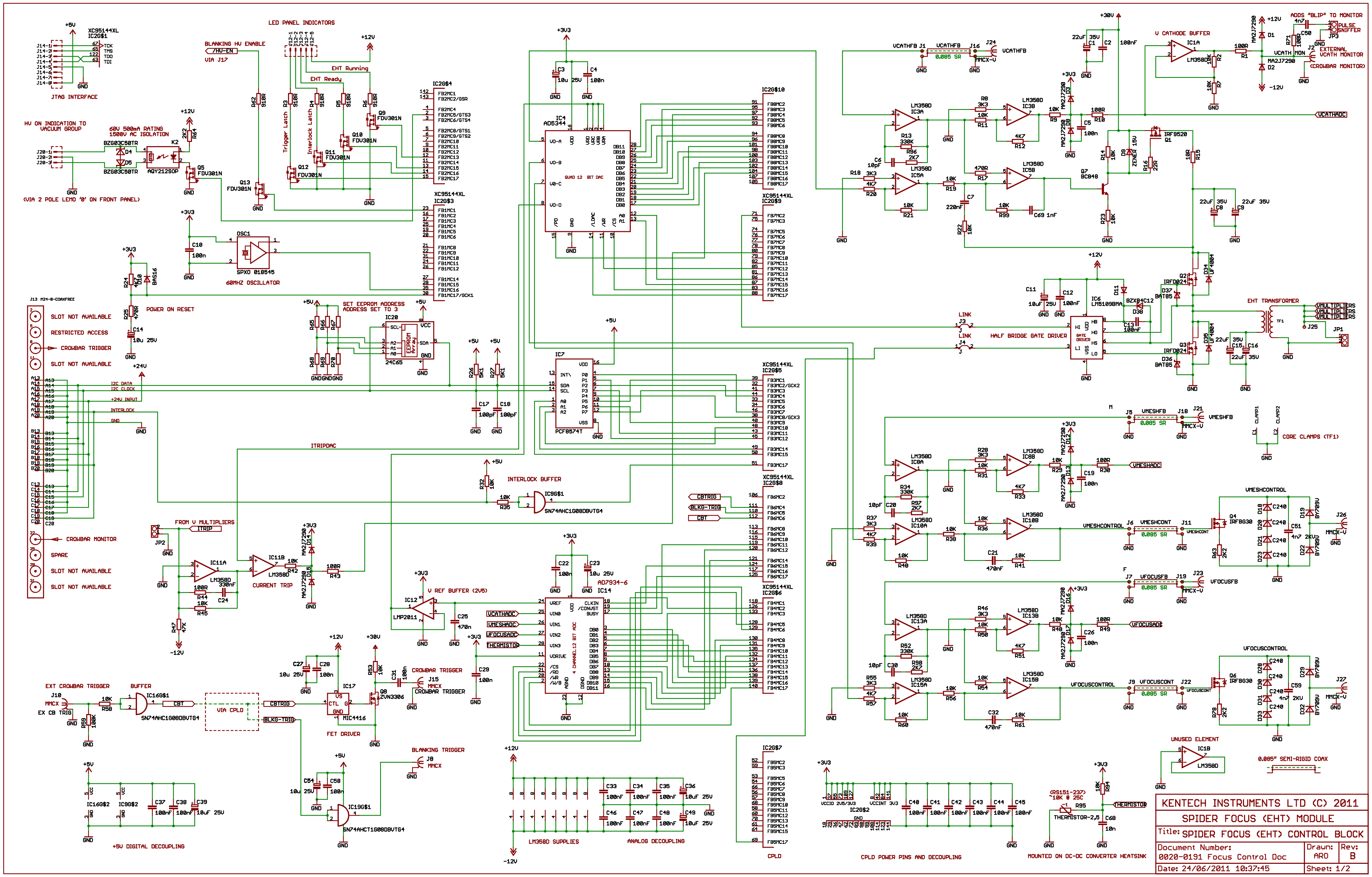
## 16.4 DISPLAY CARD

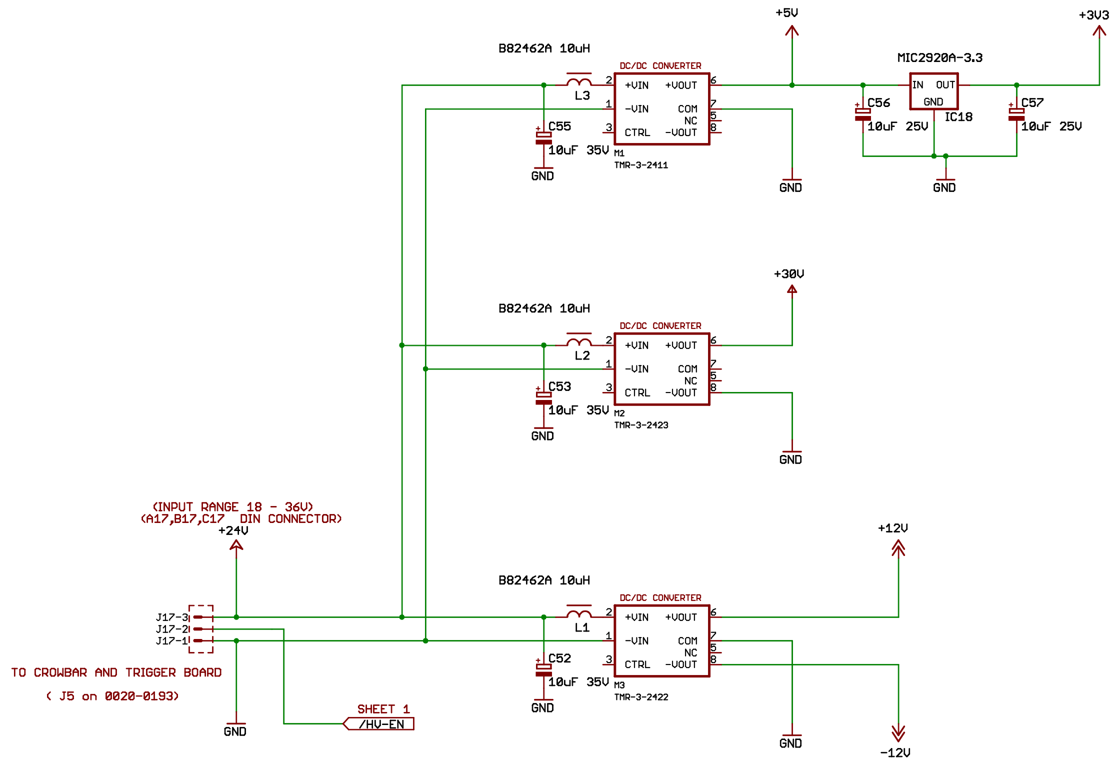

5V regulator and protection, signal conditioning
logic level Darlington Transistor arrays
Addressing
16-BIT i2C EXPANDER WITH LATCHING O/P'S
Open Collector outputs 0.5A @ 50V rating
Fast enables all outputs/LEDs with gentle release
LOGIC ENABLE ALL EXT.
LAMP TEST
L.E.D. Anodes common to +24V
Cathodes to 3k3 Resistors
Trig. Latch
Interlock Latch
EHT Go?
EHT Running?
Sweep Go?
Sweep Running?
Intensifier Go?
Intensifier Running?
Spare 1
Spare 2
Spare 3
Spare 4
FOCUS
SWEEP
MCP
SPARES
IC1 78L05 TO-92
IC3 PCF8575
SCL0_H8
SDA0_H8
Kentech Instruments Ltd (c) 2008
TITLE: 0020-0190 SPIDER Display Card (c) 2010
Document Number: SPIDER Display Card Rev 1
Drawn by: 14 1 11 JPC
REV: 1.0
Date: 14/01/2011 16:24:52
Sheet: 1/1

