# DAC-004
# DIODE LINE CAMERA
## Sensor Operating Manual
### For Multi Edge Detection Using
### Virtual Scope Configuration Software

**DAC-004 DIODE LINE CAMERA**

## Copyright

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# 1    CAMERA FUNCTION AND DEFINITION OF TERMS

## Introduction

The DAC-004 is another camera-based sensor in Fife's arsenal of sensor technologies. The camera is designed for use in the guiding industry to detect edges of a material or lines printed on the material. It can also be used in conjunction with guiding to monitor web width or as a stand-alone web width monitoring system. The camera is capable of detecting opaque or partially transparent material and can be used in applications with back lighting or front lighting. The camera has both analog and digital outputs as well as a serial connection to a PC computer for customization.

The DAC-004 diode line camera is backwards compatible with its predecessor the DAC-003. The DAC-004 contains many new features and can be customized in the field by using a serial connection to a PC computer and running **Virtual Scope** configuration software. **Virtual Scope** is a **Windows ®** based software configuration tool that provides all the controls needed to calibrate, configure, upload/download parameters, install, and troubleshoot the DAC-004 camera.

**NOTE:**
This sensor operating manual is to be used by servicing agents and operators to facilitate commissioning, operation and maintenance of the DAC-004 diode line camera. This manual provides important information in the proper use and setup of camera system and must be read by any person before they perform adjustments.

Along with this manual, use the configuration Software User Manual, Figure Sheet 1-873 for the proper installation. The configuration software will allow you to calibrate, configure, upload/download, and troubleshoot the DAC-004 camera.

## Description of Camera

The diode line camera is comprised of the camera housing, the lens and the protective tube. In the camera housing there is a CCD chip with over 7450 light-sensitive diodes (photodiodes). These photodiodes are arranged adjacent to each other in a row or line; hence the name "diode line camera". As in a photographic camera, the lens is used to adjust the focal length, aperture and distance. See Figure 1 below for camera assembly.

**Figure 1** – *DAC-004 camera assembly*

1. Protective Tube
   (for lens)
2. Self-locking Nut
   (M4) X4
3. Retaining Ring
4. Securing Screw
   (M5 x 5) X4
5. Rubber Ring
6. Threaded Rod X4
7. Focus Ring
   (28 – 80 lens)

   Focus/Zoom Ring
   (70 – 210 lens)
8. Nut (M4) X8
9. Zoom Ring
   (28 – 80 lens)
10. Aperture Set Ring
11. Mounting Bracket
12. Alignment Mechanism
13. Locking Screw X3
14. Camera
15. Arrow
    (for direction of scanning)
16. Desiccant Cartridge
17. Mounting Screw
    (M6 x 125) X4
18. Clamping Screw X2
19. Alignment Screw X3

## Mode of Operation

The DAC-004 camera is used to record an edge transition from light to dark or vice versa.  The camera has the capability to record multiple edges for center guiding or if the web width is larger than the FOV the cameras can be used in pairs to center guide.  There are two methods of using the camera with light sources, Direct Lighting *(Figure 2)* or Reflective Lighting *(Figure 3)*.  A high frequency ballast is used for the light source which guarantees an interference-free camera signal.

**Direct Lighting** – In these applications the camera is mounted across from the light source with the material between them.  The camera must be aligned so that light falls onto all photodiodes. When the material web covers part of the lamp assembly a corresponding number of the photodiodes are no longer exposed. The edge output signal changes in relation to where this transition occurs.

**Reflective Lighting** – In this mode the camera is mounted on the same side of the guided material as the light source and looks at the pattern of reflected light. In this configuration the camera could detect the edge of the material or a change in light intensity being reflected off the material itself.  Light intensity changes could be caused from different colors or materials with varying degrees of reflectivity.
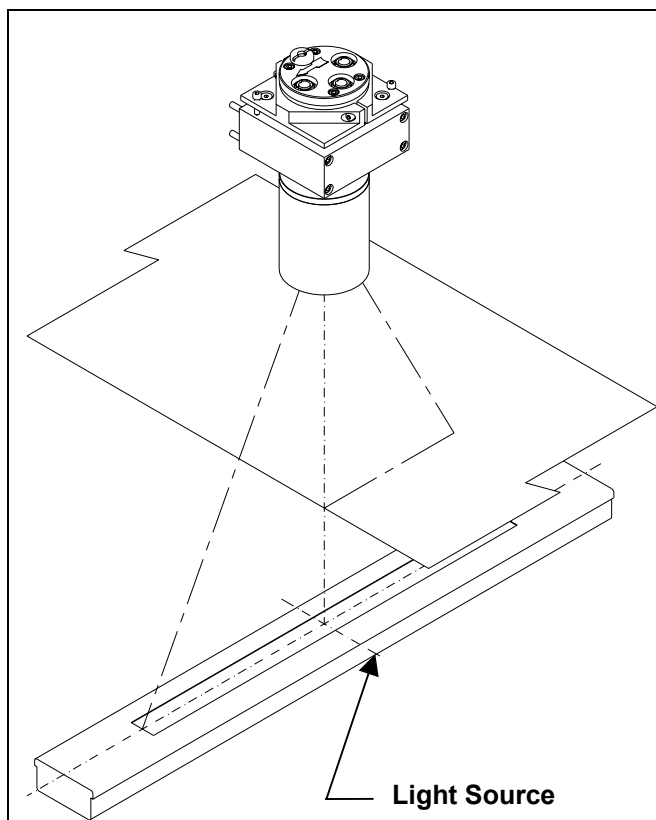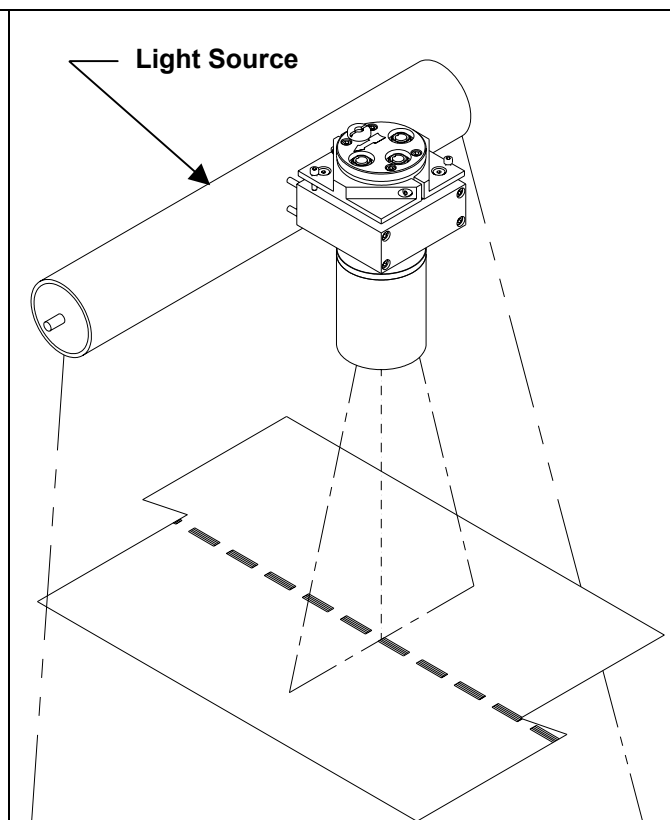


