Kentech Instruments Ltd.

Operations Manual

for

High Rate Imager
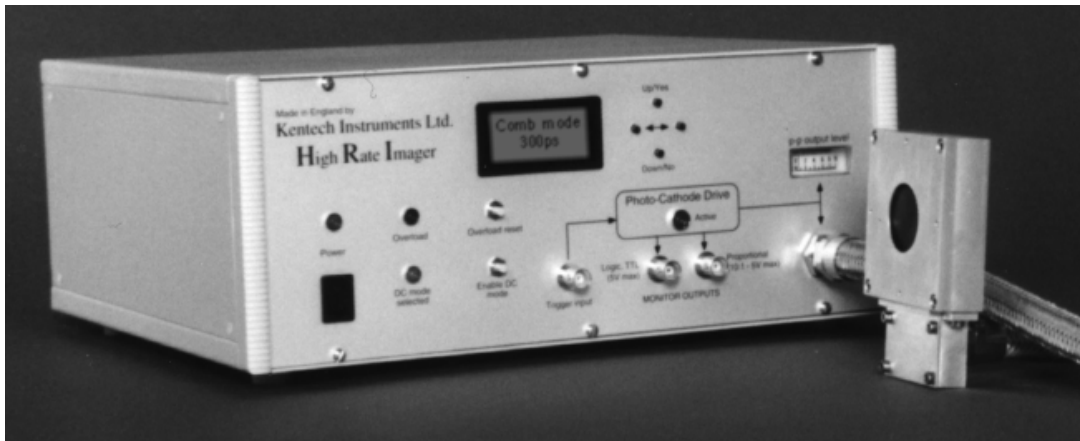
(I) <u>DISCLAIMER</u>

There are high voltage power supplies (6kV) present in this instrument when the unit is operating. Do not remove any covers from the HRI or expose any part of its circuitry. In the event of malfunction, the HRI must be returned to Kentech Instruments Ltd or its appointed agent for repair.

Kentech Instruments Ltd accepts no responsibility for any electric shock or injury arising from use or misuse of this product. It is the responsibility of the user to exercise care and common sense with this highly versatile equipment.

Image intensifier tubes are very delicate and very expensive and must be handled with great care both in use and in storage. Read this manual before unpacking and using the instrument. Kentech Instruments Ltd accepts no responsibility for any damage to the intensifier arising from misuse, we offer the manufacturer's warranty only on this component.

The accessible terminals of this instrument are protected from hazardous voltages by basic insulation and protective grounding via the IEC power input connector. It is essential that the ground terminal of this connector is earthed via the power lead to maintain this protection.

If cleaning is necessary this should be performed with a soft dry cloth or tissue only.

(II) EMC WARNING

HRI HIGH SPEED CAMERA SYSTEM

This equipment includes circuits intentionally designed to generate short high energy electromagnetic pulses and the EM emissions will be sensitive to the details of the experimental set up, particularly in proximity to the cathode.

The emmissions from this equipment exceed the limits specified in EN55011 "Emissions Specification for Industrial, Scientific and Medical equipment" by approximately 20dB (with the cathode and phosphor windows covered with a conductive screen) and the unit may cause interference with other equipment in its immediate environment. It is suitable for use only in a laboratory or a sealed electromagnetic environment, unless it is used in a system that has been verified by the system builder to comply with EC directive 89/336/EEC. Use of this apparatus outside the laboratory or sealed electromagnetic environment invalidates conformity with the EMC Directive and could lead to prosecution.

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Contents

1   INTRODUCTION

The HRI is a micro channel plate intensified, gated camera with a shortest gate time of ≤500 psecs FWHM over an 18mm diameter cathode aperture. It has a modulation bandwidth of 1GHz and can provide impulse gating with sub ns gate widths at repetition rates in excess of 100MHz. It is intended for applications such as fluorescence lifetime imaging, lidar and time resolved spectroscopy.

The camera has four modes of operation: DC, Comb, Logic and RF modulation. The wafer type design gives a large number of pixels across the full 18mm diameter cathodes. The resolution is typically 10 1pmm[-1] dropping at the shortest gate durations. In comb mode the repetition rate can be in excess of 100MHz, ideally suited for operation with mode locked lasers.

The intensifier head is of compact mechanical design and the accessibility of the input window face allows simple coupling to the user's input optical set up.

The cathode responds to 850nm light which allows easy setup with a laser diode (not supplied).

The camera is fully computer controllable via an RS232 interface. For stand alone operation a keypad and LCD display are provided. A non-volatile memory allows the calibration parameters and the current setup to be stored for later use.

The intensifier is provided in a remote housing with a flexible connection to the power supply. The input and

output faces of the housing have mounting holes for the user to attach various optical accessories.

The output format is a flat fibre optic faceplate. We are able to provide CCD readout options or users may provide

their own readout arrangements.

We are able to provide certain standard lens mounts at the input face as an option.