## 16.5 FOCUS MODULE CONTROL CARD

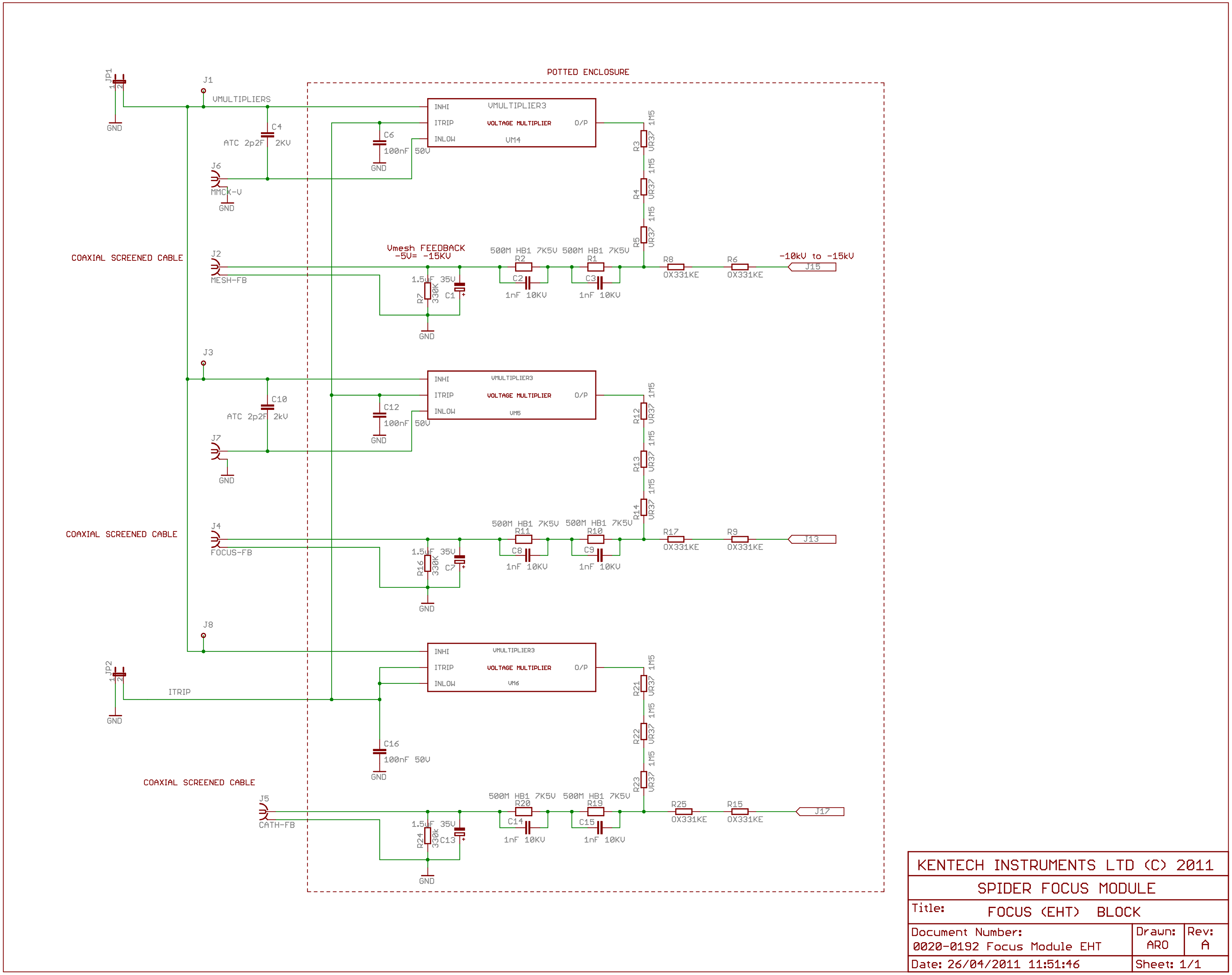
Kentech Instruments Ltd., Isis Building, Howbery Park, Wallingford, Oxfordshire, OX10 8BA, U.K.

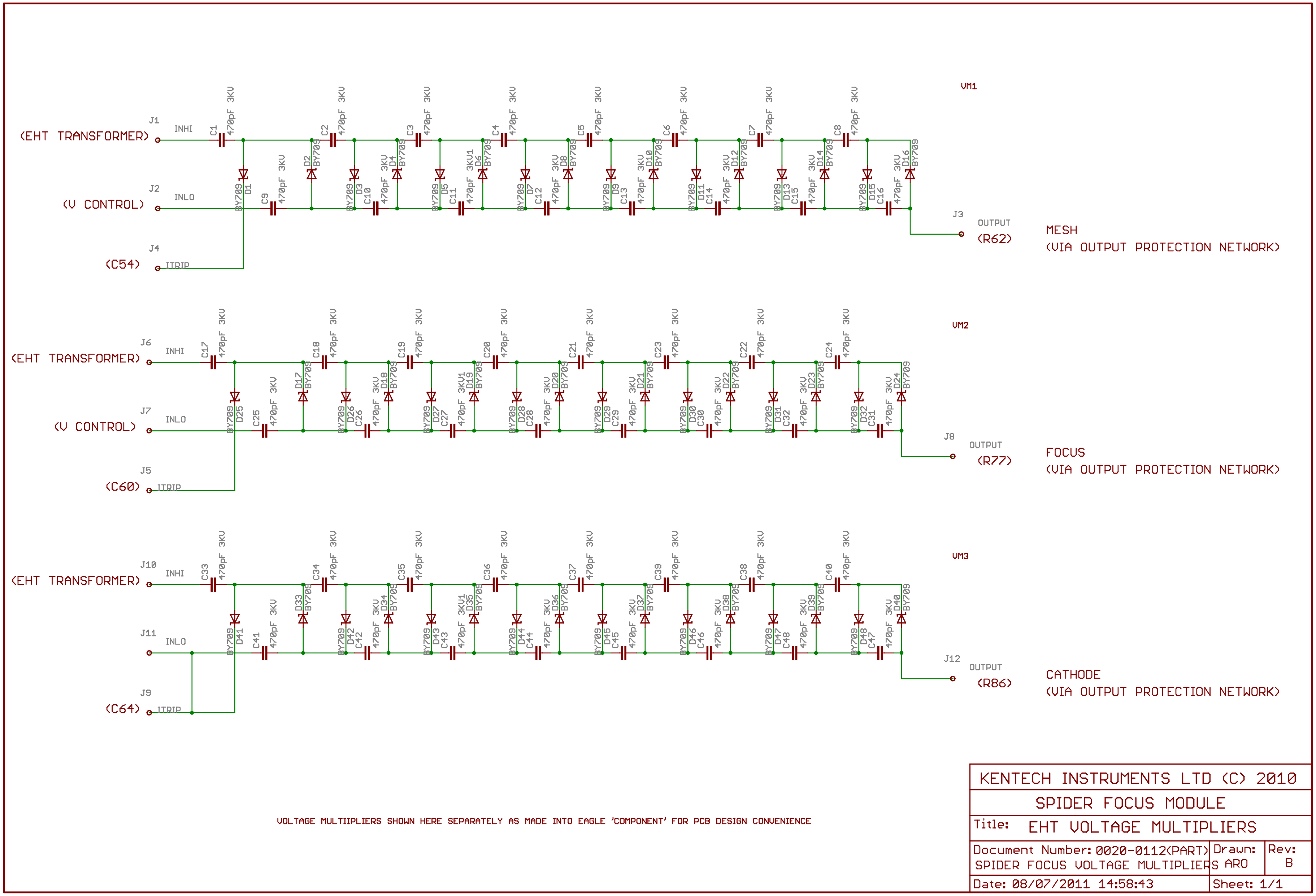
5-3-2012



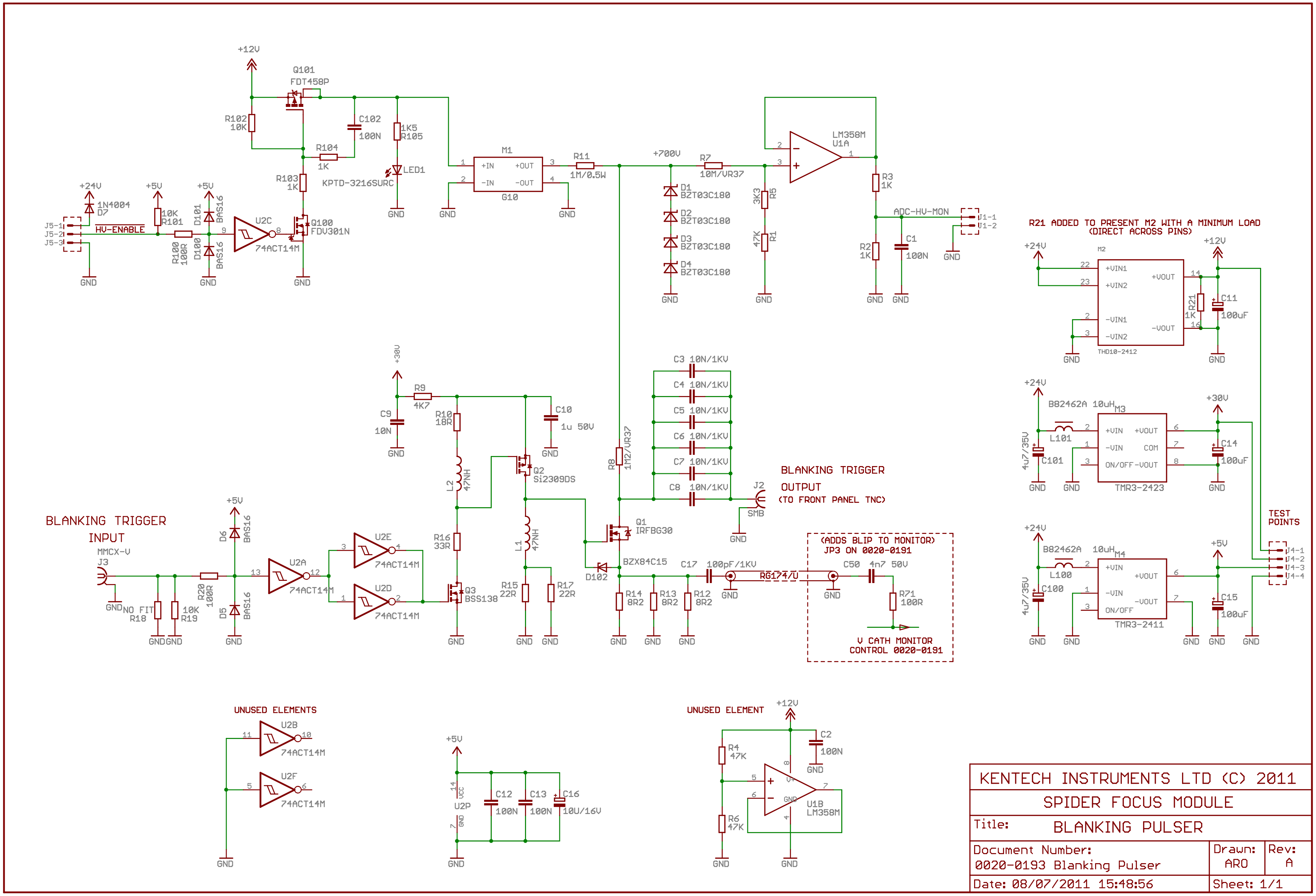



| | | |
|---|---|---|
| KENTECH INSTRUMENTS LTD (C) 2011 | | |
| SPIDER FOCUS (EHT) MODULE | | |
| Title: CONTROL BOARD POWER SUPPLIES | | |
| Document Number: 0020-0191 Focus Control Doc | Drawn: ARO | Rev: A |
| Date: 24/06/2011 10:37:45 | Sheet: 2/2 | |