**Figure 2** – *Direct lighting*



**Figure 3** – *Reflective lighting*

## Field of View (FOV)

The field of view (FOV), and thus the resolution of the camera, is dependent on the distance of the camera from the material web, and the focal length of the lens. If a zoom lens is used the FOV can be changed by adjusting the focal length of the lens, leaving the physical distance from the camera to the web unchanged. Short focal lengths, such as 35 mm (corresponding to a wide angle lens), produce a large FOV. Long focal lengths, such as 210 mm (corresponding to a telephoto lens), produce a smaller FOV.

A custom drawing is produced for each application, detailing the following data:
- Distance from camera to material web
- Distance from camera to light source (back lighting)
- Distance from light source to material web (front lighting)
- Field of View (FOV)
- Direction of scanning

## Aperture and Exposure Time

The photodiodes require a certain amount of light (intensity). This amount of light can be altered with the aperture and the exposure time. The aperture is an adjustable window on the camera that determines how much light is let into the camera. The smaller the aperture value the larger the window size. For example, an aperture of 5.6 allows a greater amount of light into the camera than an aperture of 16.
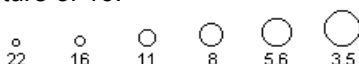


The settings of the aperture and the exposure time are mutually dependent. Therefore, as more light is let into the camera by the aperture the shorter the exposure time needs to be. If too much light strikes the photodiodes, the camera signal is overshot. The exposure has a time range from 45 ms to 1.585 ms and can be set automatically, externally or through software configuration.

## Edge Detection

Any transition across the voltage threshold from light-to-dark or from dark-to-light can be interpreted as an edge. The software configuration tool will be used to discriminate which transitions constitute a valid edge. The camera can detect up to 254 edges, but only four edges are selectable for output over FifeNet and only two of these are available as an analog output. Both analog outputs have a signal of (0 - 10 mA) as determined by the position of the edge in the camera Field of View.

## Direction of Scanning

An arrow on the rear of the camera housing indicates the physical scan direction. There are two output modes A & B. Both A and B output modes can detect two edges each, one edge from the Start of Scan (SOS) and one from the End of Scan (EOS) for a total of four detected edges. Each output mode is tied to an analog output. The analog outputs are configured to use either the SOS or EOS value of each mode. Using the digital output over the FifeNet protocol all four edges are available.

## Width

The width output is the distance between the two edge values used for analog output. This width signal is proportional to the number of photodiodes between the edges and the FOV at this location. For a more accurate width measurement a calibration template should be used to linearize the sensor.

## FifeNet

FifeNet is an RS-485, half-duplex serial communication utilizing Fife's proprietary protocol. Primarily used to interface with CDP-01 processors or SBPC's (Serial Bus Protocol Converters). FifeNet can be used to output setup parameters of the camera as well as edge outputs and width. The camera parameters can be changed by sending commands over FifeNet.

## Calibration

Performing the linearization with a calibration template aids in width measurement by compensating for lens aberrations and parallax. This has no affect on guiding accuracy. Therefore, performing linearity calibration is only necessary to improve accuracy in width measurement.

## Connector Configuration

The connectors that are shown in Figure 4 are used in different configuration setups for the DAC-004.  The list that follows explains their primary function and use.

**X1** (analog): - Primary connector for single edge output.
- Width output.
- Dual edge output with software configuration (no width).
- Configuration via INTB-30.

**X2** (analog): - Secondary connector for second edge output.
- Width output.
- Camera configuration via PC and Virtual Scope
- Configuration via INTB-30.