2   SPECIFICATIONS

Features: 110MHz maximum trigger rate from logic input

≤0.5ns to 1ms optical gate width (5% duty cycle limit)

≤300ps gate (certain conditions)

1GHz maximum RF modulation from analogue input

Internal 0.5ns comb generator

Ideal for use with mode locked lasers

Single power supply with RS232 remote control facility

Recall of previous settings

Intensifier: 18mm diameter

S25 on glass or S20 on quartz cathode

P20, P43 or equivalent phosphor

Fibre optic output

Single or double MCP is available

Resolution: Typically ≥ 12 lppmm[-1]

≥8 lppmm[-1] all modes

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Operating modes: Slave
        Slave (high duty cycle)
        Comb
        RF
        DC

Controls: Gate mode   Keypad/remote
        Optical GainKeypad/remote
        Trigger source   Keypad/remote
        RF gain   Keypad/remote
        Reset overload   Keypad/remote
        Enable DC   Keypad/remote

Indicators: Control status LCD
        Trigger indicator LED
        Overload LED
        DC mode active LED
        AC power LED

Connectors: Trigger input   BNC
        Monitor output (logic)   BNC
        Monitor output (proportional)   BNC
        RS232 interface   15 way D (rear)
        MCP inhibit   BNC (rear)
        AC power   IEC (rear)

3   **PRINCIPLES OF OPERATION**

The HRI provides intensifier gating and gain modulation by switching the photocathode potential with respect to the MCP input. The MCP input is at ground potential.

The HRI can support various modes of gain modulation. These are SLAVE gating, COMB gating and RF modulation. In addition a DC mode is provided. The average phosphor current is monitored and if it exceeds a (programmable) threshold the imager shuts down to protect the intensifier tube.

NOTE - This protection will not be effective if only a small area of the image is illuminated. Be sure that you are able to view the output image, either directly or via a CCD system, while setting up the instrument.

In **LOGIC** or **SLAVE** mode the cathode gate voltage is switched in response to the logic input signal. The duty cycle is limited to 5% in normal use although a high duty cycle mode is provided in which a 50% duty cycle is possible at reduced voltage.

Note that the PC gate signal is AC coupled to the photocathode with a time constant of approximately 2msec. The longest gate pulse is therefore 1msec in logic mode.

In **COMB** mode the HRI routes the trigger signal via an impulse generator so that each transition of the trigger signal produces a narrow gate pulse. This mode normally is used for trigger rates between 1MHz and 110MHz although it is possible to set up the HRI to allow for lower COMB repetition rates or for rates up to 300MHz.

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The COMB modes allow the user to set the impulse gate width. Please note that these are set up for a particular operating frequency range (typically 80MHz, a common mode locked laser frequency). Although the COMB mode may be used at frequencies down to 1MHz the gate width will be greater than the displayed value.

The **RF** modulation mode has a frequency range of 1MHz to 1GHz.

The principal of fast gating is that the tube is biased off by means of a small positive potential applied to the cathode with respect to the channel plate input. A short duration negative pulse is applied to the cathode in order to gate the camera on. This pulse is applied to the relatively high capacitance load presented by the cathode via a low impedance matching network. This allows the very fast gating which is available with the HRI camera.

The gate voltage applied to the cathode is limited by the high average power associated with the very high repetition rate. The temperature of the cathode window is monitored by the power supply to avoid tube damage due to excessive temperature. In normal use and at normal ambient temperatures the temperature will remain within safe limits. In the event of an excessive tube temperature the power supply will issue a warning and will shut down the intensifier.

The tube assembly is fed by several cables. These are all carried by a screened flexible conduit. The conduit fitting at the power supply end has a swivel joint to allow easy positioning of the intensifier head. The conduit carries the following signals:

Intensifier bias signals (phosphor, PC, MCP)

Pulse signal

Termination

Intensifier temperature monitor

4   THE POWER SUPPLY

The electronic package which drives the HRI head is housed in a single box. The box contains five sections. These are:

i)   Low voltage power supply

ii) Signal conditioning

iii) High voltage tube bias supply

iv) Gate pulse driver

v)   Microcontroller

The low voltage board provides power for all other sections.

The high voltage tube bias supply provides the static potentials required for the intensifier tube.

The signal conditioning section provides several functions:

Mode selection

Trigger polarity

Trigger termination

Trigger thresholding

Comb impulse generation

RF gain control

Logic selection

TTL monitor output

These functions are all under software control

The cathode gate circuit provides either impulse outputs for the comb and logic modes or the linear

amplification of the input signal for RF mode. The operating conditions for this gate circuit are under internal computer control.

5   DESCRIPTION OF THE OPERATING MODES

DC mode
Function Allow the intensifier to be operated continuously

Selection Via user menu, press DC enable button to turn on the intensifier

Other settings   MCP gain

Notes   DC active LED illuminated in this mode
     Phosphor overload is operational

Comb mode
Function Provide an impulse gate for each trigger input transition

Selection Via user menu

Other settings   MCP gain
     Comb gate width (200 - 1000ps)*
     Trigger level
     Trigger type
     Trigger polarity
     Trigger termination

Notes   Phosphor overload is operational
     Power supply overload (excessive duty cycle) is operational

Logic mode (low duty cycle)
Function Intensifier is slaved to the logic input. Highest gate voltage.

Selection Via user menu

Other settings   MCP gain
     Trigger level
     Trigger type
     Trigger polarity
     Trigger termination

Notes   Phosphor overload is operational

Power supply overload (excessive duty cycle) is operational

Logic mode (high duty cycle)
Function Intensifier is slaved to the logic input. Reduced gate voltage for high duty cycle.

Selection Via user menu

Other settings MCP gain
    Trigger level
    Trigger type
    Trigger polarity
    Trigger termination

Notes   Phosphor overload is operational
RF mode
Function Intensifier modulated in response to a sinusoidal RF input.
    Modulation bandwidth 1MHz - 1GHz.

