Formation Measurement

System Manual

6510020400

Formation Measurement

October, 2012

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Introduction

The purpose of this manual is to provide an introduction to the model Q4221-50 Formation Sensor for Experion MX.

ATTENTION

The terms *FotoForm* and *Formation Measurement* refer to the *Formation Sensor*. These terms may be used interchangeably in this manual.

Audience

This manual is intended for use by engineers or process engineers, and assumes that the reader has some knowledge of the operation of a paper machine and a basic understanding of mechanical, electrical, and computer software concepts.

About This Manual

This manual contains 12 chapters and three appendixes.

Chapter 1, **System Overview**, describes operating principles and system specifications.

Chapter 2, **EDAQ**, describes the principles and operation of the Ethernet Data Acquisition (EDAQ) board.

Chapter 3, **Installation**, provides an overview of installation procedures for the system.

Chapter 4, **Operation**, describes operation of the system.

Chapter 5, **Configuration**, describes system configuration.

Chapter 6, **Detailed Sensor Structure**, describes the structure of the Formation Sensor.

Chapter 7, **Introduction to Measurement**, describes measurement procedures for the system.

Chapter 8, **Preventive Maintenance**, describes recommended ongoing preventive maintenance tasks.

Chapter 9, **Tasks**, describes procedures for maintenance, diagnostic, and troubleshooting tasks.

Chapter 10, **Troubleshooting**, describes symptoms, alarms, possible causes, and links to associated diagnostic or troubleshooting tasks.

Chapter 11, **Storage, Transportation, and End of Life**, describes methods for storing, transporting, and disposing sensor components.

Chapter 12, **Glossary**, describes the terms and acronyms used in this manual.

Appendix A, **Part Numbers**, lists part numbers for system components.

Appendix B, **Installation Test**, describes how to test the installation of the system.

Appendix C, **Sample Measurement Procedure**, describes procedures for taking sample measurements.

Related Reading

The following documents contain related reading material.

Honeywell Part Number	Document Title / Description
	Norman, B. and Wahren, D., "Mass Distribution and Sheet Properties Of Paper," in Proc. 1973 Fundamental Properties of Paper Related to its Uses, Trans. Symp., Br. Pap. Board Ind. Fed.,, Cambridge: London, p. 7-73 (1973)
	B. Norman and D. Söderberg, “Overview of Forming literature, 1990-2000”, in Proceedings of 12th Fundamental Research Symposium, Oxford, p. 431-558 (2001)
	Kerekes, R. and Schell, C., “Characterization of Fibre Flocculation Regimes by a Crowding Factor”, J. Pulp Pap. Sci., 18(1): p. J32-38 (1992)

Honeywell Part Number	Document Title / Description
	Karema, H., Kataja, M., Kellomäki, M., Salmela, J. And Selenius, P., ”Transient fluidisation of fibre suspension in straight channel flow”, in Proceedings of TAPPI International Paper Physics Conference, San Diego, USA, p. 369-379 (1999)
	Kellomäki, M., Karema, H., Kataja, M., Salmela, J. and Selenius, P., ”Fibre flocculation measurement in pipe flow by digital image analysis”, in Proceedings of TAPPI International Paper Physics Conference, San Diego, USA, p. 461-463 (1999)
	Kellomäki, M. and Jetsu, P., “Graininess of formation”, in Proceedings of TAPPI International Paper Physics Conference, Victoria (BC), Canada, p. 193-199 (2003)
	FotoForm block diagram
08763300	Electrical schematics for the FRMM
08763400	Electrical schematics for the FRIM
6510020381	Experion MX MSS & EDAQ Data Acquisition System Manual
46024900	Precision Formation Sensor User Manual

Conventions

The following conventions are used in this manual:

ATTENTION: Text may appear in uppercase or lowercase except as specified in these conventions.

`Boldface`	Boldface characters in this special type indicate your input.
`Special Type`	Characters in this special type that are not boldfaced indicate system prompts, responses, messages, or characters that appear on displays, keypads, or as menu selections.
Italics	In a command line or error message, words and numbers shown in italics represent filenames, words, or numbers that can vary; for example, filename represents any filename. In text, words shown in italics are manual titles, key terms, notes, cautions, or warnings.
Boldface	Boldface characters in this special type indicate button names, button menus, fields on a display, parameters, or commands that must be entered exactly as they appear.
lowercase	In an error message, words in lowercase are filenames or words that can vary. In a command line, words in lowercase indicate variable input.
Type	Type means to type the text on a keypad or keyboard.
Press	Press means to press a key or a button.

[ENTER] or **[RETURN]**	**[ENTER]** is the key you press to enter characters or commands into the system, or to accept a default option. In a command line, square brackets are included; for example: **SXDEF 1 [ENTER]**
[CTRL]	**[CTRL]** is the key you press simultaneously with another key. This key is called different names on different systems; for example, **[CONTROL]**, or **[CTL]**.
[KEY-1]-KEY-2	Connected keys indicate that you must press the keys simultaneously; for example, **[CTRL]-C**.
Click	Click means to position the mouse pointer on an item, then quickly depress and release the mouse button. This action highlights or “selects,” the item clicked.
Double-click	Double-click means to position the mouse pointer on an item, and then click the item twice in rapid succession. This action selects the item “double-clicked.”
Drag X	Drag X means to move the mouse pointer to X, then press the mouse button and hold it down, while keeping the button down, move the mouse pointer.
Press X	Press X means to move the mouse pointer to the X button, then press the mouse button and hold it down.
ATTENTION	The attention icon appears beside a note box containing information that is important.
CAUTION	The caution icon appears beside a note box containing information that cautions you about potential equipment or material damage.
WARNING	The warning icon appears beside a note box containing information that warns you about potential bodily harm or catastrophic equipment damage.

1. System Overview

The Formation Sensor (see Figure 1-1) is designed for on-line measurement of uneven distribution of optical transmittance properties of a moving paper web. This manual covers the model Q4221-50 Formation Sensor for Experion MX.

The Formation Sensor comprises the FotoForm Measurement Module (FRMM) and the FotoForm Illumination Module (FRIM).

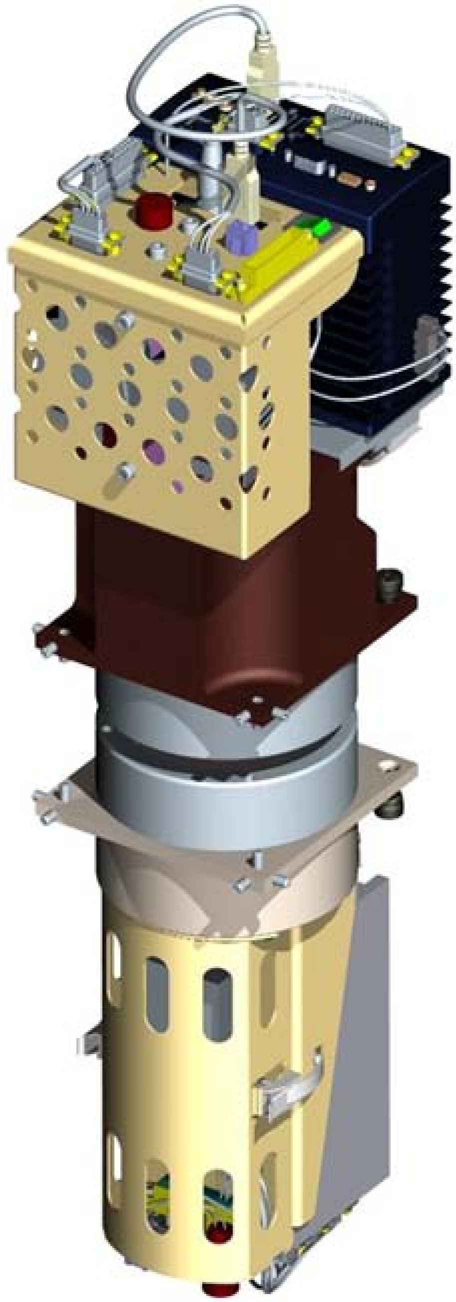
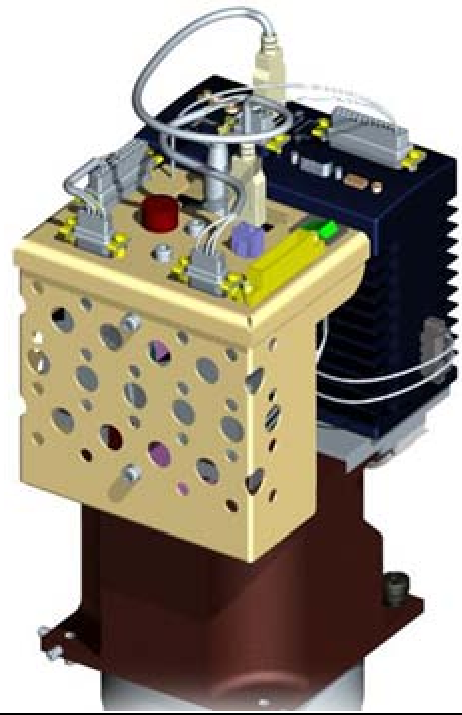
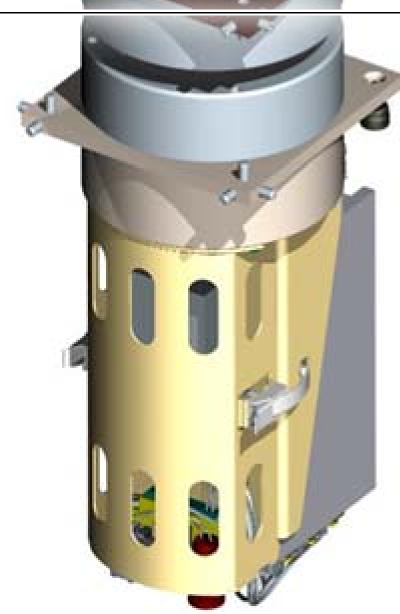


Figure 1-1 Formation Sensor

The FRMM contains the optics, camera, and processor module. The FRIM provides pulsed illumination through the web. The FRMM and the FRIM are flush to the sensor faceplate, meaning this is a non-contacting sensor. The two modules are shown and described in Table 1-1.

Table 1-1 Formation Sensor Modules: FRMM and FRIM

Description	**Image**
The FRMM: • master unit • imaging of paper/board web • computation of formation properties • communication to Experion MX Measurement Sub System (MSS) • illumination control, FRIM setup, and triggering	
The FRIM: • slave unit • outputs diffuse flashes of white light • parameters and triggering from FRMM	

1.1. FotoForm Measurement Module

The electrical connections, switches, and LEDs of the FRMM are shown in Figure 1-2 and Figure 1-3.

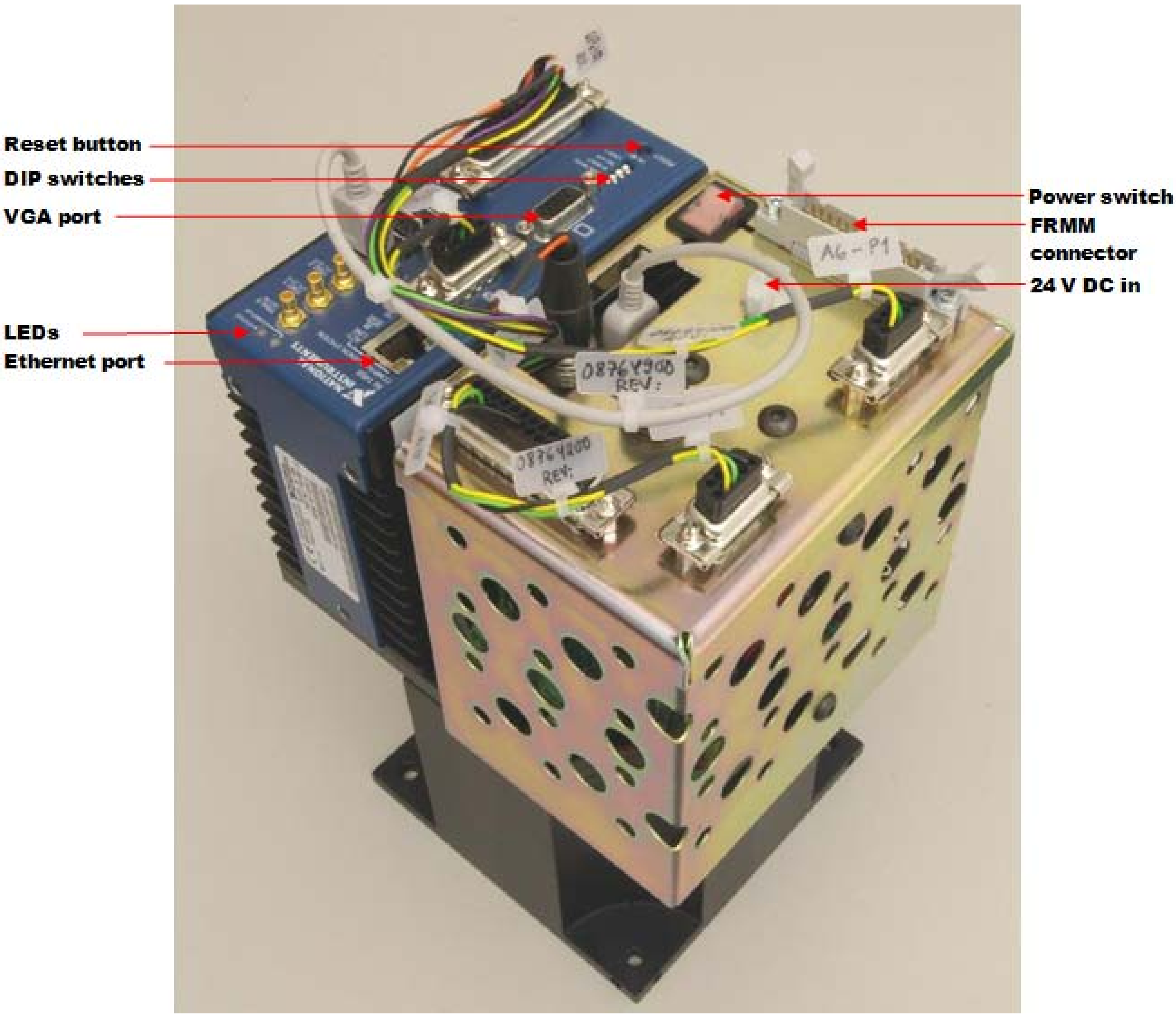


Figure 1-2 FRMM: Connections, Switches, and LEDs (1 of 2)

This FRMM is the master module of the Formation Sensor. It communicates with the FRMM Ethernet Data Acquisition (EDAQ) board through the FRMM connector. The FRMM is powered through the 24 V DC connector, which is connected to the EDAQ with the harness p/n 6580801669. There is a switch to power the FRMM on and off. The FRMM is protected by a 2 A fuse.

