SIR – Ballistic Camera
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The innovative Specialised Imaging Ballistic Range camera has been developed using the latest available components, which have allowed improved reliability and image quality without corresponding increases in costs.

The System

Ballistic Camera

Mechanical

To produce an imaging system that will endure the harsh environment of the proofing range a rigid metal construction has been used to protect the sensitive optical components that are used for image capture. This will provide rigidity, which will both protect these components and prevent any misalignment resulting from the violent shock waves generated by the large calibre weapons from which the projectiles will be launched. Considerable thought has been channelled into shock reduction of the imaging components, as this will dramatically reduce the possibility of image degradation resulting from vibrations caused by muzzle blast.

Electronics

Using the latest family of FPGA’s, Specialised Imaging Ltd have been able to substantially increase the level of integration, thereby reducing the number of components on the printed circuit boards. Board to board interconnections have been reduced by having only two PCBs thus reducing the number of connectors. All of these factors contribute to increase reliability. Using reprogrammable FPGA’s, as the main controlling component in the Specialised Imaging Ltd design, allows the potential to redesign the digital circuitry to overcome difficulties when components become obsolete. Similarly, additional functions can be added with relative ease should they become necessary. The processor unit is also in modular form, which will allow simple upgrade should the current processor becomes obsolete.

User Interface

To make the operation of the camera as user friendly as possible, an intuitive keypad and LCD display are used for local control. An integral TFT monitor aids accurate focus and set-up eliminating the need for additional monitors. Both these features are protected by a hinged metal cover, which can be firmly latched closed during dynamic operation.
Specialised Imaging Ltd has included an integral TFT monitor in preference to an optical viewfinder for the following reasons.

- The use of an optical viewfinder is only effective for setting focus, because the dynamic range of the human eye exceeds that of any electronic imaging system, therefore it is impossible to accurately gauge exposure and gain setting. For this reason SI uses the image intensifier and CCD sensor for focus allowing the user to set all parameters that contribute to optimum dynamic recordings.
- Generally, optical viewfinders do not cover exactly the same field of view as the camera, and may also suffer from parallax making it difficult to judge image composition. Use of the camera’s image intensifier and CCD sensor for focus allows the operator to compose images with ease.

**Optics / Imaging**

The optical input has been designed to accept either Nikon F or C-mount primary optics. The changeover is achieved by substituting the alternative mount supplied with the camera to suit the user’s requirements. The high-resolution MCP intensifier is used both as a means of controlling exposure time and to provide the optical gain necessary in poor lighting conditions. This allows the user to select optimum parameters from the comprehensive software options that control both the exposure duration and gain of the system. The choice of high aperture optical coupling to the CCD sensors has been made to eliminate image degradation that would result from the interaction between fibre-optic elements and sensor pixels. Further, this avoids the “chicken wire” effects and dark spots associated with the use of fibre-optics, and improve visual appearance. Considerable attention has been directed to optimising image quality in general and resolution in particular and selecting a CCD sensor with a slightly lower number of pixels should not be considered as an impediment to this important criteria.

When considering a typical MCP image intensifier, output resolution is controlled by a number of factors, notably:

- Hole pitch (the distance between centres of the channels in the MCP)
- Phosphor grain size
- Applied voltage
- Fibre-optic (if applicable)

All of these elements will additively degrade the performance giving a typical resolution figure (for a glass-in, glass-out tube) quoted by the manufacturer of around 28 lp/mm.

The use of a 40 mm image intensifier, will gives (at best) 40 x 28 pairs of points across the diameter of the tube i.e. 1120 pairs, will correlate to the maximum number of points that can be resolved by the tube which will be 2,240; assuming that the sensor can use the full 40mm width.

In reality, it is common practise to use square or rectangular image sensors.
As can be determined from the above diagrams, the square sensor gives significantly less data points in the horizontal axis than the rectangular (this assumes that the optics optimise the sensor to the maximum diameter of the tube). In practice, it is not possible to utilise the full 40mm of the intensifier tube because of difficulties aligning the elements, so less points are available for the image sensor to view.

For the Specialised Imaging SIR-HG camera, a rectangular sensor with 1536 by 1024 picture elements has been chosen and used with optical coupling, which minimises losses of resolution and contrast that inevitably result from fibre-optic coupling. This has resulted in a good match to the intensifier and provides the optimum solution for sharp, high-contrast images.

Use of a larger number of pixels (for example 2K by 2K) would not improve the resolution of the system and in reality would probably only exaggerate the visual appearance of grain in the phosphor. Many of the additional pixels would be at the top and bottom of the image format in areas that do not normally contain useful image data.

Input / Output

Specialised Imaging Ltd recognise the need for these cameras to be easily synchronised both to the event under investigation and to ancillary equipment. To satisfy this need, four programmable flash outputs and a trigger output are supplied as standard, these are synchronised to the internal 100MHz clock. A monitor output is also provided, which is fully user programmable, to synchronise external instrumentation, such as IRIG timers, down-range camera systems, etc.

The SIR-HG triggering system provides the most comprehensive range of trigger options available. The camera can be triggered by a make/break, or a rising/falling, positive or negative voltage. The edge triggers can be terminated in 50Ω or 1KΩ, and the trigger threshold can be set between -25V and +25V. A second trigger input has been included for “Pause” mode with the same characteristic as the main trigger. “Pause” mode allows the user to capture the first image/images of the sequence with the main trigger, and then capture subsequent image/images with Trigger2. This is can be particularly useful for ballistic impact studies.