Selection Via user menu

Other settings MCP gain
    RF gain

Notes   Phosphor overload is operational
    Input level of 10dBm (2V p-p) is suitable for all frequencies
    At frequencies below 300MHz 0dBm is adequate
    The response of the intensifier to the PC voltage is very non-linear so even with a sinusoidal
    signal on the PC the gain will be closer to a square wave. It is therefore advisable to overdrive
    the amplifier in order to produce a square modulation signal on the PC to decrease the on/off/on
    transition time and hence reduce the time for which the PC voltage is low and the resolution is
    low.

User modes
Function Can be set up as any kind of mode.

Selection Via user menu

Other settings MCP gain
    Trigger level
    Trigger type
    Trigger polarity
    Trigger termination
    RF gain

Notes   As shipped these modes are usually programmed as comb modes.

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* The minimum comb gate width is specified at 500ps although under certain conditions a gate width of 200ps is possible. As shipped the HRI will be set up for a particular drive frequency (usually 80MHz). Operation at other frequencies will affect the calibration so the gate widths (the shorter gate widths in particular) may differ slightly from the selected value. The comb widths may be recalibrated for other drive frequencies via the keypad and non-volatile memory if required. The principal parameter to adjust is the Negative Clamp voltage (see sections 12 and 13).

6   CONNECTIONS AND CONTROLS

6.1   FRONT PANEL

AC power plus LED
Switches ac power to the HRI power supply

Keypad and LCD display
Control of all functions of the HRI:
Save/recall last setup
Select user mode (gate mode)
Settings   MCP gain
    Trigger type (ECL/TTL/Threshold)
    Trigger polarity
    Trigger termination
    RF gain
Calibration parameters for all modes
    PC bias
    Cathode pulse driver operation
    Trigger level (VTRIG)
    Comb width
    Mode type (RF/logic/comb)

6.1.1 TRIGGER INPUT

Trigger input for all gate modes.

Note that this is an ac coupled input and is therefore not a true ECL or TTL input. For low duty cycle inputs ECL or TTL level signals may be applied however for high duty cycle signals (such as may be required for the triggering of comb mode at high rates) ECL trigger selection may not result in correct operation. This is because the ac coupling results in the average input level always being zero, causing an effective offset. For stable triggering at high rates we recommend the ECL, +T or ECL, -T trigger setting. (See notes on the trigger threshold below.)

6.1.2 MONITOR OUTPUT (TTL LOGIC)

This output is intended for the monitoring of relatively slow **logic mode** triggering. It originates from a TTL gate and therefore has limited bandwidth (~100MHz). It will track a logic trigger input and may be used to confirm the trigger settings. It will not respond in COMB modes.

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6.1.3 MONITOR OUTPUT (PROPORTIONAL)

This signal is derived from the cathode gate pulse termination network and closely represents the voltage on the photocathode, although the risetime is increased slightly by cabling and matching networks. It is ac coupled with a time constant of 250ns so will provide a differentiated version of the gate signal for gate widths greater than this time constant. It will provide a faithfully monitor of all comb mode gate signals and is the preferred monitor signal for gating at ≤100ns.

6.1.4 METER (P-P RF LEVEL)

Provides a quick analogue monitor of the cathode gate signal. In comb and logic (LDC) modes it will display ~80% during correct operation. In other modes (RF and logic(HDC)) it will display ~30% at the reduced cathode gate voltage.

6.1.5 LED CATHODE DRIVE ACTIVE

This is illuminated if either the logic monitor output is active or if the p-p RF level is greater than 5%.

6.1.6 LED DC MODE ACTIVE

When the LED is illuminated the intensifier will be turned on DC if the enable DC mode button is pressed.

6.1.7 BUTTON

Enable DC mode
See above

6.1.8 OVERLOAD LED

This LED can display two overload conditions:
i) Phosphor current overload - constant illumination
The gate circuit and intensifier are shut down due to excessive phosphor current. Press the reset overload button to recover AFTER HAVING REDUCED THE CATHODE LIGHT LEVEL OR MCP GAIN.
ii) Power supply overload - flashing
If an excessive duty cycle signal is applied to the trigger input in either comb or logic (LDC) modes then excessive power is drawn from the power supply. The power supply voltage will collapse and the overload light will flash until the overload is removed. Options are: reduce trigger rate, reduce gate pulse width or select the logic (HDC) mode.

6.1.9 RESET OVERLOAD BUTTON

If a phosphor current overload occurs (constant illumination of overload LED) then pressing this button will reset the power supply. Only do this AFTER HAVING REDUCED THE CATHODE LIGHT LEVEL OR MCP GAIN.

6.2   REAR PANEL

6.2.1 RS232

Standard RS232 format serial interface for remote control of the HRI.

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6.2.2 MCP INHIBIT

A logic high level on this input will reduce the MCP gain to minimum. This will usually be used during the readout of unblanked CCD cameras (ie full frame, frame transfer types). It is preferable to keep the cathode gate running constantly in order to increase timing stability and gate width accuracy. Blanking the MCP has least effect on the gating operation and is the preferred way of suppressing light output during CCD readout.

6.2.3 AC POWER INLET

Filtered IEC power connector. The power supplies are universal input: 100 - 240V , ac 50/60Hz, approx 100VA.

6.2.4 COOLING FAN

Do not obstruct the flow of air through the cooling fan. There is significant dissipation in the cathode gate circuit. There is a thermal trip in the power supply which my activate if cooling air is restricted.