**X3** (digital):   - FifeNet



**Figure 4** – *DAC-004 rear view*
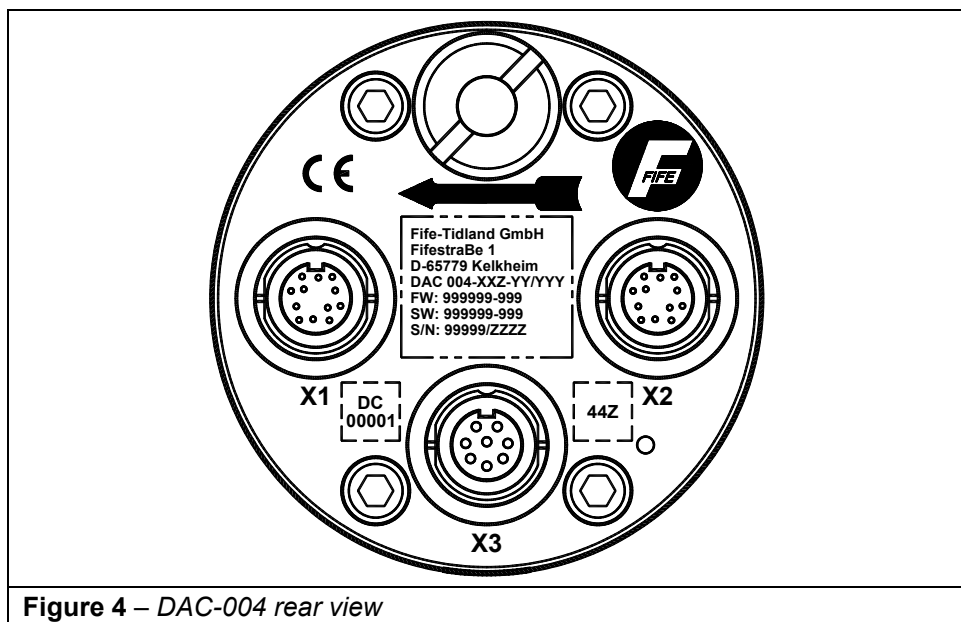
## Connector Pin–out

| X1 | |
|---|---|
| **Pin** | **Description** |
| A | Video Out |
| B | Edge A |
| C | Threshold A |
| D | *None* |
| E | Exposure |
| F | Joker A |
| G | Width * |
| H | 10-27 V dc |
| J | 10-27 V dc |
| K | Ground |
| L | Ground |
| M | Ground |

| X2 | |
|---|---|
| **Pin** | **Description** |
| A | Video Out |
| B | Edge B * |
| C | Threshold B |
| D | RS-232 TXD |
| E | RS-232 RXD |
| F | Joker B |
| G | Width |
| H | 10-27 V dc |
| J | 10-27 V dc |
| K | Ground |
| L | Ground |
| M | Ground |

| X3 | |
|---|---|
| **Pin** | **Description** |
| 1 | 10-27 V dc |
| 2 | RXD- |
| 3 | RXD+ |
| 4 | 5 V dc |
| 5 | TXD- |
| 6 | Ground |
| 7 | *None* |
| 8 | TXD+ |

**\*** The Width on X1 (pin G) and Edge B on X2 (pin B) can be switched via software.

**Video Out** = Video signal for oscilloscope input
**Edge A & B** = 0 – 10 ma
**Threshold A & B** = Input from module
**Joker A & B** = Input from module
**Exposure** = Automatic mode: 0 – 10 ma output
                 Fixed mode: Input from module
**Width** = 0 – 10 ma
**RS-232 TXD & RXD** = 115000 baud
**RXD-, RXD+, TXD-, TXD+** = FifeNet transmit and receive

# 2    INSTALLATION

## Installing the Camera Unit

A custom drawing is produced for each application, detailing the following data:
- Distance from camera to material web
- Distance from camera to lamp assembly
- Field of View (FOV)
- Direction of scanning

The installation of the camera system is based on this drawing.

*NOTE:*
*The cameras are calibrated and tested prior to shipment on the basis of the installation and camera drawings (focal length, aperture and distance). If these data are maintained on installation, only the alignment of the camera to the measuring field lamp will need to be checked at the commissioning stage.*

## Attachment

**Mounting**

The camera attaches by the mounting bracket (11) as shown in Figure 1.  The mounting bracket has an alignment mechanism (12) to align the photodiodes of the camera parallel to the light source.  When installing cameras the lens adjustment and the direction of scanning are also relevant.  The direction of scanning is indicated by the arrow (15) on the rear of the camera housing.

To mount the camera (as shown in *Figure 1*):

a)  Attach the mounting bracket (11) with the four mounting screws (17).

b)  Insert the camera (14) into the bracket (paying attention to the direction of scanning).

c)  Secure the camera with clamping screws (18).

d)  Attach and tighten the connecting cable(s).  Refer to the System Block drawing.

e)  Replace the desiccant cartridge (16) when it turns pink.
(FIFE part no. 529217-002)

**Dismounting**

On dismounting, measure and note the distance between the rear edge of the camera and the bracket, as well as the direction of scanning (arrow).  The camera is dismounted in reverse order to the order of mounting

**DAC-004 DIODE LINE CAMERA**

# 3    COMMISSIONING

## Requirements

To obtain optimum guiding, the camera must be aligned precisely to the lamp assembly.

The camera must be mounted as detailed on the installation drawing.

The arrow on the camera body indicates the direction of scanning. Align the camera so that the arrow runs parallel to the lamp assembly.  The lamp assembly must be mounted at right angles to the direction of running of the web *(Figure 5)*. It is recommended that guiding configurations with two cameras have either **both** arrows pointing toward the center of the plant or **both** arrows pointing outward.



**Figure 5** – *Top view: Diode line camera and measuring field lamp*
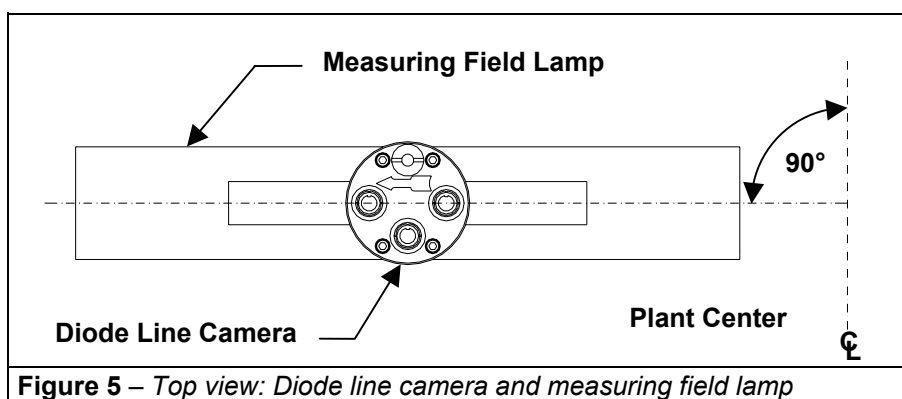
There must be no objects in the field of view of the camera.  All photodiodes must be receiving as much light as possible.  If the web is covering part of the camera field of view, the web must be removed.  Narrow webs can be shifted as appropriate.  If a test material is used during camera setup, the test material must be positioned at the same distance from the camera as the regular material web.

A serial RS232 connection is required from a PC serial port to the DAC-004 X2 port to run the Virtual Scope software to configure and align the camera as required.