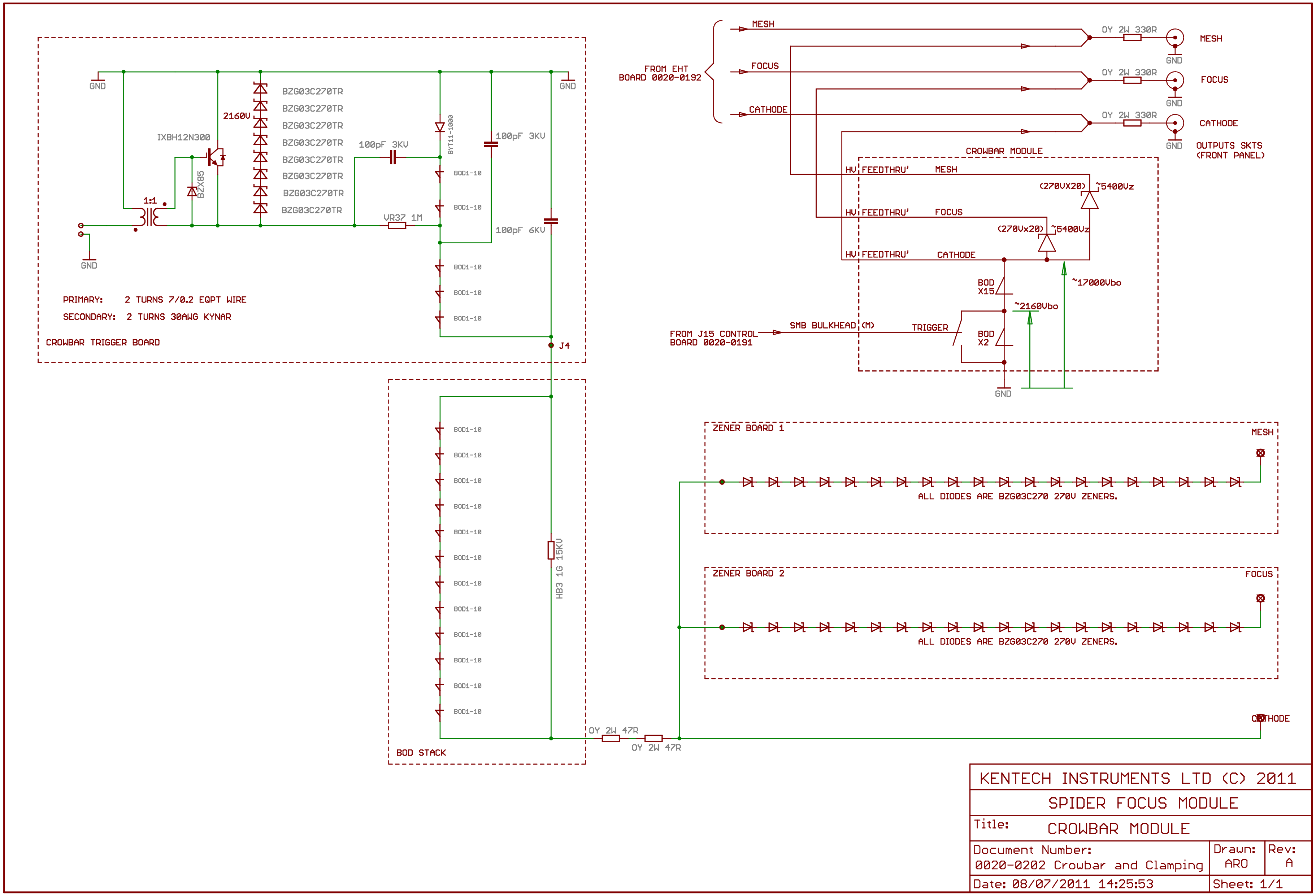

POTTED ENCLOSURE
JP1
GND
J1
VMULTIPLIERS
C4
ATC 2p2F 2KV
J6
MMCX-V
C6
100nF 50V
INHI
ITRIP
INLOW
VMULTIPLIER3
VOLTAGE MULTIPLIER
VM4
O/P
R3 VR37 1M5
R4 VR37 1M5
R5 VR37 1M5
COAXIAL SCREENED CABLE
J2
MESH-FB
Vmesh FEEDBACK
-5V= -15KV
1.5uF 35V
R7 330K
C1
500M HB1 7K5V
R2
C2
1nF 10KV
R1
C3
R8
0X331KE
R6
-10kV to -15kV
J15
J3
C10
ATC 2p2F 2kV
J7
C12
VM5
R12 VR37 1M5
R13 VR37 1M5
R14 VR37 1M5
J4
FOCUS-FB
R16 330K
C7
R11
C8
R10
C9
R17
R9
J13
J8
JP2
ITRIP
VM6
R21 VR37 1M5
R22 VR37 1M5
R23 VR37 1M5
C16
100nF 50V
J5
CATH-FB
R24 330K
C13
R20
C14
R19
C15
R25
R15
J17
KENTECH INSTRUMENTS LTD (C) 2011
SPIDER FOCUS MODULE
Title: FOCUS (EHT) BLOCK
Document Number:
0020-0192 Focus Module EHT
Drawn: ARO
Rev: A
Date: 26/04/2011 11:51:46
Sheet: 1/1


VM1
J1
INHI
(EHT TRANSFORMER)
J2
INLO
(V CONTROL)
J4
ITRIP
(C54)
J3
OUTPUT
(R62)
MESH
(VIA OUTPUT PROTECTION NETWORK)
VM2
J6
(EHT TRANSFORMER)
J7
(V CONTROL)
J5
(C60)
J8
OUTPUT
(R77)
FOCUS
(VIA OUTPUT PROTECTION NETWORK)
VM3
J10
(EHT TRANSFORMER)
J11
J9
(C64)
J12
OUTPUT
(R86)
CATHODE
(VIA OUTPUT PROTECTION NETWORK)
470pF 3KV
BY709
VOLTAGE MULTIIPLIERS SHOWN HERE SEPARATELY AS MADE INTO EAGLE 'COMPONENT' FOR PCB DESIGN CONVENIENCE
KENTECH INSTRUMENTS LTD (C) 2010
SPIDER FOCUS MODULE
Title: EHT VOLTAGE MULTIPLIERS
Document Number: 0020-0112(PART)
SPIDER FOCUS VOLTAGE MULTIPLIERS
Drawn: ARO
Rev: B
Date: 08/07/2011 14:58:43
Sheet: 1/1