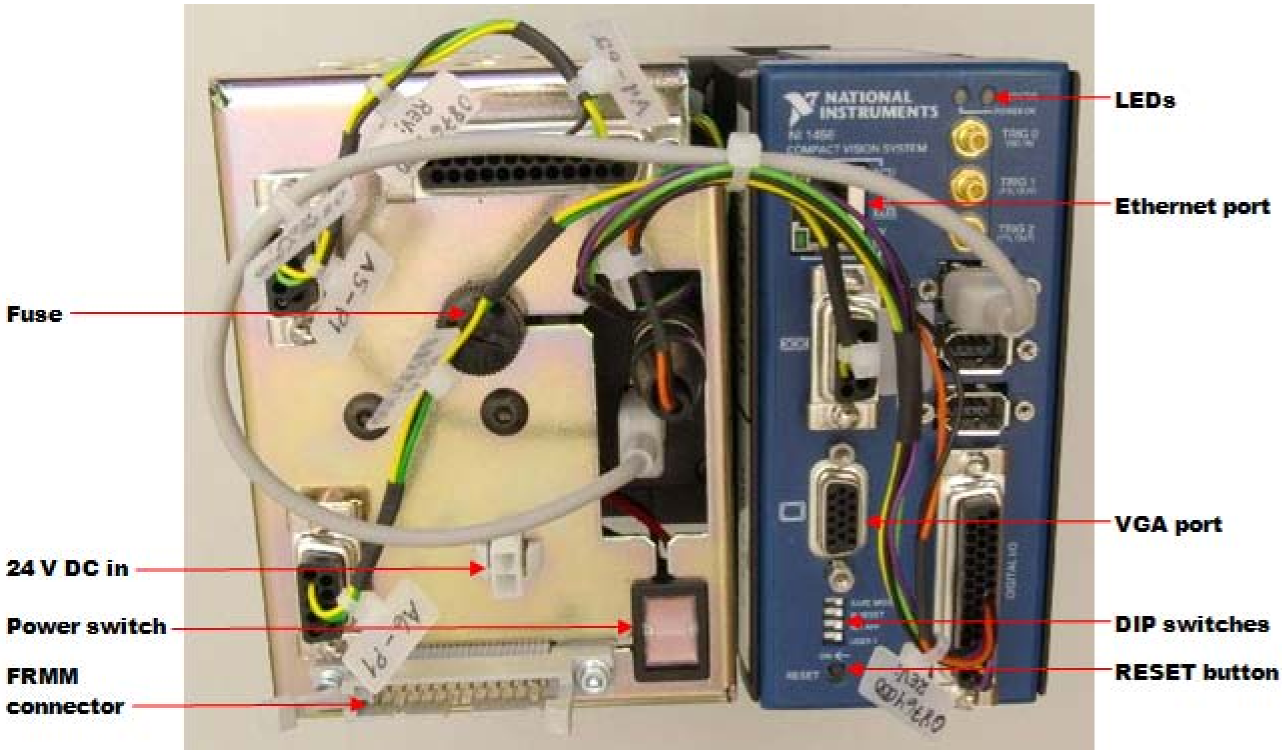


Figure 1-3 FRMM: Connections, Switches, and LEDs (2 of 2)

Pushing the **RESET** button for a couple of seconds performs a soft reboot of the FRMM. You may need to use this button during firmware updates. The DIP switches determine the operating mode of the Formation Sensor. The default operation, *measurement mode*, is achieved by setting all the switches in the off position.

A VGA port provides diagnostic information during Experion MX measurement, for example, timestamp, last mode request and/or status, and internal parameters. This feature can be utilized in troubleshooting. There is a stand-alone mode (the sensor is operated without a connection to the QCS server) in which the VGA port shows a graphical user interface to the functions. In this mode the DIP switches function like a keyboard.

An Ethernet port is used to connect the Formation Sensor to the MSS through the sensor network. Firmware updates to the sensor may be installed using a maintenance PC connected to the sensor network. It can be used in PC control mode, where various functions of the sensor can be tested. For example, the quality control test performed by the factory uses this port. The status LEDs report various states of the FRMM. They can be very helpful in troubleshooting.

The sensor gap side of the FRMM is shown in Figure 1-4.

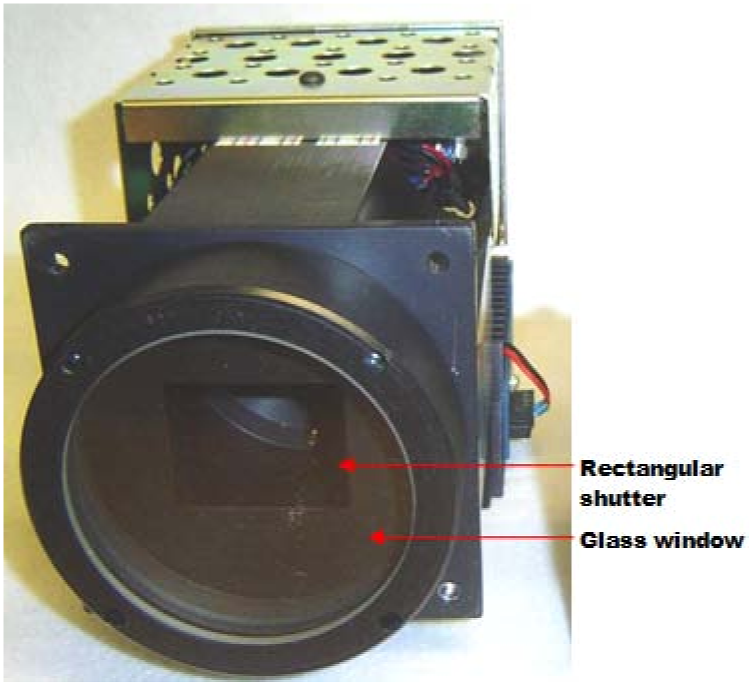


Figure 1-4 FRMM: Sensor Gap Side

When the FRMM is installed on the sensor baseplate, the protective glass window, which is borosilicate at a thickness of 10 mm (0.39 in.), is flush to the sensor baseplate plate, meaning it does not create a bump or a pit on the face plate level in the sensor gap. This provides two benefits:

- the sensor is non-contacting
- the window stays clean

There is no compressed air needed for the Formation Sensor. Behind the window there is a rectangular baffle that enhances contrast of the measurement images by blocking stray light from coming into the camera.

1.2. FotoForm Illumination Module

The electrical connections, switches, and status/data display of the FRIM are shown in Figure 1-5. The FRIM is the *slave* module of the Formation Sensor.

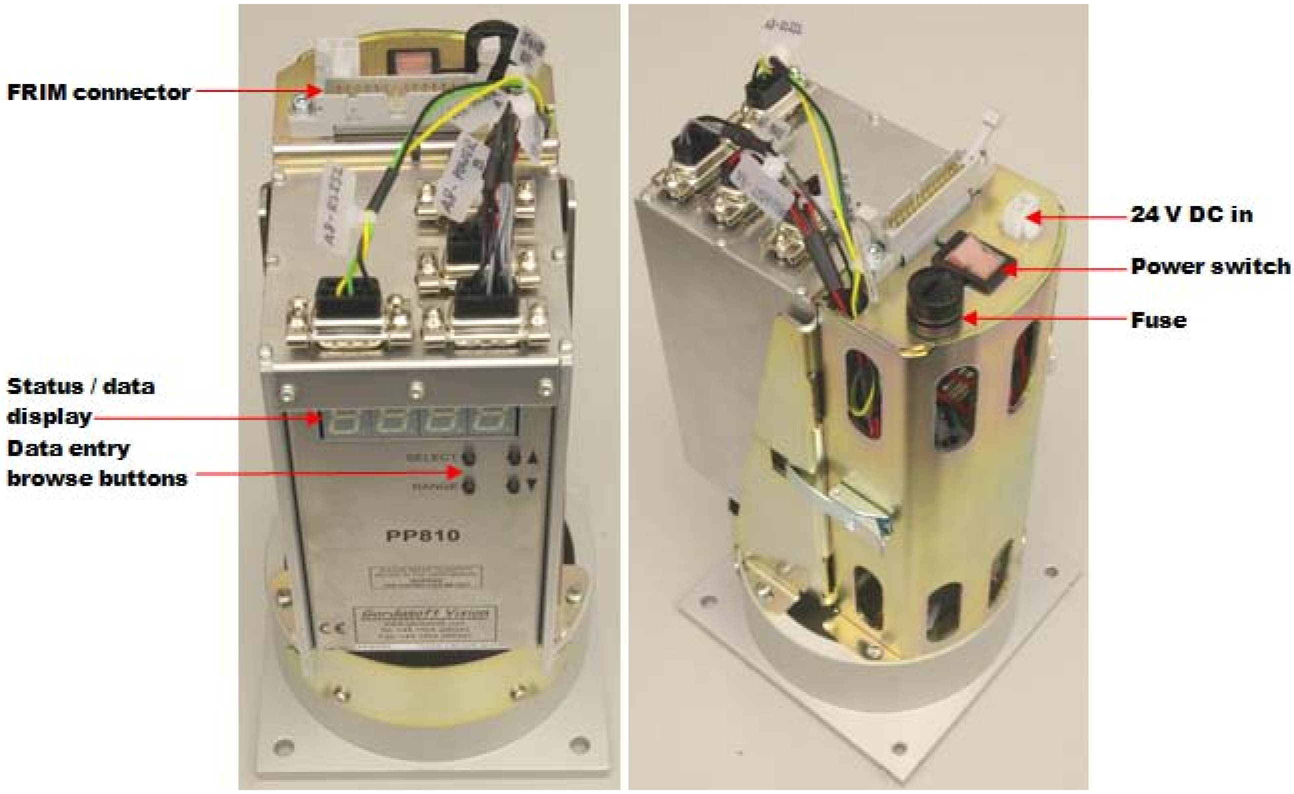


Figure 1-5 FRIM: Connections, Switches, and Display

The FRIM gets commands from the FRMM through the FRIM connector, which is connected to the FRIM EDAQ. The FRIM is powered through the 24 V DC connector that is connected to the EDAQ. There is a switch to power the FRIM on and off. The FRIM is protected by a 2 A fuse.

When the FRIM is powered, the display will show **-----** alternating at two heights (idle). The data entry browse buttons can be used for troubleshooting and manually controlling the FRIM parameters.

WARNING

The FRIM can be configured by using the data entry buttons in a way in which its circuitry may be damaged. Make sure you understand what you are doing before making any manual adjustments.

Figure 1-6 shows the sensor gap side of the FRIM. As with the FRMM, the sensor is installed so that the protective window is flush to the faceplate of the sensor baseplate. Under the window there is an opal glass diffuser which makes the pulsed light spread uniformly to the imaging area of the FRMM.

Figure 1-6 FRIM: Sensor Gap Side

1.3. Measurement Principle

FotoForm is based on digital imaging and image analysis performed in the sensor. The measurement principle is shown in Figure 1-7. The sensor traverses over the running paper web inside the scanner head. The FRIM (the source) and the FRMM (the receiver) are mounted on opposite sides of the web and they are both flush to the scanning head front plate.

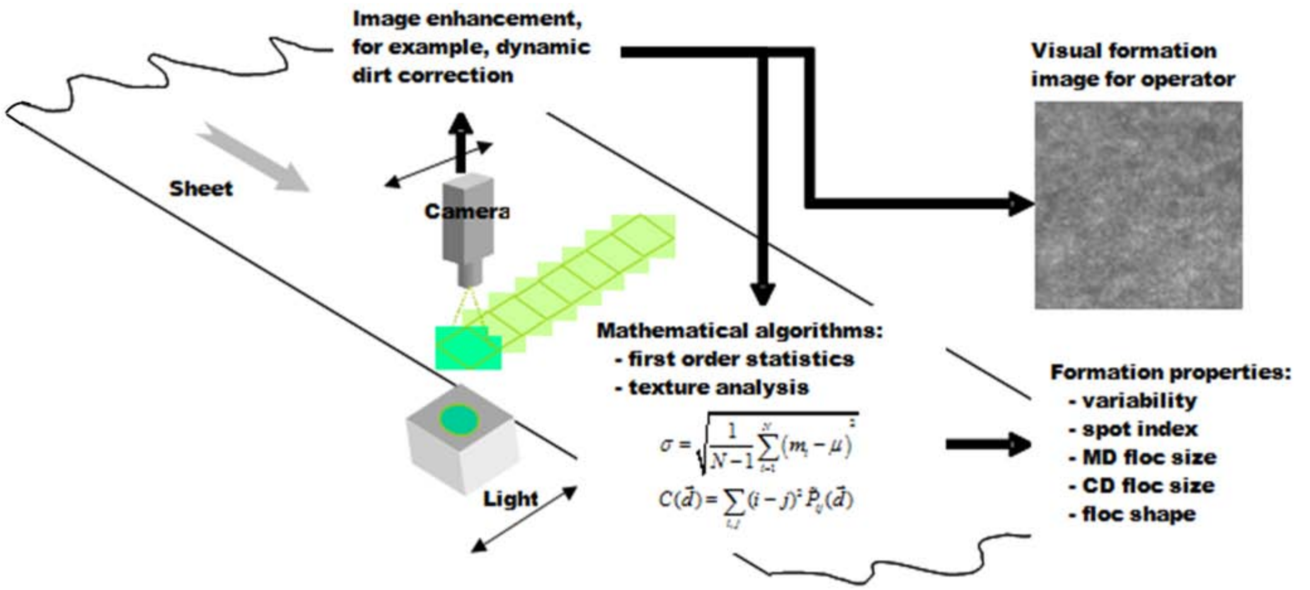


Figure 1-7 Measurement Principle

There is a 10 mm (0.39 in.) open gap between the FRIM and the FRMM, where the web moves. The FRMM takes digital images of the web. The web is transilluminated with light pulses emitted by the FRIM. The pulses are triggered by the FRMM.

Images of the web are enhanced. For example, dirt of the windows is digitally removed, and then analyzed by mathematical algorithms in the FRMM. The results (formation properties) are sent to the QCS server for building trends and profiles. In addition, images of formation are sent to the operator station to enable visual assessment of formation. This function makes the Formation Sensor a *scanning lightbox*.

The operation principle of FotoForm in the Experion MX system is shown in Figure 1-8. The sensor needs 24 V DC power, but no pressurized air or water. Internal operation of the sensor is controlled by the processor module of the FRMM. It receives mode commands from the MSS through the sensor LAN.

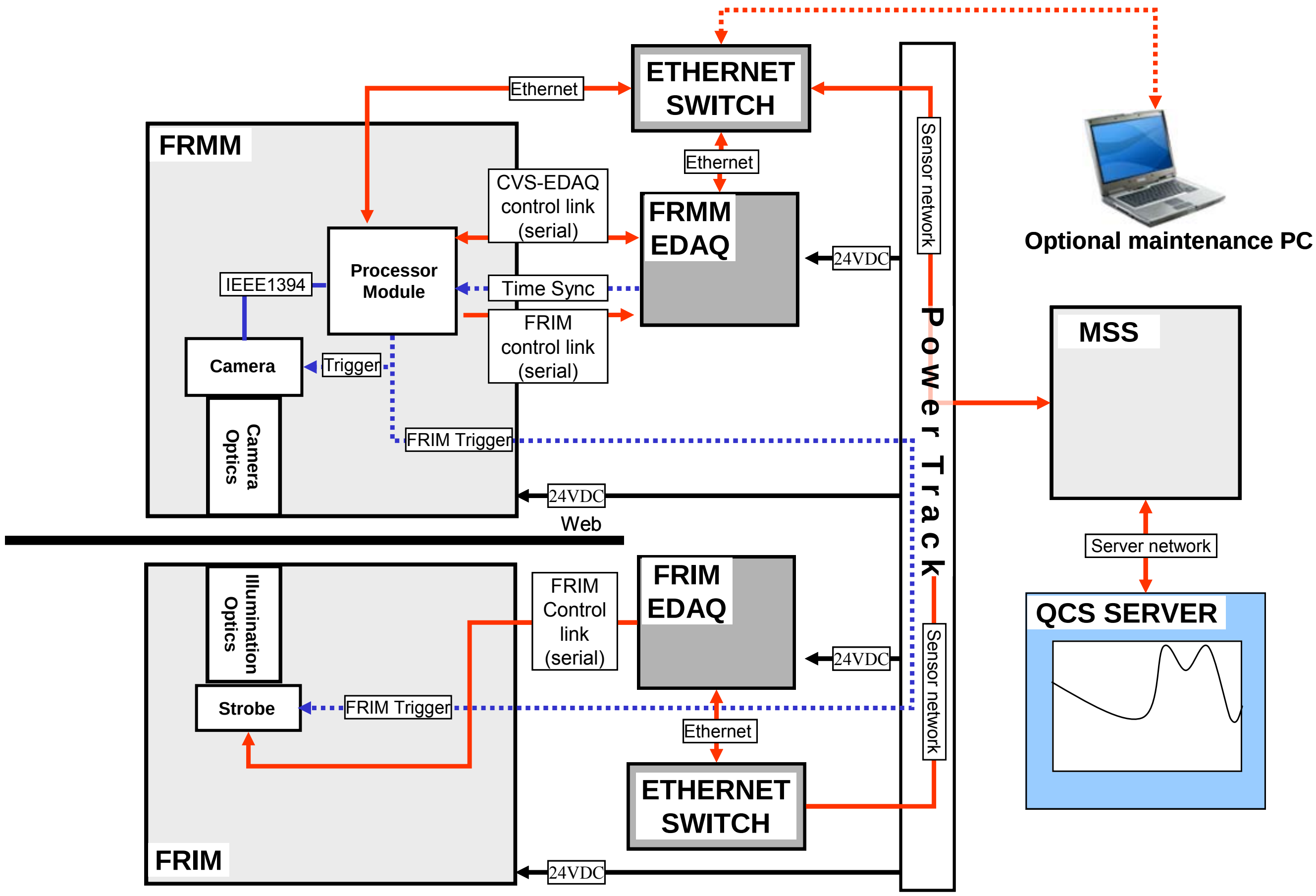


Figure 1-8 Formation Sensor Operation Principle

Time synchronization and IP address are given to the processor module by the FRMM EDAQ board using a CVS-EDAQ control link and the Time Sync trigger line. CVS (Compact Vision System) is the model name of the processor module NI CVS-1456 p/n (20001067). The processor module executes commands and reports slice data, standardization data, alarms, and so on, back to the MSS. The MSS is connected to the QCS server through the Ethernet connection.