7   TRIGGER THRESHOLD

In the +T and -T trigger modes the trigger threshold is programmable. For a given mode this threshold may be accessed through the "edit machine parameters" window and is the parameter marked VTRIG. This parameter applies an offset to the ECL logic input and allows stable triggering from signals as small as 300mV p-p. The number is displayed in raw format ie not in volts. (This is because it was added to the firmware at a rather late stage!) The number displayed is applied to an internal D-A converter. A number of 2600 is close to zero bias - ie the input is right on the threshold. A increase in the count of +400 is roughly equivalent to +100mV bias which would give a -100mV threshold.

Typical settings would be:
+T VTRIG = 2200   Threshold is +ve 100mV
-T   VTRIG = 3000   Threshold is -ve 100mV

If VTRIG is set close to 2600 (ie zero bias) then the high trigger sensitivity can result in oscillation. This will show up as a deflection of the p-p level meter, even in the absence of a trigger input.

By far the safest way to set the trigger settings is to view the proportional monitor output with a scope while triggering the scope from the trigger signal. In this way the gate pulse on the cathode is observed and correct trigger operation may be checked unambiguously.

8   THINGS TO AVOID

The following things should be avoided or else irreparable damage may result.

Excessive illumination on the photocathode
Bright light on the cathode can reduce its sensitivity, even if the HRI is not switched on. Sunlight or bright artificial light should NEVER be allowed on the photocathode.

Excessive illumination at the phosphor output.
Even with low light levels on the cathode it is possible to obtain a very bright image on the phosphor if the MCP gain is high. Although the phosphor current is limited to protect the intensifier, this will not protect the

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intensifier if the illumination pattern is a small spot.

When first powering up the imager be sure that you are able to view the phosphor image, either directly or via a CCD camera providing a frame rate of several Hz.

Excessive voltage applied to an input or output.

The maximum trigger input is +/- 5V. Exceeding this limit may damage the trigger circuitry.

Do not apply any signal to an output.

Excessive force applied to the input or output faces of the intensifier tube.

When coupling a CCD camera to the phosphor output or coupling a diagnostic to the cathode input be sure that no great force is applied to the windows.

The loading on the phosphor window must be no more than ~40gms.

Ensure that the any glass to glass contact is parallel otherwise input and output optical surfaces may be scratched or chipped.

Mechanical shock.

Protect the HRI from mechanical shocks.

Condensing atmospheres.

Do not allow the HRI to come in contact with a condensing atmosphere or high voltage circuits may suffer electrical breakdown.

9   OPERATIONAL NOTES.

Switch on

It is possible to save the current user settings (ie gate mode, MCP gain etc) and to recall them when the HRI is next powered up. If a high MCP gain is stored then recalling the last settings can immediately put the HRI into a high gain state. If the experimental set up is new or has been changed then it is safer to set up the HRI manually so that the MCP gain starts low.

Timing

Timing the imager is particularly critical when short exposures are required. The first requirement is a trigger signal of stable timing (to within much less than the gate window) and stable amplitude. Since the logic trigger circuits integrate the trigger signal for a nanosecond or so, a varying amplitude will cause a timing change.

A second requirement is a stable delay generator, ideally a passive switched cable network, to set the timing. Kentech are able to provide a passive (50Ω) computer controlled delay generator which may be used to set a trigger delay of 0 - 20ns in 25ps steps.

Monitor outputs

Remember that the TTL monitor output will not respond to very short gate pulses due to the limited bandwidth of TTL circuits. The proportional monitor output provides a directly divided monitor of the cathode gate signal and is the preferred monitor for fast gating

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10   TESTS

10.1 STATIC TESTS.

The imager should be set up with a resolution grid imaged onto the cathode. The pulser need not be triggered for this test.

A controlled and uniform light source should be used to back light the target. This may be a variable output microscope lamp with a diffuser and ND filters (say ND 2) over the front. All other light sources should be excluded from the photocathode by using a black tube.

A microscope or CCD camera should be set up to view the output. This can be an objective lens mounted close to the output. Take care not to scratch the fibre optic window.

In a dimly lit room (ie just enough light to manoeuvre), and with the microscope lamp off turn on the imager in the DC mode with the gain set to minimum. Depress the DC button and gradually turn up the MCP gain to ~600V (single MCP) or 1100V (double MCP). No image on the phosphor should be visible at this stage. Gradually turn up the lamp until a dim image is seen. Then turn up the gain until a clear image of the resolution mask is present on the output.

In DC mode the imager should be able to resolve lines separated by less than 80 microns.

Ensure that the image is uniform and that no area of the cathode has been reduced in sensitivity due to excessive illumination.

10.2 DYNAMIC TEST

For this test a high repetition rate (~80MHz) short pulse light source is required. A laser diode is very convenient although a mode locked laser may also be used. The source should have a wavelength ≤850nm. There are several suitable diode light sources available commercially (we have used one manufactured by Picoquant in Germany). A delay generator, such as the Precision Programmable 50Ω Delay Line manufactured by Kentech Instruments will also be required.

Be sure to use the appropriate laser safety goggles.

Arrange for the laser to illuminate the cathode uniformly. The average power on the cathode should be attenuated to around 1μwatt. Connect the trigger output from the laser diode controller to the HRI trigger input via the delay line.

In a dimly lit room and with the laser diode blocked off, switch on the HRI and select comb mode, 1000ps gate width. Set an appropriate trigger mode (eg +T, ECL and VTRIG = 2300 for a 1V positive trigger signal).

Ensure that the HRI is triggering (examine the p-p RF meter and the cathode gate active LED).