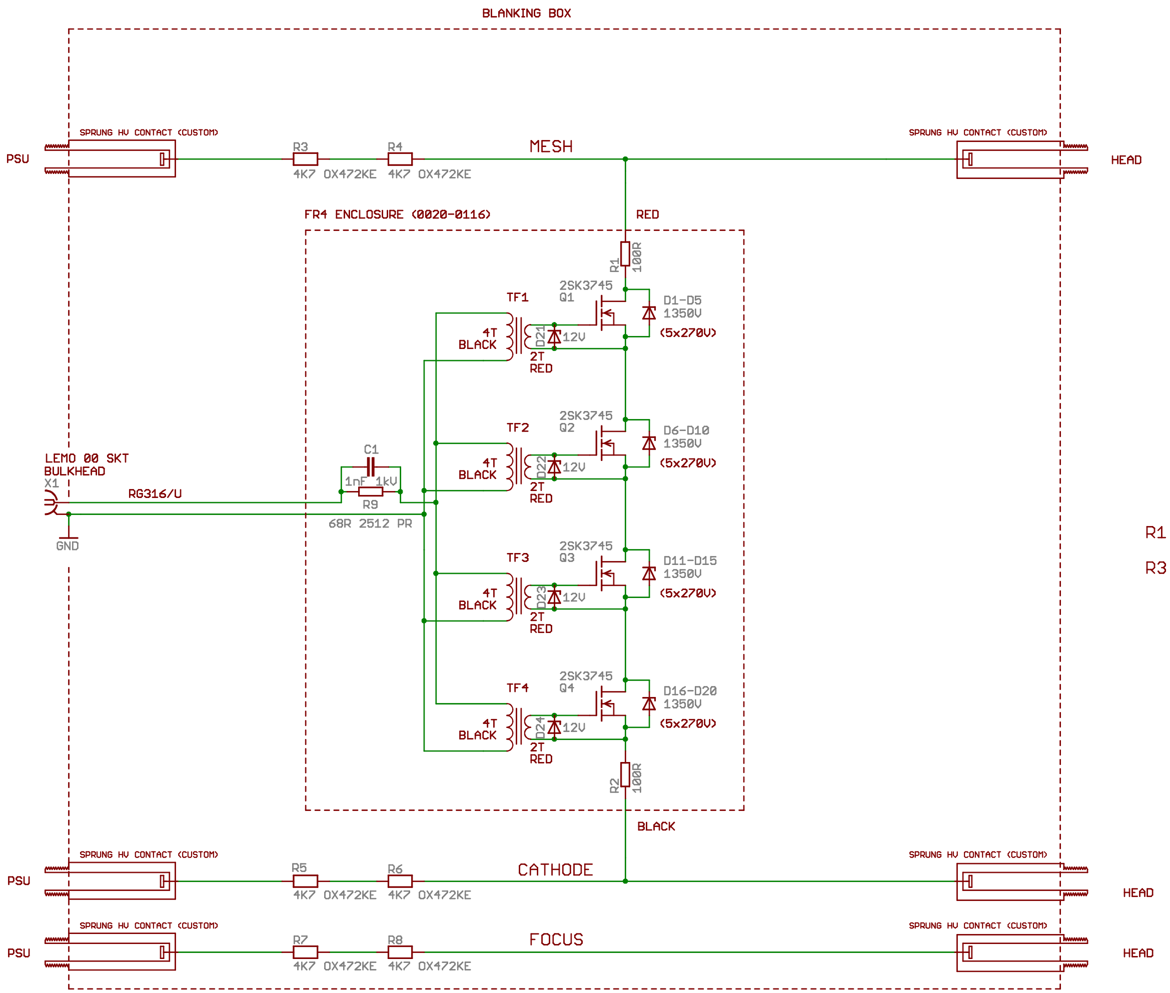
## 16.6 BLANKING PULSER TRIGGER CARD


BLANKING TRIGGER INPUT
BLANKING TRIGGER OUTPUT (TO FRONT PANEL TNC)
HV-ENABLE
ADC-HV-MON
R21 ADDED TO PRESENT M2 WITH A MINIMUM LOAD (DIRECT ACROSS PINS)
TEST POINTS
(ADDS BLIP TO MONITOR) JP3 ON 0020-0191
V CATH MONITOR CONTROL 0020-0191
UNUSED ELEMENTS
UNUSED ELEMENT
KENTECH INSTRUMENTS LTD (C) 2011
SPIDER FOCUS MODULE
Title: BLANKING PULSER
Document Number: 0020-0193 Blanking Pulser
Drawn: ARO
Rev: A
Date: 08/07/2011 15:48:56
Sheet: 1/1

## 16.7 CROWBAR MODULE


GND
BZG03C270TR
2160V
IXBH12N300
BZX85
1:1
100pF 3KV
100pF 6KV
VR37 1M
BYT11-1000
BOD1-10
J4
PRIMARY: 2 TURNS 7/0.2 EQPT WIRE
SECONDARY: 2 TURNS 30AWG KYNAR
CROWBAR TRIGGER BOARD
MESH
FOCUS
CATHODE
FROM EHT BOARD 0020-0192
OY 2W 330R
OUTPUTS SKTS (FRONT PANEL)
CROWBAR MODULE
HV FEEDTHRU'
(270VX20)
~5400Vz
~17000Vbo
~2160Vbo
BOD X15
BOD X2
TRIGGER
SMB BULKHEAD (M)
FROM J15 CONTROL BOARD 0020-0191
BOD STACK
HB3 1G 15KV
OY 2W 47R
ZENER BOARD 1
ZENER BOARD 2
ALL DIODES ARE BZG03C270 270V ZENERS.
KENTECH INSTRUMENTS LTD (C) 2011
SPIDER FOCUS MODULE
Title: CROWBAR MODULE
Document Number: 0020-0202 Crowbar and Clamping
Drawn: ARO
Rev: A
Date: 08/07/2011 14:25:53
Sheet: 1/1