*NOTE:*
*Start the Virtual Scope software program to aid in commissioning the camera (DAC04Tool.exe).  Each time you open the program it loads in default values. You should upload to the PC from the camera or from a file before making any changes so you can work from the current camera configuration.*
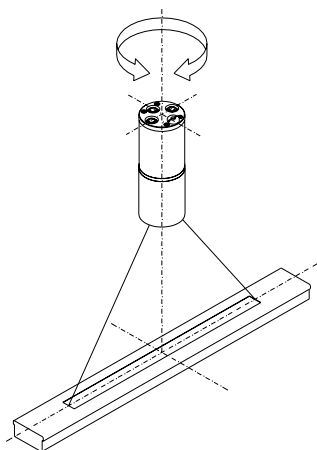
## Aligning the Camera

**Aligning the camera parallel
to the lamp assembly**

Use the Scope to view DAC-004 signal.

Press the Run/Stop button to start acquiring pixel data.

The horizontal controls allow different portions of the signal to be viewed in more detail, but for this adjustment, the entire signal needs to be visible. Insure that the horizontal pixels/div setting is set to 760 or greater and the Delay value is –128 (see *Figure 6*). These settings are displayed at the bottom of the 'scope' window. Adjust the 'Pixels' or 'Delay' sliders as required. Clicking the Reset button will set them to these values. See configuration software Figure Sheet 1-873 for more information.

Uniform illumination of the photodiodes produces a virtually horizontal bright-level characteristic on the oscilloscope screen (*Figure 7*). An oblique characteristic (*Figure 6*) means that the photodiode line is not aligned parallel to the lamp assembly. Loosen clamping screw (18) as shown in Figure 1 and rotate the camera in its fixture until the video signal improves, then retighten screw.
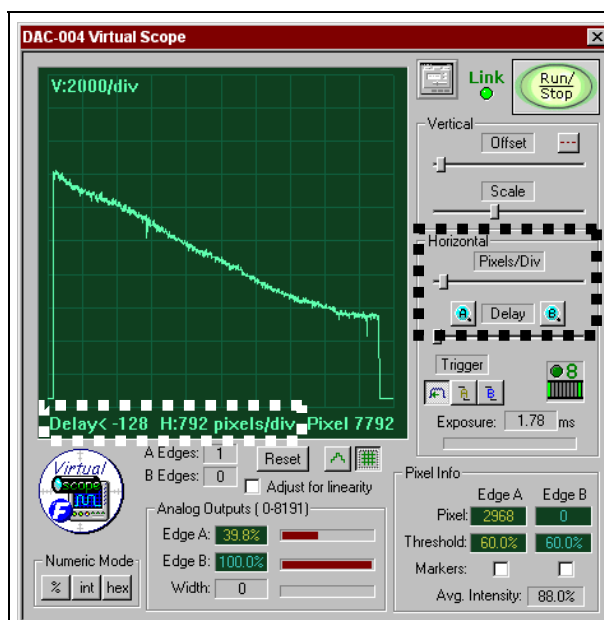


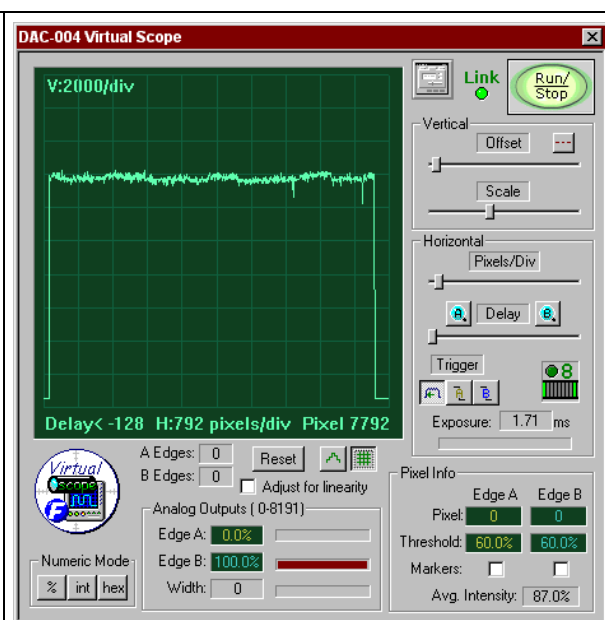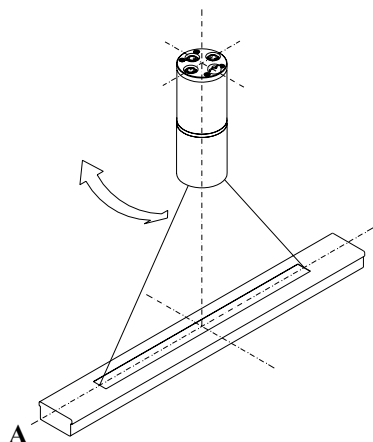**Figure 6** - *Not parallel to the lamp assembly*



**Figure 7** - *Parallel to the lamp assembly*

## Aligning the camera on the A axis



Check that the camera is aligned to the center of the lamp assembly (maximum brightness).  Unscrew the three locking screws (13), as shown in *(Figure 1)*, then use alignment screws (19) to tilt the camera on the A axis.  If using automatic exposure adjust until exposure time is the shortest, if fixed exposure is used adjust until the video signal has reached its maximum amplitude.  Carefully screw in locking screws (13) to their full extent and then tighten in crisscross sequence.

## Aligning the camera on the B axis (optional)
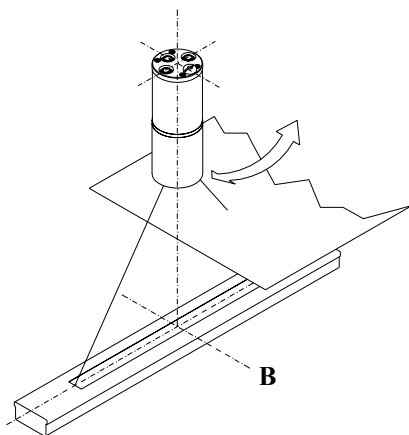


The lens adjustments for the aperture, focus and zoom should be completed on the following three pages before performing this procedure.