The QCS server gathers the FotoForm data and provides standard tools for displaying the data as profiles and trends. The FRIM control serial link runs from the processor module to the FRMM EDAQ, which sends the messages over the sensor LAN to the FRIM EDAQ.

The FRIM EDAQ converts the messages back to the serial link between the EDAQ and the strobe controller. The FotoForm software includes special tools for displaying online images of formation, and studying history and targets of formation for different grades. Also, the sample measurement mode with a formation image gallery is included.

The processor module operates an industrial camera with two connections:

- IEEE 1394 cable (power, image transfer, and configuration)
- trigger cable

The camera is configured automatically for different grades and operation modes by the processor module. Imaging by the camera and illumination by the FRIM is timed by the triggering from the processor module. The camera optics project a sharp image of the web on the CCD chip of the camera independent of the position of the web in the sensor gap. Images are transferred to the processor module, which calculates formation properties from them after automatic image enhancement, for example, dirt correction.

The FRIM includes pulsed white light source, strobe controller, and illumination optics, which makes the pulse very diffuse. Intensity and duration of light pulses are configured by the FRMM processor module through a serial link which is passed through the sensor LAN using EDAQ boards. The strobe controller emits a light pulse, with the configured characteristics, every time it receives a trigger pulse from the processor module. There is a dedicated trigger line from the FRMM to the FRIM in the Power track.

In addition to normal operation mode, FotoForm includes two other modes:

- PC-controlled mode
- DIP-switch controlled mode

The details of those two modes are not explained in this manual.

The PC-controlled mode is used in the factory testing procedure, but it may also be used by Honeywell technicians on the field for troubleshooting purposes. In this mode, the processor module and a PC are connected together with a cross-wired Ethernet cable (the FRMM Ethernet port is shown in Figure 1-2), or through the sensor LAN switch. Special software on the PC can be used to control the functions of the Formation Sensor.

The DIP-switch controlled mode provides a stand-alone, manual method of testing the Formation Sensor. In this mode, the DIP switches of the sensor (see Figure 1-2) are used to navigate through the menus and make selections. Menus and results can be seen graphically on a monitor if it is connected to the VGA port of the FRMM (see Figure 1-2).

1.4. Specifications

Key characteristics of imaging are listed in Table 1-2.

Table 1-2 Imaging Characteristics

Item	**Characteristics**
Imaging area	44.5 by 44.5 mm (1.75 by 1.75 in.)
Pixel size	0.174 mm (0.00685 in.)
Depth of field	10 mm (0.4 in.)
Web movement during image exposure	0.2 mm (0.00787 in.)
Maximum machine direction speed	2200 m/min (720 ft/min)
Basis weight range	0–600 g/m^2 (0–160 lb; 17 by 22 in.)
Measurement frequency	10 Hz
Dirt correction	Automatic
Adjustment to varying basis weight	Automatic
Moving parts	None
Contacting sheet guiding	None

As described in Section 7.1, the imaging area corresponds to small scale formation. Web movement during image exposure is in the order of one pixel for up to 2200 m/min (720 ft/min) machine direction web speed, which means that the images are always very sharp. The depth of field of the FotoForm imaging system is enough to cover the entire sensor gap. That is why contacting sheet guiding is not needed: the web can move freely within the sensor gap. The sensor adapts itself easily to all grades up to 600 g/m^2 basis weight due to automatic light pulse adjustment. Automatic dirt correction and the absence of moving parts makes the operation and maintenance of the sensor easy and robust.

The effect of the relatively low measurement frequency of 10 Hz on the positioning of the slice measurements is shown in Figure 1-9:

- a = low CD scan speed (overlapping images)
- b = high CD scan speed (gaps between images)

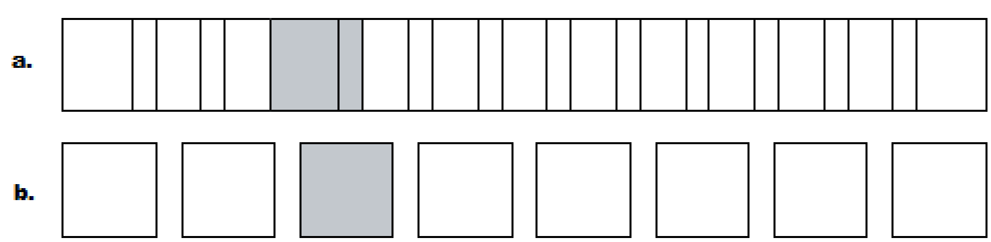


Figure 1-9 Positions of Formation Images in Cross Direction

For a low cross direction scan speed, the images overlap. For example, for a cross direction scan speed of 200 mm/s (7.87 in./s) there is a 24.5 mm (0.96 in.) overlap. For a high cross direction scan speed, there are gaps between the images. If the cross direction scan speed is 600 mm/s (23.6 in./s), there are 13.5 mm (0.53 in.) gaps in the cross direction.

The Honeywell model Q4221-50 Formation Sensor provides powerful tools for analyzing paper formation. State of formation is characterized by a carefully selected set of intuitive descriptors, called *formation properties*. The properties and their range and typical values are summarized in Table 1-3.

Table 1-3 Formation Properties

Property	Units	Value	Range	Appearance (low value)	Appearance (high value)
Variability	0.1%	40–200	0–1000	Uniform look-through	Large difference between light and dark areas
Spot Index	-	-20–20	-100–100	Zero: balance between light and dark areas	Positive: light spots dominate
				Negative: dark spots dominate	Large positive: holes (for example, pinholes)
MD Floc Size	mm	1.0–3.0	0.0–40.0	Small flocs (grainy)	Large flocs (cloudy)
CD Floc Size	mm	1.0–3.0	0.0–40.0	Small flocs (grainy)	Large flocs (cloudy)
Floc Shape	%	70–150	0–1000	100: isotropic flocs	
				< 100: flocs are larger in cross direction (for example, rush/drag > 1)	> 100: flocs are larger in machine direction (for example, rush/drag < 1)

2. EDAQ

The EDAQ board is responsible for converting all analogue and digital signals to and from sensors to Ethernet.

It replaces the functionality of the National Instruments™ cards seen in previous Honeywell scanner systems.

The board is based on an ARM CPU running the Linux operating system and a Field-Programmable Gate Array (FPGA) that controls real-time data acquisition.

The EDAQ contains software licensed under third party licenses including the Gnu Public License (GPL). A copy of that software and its source code can be obtained from *http://www.honeywell.com/ps/thirdpartylicenses* or found on the Experion MX distribution media under *C:\Program Files\Honeywell\Experion MX\MSS\SenLan\Images\GPL*.

The EDAQ board contains a large number of input/output (I/O) systems, including:

- analog inputs (16 inputs of 12 bits @ 4 kHz and 8 inputs of 10 bits @ 1 Hz)
- analog outputs (2 @ 12 bits)
- digital inputs (16 @ 24 V logic)
- digital output (16 @ 24 V logic)
- frequency input (400 Hz to 500 kHz)
- three serial ports
- USB (presently unused)
- Ethernet

Except for a few dedicated signals such as the green light (radiation safety), all sensor signals connect through the EDAQ to the new Experion MX MSS by Ethernet.

The EDAQ contains sensor-specific code for all sensors. All EDAQs, including the frame controller (FC) EDAQ (in the endbell), and the head alley EDAQ, are identical and can be interchanged.

This chapter gives a brief overview of the EDAQ board and some of the diagnostic information. More detail is provided in the *Experion MX MSS & EDAQ Data Acquisition System Manual* (p/n 6510020381).

2.1. Physical Layout

Figure 2-1 and Figure 2-2 show the EDAQ PCBA as it is mounted next to a sensor. To the left are the digital and analog I/Os, which connect directly to a sensor. Below these two large connectors is a 16-pin expansion connector that is only used when the EDAQ is attached to the FC expansion board.

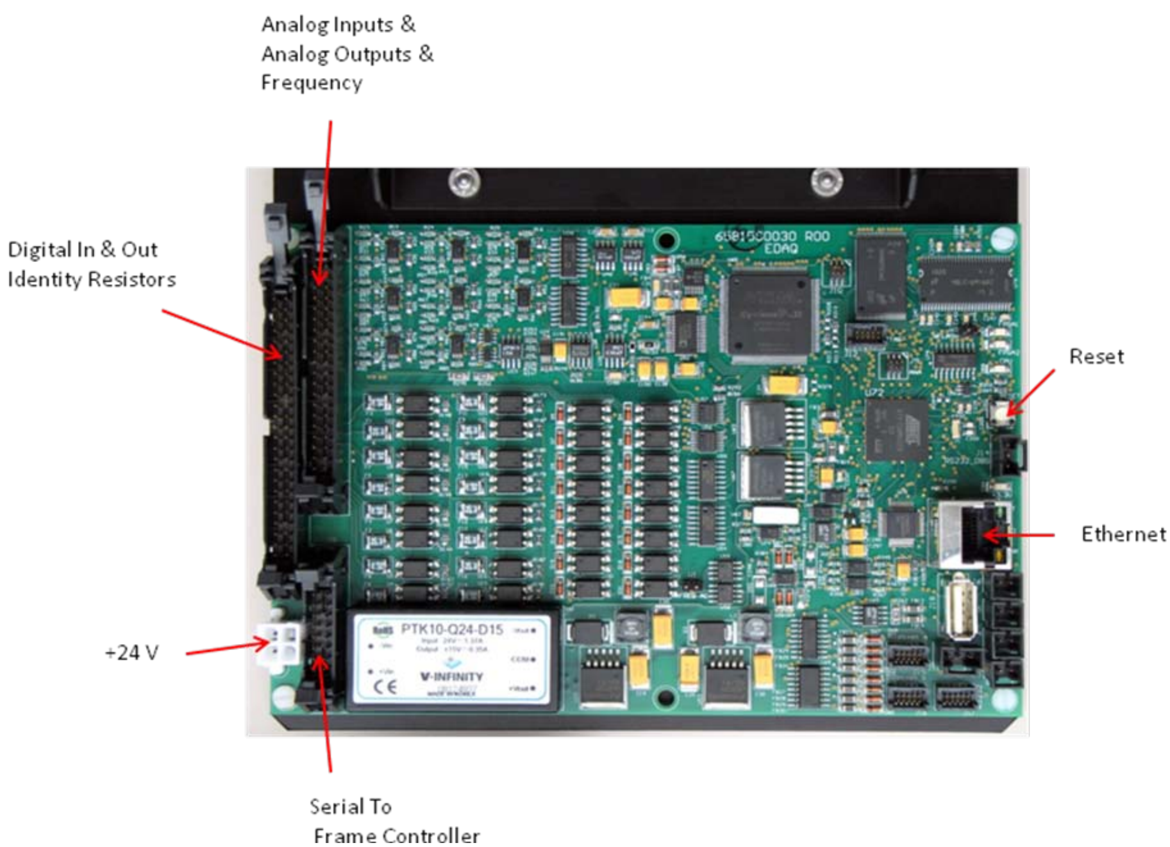


Figure 2-1 EDAQ Board

As shown in Figure 2-2, J1 is the large 50-pin connector on the far left. J2 is the smaller 40-pin connector. J8 on the lower left is used for the FC only. To the right are the Ethernet port, some diagnostic LEDs, serial connections, and temperature inputs. There are no test points for use in the field. A serial debug port is available (115200 kb/s, no flow control, 8N1) that may be connected to any PC running a serial terminal program. For diagnostic purposes, service personal may be asked to connect a serial cable between the debug port and the RS-232 of any neighboring EDAQ.

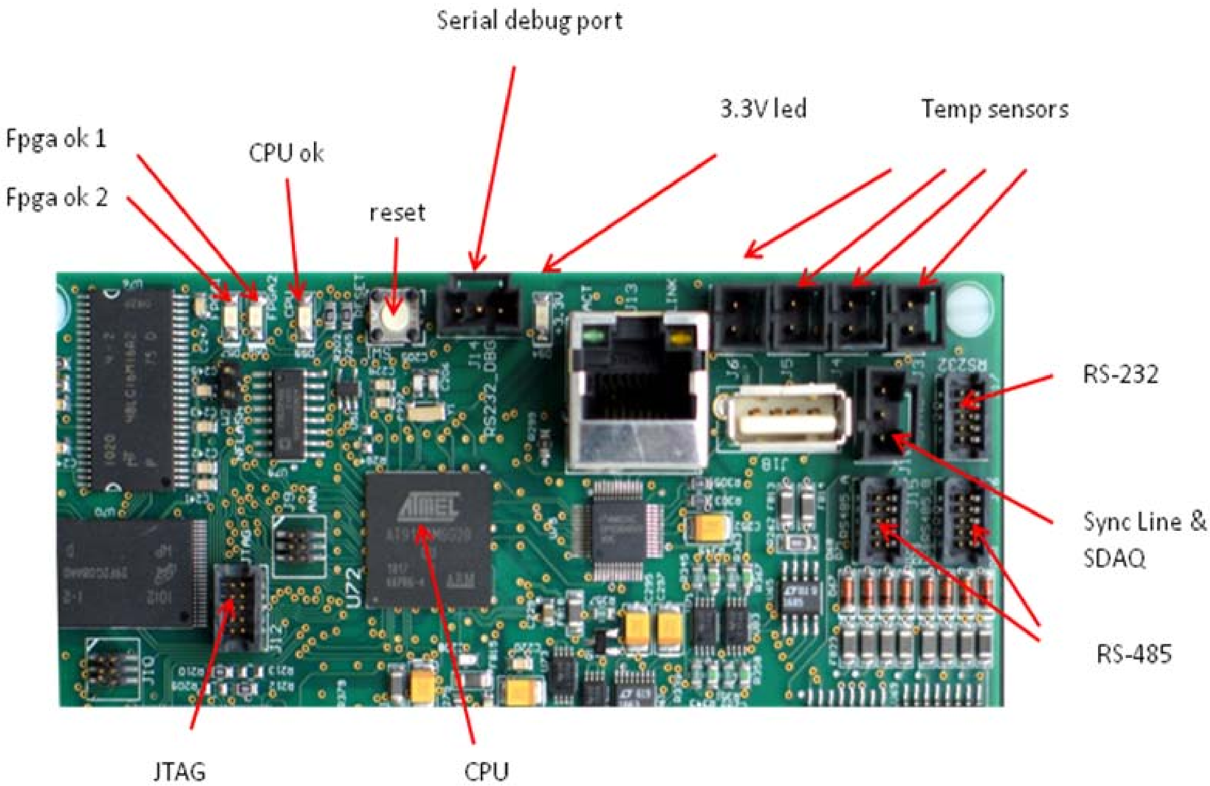


Figure 2-2 EDAQ Board: Ports and Diagnostic LEDs

2.2. Hardware Status Information

There are four diagnostic LEDs on the EDAQ (see Figure 2-2).

- The *3.3 V LED*. When lit, this indicates that all power supplies on the board are functional. The signal is derived from the 3.3 V power supply, which in turn is derived from the 15 V power supply, which is derived from the + 24 V input.
- The *CPU OK LED*. This LED is under control of the central ARM CPU. It will be lit when the main sensor application (edaqapp) is running on the CPU.
- The *Fpga ok 1* (not used at present).
- The *Fpga ok 2*. This LED will blink if the FPGA is loaded and running code.

The Ethernet connector contains two LEDs:

- amber indicating a good link to the switch
- green indicating activity on the network

2.3. EDAQ Reset

A soft reset of the EDAQ may be performed through a Web interface running on the scanner MSS. This interface may be accessed from a QCS operator station.

A hardware reset can be performed by pressing the white button next to the debug cable. This resets both the CPU and FPGA, and is equivalent to a power on/off.

2.4. EDAQ Sensor Identification and IP Addressing

Assuming the firmware (flash code) is the same, all EDAQs are identical. EDAQs can be freely interchanged between sensors and the scanner endbell.

Each EDAQ contains all the code for all supported sensors, and loads the appropriate software depending on the identification ID code read at boot time. Two resistors are used to uniquely identify the EDAQ.