## 16.8 BLANKING MODULE IN STREAK TUBE




SPIDER / DISC variation

R1 and C1 not incuded in models for DISC

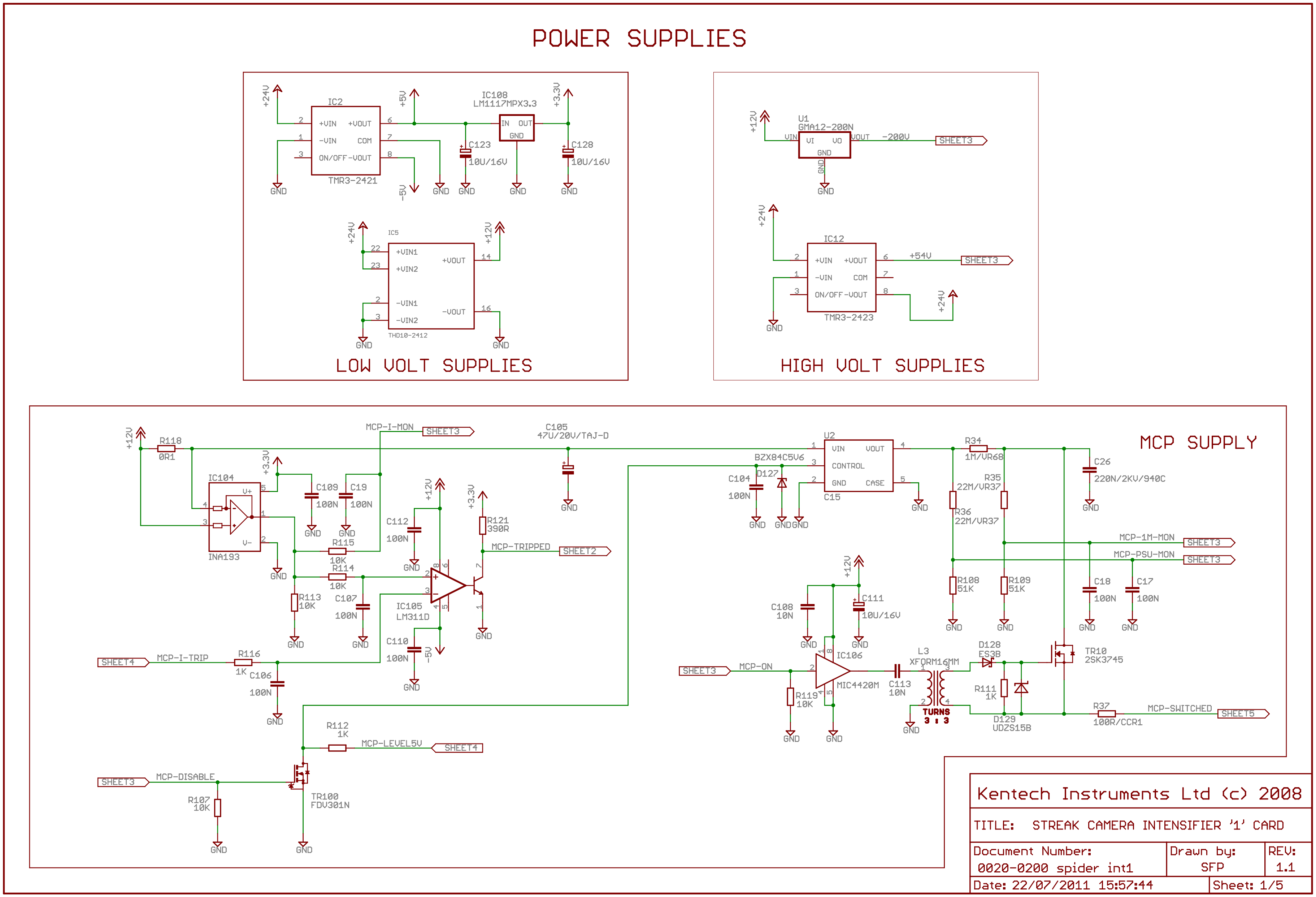
R3 to R8 are 470R on DISC systems

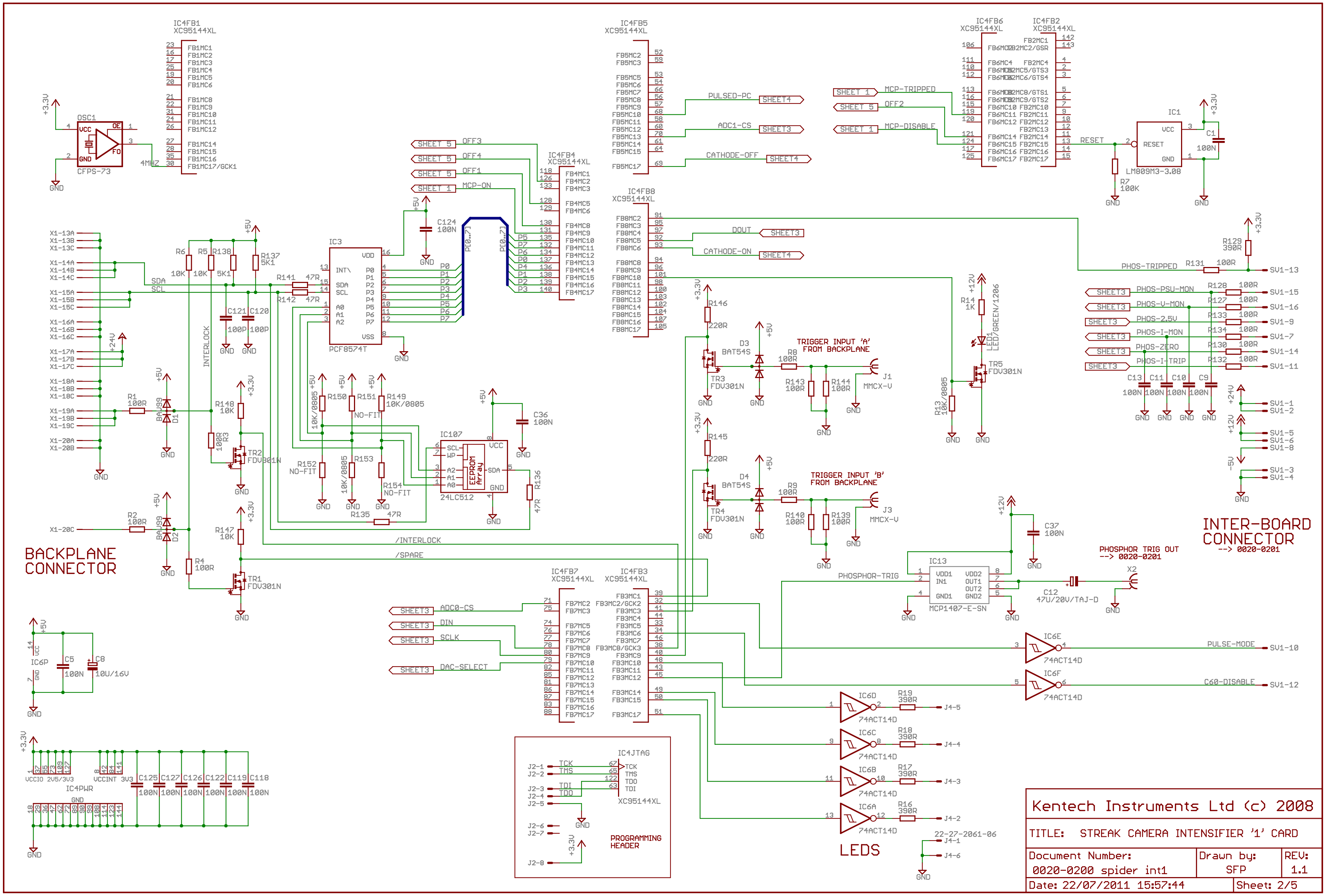
Manufacturing Notes:

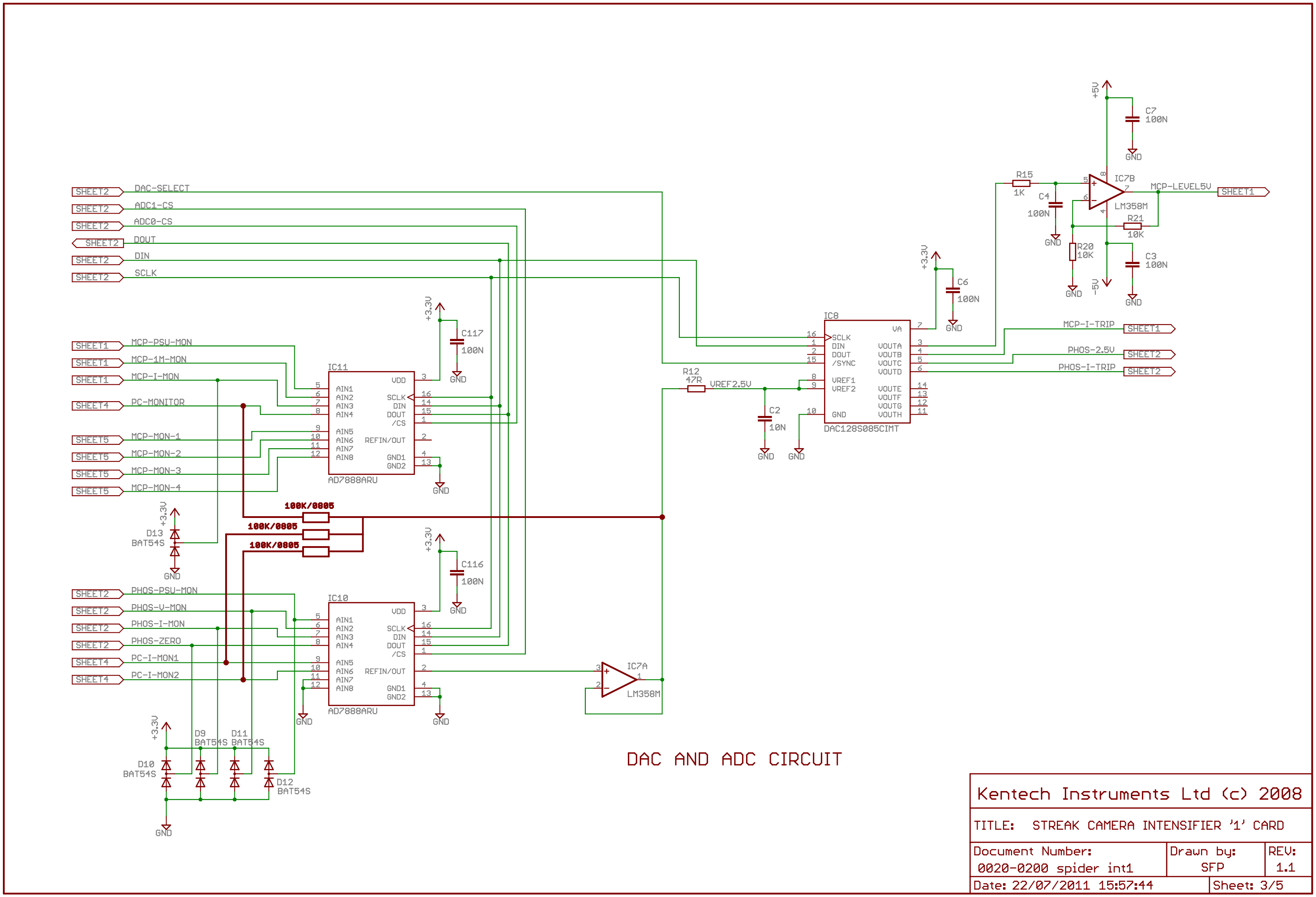
1. Transformer winding use TV10 flexible high voltage wire (Sumitomo Electric UL style 3239 105C)
2. FR4 enclosure and blanking box fully potted using two part RTV silicone rubber (rs409-5737)

| KENTECH INSTRUMENTS LTD (C) 2011 | | |
|---|---|---|
| SPIDER BLANKING BOX | | |
| Title: BLANKING MODULE | | |
| Document Number: 0020-0116 Blanking Board | Drawn: ARO | Rev: A |
| Date: 24/06/2011 11:36:13 | Sheet: 1/1 | |