Extend a plumb line from the center of the camera fixture mount and place the web edge against this line. The edge output on the Virtual Scope in integer format is (0 ... 8191).  Unscrew the three locking screws (13), as shown in Figure 1, then use alignment screws (19) to swivel the camera on the B axis until the output is near 4096.  Carefully screw in locking screws (13) to their full extent and then tighten in crisscross sequence.

## Adjusting the Lens

The protective tube (1) must be removed first as shown in Figure 1 in order to access the lens. The lens adjustment of the aperture, field of view, and focus should only be performed if the settings of the camera are not adequate for the installation. On orders for complete systems the camera lens is set prior to shipment. For parts orders the camera will need to be set at the customer location according to the following procedure.

**Adjusting the aperture**

The exposure indicates the amount of time that light is allowed to collect on the CCD array between scans. The camera output can only respond as fast the exposure time, so smaller exposure times produce a faster camera output response. The 'Exposure' time in milliseconds is located at the bottom of the horizontal controls. For guiding purposes this time should be as short as possible and should not exceed 20 (ms). Adjust the aperture by turning the aperture set ring (10) as shown Figure 1. An almost square signal will be seen on the Virtual Scope when the aperture is set correctly (see *Figure 9*).

**Automatic─** For automatic exposure adjust the aperture until the exposure time is the shortest without saturating. If the photodiodes receive too much light the aperture is too large for the current exposure time as in Figure 8. To adjust the amount of light, rotate the aperture ring on the camera. The smaller the number on the aperture ring the more light is let into the camera. Set the aperture to the lowest number without saturating the signal in Figure 9.

**Fixed─** For fixed exposures adjust aperture until the desired Average Intensity is reached (default is around 85%) or to the highest Intensity possible if desired intensity is not achievable.
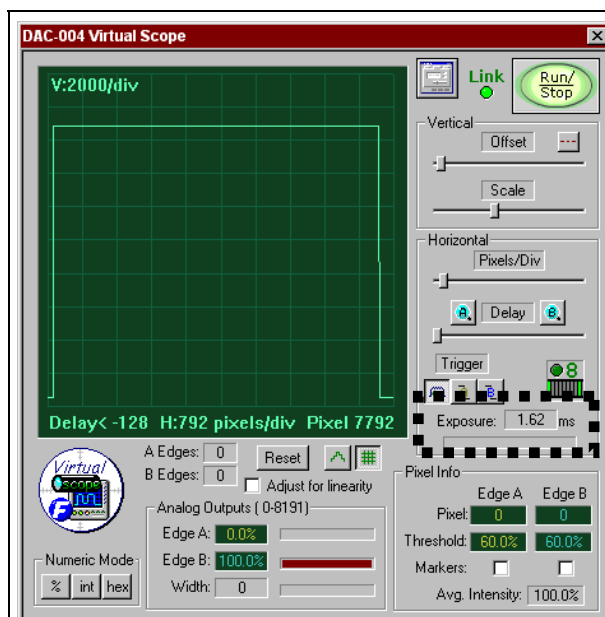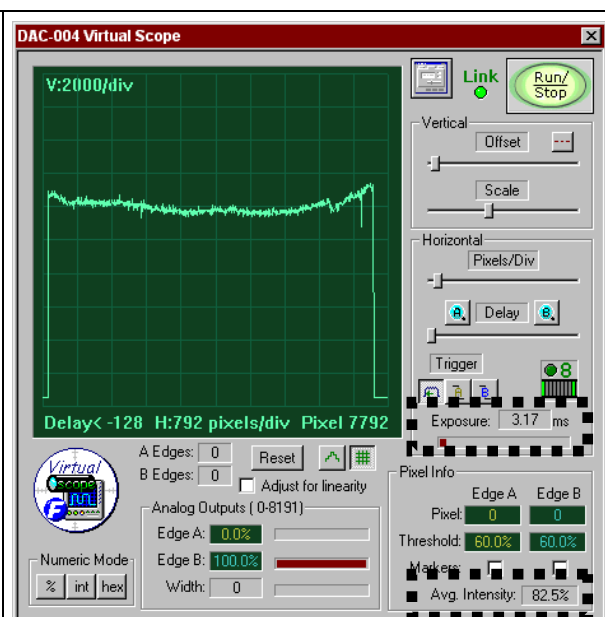


| **Figure 8** – *Signal saturated* | **Figure 9** – *Signal not saturated* |

**Adjusting the Field of View
(focal length - zoom)**

Loosen nuts (2) and (8) as required to move the zoom ring in and out.

Move the pixels/div and Delay slide all the way to the left or select [Reset] button to set the scope parameters for performing Field of View (FOV) adjustment. Insure that the horizontal pixels/div setting is set to 760 or greater and the Delay value is –128.

The Field of View (FOV) should be set slightly larger than the widest width of material. A test material slightly narrower than the desired camera FOV is required. The test material is placed in the center of the FOV in Figure 10, so that both edges are visible on the Virtual Scope, in Figure 11. The test material must be at the same distance from the camera as the regular material web.
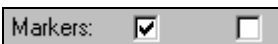
Change the FOV with the zoom ring (9) or (7) on the lens in Figure 1 depending on which lens is used.

If the automatic exposure time is also used to monitor lamp contamination, it must be ensured that the FOV is not set too small, as otherwise too little light will strike the photodiodes. The exposure time should not reduce significantly in relation to the video picture with no web.

Retighten nuts (2) and (8).