For sensor-connected EDAQs, there is a sensor model resistor embedded in the cable harness connecting the sensor to the EDAQ. This resistor determines the function code. Function codes are unique for each sensor model to the extent that the EDAQ needs to differentiate the models. For example, all Source 9 basis weight measurement sensors presently have the same function code, regardless of radioactive isotope.

In addition, the head power distribution board has a resistor for each EDAQ platform connector. This determines the position of the EDAQ in the head. The EDAQ can self-identify both its position and function.

Refer to your scanner system manual to troubleshoot the EDAQ if it does not identify itself properly (or to find the correct resistor values).

Every EDAQ has a unique IP address on the scanner network. If the EDAQ can identify its position, it will set its IP address to 192.168.0.*XYZ* (where *XYZ* is the position number in the head). The FC-EDAQ always sets itself to IP number 192.168.0.2. The MSS is always 192.168.0.1 on the scanner network, and usually 192.168.10.*n*+100 (where *n* is the number of MSSs on the same MX Experion network) on the Experion MX LAN. The MSS is assigned 192.168.10.101 at the factory, but this can be set to any IP address by using the MSS Web page. Refer to your scanner system manual.

If an EDAQ fails to determine a position, it requests an address of the local DHCP server (which is either running on the FC-EDAQ or the MSS). Any laptop will get an IP address when plugged into any of the scanner Ethernet switches.

2.5. Obtain Status Information

An overall status page is available from a QCS operator station under the **MSS Setup Diagnostics** tab (select the **MSS Summary** display).

On the left side of the **MSS Summary** display, as shown in Figure 2-3, is the list of expected EDAQs with three types of status indicators (from left to right).

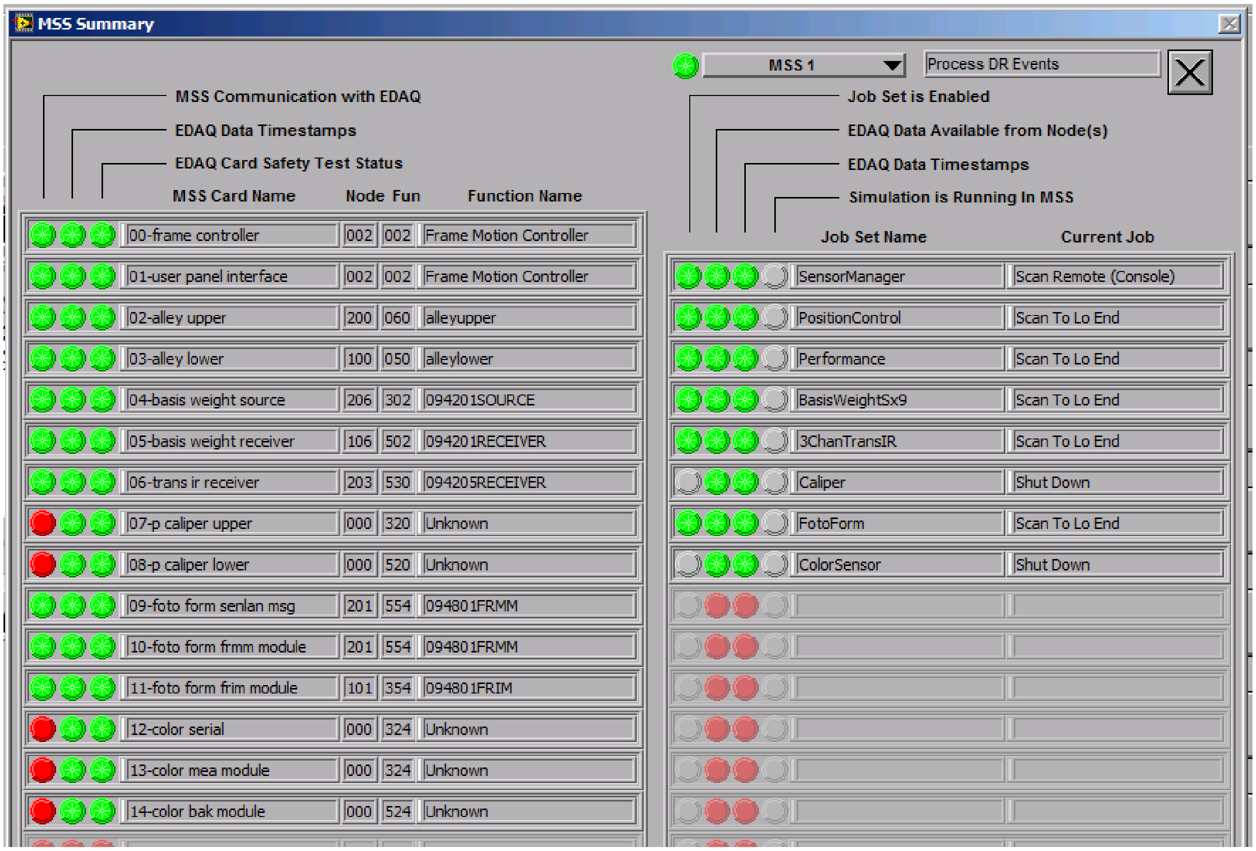


Figure 2-3 MSS Summary

Table 2-1 MSS Summary Display Status Indicators and Descriptions

Column	Description
MSS Communication with EDAQ	EDAQ is communicating (through the EDAL protocol) with the MSS
EDAQ Data Timestamps	Data that the MSS is expecting from that EDAQ is being supplied at the expected rate
EDAQ Card Safety Test Status	EDAQ is not reporting any errors such as interlock or motion control issues

Sensors that are part of the Real Time Data Repository (RTDR), but are not enabled on the scanner, appear in the left column indicators in red, for example, *07-caliper upper* in Figure 2-3.

2.6. MSS and EDAQ Web Pages

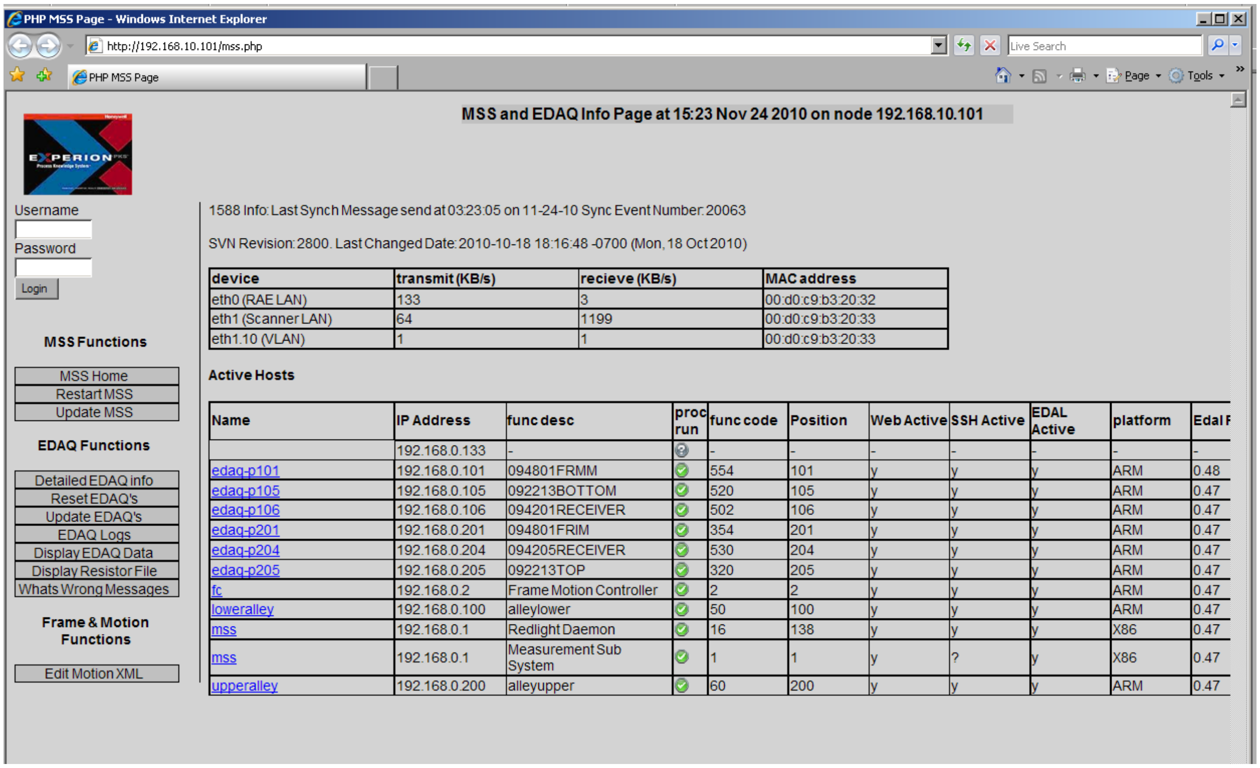
More detail is available on the MSS and the EDAQs, which all run Web servers and can display server pages containing information on the state of the system. As a general rule, consult the MSS Web pages first. They are accessible in three different ways:

- go to the **MSS Diagnostic** tab, click on **MSS Monitor**, choose the appropriate MSS, and click on **MSS Web** page

- open a browser on any computer connected to the Experion MX level network, and use the address *http://192.168.10.101/mss.php* (the first MSS on the LAN), or the address set up for the MSS in the Experion MX system

- open a browser on any computer connected to the scanner LAN switch, and use the address *http://192.168.0.1/mss.php* or *http://192.168.10.101* (for the first MSS on the system)

Figure 2-4 shows **PHP MSS Page** (the main MSS Web page).


PHP MSS Page - Windows Internet Explorer

http://192.168.10.101/mss.php

PHP MSS Page

MSS and EDAQ Info Page at 15:23 Nov 24 2010 on node 192.168.10.101

Username

Password

Login

MSS Functions

MSS Home

Restart MSS

Update MSS

EDAQ Functions

Detailed EDAQ info

Reset EDAQ's

Update EDAQ's

EDAQ Logs

Display EDAQ Data

Display Resistor File

Whats Wrong Messages

Frame & Motion Functions

Edit Motion XML

1588 Info: Last Synch Message send at 03:23:05 on 11-24-10 Sync Event Number: 20063

SVN Revision: 2800. Last Changed Date: 2010-10-18 18:16:48 -0700 (Mon, 18 Oct 2010)

device	transmit (KB/s)	recieve (KB/s)	MAC address
eth0 (RAE LAN)	133	3	00:d0:c9:b3:20:32
eth1 (Scanner LAN)	64	1199	00:d0:c9:b3:20:33
eth1.10 (VLAN)	1	1	00:d0:c9:b3:20:33

Active Hosts

Name	IP Address	func desc	proc run	func code	Position	Web Active	SSH Active	EDAL Active	platform	Edal F
	192.168.0.133	-		-	-	-	-	-	-	-
edaq-p101	192.168.0.101	094801FRMM		554	101	y	y	y	ARM	0.48
edaq-p105	192.168.0.105	092213BOTTOM		520	105	y	y	y	ARM	0.47
edaq-p106	192.168.0.106	094201RECEIVER		502	106	y	y	y	ARM	0.47
edaq-p201	192.168.0.201	094801FRIM		354	201	y	y	y	ARM	0.47
edaq-p204	192.168.0.204	094205RECEIVER		530	204	y	y	y	ARM	0.47
edaq-p205	192.168.0.205	092213TOP		320	205	y	y	y	ARM	0.47
fc	192.168.0.2	Frame Motion Controller		2	2	y	y	y	ARM	0.47
loweralley	192.168.0.100	alleylower		50	100	y	y	y	ARM	0.47
mss	192.168.0.1	Redlight Daemon		16	138	y	y	y	X86	0.47
mss	192.168.0.1	Measurement Sub System		1	1	y	?	y	X86	0.47
upperalley	192.168.0.200	alleyupper		60	200	y	y	y	ARM	0.47

Figure 2-4 PHP MSS Page

The left panel shows a column of options divided into:

- **MSS Functions**
- **EDAQ Functions**
- **Frame and Motion Functions**

Enter the username (**`admin`**) and password (`hmxresult`) for advanced diagnostic options that are not necessary for normal operation and not discussed in this manual.

The main area shows two tables. The top table contains transmission volume information to and from the MSS. The device labeled **eth1 (scanner LAN)** typically shows it receiving a few MBs. The MAC addresses of the MSS are also shown–the **eth0 (RAELAN)** address is the one required in the setup.

The second table lists all EDAQs discovered on the scanner LAN, their IP numbers, a brief description (related to model number), a program status column, the associated function code and position code, and whether the communication protocols are running (http, SSH, and Edal, the proprietary sensor data transmission protocol).

The EDAQ network name is specified by edaq-p*XYZ* where *XYZ* is both its position and last octet of the IP address. The EDAQs attached to the head power distribution boards are known as *upper* and *lower* alley respectively. The FC-EDAQ is known as *fc*.

The **proc/run** status column is green if all processes known to run on the EDAQ are present. Hovering the cursor over the status indicator calls up a list of running and stopped processes.

More detailed information on each EDAQ can be obtained by clicking **Detailed EDAQ info** on the left panel.

The resulting table (see Figure 2-5) shows a number of technical details that are not discussed in this document. Important columns include **Process load** (usually less than 0.5), **local time** (matches MSS time clock shown at top), and **Offset From MSS (µs)** (less than 50 µs a few minutes after start up).

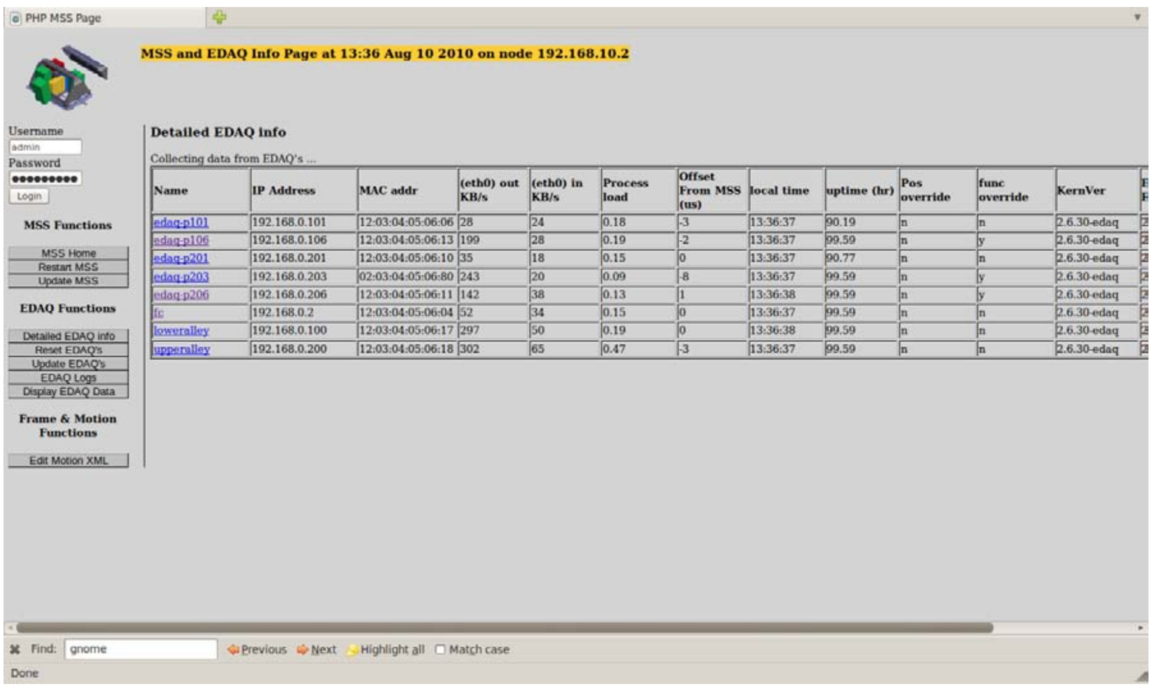


Figure 2-5 Detailed EDAQ Information: Partial Display

3. Installation

This chapter describes the procedure for installing Formation Sensor into the Experion MX Q4000 scanner, including the mechanical and communication aspects.

For information on choosing a location for the color sensor at a paper machine, and tips for possible process challenges, see Section 3.8.

3.1. Hardware Configuration

The model Q4221-50 Formation Sensor is installed into an Experion MX Q4000 scanner as an inboard sensor. The orientation of the FRMM in the instructions in this chapter is shown in such a way that the vertical direction of the formation image coincides with the machine direction of the web.