## 16.9 INTENSIFIER CARD

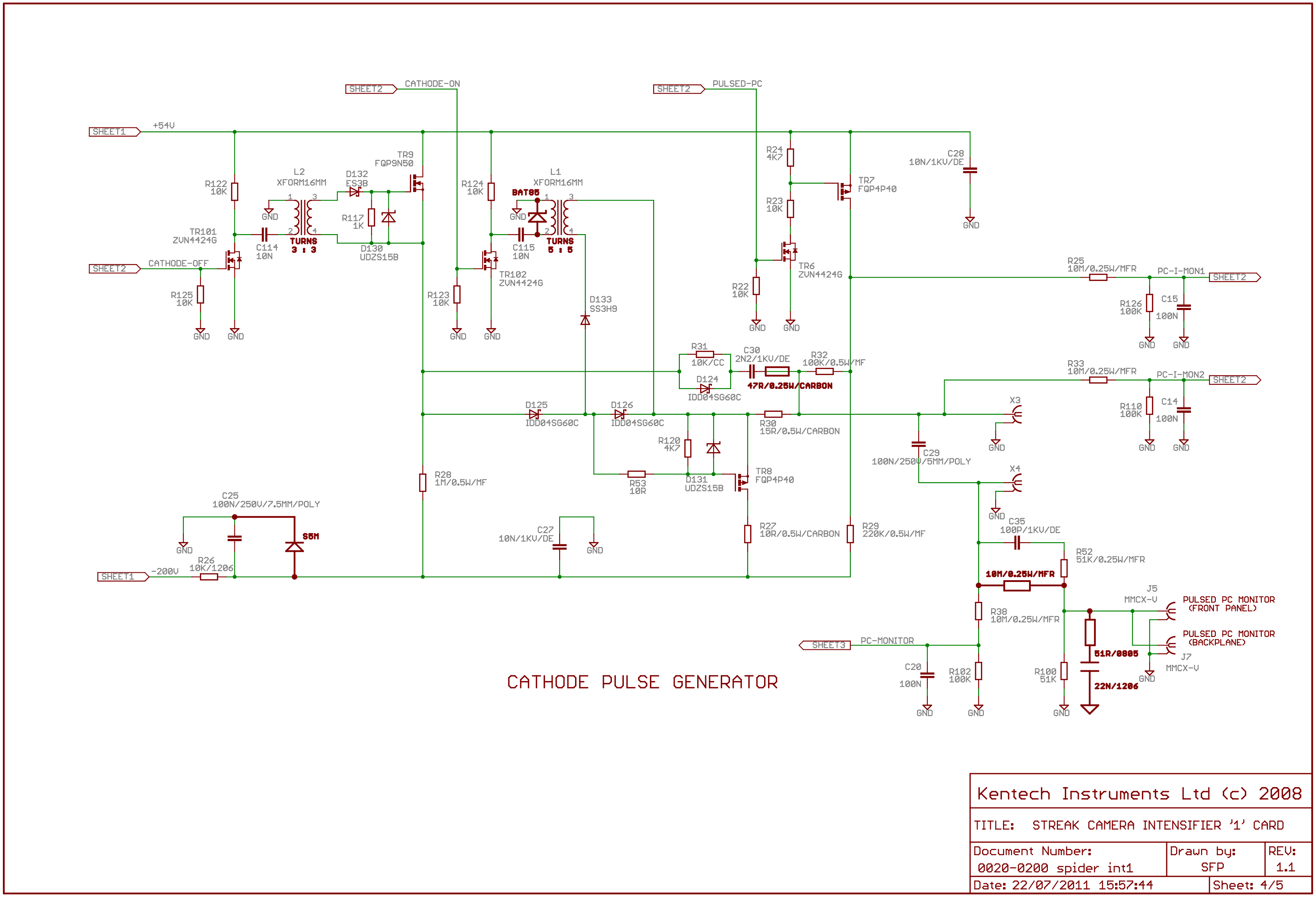

POWER SUPPLIES
LOW VOLT SUPPLIES
HIGH VOLT SUPPLIES
MCP SUPPLY
IC2
TMR3-2421
IC108
LM1117MPX3.3
C123
10U/16V
C128
10U/16V
IC5
THD10-2412
U1
GMA12-200N
-200V
IC12
TMR3-2423
+54V
MCP-I-MON
C105
47U/20V/TAJ-D
U2
BZX84C5V6
R34
1M/VR68
C26
220N/2KV/940C
R35
22M/VR37
R36
22M/VR37
MCP-1M-MON
MCP-PSU-MON
IC104
INA193
R118
0R1
C109
100N
C19
100N
R115
10K
R114
10K
R113
10K
C107
100N
C112
100N
IC105
LM311D
R121
390R
MCP-TRIPPED
C110
100N
MCP-I-TRIP
R116
1K
C106
100N
R112
1K
MCP-LEVEL5V
MCP-DISABLE
R107
10K
TR100
FDV301N
C108
10N
C111
10U/16V
IC106
MIC4420M
MCP-ON
R119
10K
C113
10N
L3
XFORM16MM
TURNS
3 : 3
D128
ES3B
R111
1K
D129
UDZS15B
TR10
2SK3745
R37
100R/CCR1
MCP-SWITCHED
R108
51K
R109
51K
C18
100N
C17
100N
Kentech Instruments Ltd (c) 2008
TITLE: STREAK CAMERA INTENSIFIER '1' CARD
Document Number:
0020-0200 spider int1
Drawn by:
SFP
REV:
1.1
Date: 22/07/2011 15:57:44
Sheet: 1/5

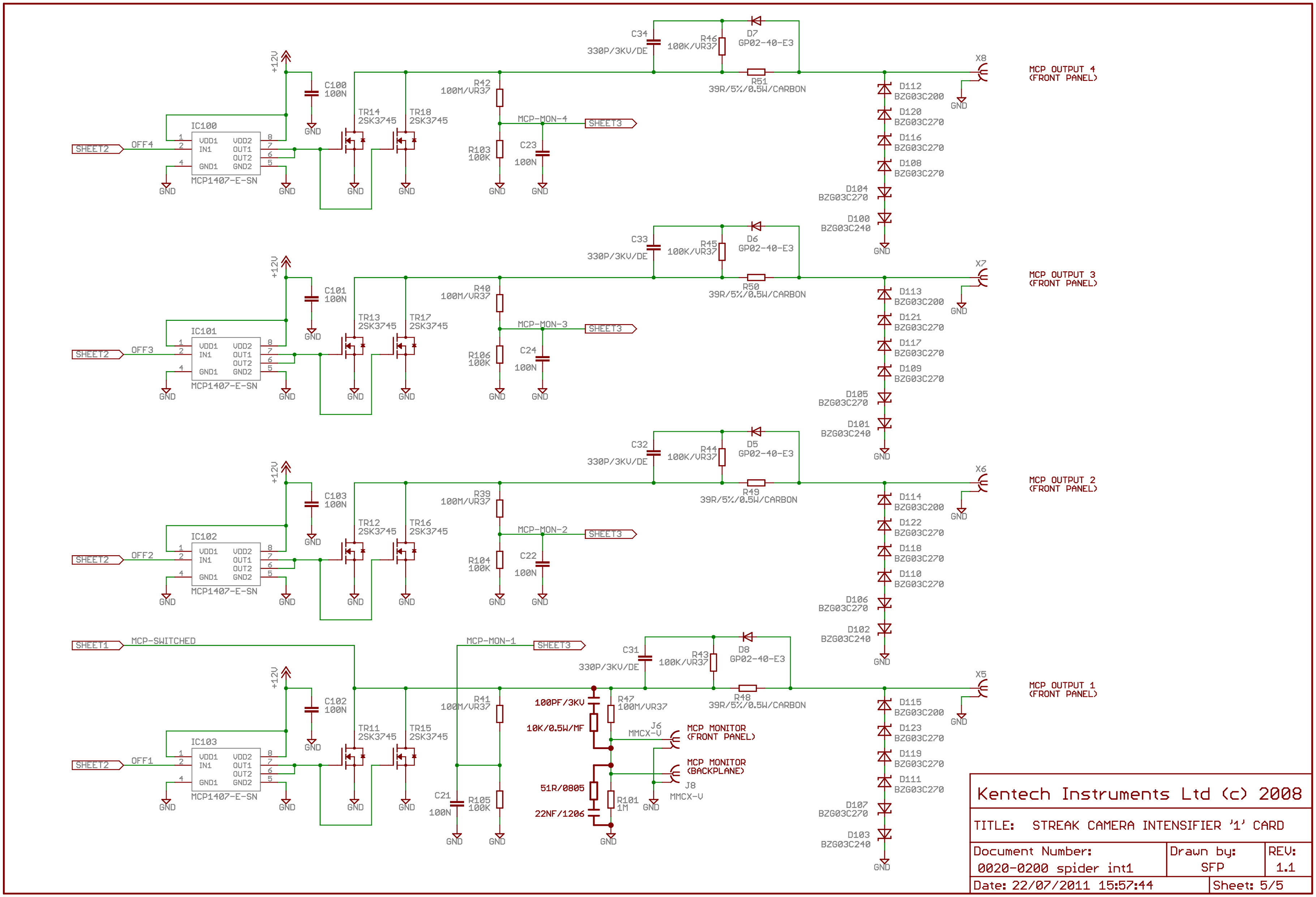

BACKPLANE CONNECTOR
INTER-BOARD CONNECTOR
--> 0020-0201
PHOSPHOR TRIG OUT
--> 0020-0201
TRIGGER INPUT 'A' FROM BACKPLANE
TRIGGER INPUT 'B' FROM BACKPLANE
LEDS
PROGRAMMING HEADER
Kentech Instruments Ltd (c) 2008
TITLE: STREAK CAMERA INTENSIFIER '1' CARD
Document Number:
0020-0200 spider int1
Drawn by:
SFP
REV:
1.1
Date: 22/07/2011 15:57:44
Sheet: 2/5


DAC AND ADC CIRCUIT
SHEET2 DAC-SELECT
SHEET2 ADC1-CS
SHEET2 ADC0-CS
SHEET2 DOUT
SHEET2 DIN
SHEET2 SCLK
SHEET1 MCP-PSU-MON
SHEET1 MCP-1M-MON
SHEET1 MCP-I-MON
SHEET4 PC-MONITOR
SHEET5 MCP-MON-1
SHEET5 MCP-MON-2
SHEET5 MCP-MON-3
SHEET5 MCP-MON-4
SHEET2 PHOS-PSU-MON
SHEET2 PHOS-V-MON
SHEET2 PHOS-I-MON
SHEET2 PHOS-ZERO
SHEET4 PC-I-MON1
SHEET4 PC-I-MON2
IC11 AD7888ARU
IC10 AD7888ARU
IC8 DAC128S085CIMT
IC7A LM358M
IC7B LM358M
C117 100N
C116 100N
C6 100N
C7 100N
C3 100N
C4 100N
C2 10N
R12 47R
VREF2.5V
R15 1K
R20 10K
R21 10K
100K/0805
D13 BAT54S
D9 BAT54S
D10 BAT54S
D11 BAT54S
D12 BAT54S
MCP-LEVEL5V SHEET1
MCP-I-TRIP SHEET1
PHOS-2.5V SHEET2
PHOS-I-TRIP SHEET2
+3.3V
+5V
-5V
GND
Kentech Instruments Ltd (c) 2008
TITLE: STREAK CAMERA INTENSIFIER '1' CARD
Document Number: 0020-0200 spider int1
Drawn by: SFP
REV: 1.1
Date: 22/07/2011 15:57:44
Sheet: 3/5