Select DC mode and ensure the MCP gain is at minimum. Allow the laser light to reach the cathode. Press the 'enable DC mode' button and turn up the MCP gain until an image is visible on the phosphor. This establishes a reasonable MCP gain level for the test.

Return to comb mode, 1000ps gate width. The HRI should be triggering. Adjust the delay until an image appears. By varying the delay the optical gate profile may be measured. It may be necessary to increase the MCP gain slightly.

This test may be carried out for all impulse gate modes although for longer gate durations the trigger rate will have to be reduced appropriately.

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For RF gating a frequency divider will be required in order to trigger the laser diode synchronously with the RF drive signal. In other respects the test is the same. As the delay is adjusted the modulation of the cathode will be measured as the laser diode pulse is marched through the RF modulation signal.

The modulation bandwidth is 1GHz although at the highest frequencies (0.7 - 1GHz) the amplifier gain rolls off. Optimum modulation at high frequency may require the fine adjustment of the PC bias voltage via the 'edit machine parameters' window. Refer to the software section below.

Be sure that the RF drive signal contains little or no sub harmonic content as the gain roll off at high frequencies will exaggerate this component. (Certain signal generators produce high frequencies by a multiplication process and the output can contain sub harmonics).

11   CIRCUIT DESCRIPTIONS

11.1 LV POWER SUPPLY

The low voltage board provides power for all other sections. It includes a 24V supply and a switchable 54V amplifier supply. Logic voltages (ECL and TTL) are also generated on this board. All power supplies are universal input and will operate in Europe, USA or the far East.

11.2 HV POWER SUPPLY

The high voltage tube bias supply provides the static potentials required for the intensifier tube. The board contains several programmable regulators driven from a common oscillator. The voltages produced from this board are:

Phosphor 5.8kV plus MCP voltage (with current overload detection)

MCP   200-950 (single MCP) or 500 - 1800 (double MCP) factory selected.

Cathode bias
    Average   -50 to +50

Cathode bias
    Neg. clamp   -50 to +50

11.3 SIGNAL CONDITIONING BOARD

The signal conditioning board provides the following functions:

Mode selection
    RF, comb, logic or inhibit

Trigger polarity
    +ve or -ve, edge triggered for comb, level triggered for logic modes

Trigger termination
    TTL 2k2 or 50Ω, ECL 50Ω always

Trigger thresholding
    In ECL mode this is adjustable from ~-0.5V to ~+0.5V

Comb impulse generation
    The low level comb pulse width may be programmed

RF gain control
    Approximately 20dB of adjustment

Logic selection
    TTL or ECL

TTL monitor output

The low level pulser drive signal is detected and converted to TTL levels

These functions are all under software control via a system bus.This bus contains analogue and digital signals together with 24V, +5V and -5V power rails.

It contains a mixture of TTL and ECL logic together with a broadband gain controlled preamplifier for RF mode. Wideband relays are used to divert the single trigger input to the various parts of the board according to the gate mode.

11.4 CATHODE GATE CIRCUIT

The cathode gate circuit provides either impulse outputs for the comb and logic modes or the linear amplification of the input signal for RF mode. The operating conditions for this gate circuit are under internal computer control. Setting the amplifier parameters is part of the calibration procedure.
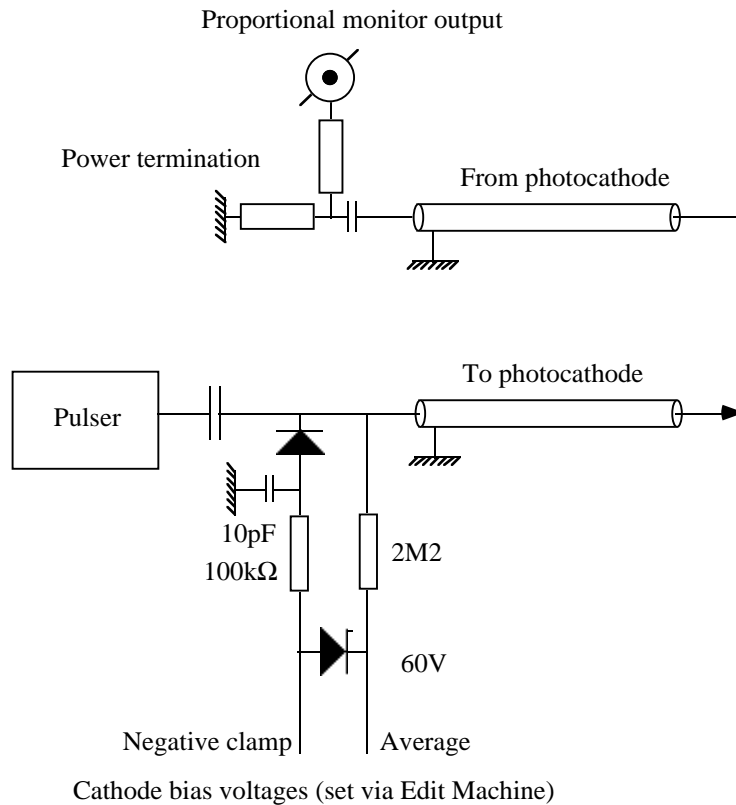
11.5 MICROCONTROLLER

The HRI is controlled by a TDS2020 Forth microcontroller based on a Hitachi H8 microprocessor. The card contains 6 12bit D-A converters which control the pulser, power supply and signal conditioning cards. In addition the microprocessor monitors the push buttons, tube temperature, phosphor current and power supply load.

Communications with the microcontroller are via an RS232 serial link. This is usually set to 9600 baud without parity.