3.2. Install the Sensor

This section describes installation procedures for the Formation Sensor.

ATTENTION	Do not power on the sensor scanner unless instructed.

This procedure includes QCS server stops and starts. If there are any special instructions on the site, how to shut down or start the servers, or in which order those steps should be done, follow local instructions. This situation is met, for example, if there are data collecting systems or links which need special start and/or stop steps.

There is a power on/off switch on the sensor. When there is a request to power the sensor on or off, it means that the scanner may stay powered on while sensor power is controlled by the sensor switch.

CAUTION

> Turn the sensor power switch off before plugging in, unplugging, or installing any cables or boards.
>
> Do not attach the cables to the sensor or turn on the power until you have checked the wiring.

3.2.1. Mount the Sensor

Power off the sensor before proceeding.

The FRMM and the FRIM are mounted directly opposite each other, with one in the upper head and the other in the lower head. Generally it is better to mount the FRMM to the upper head to avoid dirt build-up on the FRMM window.

Formation is a property of the entire sheet thickness; however, with very heavy grades, formation of the FRMM side of the web is more emphasized than the opposite side.

The FRMM and the FRIM on the Formation Sensor are mounted on the baseplate so that they can be easily installed and removed from the scanner head. This assembly includes the EDAQ board, which is mounted next to the sensor (see Figure 3-1).

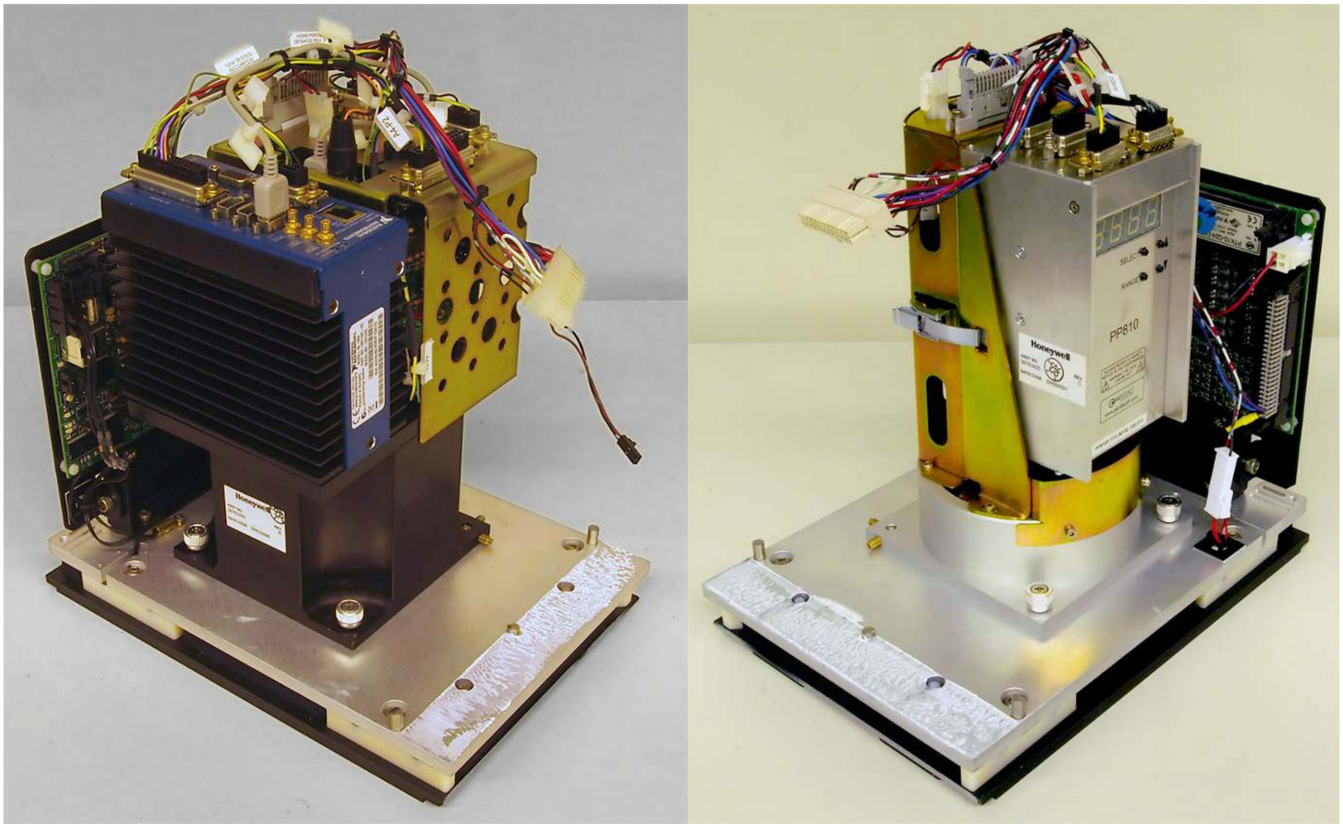


Figure 3-1 FRMM (left); FRIM (right)

Exercise care when mounting or removing the Formation Sensor, and ensure that you avoid accidental detaching of any wires and/or cables.

To mount the sensor:

1. Check both the FRMM and the FRIM to ensure that there are no visibly broken parts, for example, bad cables.

2. Ensure that every cable is connected properly.

3. Check for integrity and cleanliness of the FRMM and FRIM windows, and replace the window assembly if there are any cracks or bad scratches.

4. Mount the FRIMM opposite the FRMM.

3.2.1.1. Mount the FRMM, and Connect Power and Signals

Install the FRMM into an empty (upper head) sensor slot in the Experion MX scanner (see Figure 3-2).

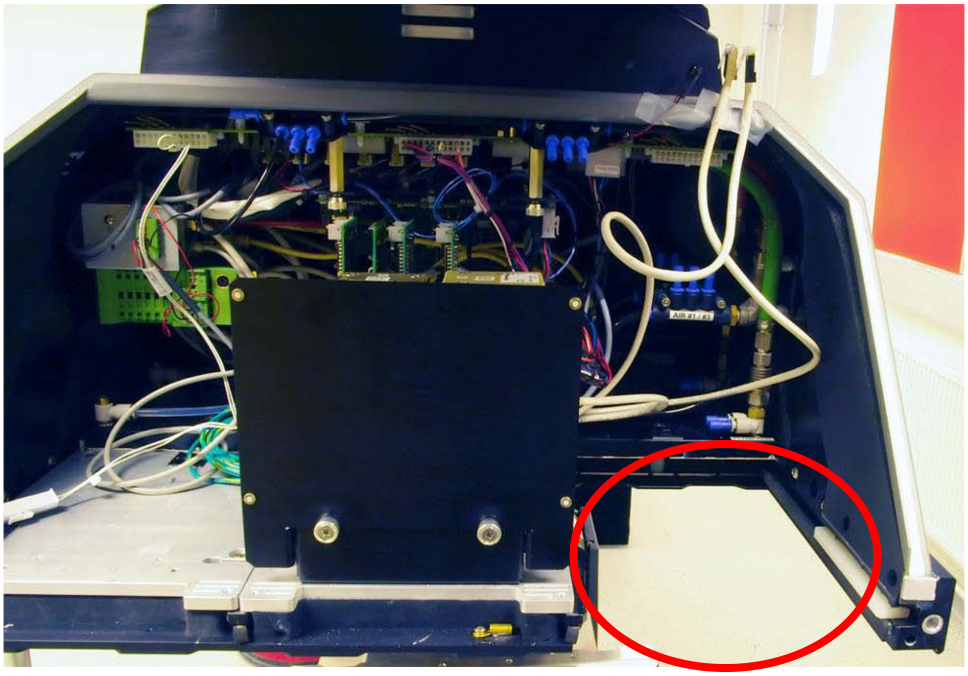


Figure 3-2 Empty Slot for FRMM Installation

1. Connect the two Ethernet cables to the sensor head LAN switch and one trigger cable to the Power track (see Figure 3-3 and Figure 3-4).

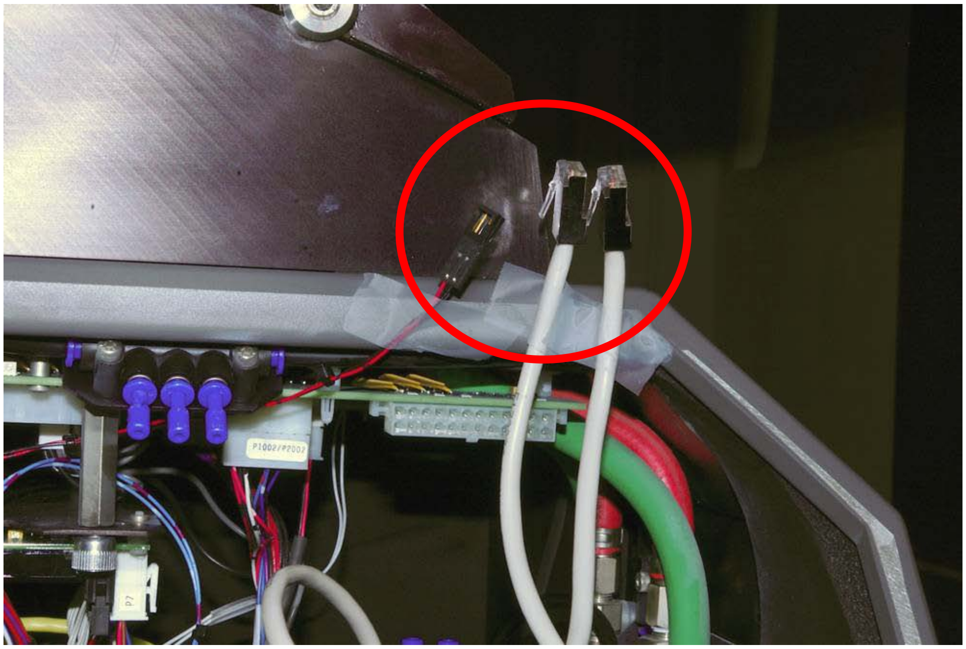


Figure 3-3 Two Ethernet Cables, Trigger Cable, and Power Connector

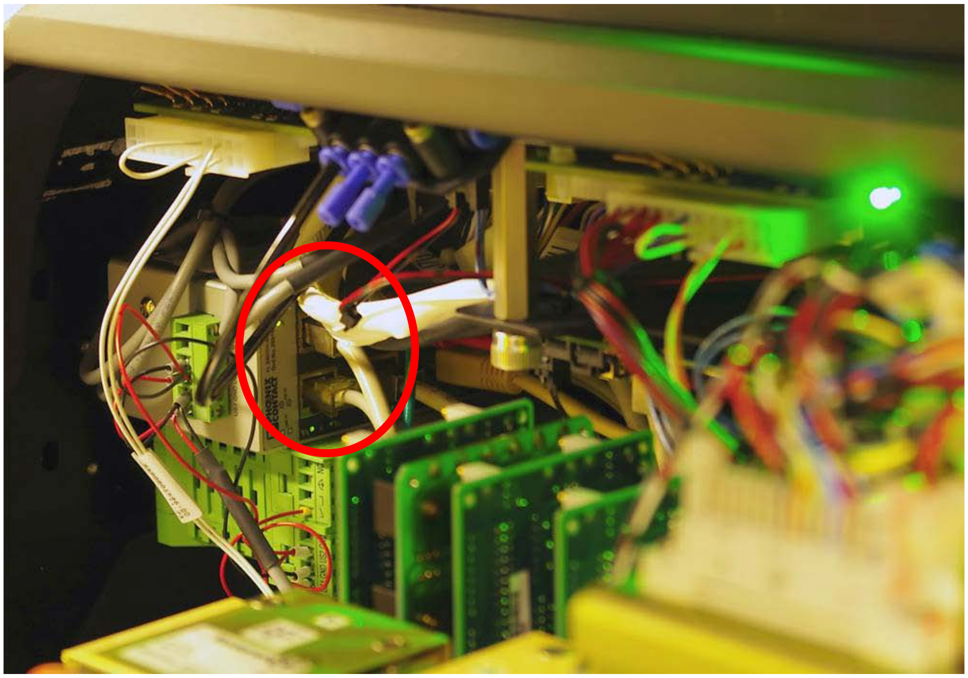


Figure 3-4 Connecting the Two Ethernet Cables

2. Slide the FRMM partly into the empty slot, and connect the Ethernet cables to the processor module of the FRMM, and the FRMM EDAQ (see Figure 3-5).

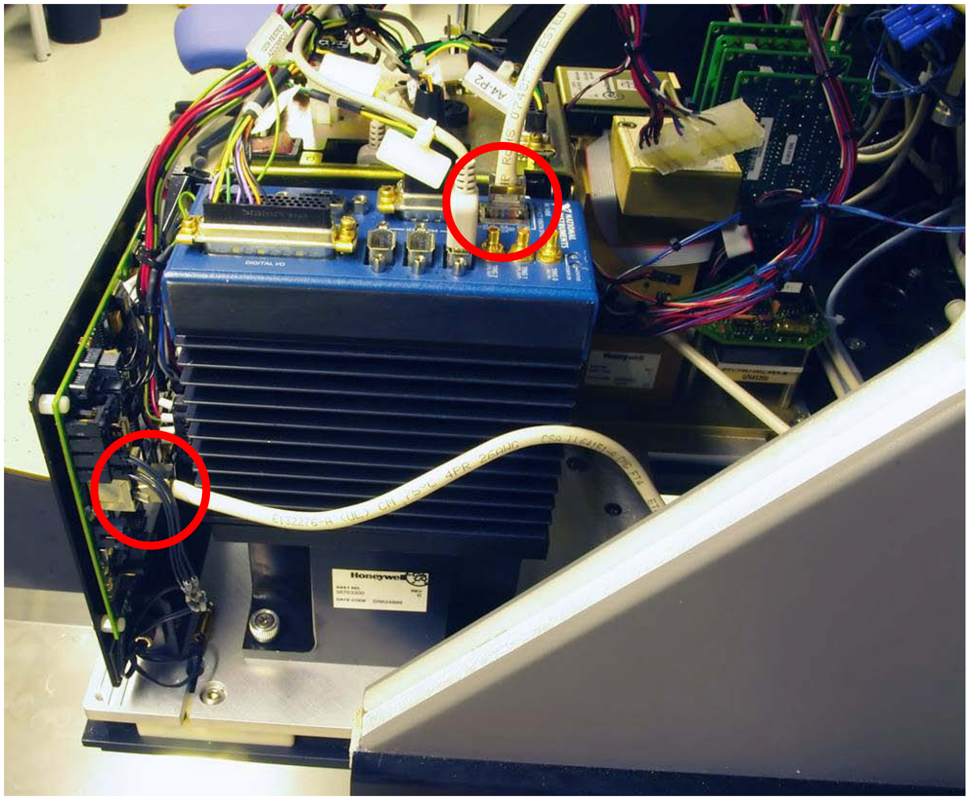


Figure 3-5 Sliding the FRMM into the Empty Slot

3. Connect the FRMM power and trigger cables (Figure 3-6) to the head trigger cable (Figure 3-7) and the power connector (Figure 3-8).