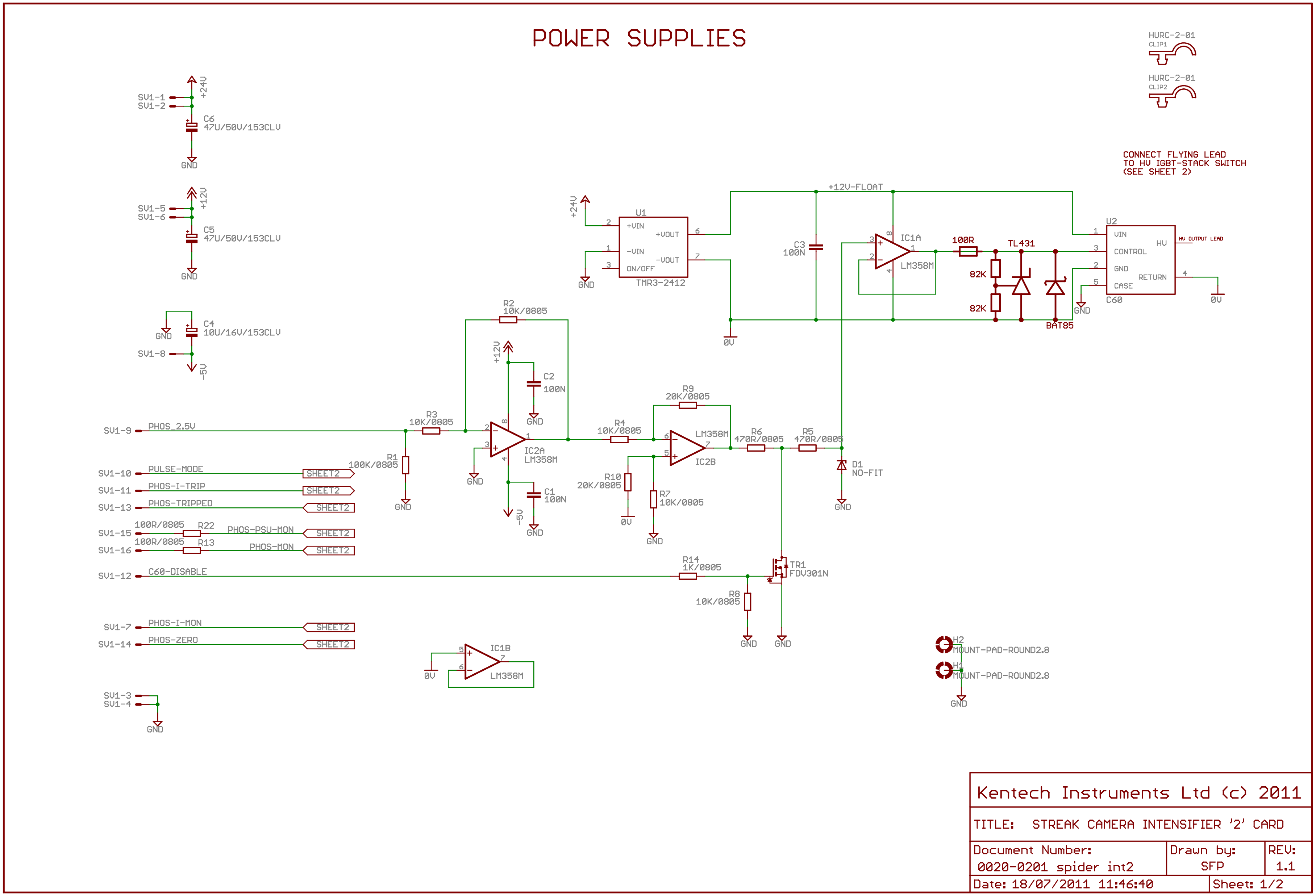
Kentech Instruments Ltd., Isis Building, Howbery Park, Wallingford, Oxfordshire, OX10 8BA, U.K.

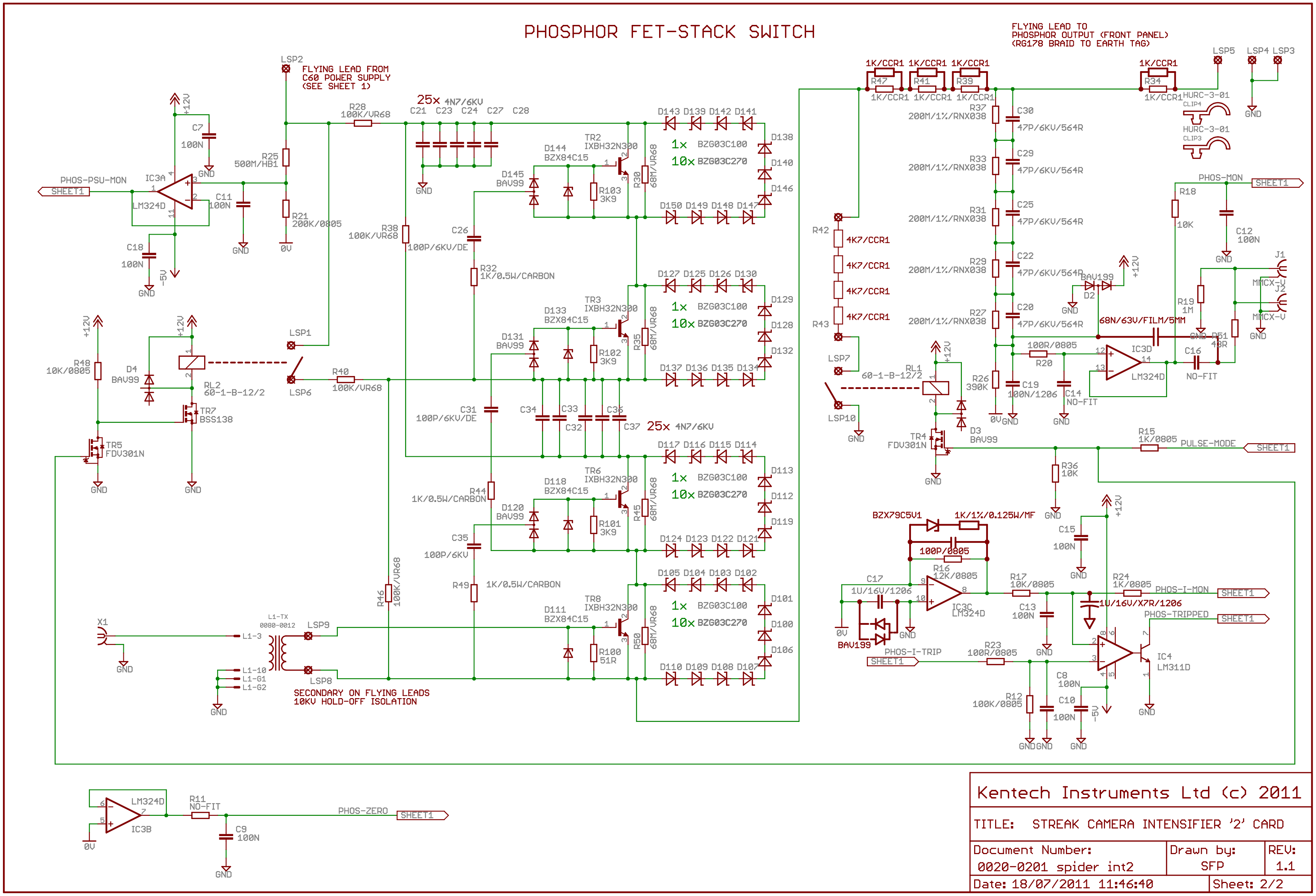
5-3-2012




Kentech Instruments Ltd (c) 2008
TITLE: STREAK CAMERA INTENSIFIER '1' CARD
Document Number:
0020-0200 spider int1
Drawn by:
SFP
REV:
1.1
Date: 22/07/2011 15:57:44
Sheet: 5/5
MCP OUTPUT 4 (FRONT PANEL)
MCP OUTPUT 3 (FRONT PANEL)
MCP OUTPUT 2 (FRONT PANEL)
MCP OUTPUT 1 (FRONT PANEL)
MCP MONITOR (FRONT PANEL)
MCP MONITOR (BACKPLANE)
MCP-SWITCHED
MCP-MON-1
MCP-MON-2
MCP-MON-3
MCP-MON-4
OFF1
OFF2
OFF3
OFF4
MCP1407-E-SN
2SK3745
GP02-40-E3
39R/5%/0.5W/CARBON
330P/3KV/DE
100K/VR37
100M/VR37
100PF/3KV
10K/0.5W/MF
51R/0805
22NF/1206