A non volatile memory stores calibration data for the various gate modes together with use set up information.

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12   CATHODE BIASING ARRANGEMENTS

The reverse bias at the photocathode is carefully controlled to allow operation close to cut off. There are two programmable voltages "average" and "negative clamp" bias levels. These are fed the the cathode as shown below.

Proportional monitor output

Power termination

From photocathode

To photocathode

Pulser

10pF

100kΩ

2M2

60V

Negative clamp   Average

Cathode bias voltages (set via Edit Machine)

These may be edited via the machine parameter window.
Note that the hardware limits on these voltages are:

(Average - 60) < (Negative clamp) < (Average)

Setting the bias voltages outside these limits will cause no damage but will result in undefined voltage levels.

For conventional biasing (ie no peak rectification) set

Negative clamp = Average - 50 volts

13   HRI SOFTWARE INSTRUCTIONS

13.1   INTRODUCTION

The HRI software allows complete control of the operation of the instrument including editing of user parameters and machine parameters from the front panel buttons. The HRI can also be fully controlled by the RS232 interface. Certain calibration parameters are changeable only from the RS232 interface. User parameters, machine parameters and calibration parameters can be saved in EEPROM.

13.2   POWER UP

On power up the "Kentech Instruments" banner will be displayed for approx 1 second, then the display moves automatically to menu page 1. The hardware adopts mode 0 (inhibit) safe user parameters, MCP voltage set to minimum and the RF amplifier off, most positive cathode bias.

13.3   MENU PAGE 1

    Edit user...   >
    Save = no
    Restore = no
    Edit machine... >

From this menu only, if a serial character is received on the RS232 interface, the HRI enters remote control mode and displays the "remote" banner.

The cursor will be under E on line 1. Any line can be selected by moving the cursor with **up** and **down**. Pressing **right** initiates the appropriate action for each line.

Right on line 1 moves to the User Page
Right on line 4 moves to Menu Page 2

Right on line 2 moves the cursor under the n of no. To save user settings, press **yes** so that the line now reads

    Save = yes

If you really wish to save user parameters, press **left** to commence saving, Otherwise press **no** to return the display to

    Save = no

then the press **left** key. The cursor now moves back under the S of save.

Right key on line 3 invites you to restore user settings to the previously stored value in a similar manner.

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Note: the < and > characters indicate access points to other pages.

13.4 USER PAGE

User page is entered from menu page 1. All the parameters that can be edited in user page are known as user parameters. The appearance of this page varies with the operating mode selected.

There are a maximum of 29 modes:-

Mode 0 is INHIBIT, modes 1 to 20 inclusive are comb modes 100ps to 2ns inclusive, mode 21 is RF, mode 22 is logic low duty cycle (ldc), mode 23 is logic high duty cycle, mode 24 is dc, and modes 25 to 28 are user modes 1 to 4.

Generally not all of the comb modes will be available due to hardware constraints.

The mode editor is displayed on line 1 in all modes. In mode 0 (power up default) line 1 reads:-

<u>M</u>ode=INHIBIT

lines 2 to 4 are blank.

Left returns to menu page 1. **Right** moves the cursor under the I of inhibit.

<Mode=<u>I</u>NHIBIT

Up and **down** will step through all the available modes except for the comb modes, where only one one comb width is displayed. For example

<Mode=<u>C</u>omb 300ps
MCP =   0V

Trig=+,TTL,50

Right here moves the cursor under the 3 of 300ps and enters the comb editor, the **up** and **down** will step through the available comb modes. **Left** will exit the comb editor and enter the mode editor, the selected comb mode will now be the one displayed by the mode editor. **Left** again will exit the mode editor.

The MCP editor is displayed on line 2 in all modes except mode 0 (INHIBIT). To edit, move the cursor under the M of MCP using **up**/**down**, use right one or more times to select a digit then **up**/**down** to edit. Use **left** one or more times to exit the MCP editor.

Note that the cursor can only be moved up and down between the various parameters to be edited in the left hand position.

The RF gain editor is displayed on line 3 in rf and user modes. Operation is very similar to the MCP editor.

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The trigger editor is displayed on line 4 in comb, logic or user modes. Use **down** to select line 4, **right**/**left** to select the item then **up**/**down** to toggle. Use **left** one or more times to exit the trigger editor.

13.5   MENU PAGE 2

<u>A</u>mplifier setup...>
Other setup...   >

Save machine=no   >

On line 1, **left** leads back to menu page 1, **right** leads to the amplifier setup page. On line 2, **right** leads to the other setup page and line 4 invites you to save machine parameters - do not do this unless you understand the consequences.

Amplifier setup page

<G1= 3.40V, D1= 21V
 G2= 4.10V, D2= 12V
 G3= 0.00V, D3= 54V
 VS=54V VTRIG=2600

On lines 1 to 3 you can edit the bias for stages 1 to 3 in the rf amplifier. D1 to D3 are the respective drain voltages which are read and displayed for information, they are not editable directly.

On line 4, the rf amplifier supply voltage can be toggled between 24 and 54V, and the ECL trigger threshold can be edited.

This threshold is not displayed in volts. The value 2600 is roughly equal to a zero volt trigger threshold. A lower number increases the threshold voltage. A change in the count of 400 is approximately equal to 100mV.

Other setup page

<Average=+17.0V
 Clamp=-14.2V
 RF=ON Port7=123
 Comb=OFF Width 20

Lines 1 and 2 are used to edit the bias conditions of the intensifier. Lines 3 and 4 can be used to toggle the RF flag, switch on and off the comb generator and edit the comb width. The facility to set the unused bits of port 7 is editable but is not implemented.