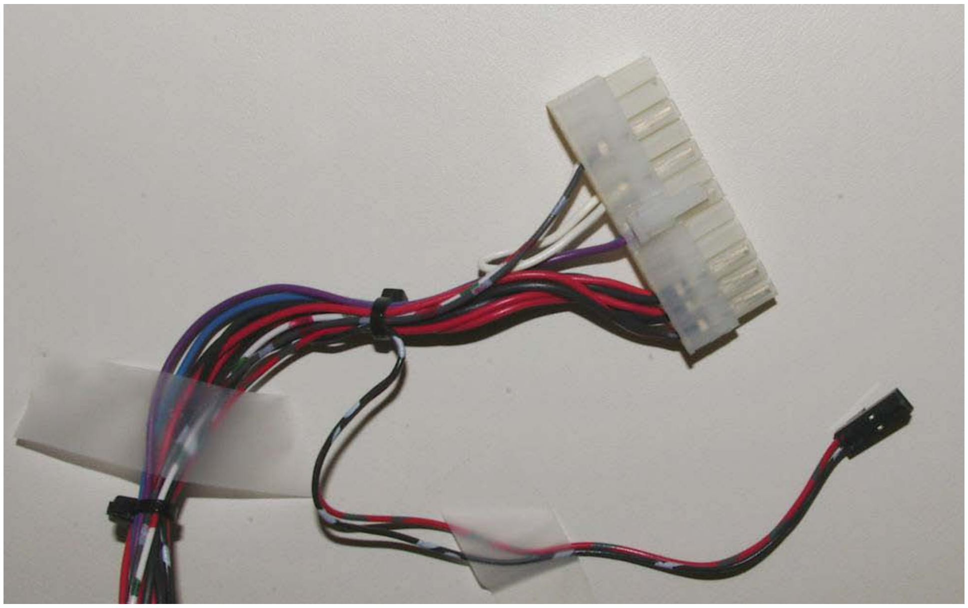


Figure 3-6 FRMM Power and Trigger Connectors

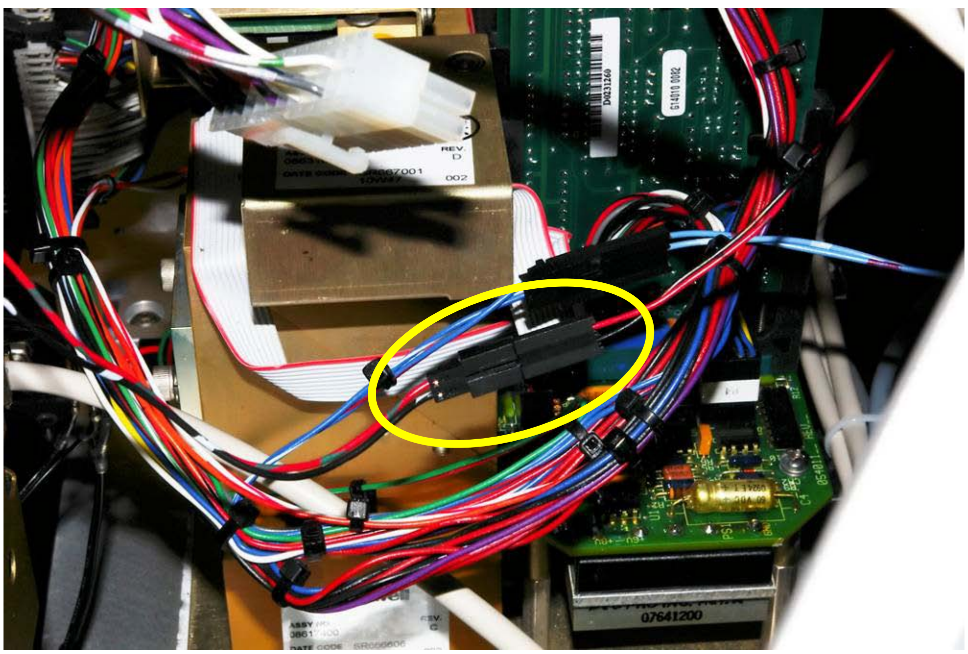


Figure 3-7 Connecting FRMM Trigger Cable

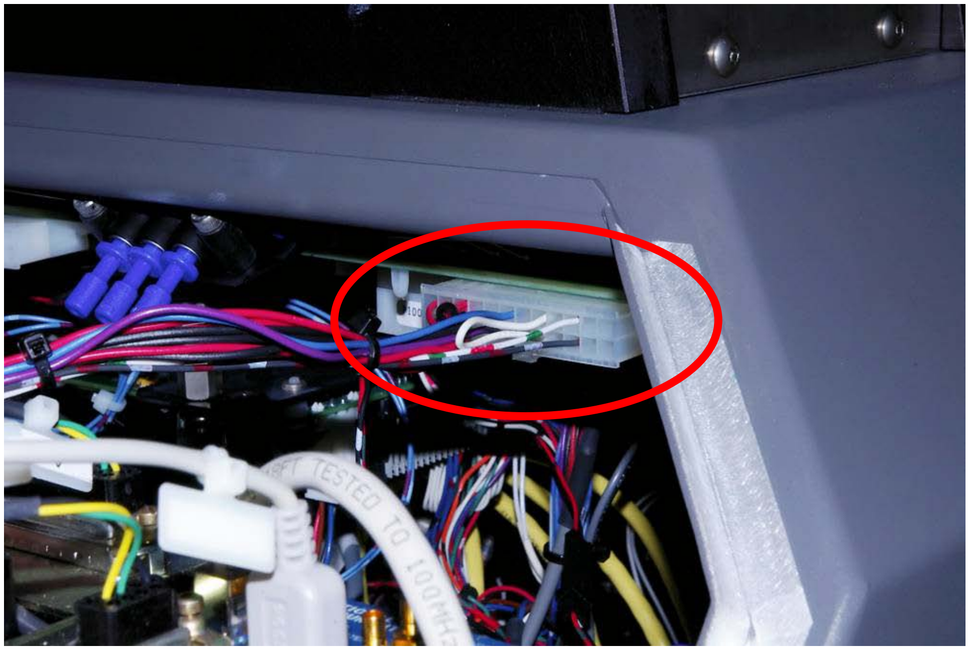


Figure 3-8 Connecting FRMM Power Cable

4. Slide the FRMM all the way in.

5. Tighten the FRMM locking screws (Figure 3-9) and the locking screw caps (Figure 3-10), and mount the sheetguide (Figure 3-11).

Figure 3-9 Tightening FRMM Locking Screws

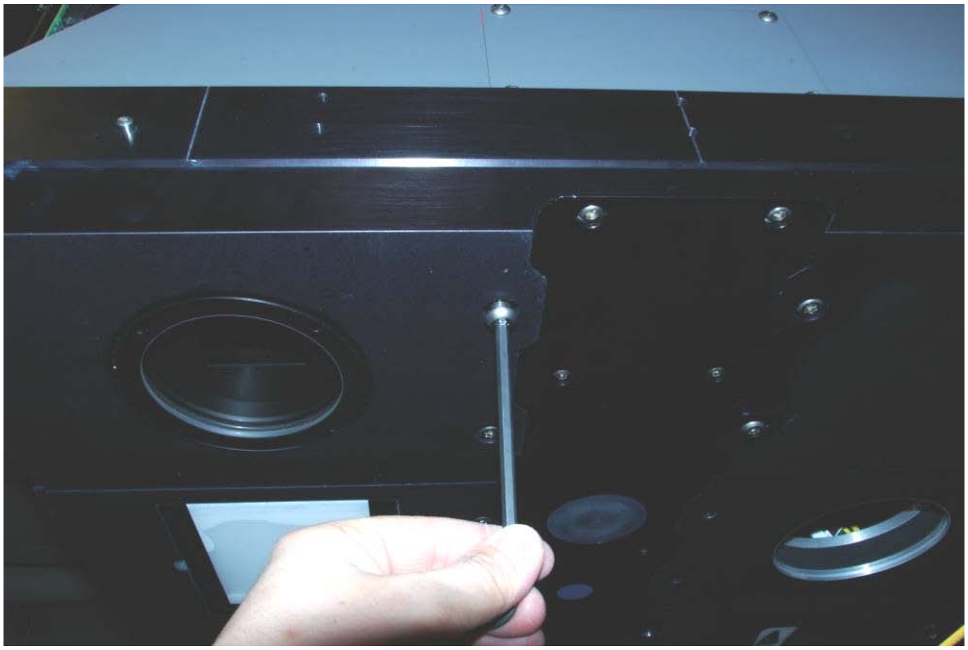


Figure 3-10 Tightening FRMM Locking Screw Caps

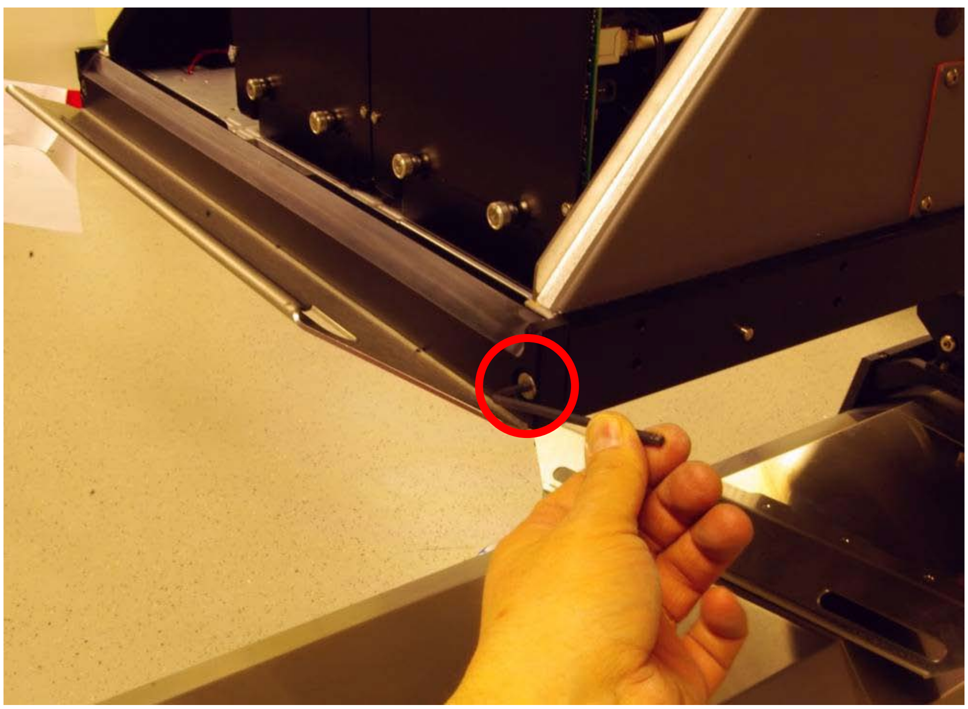


Figure 3-11 Mounting the Sheetguide

6. The FRMM installation is complete (see Figure 3-12).

Figure 3-12 FRMM Installed Into Upper Head

3.2.1.2. Mount the FRIM, and Connect Power and Signals

Install the FRIM into an empty (lower head) sensor slot in the Experion MX scanner (see Figure 3-13).

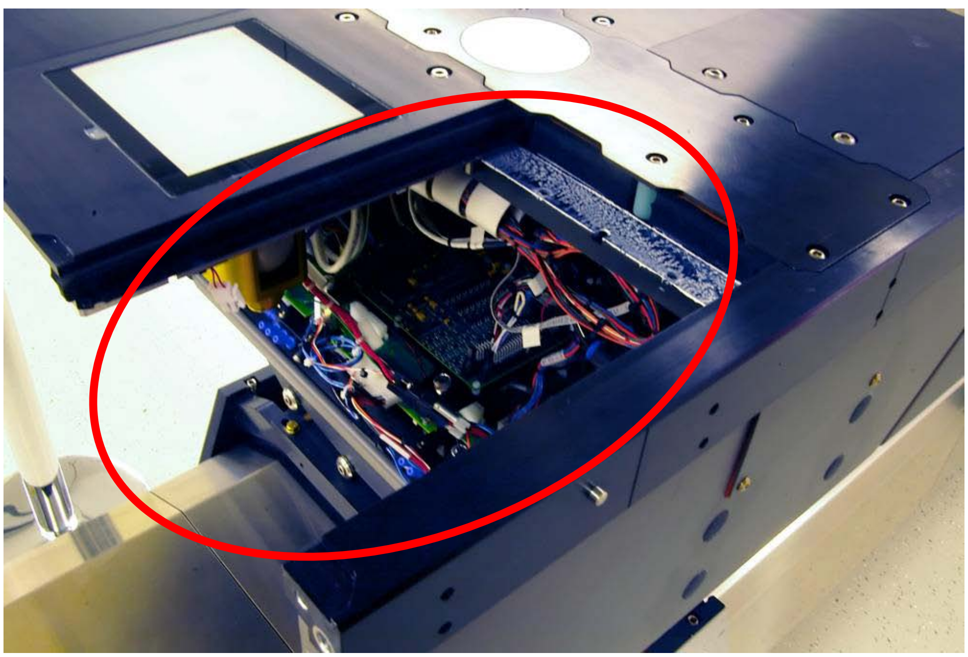


Figure 3-13 Empty Lower Head Slot

1. Slide the FRIM partly into the empty slot adjacent to the FRMM in the opposite head (see Figure 3-14).

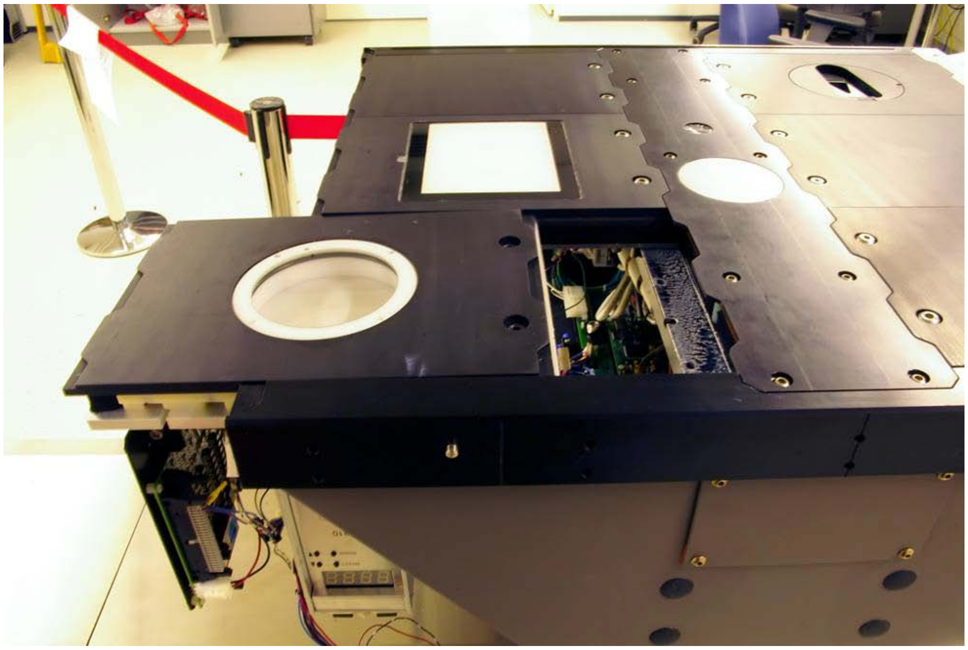


Figure 3-14 Sliding FRIM Partly Into the Slot

2. Connect one Ethernet cable to the sensor head LAN switch, and one trigger cable to the Power track (see Figure 3-15).

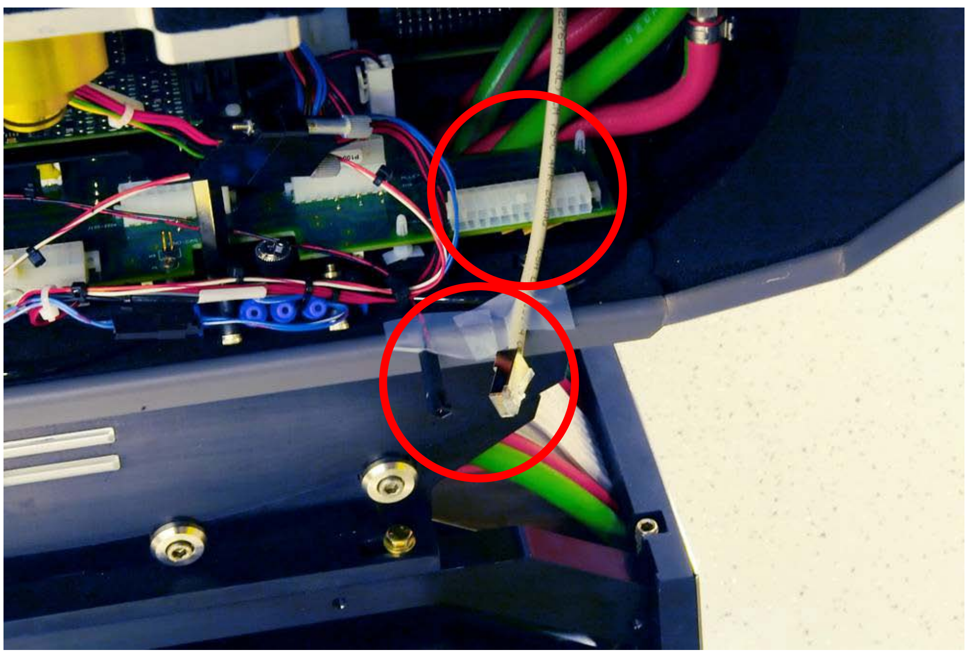


Figure 3-15 Ethernet Cable, Trigger Cable, and Power Connector

3. Connect the FRIM trigger and power cables to the head trigger cable (Figure 3-16) and the power connector (Figure 3-17).