**Figure 10** – *Camera drawing*          **Figure 11**
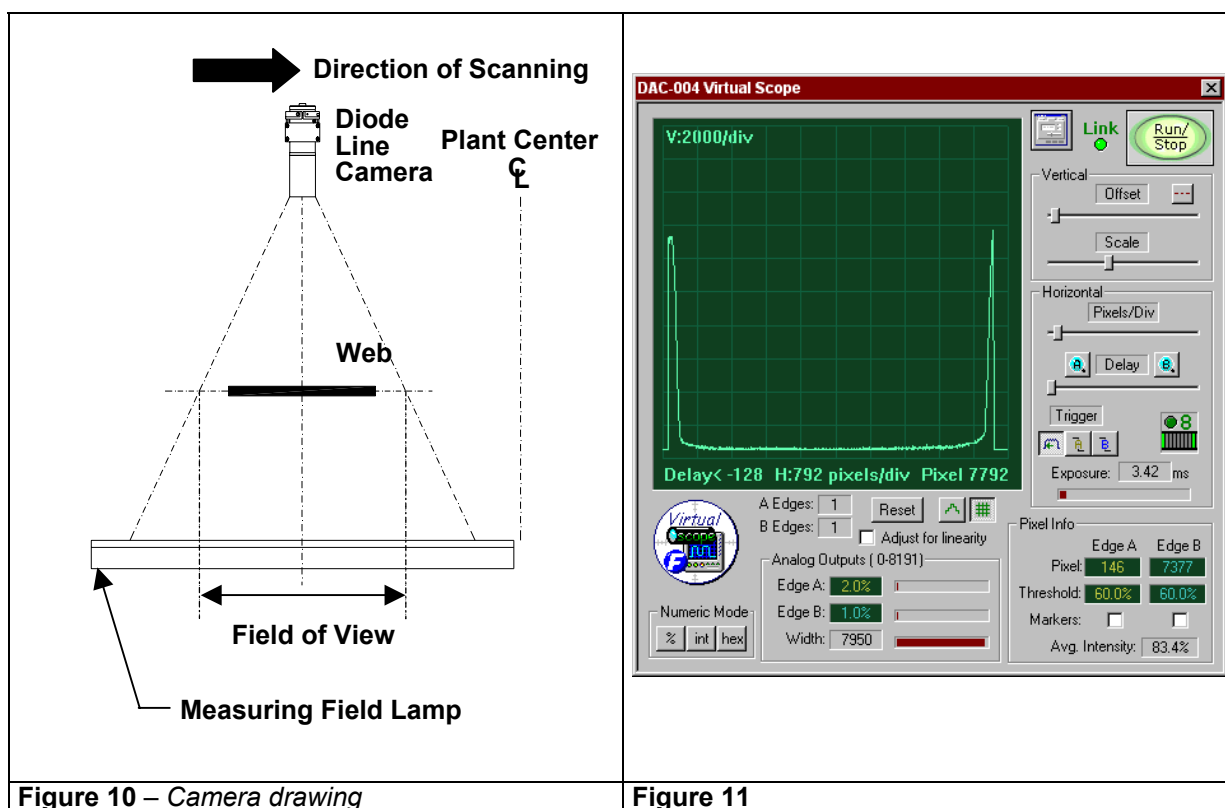
**Adjusting the distance setting (distance - focus)**

1. Unscrew securing screws (4) before beginning these procedures.

2. [icon] To focus the camera put the Virtual Scope in pixel view.

3. Markers: ☑ ☐ Turn on the "Marker" signal for the desired slope.

4. [Pixels/Div slider] Set the Pixels/Div slider all the way to the right so that the pixels/div is set to 5.

5. [A Delay B slider] Then select the A or B trigger corresponding to the marker selected in step 2 above. This will automatically set the trigger to the desired slope.

6. Adjust the focus ring on the lens (7) in Figure 1, to achieve the steepest slope as shown in Figure 13.
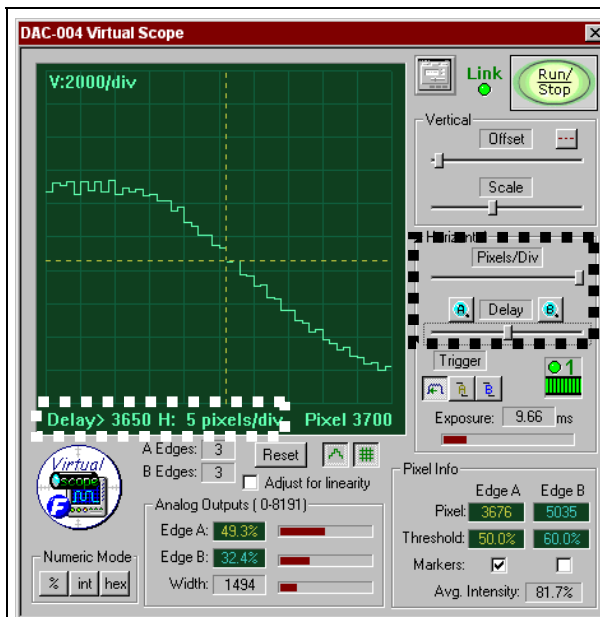
7. Retighten securing screws (4).
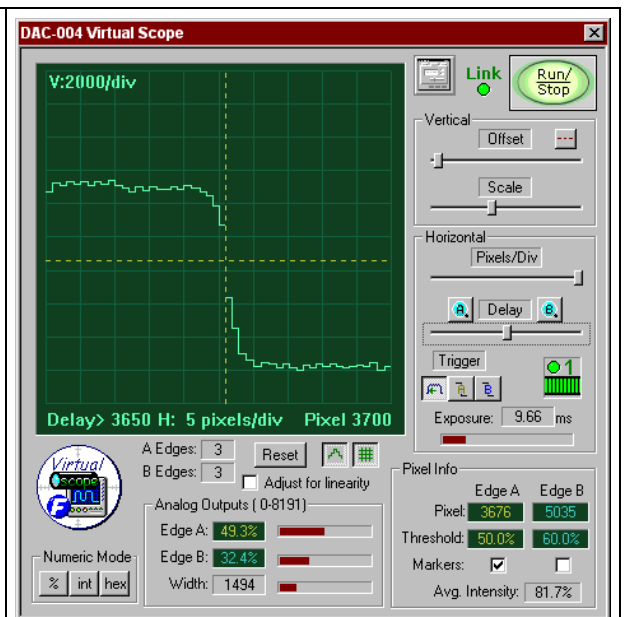


**Figure 12** - *Camera out of focus (pixel view)*

**Figure 13** - *Camera focused (pixel view)*

## Linearization Calibration

Linearization only needs to be performed if the width output is going to be used.

A serial connection from the PC running the Virtual Scope calibration software to the DAC-004 and a calibration template larger than the Field of View is required to perform the linearization process. *NOTE: If a software kit or calibration template did not come with your system they can be obtained from Fife.*

**1.**  The DAC-004 camera lens must be aligned and configured using Virtual Scope configuration software before the linearization process can be preformed. First place the calibration template at the same distance from the camera as the web.