Note that all editing actions have immediate effect on the hardware. The various parameters may be edited while the HRI is operating and while observing the effects.

13.6 REMOTE CONTROL

The RS232 uses a very simple ascii protocol to drive the Forth interpreter, very similar to the delay generator. Use 9600 baud, 8 bit data, 1 stop bit, no parity. The HRI will enter remote control mode **from menu page 1 only** on receipt of one character from the serial port. All incoming characters are put into an 80 byte buffer under interrupt control, so all command lines should be less than 80 bytes long. Command words and numbers should be followed by either a carriage return or at least one space. The HRI uses 16 bit numbers only, use numeric characters only, do not use commas or decimal points. Commands are case sensitive.

The HRI will echo each character as it is received (so a simple terminal emulator can be used) and will output "ok" after each command line successfully executed.

The following list of commands may be used to inspect and alter the user parameters:-

LOCAL	puts the HRI back into local control
!MODE	sets the mode to the preceding number
	e.g. 22 !MODE
!MCPVOLTS	sets the MCP voltage in volts to the preceding number
	e.g. 750 !MCPVOLTS
!RFGAIN	sets the RF gain in per cent to the preceding number
	e.g. 69 !RFGAIN
50TRIG	Select 50Ω trigger input termination
HITRIG	Select high impedance trigger termination
TTLTRIG	Select TTL trigger
ECLTRIG	Select ECL trigger
+VETRIG	Select positive trigger
-VETRIG	Select negative trigger
LVLTRIG	Select level trigger
LOGTRIG	Select logic trigger
.STATUS	Lists the current user parameters

The mode numbers are:

0	Inhibit
1	Unused
2 - 10	Comb modes (200ps to 1000ps)
11-20	Unused
21	RF
22	Logic (LDC)
23	Logic (HDC)
24	DC
25	User mode 1
26	User mode 2
27	User mode 3
28	User mode 4

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14   HRI VARIABLES

These are the variables as displayed on the front panel LCD. The user variables may be edited freely however only modify the machine parameters with caution as they control all features of a given gating mode. The trigger threshold (VTRIG) is the one exception as this will be required to be set at an early stage in the trigger setup of the equipment.

Modifications to the machine parameters will only be saved if **Save machine = yes** in **menu page 2**. Although modifications to machine parameters may be made in any mode without saving, and the hardware effect may be noted, they will immediately be lost if the mode is changed before saving them.

User variables:

Mode	Selects gating mode
Comb gate width	Selects gate width in comb mode
MCP gain	MCP voltage
RF gain	Approx 20dB of RF gain adjustment
Trigger	Selects ECL or TTL, +ve,-ve or level threshold,
	50Ω or 2k2 termination

Machine variables

Amplifier setup window
G1 1st stage bias
G2 2nd stage bias
G3 3rd stage bias
VS Pulser supply voltage (24 or 54 volts)
VTRIG   T mode trigger threshold (not in volts)

Other setup window
Average   Photocathode bias
Clamp   Photocathode bias -ve limit
RF ON = RF mode active
Port 7   Unused
Comb   ON = comb mode (except if RF = ON)
Width   Internal comb generator delay setting

Other internal calibration parameters which can only be accessed via a terminal:

Max MCP voltage
Min comb width setting
Max comb width setting
Phosphor current trip level
LCD bias
RF level to turn on "active" light
Intensifier temperature trip level

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15   OPTIONAL EXTRAS

15.1   Double MCP intensifier

We are able to provide a high gain double MCP intensifier for photon counting applications. For this option the power supply is fitted with a higher voltage MCP bias supply.

15.2   CCD readout

We can provide various CCD readout options ranging from cheap video format to 14 bit high resolution slow scan cameras.

15.3   Special laser trigger circuitry

A stable trigger signal is an absolute requirement for high precision time resolved measurements. We aer able to advise on or design custom trigger arrangements to suit you laser system.

15.4   Kentech precision programmable delay line

For trigger delay control the user may simply delay the low level input trigger signal feeding the front panel trigger input connector by connecting it via a Kentech precision programmable delay line (this item is an optional extra). The delay line provides 20ns of adjustment in 25ps steps and may be used at trigger rates >100MHz.

The Kentech precision programmable delay line is provided with front panel key controls and an LCD display. Delay programming is achieved by editing the LCD display with the push buttons. The unit stores the current manually programmed delay setting in non-volatile memory.

The RS232 interface provides remote control of the delay. The default RS232 baud rate is 9600. Make initial communications with the delay line with a dumb terminal (or emulator) and type HELP (CR). A complete list of functions will be returned to the terminal.