## 16.10 PHOSPHOR PULSER CARD


POWER SUPPLIES
HURC-2-01
CLIP1
HURC-2-01
CLIP2
CONNECT FLYING LEAD
TO HV IGBT-STACK SWITCH
(SEE SHEET 2)
SV1-1
SV1-2
+24V
C6
47U/50V/153CLV
GND
SV1-5
SV1-6
+12V
C5
47U/50V/153CLV
GND
C4
10U/16V/153CLV
SV1-8
-5V
U1
+VIN
+VOUT
-VIN
-VOUT
ON/OFF
TMR3-2412
+12V-FLOAT
C3
100N
IC1A
LM358M
100R
TL431
82K
82K
BAT85
U2
VIN
CONTROL
GND
CASE
HV
RETURN
HV OUTPUT LEAD
C60
0V
R2
10K/0805
C2
100N
SV1-9
PHOS_2.5V
R3
10K/0805
IC2A
LM358M
R9
20K/0805
R4
10K/0805
LM358M
IC2B
R6
470R/0805
R5
470R/0805
D1
NO-FIT
R1
100K/0805
SV1-10
PULSE-MODE
SHEET2
SV1-11
PHOS-I-TRIP
SHEET2
SV1-13
PHOS-TRIPPED
SHEET2
C1
100N
R10
20K/0805
R7
10K/0805
SV1-15
100R/0805
R22
PHOS-PSU-MON
SHEET2
SV1-16
100R/0805
R13
PHOS-MON
SHEET2
SV1-12
C60-DISABLE
R14
1K/0805
TR1
FDV301N
R8
10K/0805
SV1-7
PHOS-I-MON
SHEET2
SV1-14
PHOS-ZERO
SHEET2
IC1B
LM358M
H2
MOUNT-PAD-ROUND2.8
H1
MOUNT-PAD-ROUND2.8
SV1-3
SV1-4
Kentech Instruments Ltd (c) 2011
TITLE: STREAK CAMERA INTENSIFIER '2' CARD
Document Number:
0020-0201 spider int2
Drawn by:
SFP
REV:
1.1
Date: 18/07/2011 11:46:40
Sheet: 1/2


PHOSPHOR FET-STACK SWITCH
FLYING LEAD FROM
C60 POWER SUPPLY
(SEE SHEET 1)
FLYING LEAD TO
PHOSPHOR OUTPUT (FRONT PANEL)
(RG178 BRAID TO EARTH TAG)
25x 4N7/6KV
1x BZG03C100
10x BZG03C270
SECONDARY ON FLYING LEADS
10KV HOLD-OFF ISOLATION
PHOS-PSU-MON
PHOS-MON
PULSE-MODE
PHOS-I-MON
PHOS-TRIPPED
PHOS-I-TRIP
PHOS-ZERO
Kentech Instruments Ltd (c) 2011
TITLE: STREAK CAMERA INTENSIFIER '2' CARD
Document Number:
0020-0201 spider int2
Drawn by:
SFP
REV:
1.1
Date: 18/07/2011 11:46:40
Sheet: 2/2

# 17. SAFETY INFORMATION

| Units are volts, amps, ohms, joules | **Streak tube drive** | | | | | | **Max Module Drive** | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Description** | Cathode | Focus | Mesh | Blanking trigger | Positive ramp | Negative ramp | Phosphor | MCP OUT 1 of 4 | Photocathode1[5] | Photocathode2 |
| **Max absolute voltage in normal use** | 15000 | 15000 | 15000 | 800 | 1500 | 1500 | 10000*** | 1000 | 200 | 200 |
| **Max DC absolute voltage in abnormal/fault conditions** | 20000 | 20000 | 20000 | 1000 | 1500 | 1500 | 6000 | 1000 | 200 | 200 |
| **Max absolute DC current from the supply** | 0.003 | 0.003 | 0.003 | 0 | 1.00E-04 | 1.00E-04 | 1.66E-04 | 1.00E-03 | 1.00E-03 | 0.001**** |
| **Max absolute DC voltage in fault conditons** | 20000 | 20000 | 20000 | 1000 | | 1500 | 6000 | 1000 | 250 | |
| **Max pulsed absolute current** | 100** | 100** | 100** | 16 | 30 | 30 | 1.68 | 20 | 4 | 4 |
| **Max Pulsed current from the supply in normal use causing the absolute output voltage to rise** | N/A | N/A | N/A | 16 | 30 | 30 | 1.68 | 20 | 4 | 4 |
| **Storage capacitance in the supply in DC mode** | 3.00E-11 | 3.00E-11 | 3.00E-11 | 6.00E-08 | 3.00E-08 | 3.00E-08 | 5.00E-08 | 2.20E-07 | 1.00E-08 | 1.00E-08 |
| **Storage capacitance in the supply in pulsed mode** | | | | | | | 1.25E-08 | | | |
| **Output impedance in pulsed output** | NA | NA | NA | 50 | 50 | 50 | 75 | 50 | 50 | 50 |
| **Pulse duration** | NA | NA | NA | <1e-4 RF burst | 0 to DC | 0 to DC | 1.00E-04 | 1.00E-04 | 0.0001* | 0.0001* |
| **Capacitance of 50 metres of cabling** | 2.80E-09 | 2.80E-09 | 2.80E-09 | 5.00E-09 | 5.00E-09 | 5.00E-09 | 2.80E-09 | 5.00E-09 | 2.00E-08 | 2.00E-08 |
| **Stored energy in the cabling** | 3.15E-01 | 3.15E-01 | 3.15E-01 | 1.60E-03 | 5.63E-03 | 5.63E-03 | 5.04E-02 | 2.50E-03 | 4.00E-04 | 4.00E-04 |
| **Stored energy in the supply** | 3.38E-03 | 3.38E-03 | 3.38E-03 | 1.92E-02 | 3.38E-02 | 3.38E-02 | 9.00E-01 | 1.10E-01 | 2.00E-04 | 2.00E-04 |

Table 2 Safety information

# 18. INTERFACE BOX MECHANICAL DETAILS

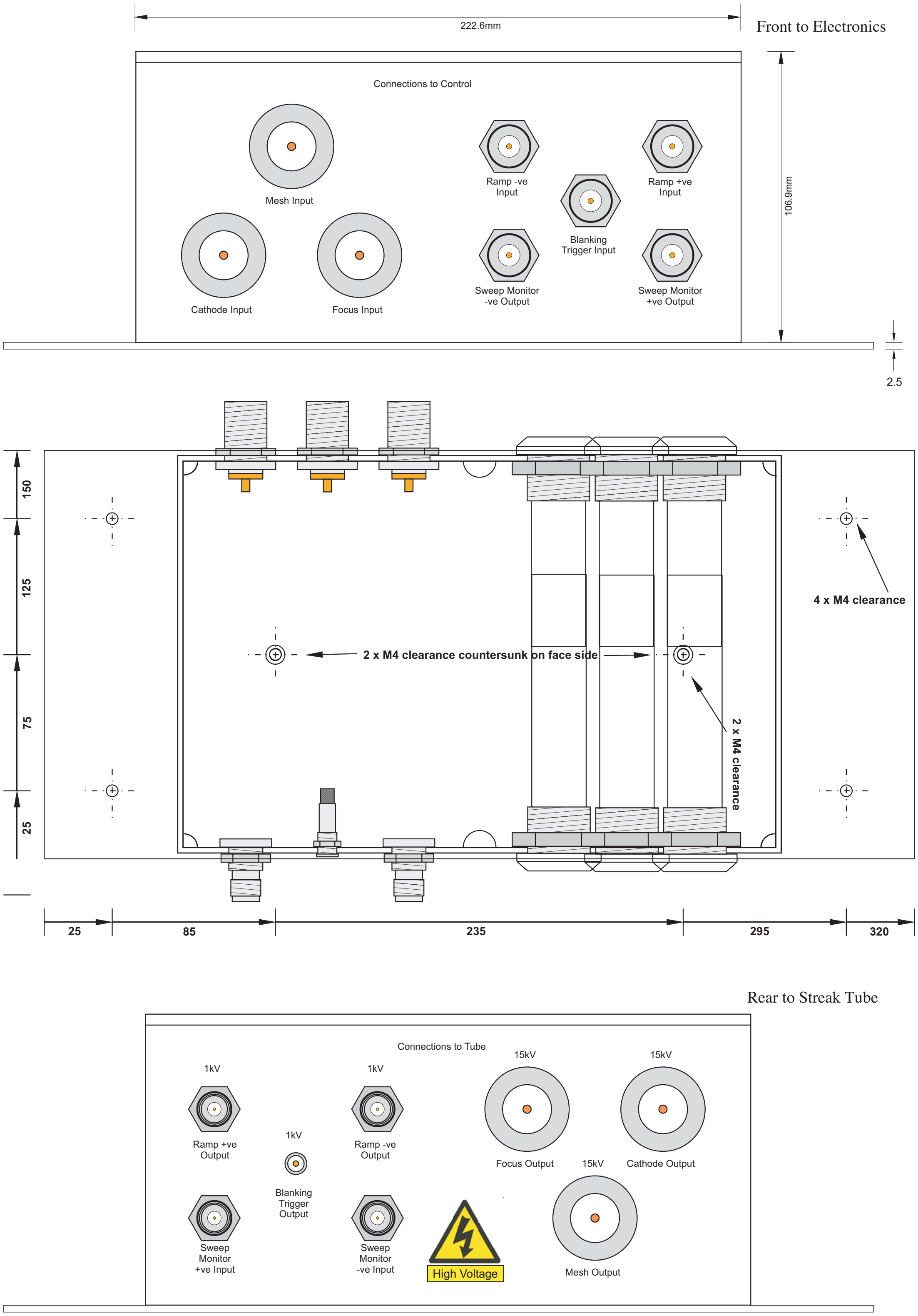



Figure 65 Interface box mounted on a plate. Dimensions shown.