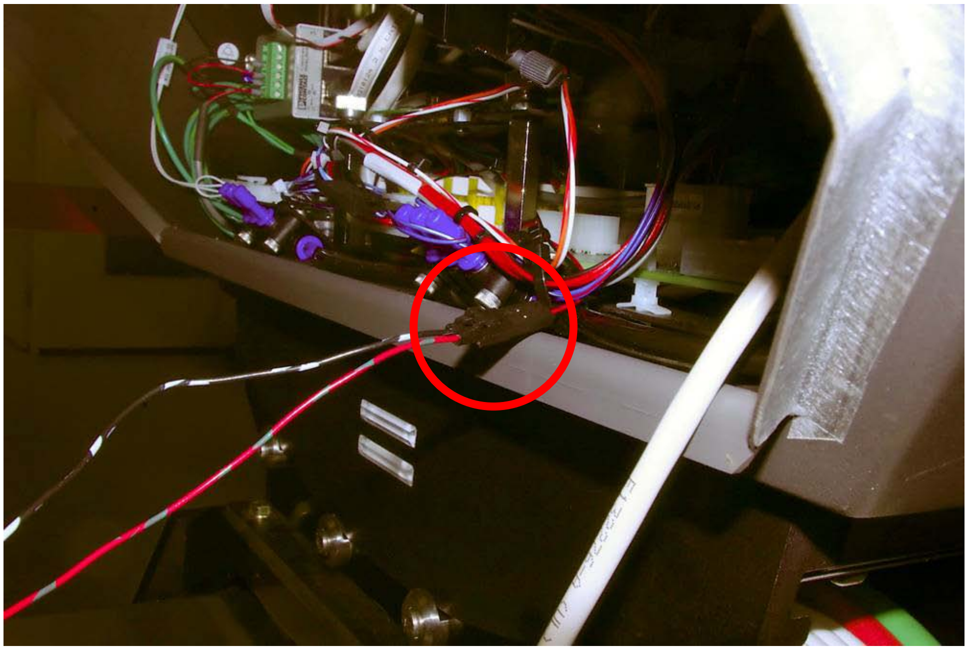


Figure 3-16 Connecting the FRIM Trigger Cable

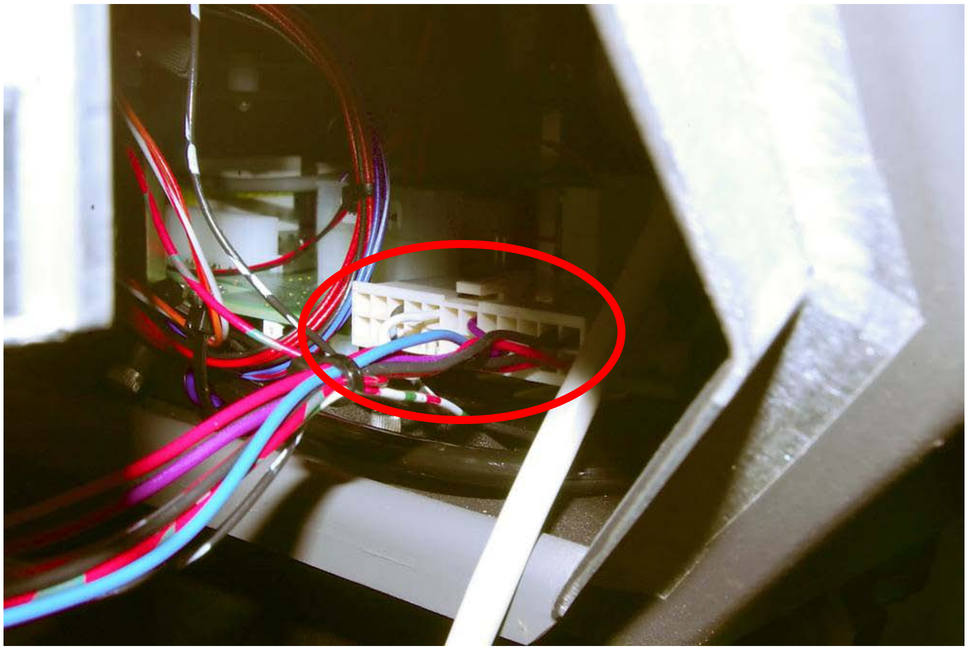


Figure 3-17 Connecting the FRIM Power Cable

4. Connect the Ethernet cable to the FRIM EDAQ (see Figure 3-18).

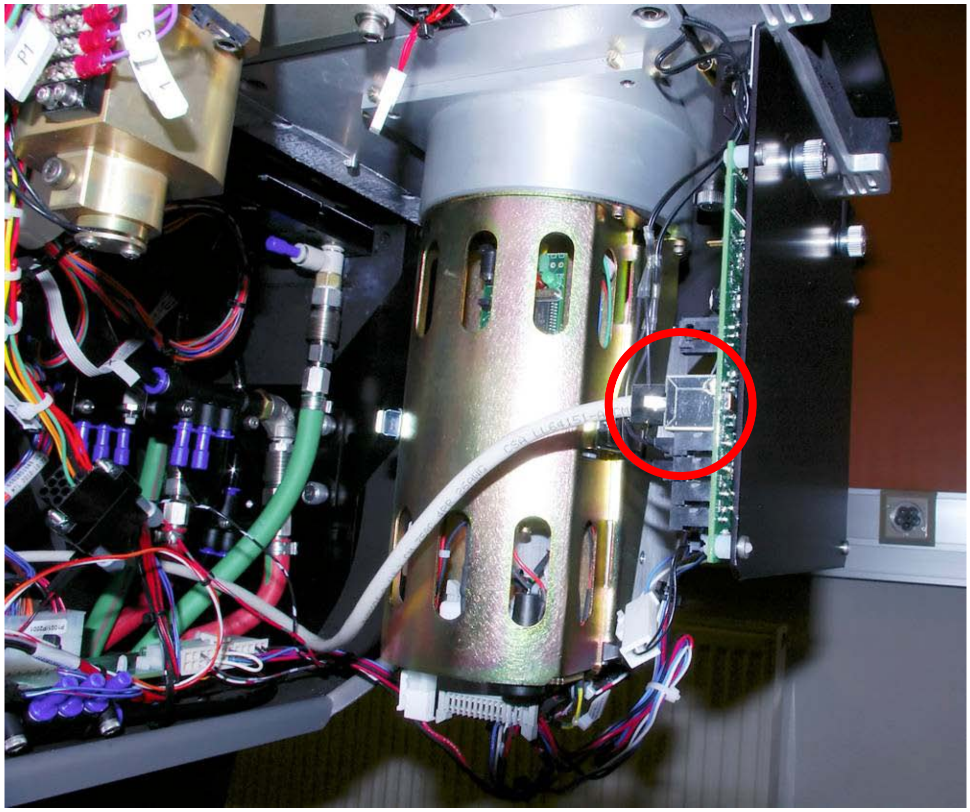


Figure 3-18 Connecting Ethernet Cable to the FRIM EDAQ

5. Slide the FRIM all the way in.

6. Tighten the FRMM locking screws and the locking screw caps, and mount the sheetguide (see Subsection 3.2.1.1).

7. The FRIM installation is complete (see Figure 3-19).

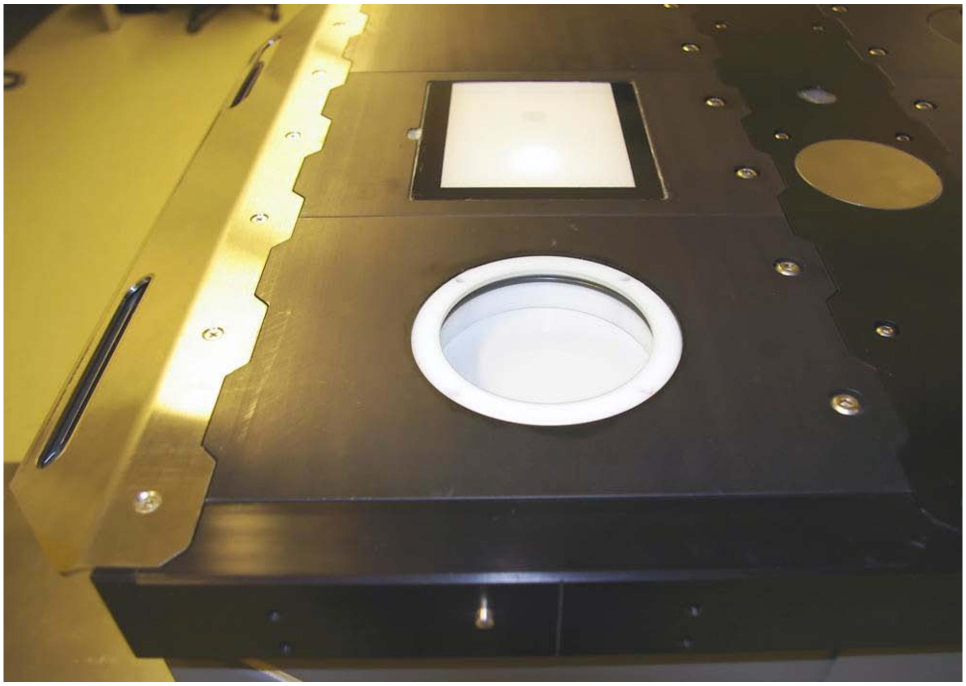


Figure 3-19 FRIM Installed In the Lower Head

3.3. Install the Software

Table 3-1 summarizes the software installation steps. Software installation can be done simultaneously with hardware installation.

Table 3-1 FotoForm Software Installation Checklist

1	Check that the QCS system meets FotoForm software requirements
2	Install FotoForm software to the QCS system
3	Start RAE
4	Configure MSS job set IO setup parameters

Check that the QCS system meets the software requirements for FotoForm (see Section 5.2).

3.3.1. Install the FotoForm Software to the QCS system

3.3.1.1. RAE 610 or Newer

FotoForm software is integrated in RAE 610 or newer.

3.3.1.2. RAE 600–603

FotoForm software is not fully integrated in RAE 603 or older versions. In those versions, the FotoForm add-on software must be installed. Detailed installation instructions are provided in Section 5.2.

1. Start RAE.
2. Configure MSS job set IO setup parameters.

3.3.1.3. MSS Job Set IO Setup

Strobe positions (slice data) and delays have to be configured in the **MSS Setup Diagnostics**, **MSS Job Set IO Setup** display (see Figure 3-20). Descriptions of the parameter values are listed in Table 3-2. The values of the parameters are the same for all FotoForm strobes. Ensure that you also set these parameters for the spare strobes.

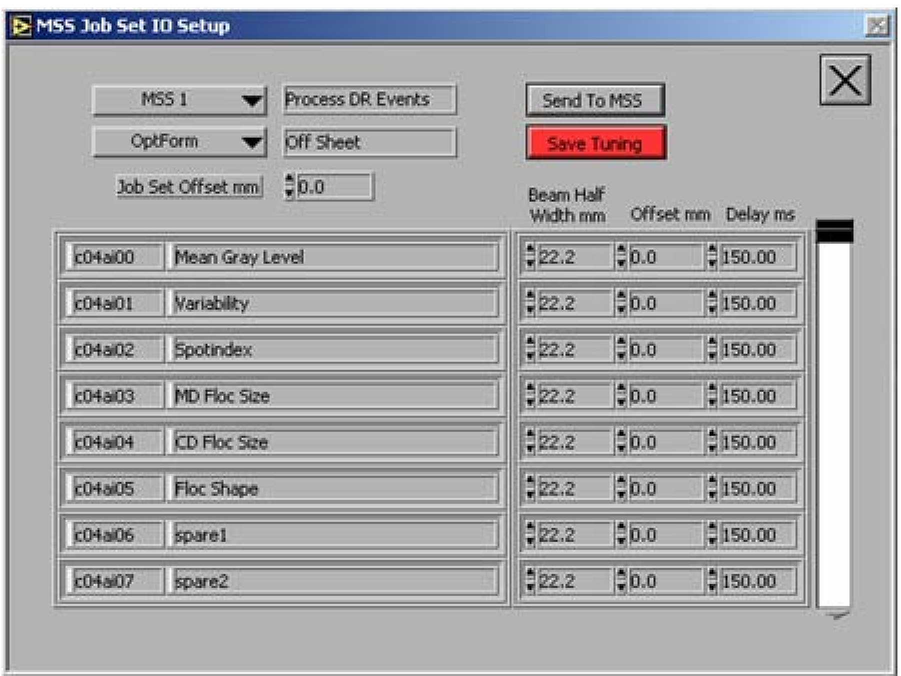


Figure 3-20 MSS Job Set IO Setup Display

Table 3-2 MSS Job Set IO Setup Parameters

Parameter	Description	Value
Job Set Offset mm	Offset of the Formation Sensor from the main sensor (usually basis weight)	Depends on installation position
Beam Half Width mm	Half width of the Formation Sensor aperture (half width of image)	22.2
Offset mm	All formation values are at the same cross direction position	0.0 (always)
Delay ms	Profile registration parameter	150

3.4. Formation Sensor Start-up Sequence

The Formation Sensor can not start up before the sensor IP Address, position code, and function code are known. This information is needed to establish the MSS connection. Two resistors are used to uniquely identify the EDAQ of the Formation Sensor. There is a sensor model resistor embedded in the cable harness connecting the sensor to the EDAQ. This resistor determines the function code. Function codes are unique for each sensor model.

In addition, the head power distribution board has a resistor for each EDAQ platform connector. This determines the position of the EDAQ in the head. The EDAQ can self-identify both its position and function. Formation sensor links are explained in Subsection 3.4.1 and in Figure 3-21.

3.4.1. Communication Links

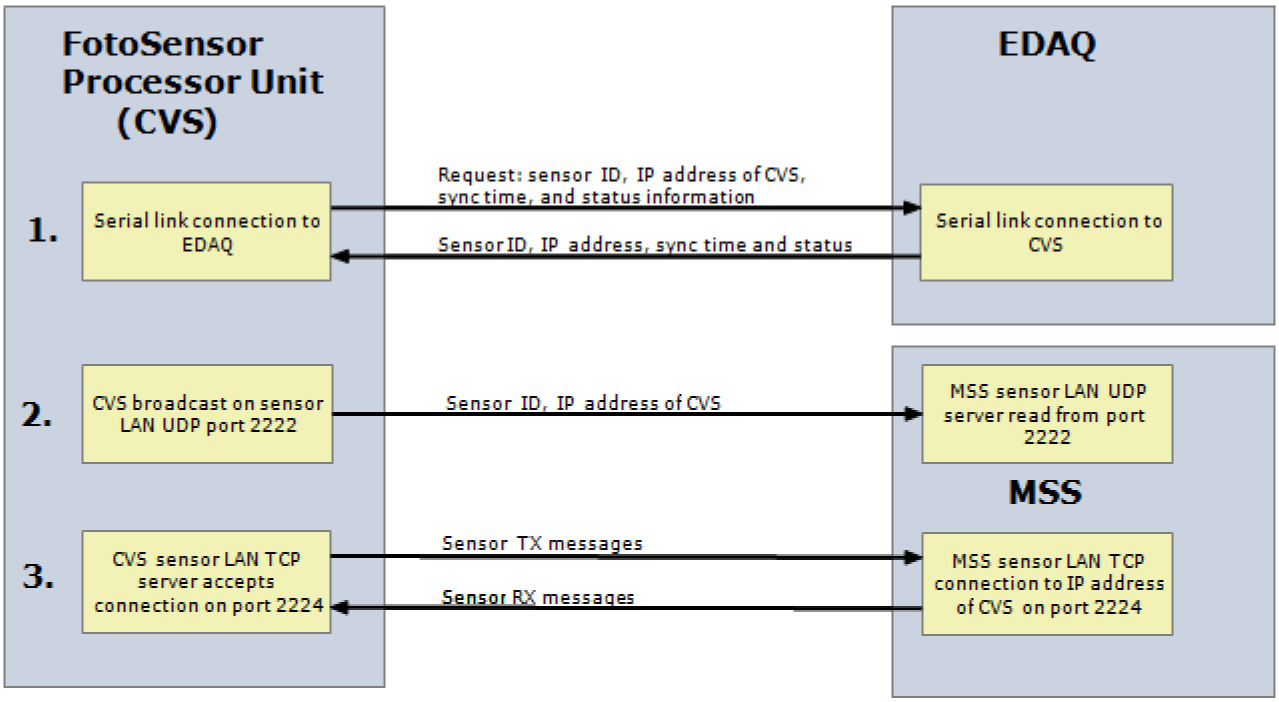


Figure 3-21 Formation Sensor Communication Links

1. Initially, the Formation Sensor does not have a valid IP address, position code, or function code. The sensor requests the IP address of the CVS, sensor position code, and function code from the EDAQ via a serial link.