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Commercial-in-Confidence

It is recognised that some customers may already have an infrastructure in place for fibre-optic communications so Specialised Imaging Ltd offer both copper and fibre optic options. The 100Mb Ethernet standard has been chosen in preference to the higher Gigabit for the reason, that components are more widely available for the former standard, thus allowing COTS products to be used. Additionally, the Gigabit standard is still in its infancy with continuing updates being implemented it was considered more prudent to design the interface protocol on 100Mb Ethernet standards.

Flash

Specialised Imaging Ltd has chosen a supplier of high intensity light sources who has a proven track record for high quality, and reliability. The flashes that have been included with the offered system have a rugged design; conform to all relevant European legislation and an impressive list of safety features. Specialised Imaging Ltd has a good working relationship with this company, and are authorised to provide first line support and maintenance of this product.

Tripod

A heavy-duty tripod, originally designed to support radar and microwave antennas in battlefield conditions, is being offered in preference to less robust and cheaper alternatives. This heavy-duty tripod, with central spider, disc shaped feet and adjustable telescopic legs provides adequate support for the SIR-HG Range camera in proofing ground environments. A pan and tilt head is supplied to allow the user to manually position the camera through its azimuth and elevation axes. A quick release interface mechanism is used to self-locate the camera on the pan and tilt head.

Computer

The SIR software has been designed to operate on a single screen with a minimum resolution of 1024x768. There is a comprehensive suite of image reduction and analysis tools, which are not processor intensive, so a computer with a 1.2GHz or greater processor will be adequate. A laptop computer is considered the most appropriate for operating this type of equipment.
Operational Details

System Setup

The SIR-HG range camera can be used in a standalone configuration or, if required, in a multiple camera configuration where all cameras can be controlled from a single computer system.

Focus

A remote focus image can be viewed live on the PC so that the user can confirm the camera field of view before the camera is armed in preparation for a dynamic recording.

Local focus is carried out at the camera head by pressing the Focus button. As a safety precaution, when entering focus mode, the exposure and gain are set to minimum. The user must set gain and exposure values to obtain a viewable image on the integral TFT screen before adjusting the objective lens. As an added precaution, the focus mode will automatically timeout after five minutes of inactivity.

PC control

The software will operate under Windows 2000 or XP professional. Both graphical and text methods of data entry will be offered to the user; either method is valid according to individual preferences. Zoom and pan controls are available to aid image manipulation using built-in functions. A control panel giving the user, immediate access to Arm, Focus, Gain, and Trigger controls is always visible. All camera setup, alignment, and calibration can be archived in a format that can be imported into other software packages. Depending on the configuration of the software, up to 8 cameras can be controlled from a single computer.

Image acquisition process

The most important operation for a range camera system is capturing the dynamic image. The most common cause of image failure is the trigger, followed closely by the operator failing to arm the camera. If the arm control is buried under layers of menu, then it is possible that the user cannot get to the correct screen/menu in time. With the SIR-HG system the Arm button is always on top and always in a set position. However, as an extension to this an auto-arm function has been included. In this mode once the camera is triggered the image is automatically stored and the camera rearmed. The user can choose between a fixed number of shots or continuous rearming.
Support and Service

It is a company policy for all staff to respond immediately and positively when faced with customer enquiries, and to provide as much support as possible to overcome problems experienced by users. Specialised Imaging Ltd believes that a prime contractor has the responsibility to service and support any third party products supplied to a customer as part of a system. To this end, wherever possible training and technology transfer regimes are arranged with suppliers to enable Specialised Imaging to provide first-line support for all deliverables.

In common with all Specialised Imaging Ltd products, there is a high level of self-test, system monitoring and diagnostic procedures built into the circuitry and software of the SIR-HG camera. These built-in self-test facilities allow most faults to be quickly identified. The system is largely modular in design, and therefore most repairs can be carried out very quickly by replacing the appropriate module and, provided that the parts are available, most repairs can be completed within two or three hours by appropriately skilled technicians.

Obsolescence

The Specialised Imaging range camera is an all-new design utilising the latest components wherever possible in order to leverage the best performance from state-of-the-art electronics. Specialised Imaging is fully aware of the impact of obsolescence on the maintainability of expensive equipment, and will constantly monitor the availability of parts used in all products. In the event that components become obsolete or difficult to obtain, it is our policy to identify replacements and, where this is not possible, to maintain an adequate stock of these parts to fulfil the expectations of existing customers.

Capabilities

Specialised Imaging Ltd has a fully equipped machine shop, which includes 3-axis CNC Milling machines, which allow us to respond quickly to customer’s special requirements and to manufacture custom components with high precision and quality. The In-house design team is also available to design electronic systems and sub-systems on a contract basis using state-of-the-art FPGA and PCB design tools. Embedded and PC (MMI & analysis) software can also be written as a system or sub-system for external contracts using a range of C compilers and Windows development tools.

We have invested heavily in the test, manufacturing and service areas of the business to ensure that all necessary equipment is available to our engineers. This includes surface mount PCB rework equipment, high-end oscilloscopes, and specialised tools for high voltage electronic design and service.

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Ballistics

Detonics

Plasma

Impact studies

Combustion research

Low light machine vision system

Elasticity, crack propagation and shock resistance

Medical testing and research

Spray and particle analysis

Nanotechnology and micro-machines

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