**2.**  Select the Linearization button from the Main screen of the Virtual Scope software to start the calibration.
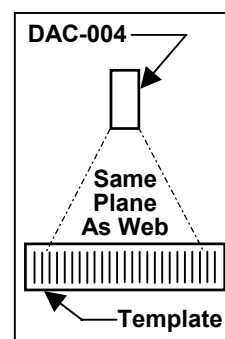
**3.** Select the ▢ Linearize ▢ button. The calibration routine will run and return data like the example shown below.



The calibration template consists of 254 lines of a given thickness with the gap between the lines of the same thickness. The Pixels/Target line is the distance from the beginning of one line to the beginning of the next line. With this information you can determine the actual FOV of the camera.

$$FOV = (linewidth + gapwidth) / PixelsPerTargetLine * 7450$$

 If FifeNet is being used to communicate with the camera and the Edit/View button is checked "yes", you can enter the scale factor of the template to get a unit adjusted output. If you enter in the scale factor X 1000 this will give you an output to three decimal places. If the scale factor is 0.096 inches enter 96.

 You can view this unit-adjusted output by selecting the Variables button from the Main menu of the Virtual Scope software.
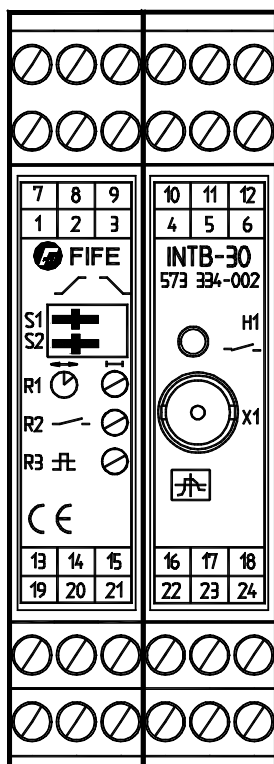
 Therefore the Width of 8883 is equivalent to 8.883 inche.

# 4    ADJUSTMENT MODULES

**Setting the INTB-30
Adjustment Module
(FIFE Part-No. 573334-00Z)**

**Operating elements**



| **Switch:** | S1: JOKER control |
| | S2: Automatic exposure system |

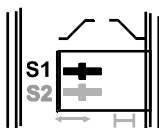| **Potentiometer:** | R1: Exposure time setting |
| (fixing screw) | R2: Alarm threshold for exposure time |
| | R3: Trigger threshold |

| **BNC jack:** | X1: Video signal (output) |

| **LED display:** | H1: Contamination monitoring |

**Joker control**

Switch S1 determines the value of the analog output signal if the web edge has left the camera range.  The scanning direction must be noted for this.



• Scanning direction towards the center of the system:

Without web (field of view free):       analog signal =  10mA
With web (field of view covered):      analog signal =  0mA
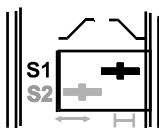


• Scanning direction away from the center of the system:

Without web (field of view free):       analog signal = 0mA
With web (field of view):                  analog signal = 10mA

**Exposure time**
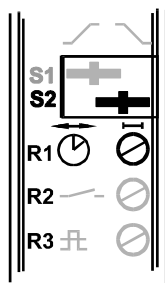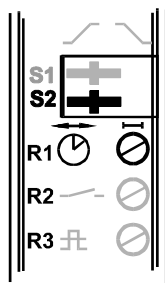
With switch S2 it is possible to select between manual setting of the exposure time and an automatic exposure time system (see *Aperture and exposure time* on *Page 1-4*).



- Manual exposure time:
  Potentiometer R1 is used to set the exposure time manually.



- Automatic exposure time with limit:
  The limit of the automatic exposure time is adjusted with potentiometer R1.

**Monitoring of contamination**

The exposure time is also used for monitoring of the camera and measuring field lamp for contamination.  These signals are present on terminals 9 and 11.
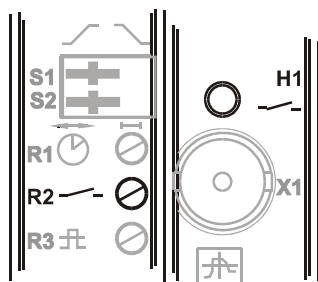


Contamination of the camera and the measuring field lamp are indicated by light diode H1.

The alarm threshold for initiating contamination monitoring can be set individually with potentiometer R2 depending on the web material and the environment.

To set the alarm threshold with R2, the camera and measuring field lamp should be contaminated with the appropriate amount of contamination.  If it is not possible to contaminate them, the manual exposure time setting can be used to simulate the reaction of the camera to contamination.

*NOTE:  Follow these steps to simulate the contamination procedure.*

a.) Set switch S2 to 'Manual exposure time'

b.) Set the exposure time according to the desired alarm threshold for contamination monitoring with potentiometer R1.

The factory setting for the alarm threshold is about 22ms, control value on terminal 5 = 5V

**c.)** Set potentiometer R2 so that light diode H1 displays the switchover point

**d.)** Set the exposure time back to the previously set value with potentiometer R1 (generally as far as possible to the right, thus for the maximum exposure time)

**e.)** Set switch S2 to the desired function. (generally for the automatic exposure time)

**Signal threshold**
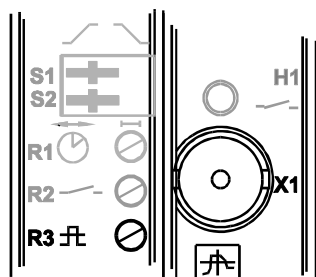


The threshold for the bright-dark rating of the photo diodes is set with potentiometer R3. The signal threshold can be verified with an oscilloscope on BNC jack X1. A measurement signal can be generated for this purpose by partially covering the camera directly on the lens (See *Figure 14*).