These are the HELP screens:

Type:
  HELP (CR)

 ******** Easy Help **********
 Delay range 0 - 20ns in 25ps steps
 In ABSOLUTE mode the internal base delay is included

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so the delay range is offset by this minimum delay

All numbers to be integers, no decimal points

The delay will be rounded to the nearest 25ps

All commands in upper case.

xxx PS (CR) ——————— to set delay in picosecs

?PS (CR) ——————— to read delay

LOCAL ——————— return to keypad control

VERSION ——————— to obtain the firmware version

+HELP ——————— advanced help

Type:
   +HELP (CR)

******** Advanced Help **********

RELATIVE ——————— to ignore internal base delay

ABSOLUTE ——————— to include internal base delay

CYCLE ——————— to cycle through all delays

CYCLETIME ——————— variable containing no
                          of ms for CYCLE

TESTRELAYS ——————— exercise each of 12 relays in turn

?BAUD ——————— displayed stored baud rate

xxx SET_BAUD ——————— set baud rate to 75, 300, 600,
                 1200, 2400, 4800 or 9600"
                 which will have effect after next restart

++HELP ——————— for service engineering

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16   STANDARD ITEM LIST
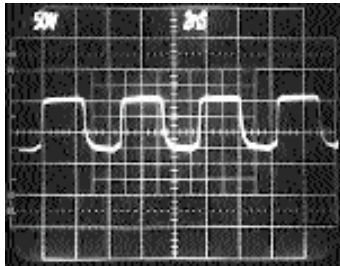
1   1 x HRI head
2   1 x HRI power supply
3   1 x power supply ac lead
4   1 x operations manual
5   Extras (if any)
    ....
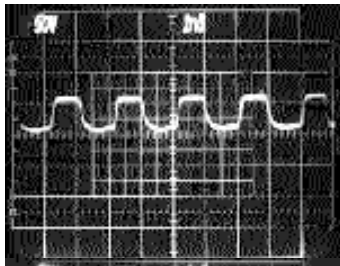   ....
    ....
    ....
    ....
    ....

Some of these items are shipped in assembled form.

Items checked by .... Date ....

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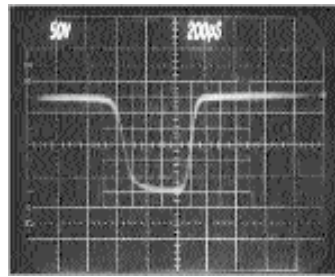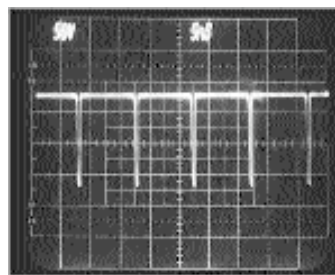## RF Modulation

200MHz

500MHz
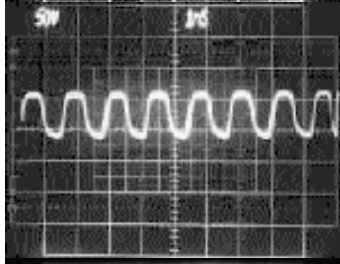
750MHz
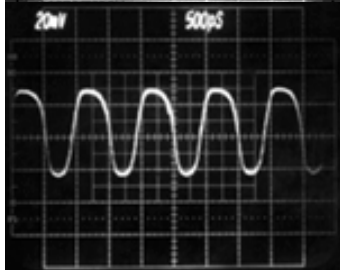
1GHz

100MHz Impulse drive
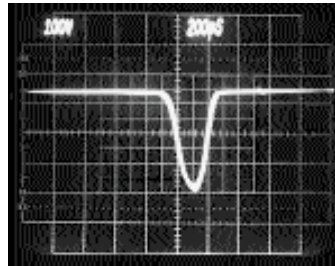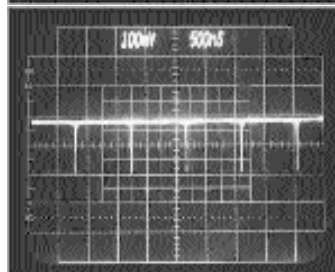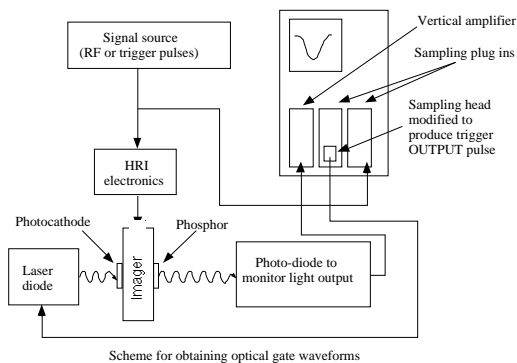
0.3ns gating at 100MHz

0.5ns gating at 100MHz

100MHz

1MHz Impulse drive

0.5ns gating at 1MHz

1MHz

Signal source
(RF or trigger pulses)

Vertical amplifier

Sampling plug ins

Sampling head
modified to
produce trigger
OUTPUT pulse

HRI
electronics

Photocathode

Phosphor

Laser
diode

Imager

Photo-diode to
monitor light output

Scheme for obtaining optical gate waveforms
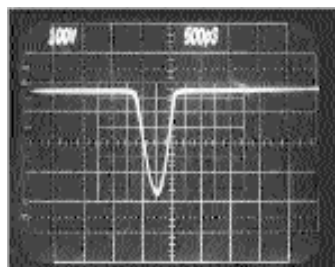
Declaration of Conformity

We:- **Kentech Instruments Ltd**
Unit 9, Hall Farm Workshops
South Moreton
Didcot
Oxon   OX11 9AG, UK

Certify that this apparatus:-

Kentech High Rate Imager

Is designed to meet the protection requirements of European Community Directives:-

73/23/EEC   Low Voltage Directive
89/336/EEC   Electromagnetic Compatibility Directive
93/68/EEC   CE Marking Directive

The following harmonised standards have been applied:-

BS EN50082-2 Generic Immunity Standard
Part 2 Industrial
BS EN 61010-1 Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use

Name: P. A. Kellett   **Signature:**   P. A. Kellett

On behalf of Kentech Instruments Ltd

Position: Director   **Issued:**   12th February 98

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