**Circuit diagram**
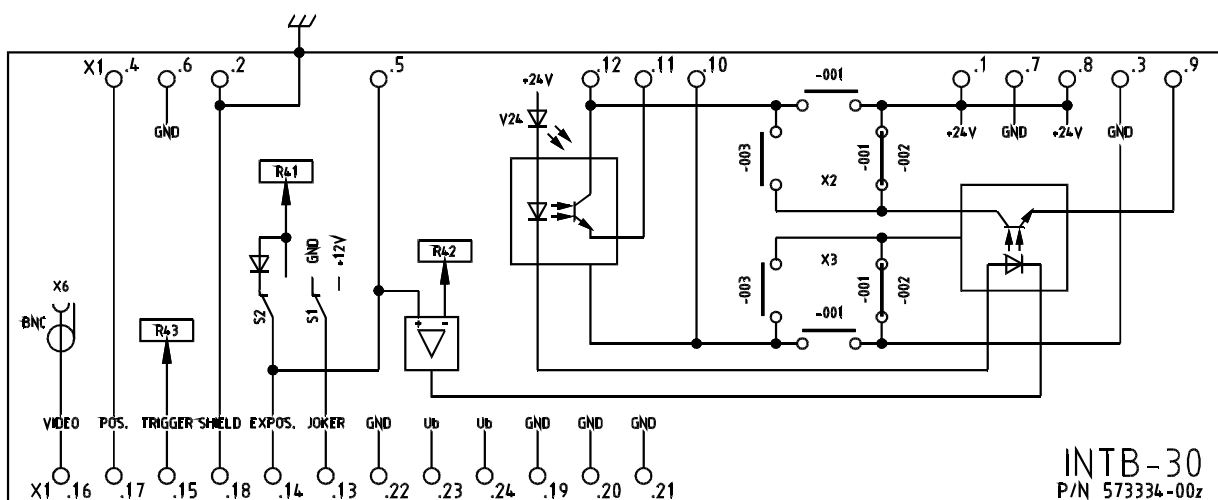


The variable z in the FIFE Part Number describes the assignment of the jumpers in the circuit diagram.

**Assignment of the terminals**

**Terminals 1 through 12: Control box connection**
(Corresponds to terminals 1 through 12 on the front side of the module)

**1.**   Supply voltage (+24V)
**2.**   Connection for cable shielding
**3.**   Ground (GND)
**4.**   Camera output based on edge position (0–10mA)
**5.**   Exposure time
**6.**   Ground (GND)
**7.**   Ground (GND)
**8.**   Power supply (+24V)
**9.**   For Version 573334-003 potential-free, for versions 573334-001 and -002 potential-bound switch output for exposure time errors
**10.**  Power supply (ground) for terminals 11 or 9
**11.**  For versions 573334-002 and -003 potential-free, for version 573334-001 potential-bound switch output for exposure time errors
**12.**  Power supply (ground) for terminals 11 or 9

**Terminals 13 through 24: Camera connection**
(Corresponds to terminals 13 through 24 on the front side of the module)

**13.**  JOKER control
**14.**  Exposure time:
        Input for automatic exposure time
        Output for manual exposure time
**15.**  Bright-dark threshold
**16.**  Video signal
**17.**  Camera output based on edge position (0–10mA)
**18.**  Cable shielding
**19.**  Ground (GND)
**20.**  Ground (GND)
**21.**  Ground (GND)
**22.**  Ground (GND)
**23.**  Power supply (+24V)
**24.**  Power supply (+24V)

# 5    TECHNICAL DATA

## Product Specifications

**Nameplate**
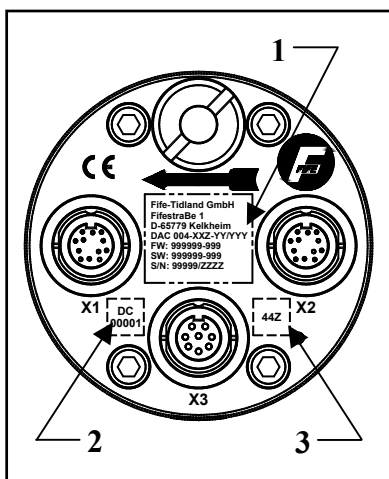
**The following information will be found on the nameplate:**

**1.**    Address Fife-Tidland GmbH

DAC 004-XXZ-YY/YYY: model designation
XX = CCD Distance, mm (44, 52, 60, 68, 74, 82)
Z = Cylindrical Lens (No – blank, Yes – 1)
YY/YYY = Zoom Lens, mm (28/80, 70/210)

FW: revision number of the firmware

SW: software number

S/N: serial number/year of construction

**2.**    Serial number
(Identification code DC and 5-digit number)

**3.**    Model number

**Protection type**

Classified as per IP 67 (DIN 40050)

Plug connectors that are not used must be closed off with a blind stop.

**Operating temperature**

0 - 55°C

**Ambient conditions**

Non-condensing

**Output signal**

Analog: 0 - 10mA
Digital: 16-bit

**Power supply voltage**

12V - 24V (max. 245 ma)

**Dimensions**

For customer-specific dimensions, please refer to the customer drawing.

**Standards**

The DAC-004 camera has been constructed according to the standards and regulations of the European Union.  A declaration of conformity is available on file.

EMC test based on:
EN 55011
EN 61000-602

**Options**

Adjustment module INTB-30
Drawing number 573334-00z

Adjustment module
Drawing number 585274-001

**Replacement part**

Desiccant cartridge M134973

**Accessory**

Test adapter VPA-01 M135871
Signal cable for connecting the oscilloscope

**Calibration templates**

Currently Available
69898-001    FOV up to 253.500 mm [9.9803 in.]
69898-002    FOV up to 380.250 mm [14.9705 in.]
69898-003    FOV up to 507.000 mm [19.9610 in.]
69898-004    FOV up to 760.500 mm [29.9410 in.]
69898-005    FOV up to 1014.000 mm [39.9210 in.]

# 6    MAINTENANCE

## Maintenance Procedures

Carry out the following maintenance work at regular intervals (depending on the on-site dirt contamination levels and temperature fluctuations).

**Camera**

Replace the desiccant cartridge when it turns pink.
(FIFE part no. 529217-002)

Clean the glass on the protective tube with a soft, non-linting cloth.  Do not use aggressive cleaning agents.

**Lighting**

Different lamps are used based on the application.  Check your lamp for proper maintenance procedures.

**DAC-004 DIODE LINE CAMERA**