2. Initially, MSS does not know the sensor IP address, position code, or function code. The sensor broadcasts the IP address, sensor position code, and function code on UDP port 2223.

3. MSS reads the CVS IP address, sensor position code, and function code from UDP port 2223. MSS uses this information to establish a TCP connection with the sensor on Port 2224. The MSS link is open for sensor communication. The sensor receives a system timestamp once per second through the EDAQ serial link. Either side can close the connection.

3.5. Check Sensor Installation and Communication

To verify successful installation and confirm working communication:

1. Start the QCS server.
2. Power on the sensor and the scanner, and wait for at least two minutes before proceeding.
3. Enable FotoForm in the **Scanner/Sensor Status** display.
4. On the server, using the **MSS Diagnostic** display, verify that **MSS Communication with EDAQ**, **EDAQ Data Timestamps**, and **EDAQ Card Safety Test Status** have green status.
5. On the server, using the **MSS Diagnostic** display, verify that sensor **Job Set** is enabled, and **EDAQ Data Available from Node(s)**, and **EDAQ Data Timestamps** have green status.

3.6. Check Sensor Functions

The Formation Sensor is best tested by making a sample measurement while in maintenance mode:

1. Go to the **Scanner → Sensor → Sensor Maintenance** display.
2. Select **FotoForm Sensor Processor**.
3. Load the recipe and enter maintenance mode.
4. Check that the sample integration time equals 40 seconds (change it if it is not already set to this value).
5. Go to the **FotoForm → FotoForm Image Gallery**, and switch to samples mode.
6. Save the previously measured samples, and click the **Clean** button to erase previously measured samples.
7. Go back to the **Sensor Maintenance** display.
8. Insert a sample into the sensor gap between the FRMM and the FRIM.

9. Push the **Sample** button of the Experion MX scanner, or click **Sample** on the **Sensor Maintenance** display.
10. After sampling finishes, go to the **FotoForm Image Gallery** and switch to samples mode.
11. If you can see a new paper surface photo with meaningful data, the sensor is working properly.

3.7. Primary Performance Evaluation

If you have formation standard slides, make a sample measurement of them and compare with nominal values of the slides.

3.8. Choose a Location for the Sensor

The Formation Sensor may be installed to any scanner in the paper machine. However, the most typical single-sensor configuration is to place it near or before any coaters or sizers, for example, measuring the base paper/board.

3.9. Passline, Tilt, and Waviness of the Web

The sensor has been designed to allow free web movement in the sensor gap (this is a non-contacting sensor). However, tight waviness or curls of the web may have effects which are not compensated for. Try to avoid anything that may lead to such phenomenon at the sensor.

4. Operation

This chapter describes Formation Sensor operation modes.

4.1. Configuration Parameters

When the Formation Sensor gets the MSS link-up, it first requests configuration parameters.

4.2. On-sheet Sensor Operation

To perform a scan:

1. Prepare scan.
2. Do slice measurements at a frequency of 10 Hz, and gather the scan average of the image intensity.
3. Pass the data to end-of-scan operations.

To perform a slice measurement:

1. Take a transilluminated image of the web.
2. Do an image enhancement (dynamic dirt and shading correction).
3. Apply the mathematical algorithms to the corrected image to calculate all five formation properties presented in Section 7.3.
4. Save the image, to a buffer, of the last 100 valid frames (*valid* means not underexposed or overexposed).

5. Send time-stamped characters to the QCS system for profile/trend building/display.

6. If this is an image monitoring slice, send the image to the QCS system.

   Up to four positions can be selected from which the image is sent to the **Experion MX** display (allows on-line lightbox operation).

4.3. End-of-scan Operation

All parameters of imaging (including camera and light pulse parameters) are adjusted at end-of-scan. These tasks include:

1. Auto-adjust the light source intensity based on scan average in order to have a constant signal level (mean graylevel) from the camera. This allows significant grade changes without any preparation: the sensor adjusts itself automatically to changing light absorption of the web.

2. Make imaging adjustments based on machine direction line speed.

3. Update the illumination correction image for automated illumination non-uniformity and dirt correction based on the valid image buffer updated in the slice measurement procedure (see Section 4.2).

   The update interval is selectable from once per standardization (default) up to once per scan.

   Update of the illumination correction image causes the scanner to wait for about 1.5 seconds at the end position of the scan before scanning continues. Due to this delay, it is recommended that the default update interval be used unless extreme dirt build-up between standardizations is expected.

   Illumination correction image can be viewed on the **FotoForm Engineering** display (see Subsection 5.3.5).

4.4. Perform a Standardize and a Reference

The Formation Sensor does not have any parameters for calibrating the results based on standardization. The only function of standardization is to help the automatic adjustment of light intensity to stabilize faster when there are large changes in optical density of the web.

To perform a standardization:

1. Initialize the camera and the strobe controller (set to initial output current).
2. Take 10 images, and record the mean graylevel.
3. Increase the light pulse intensity by adding current, and repeat Step 2 until all the currents have been measured.
4. Fit normalized graylevel (= graylevel/max(graylevel)) vs. current to get the slope and offset for current control.
5. Send the standardization response data to the QCS system. The success of the standardization result can be viewed on the **FotoForm Engineering** display (see Subsection 5.3.5).

Standardization response data includes:

- slope
- offset
- calibration curve
- residue of the linear fit
- number of saturated (overexposed) pixels

For the Formation Sensor, the reference procedure is identical to the standardization procedure.

4.5. Background

The Formation Sensor does not have a background function.

4.6. Perform a Sample Measurement

The Formation Sensor has sample measurement available as an offsheet function in maintenance mode.

To perform a sample measurement (for detailed instructions, see Appendix C):

1. Configure the system for maintenance mode.
2. Set the sample integration time to 40 seconds or more.
3. Enter the sample to the sensor gap in the same orientation as the paper web (machine direction and cross direction as in the paper web).
4. Push the **Sample** button.
5. Repeat Steps 3 and 4 until all samples have been measured.
6. Look at the results gathered on the **Maintenance** display and on the **FotoForm Image Gallery** display.

To make a sample measurement, internal procedure:

1. Initialize the camera and light according to sample machine direction speed parameter, and use the previous current.
2. Take 10 images and calculate the mean graylevel.
3. If the mean graylevel was out of bounds, adjust the current, and go back to Step 2; otherwise proceed to Step 4.
4. Take the specified number of images and calculate which of the images is the most typical. The selection is based on the least squared error with respect to mean values of all the formation characters.
5. Report the parameters of the most typical image.

5. Configuration

The Formation Sensor works with the QCS system by exchanging configuration data, state change requests and measurement results. In this chapter the details of FotoForm software are described.

5.1. Functional Overview

An overview of FotoForm software is shown in Figure 5-1.

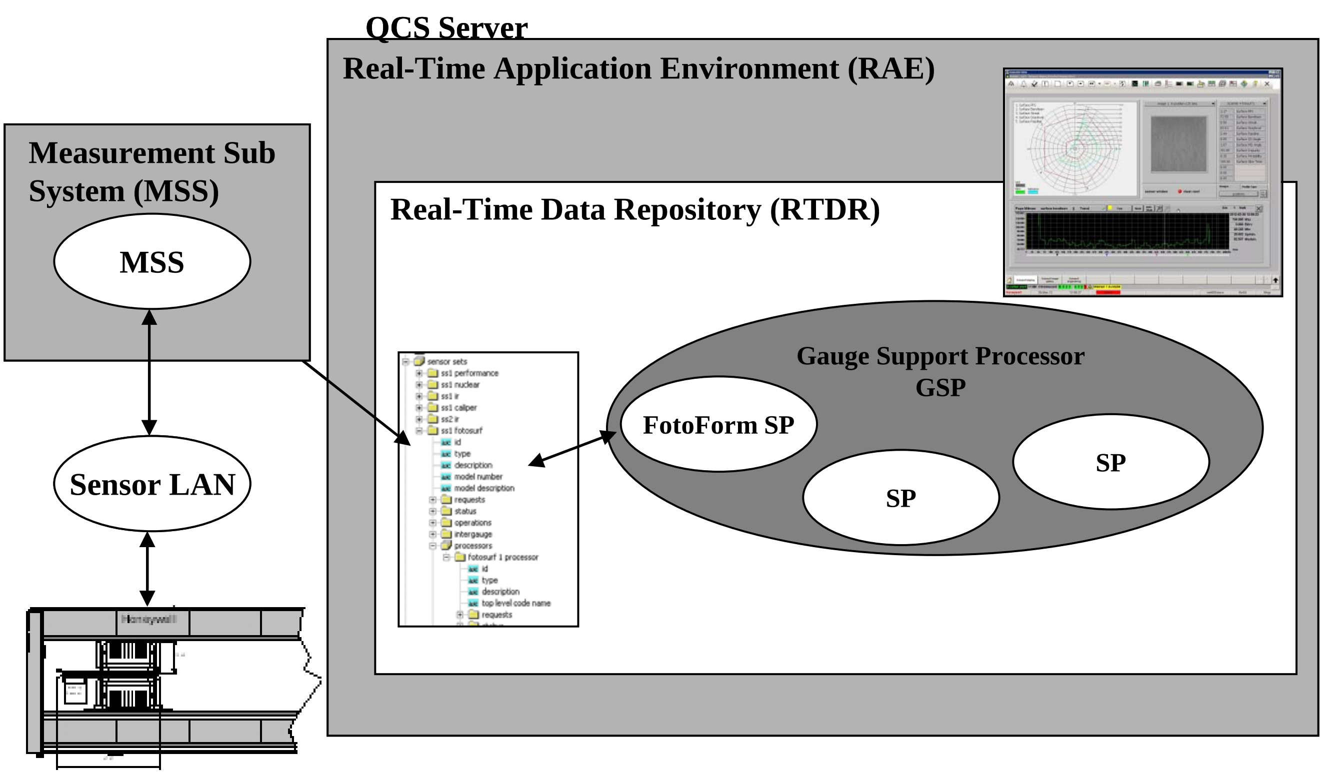


Figure 5-1 FotoForm Software Overview

The Formation Sensor communicates with the MSS over the sensor LAN. The MSS communicates state changes and statuses with the sensor. It also processes measurement data into, for example, profiles and trends, and saves the data into the Real-Time Data Repository (RTDR), which it shares with the QCS server.

FotoForm processing is done by the FotoForm Sensor Processor (SP) inside the Gauge Support Processor (GSP). Processed data can be visualized by FotoForm displays. Formation data can be stored and processed further by external databases like Honeywell's Uniformance® Process History Database (PHD).

5.1.1. Data Flow

The Formation Sensor is connected to the MSS via the sensor Ethernet LAN. All communication to and from the sensor is done via this link, which operates at 100 Mbit/s.

The camera sensor link (CSL) data is located in the *scannerX/mss/ssX fotoform/setup* RTDR record, where *X* is the sensor set number. Message types sent by the Formation Sensor to the MSS are listed in Table 5-1. Message types sent by the MSS to the Formation Sensor are listed in Table 5-2. Detailed descriptions of these messages are outside of the scope of this manual.

Table 5-1 Message Types: Formation Sensor → MSS

Message	Type	Bytes	Sensor → RTDR
Configuration Data Request	10_H/16	1	---
Alive and Well	30_H/48	4	---
Mode Status	11_H/17	1	---
Stdz Data	12_H/18	80	Standardize Data Buffer
Slice Data	13_H/19	44	OFSxAIA… OFSxAIJ (*ScannerX/mss/ssX optform/sensor inputs/*)
End of Scan Data	14_H/20	40	End Of Scan Data Buffer
Image Data	15_H/21	20001	Image Data Buffer 1..5
Diagnostic Data	16_H/22	40	Diagnostic Data Buffer
Alarm Message	17_H/23	40	Alarm Message Buffer
Versatile Data	32_H/50	Max 2 Mb	Versatile Data Buffer

Table 5-2 Message Types: MSS → Formation Sensor

Message	Type	Bytes	RTDR → Sensor
Configuration Data	20H/32	200	Configuration Data Buffer
Alive and Well	30H/48	4	Process Data (Line speed in meters per second is sent to the sensor within the *Alive and Well* acknowledgment message)
Mode Change Request	21H/33	1	---
Diagnostic Request	22H/34	2	---
Initial TIC Count	23H/35	1	---
Trigger Image	24H/36	5	---
Recipe Parameters	31H/49	80	Recipe Data Buffer
Versatile Data	32H/50	Max 2 Mb	Versatile Data Download

5.1.2. Sensor Processor

The Formation Sensor SP is located under the *C:\Program Files\Honeywell\Experion MX\Gauging\Labview VIs\ Processors\Precision FotoForm* folder, and it handles all data sent from the sensor.

The correspondence between the SP activity, the sensor inputs child record, and the virtual instrument (VI) that handles data is shown in Table 5-3.

Table 5-3 Correspondence Sensor Processor/Sensor Inputs Child Record

Sensor Processor Activity	Sensor Inputs Child Record	Handled By VI
Maintenance Background	Background	Not in use
Maintenance Reference	Reference	SP PFFx Reference.vi
Maintenance Sample	Sample	SP PFFx Single Point.vi
		SP PFFx Sample Image Data.vi
Production Background	Background	Not in use
Production Standardize	Reference	SP PFFx Reference.vi
Production Single Point	Single Point	SP PFFx Single Point.vi
Production Periodic Measurement	Periodic	SP PFFx Single Point.vi
Production EOS Forward and Production EOS Reverse	Scan	SP PFFx End of Scan.vi
		SP PFFx Image Data.vi
Production Buffered Single Point	Buffered Single Point	SP PFFx Buffered Single Point.vi
Scan Forward	Scan	SP PFFx End of Scan.vi
Scan Reverse	Scan	SP PFFx End of Scan.vi

The SP processes the functions described in Table 5-4.

Table 5-4 Sensor Processor Functions

VI	Function/Execution
SP PFFx Disable Processor.vi	Disables sensor set and sensor processor when CSL is down. *Function checks* is sensor sending data read from the *./job set/sensorsendingdata RTDR* parameter. Running cycle = 2s.
SP PFFx Read Line Speed.vi	Reads current line speed and scales it to m/s. *./scannerX/status/scan data/speed * ./calibration parameters/ speed slope + ./calibration parameters/ speed intercept* → *./scannerX/mss/setup/process* data buffer. Running cycle = 2s.
SP PFFx Image Folders Create.vi	Creates image folders if they do not exist. Saves image data from the files that exist to the RTDR. Executed once at server startup.
SP PFFx Save Grade Images.vi	Saves image data to reference images. Wait event (user1 = 65536) from the **Image Gallery** display. Event is set by the *PFF Save New Grade Image.vi* when saving image to reference image.
SP PFFx Reference by Grade Change.vi	Gets reference image for the **Image Gallery** display, and copies grade based configuration parameters to the recipe data buffer for sending to the sensor. Wait event (Code start = 16) by the grade change.
SP PFFx Display Data Request.vi	Gets history image data for the **FotoForm Display**. Gets reference image data for the **Image Gallery** display. Wait event (Data changed = 2) from the **Image Gallery** display and **FotoForm Display**. Event is set by: *Image Gallery Request.vi* in reference image access; *History Image Request.vi* in slice data history access.
SP PFFx Display Functions.vi	Wait event (Data changed = 2) from the **Image Gallery** display. Function makes the next operations: • Save Sample Images • Clean Sample Images • Get Sample Images • Delete Sample Images
SP PFFx Handle Versatile Message.vi	Sends configuration data to the sensor. Sensor sends configuration request after startup by versatile data. Reads illumination correction data sent by the sensor. Reads configuration data sent by the sensor. Wait event (Versatile = 2097152) from the MSS. Event is set when sensor sends Versatile data message: Configuration request by the *State Machine.vi*; Configuration data by the *Parameters.vi*; Illumination Correction Image by the *Edge.vi*.
SP PFFx Sample Image Data.vi	Reads and saves sample image data in sample mode. Image data is sent by the sensor to the *./scannerX/mss/ssX optform/setup/image* data buffer 5. Executes once when sample is ready (in *Maintenance Sample*).
SP PFFx Image Data.vi	Handles image data sent by the sensor. Reads image data setup from the *./configuration parameters/image* data setup RTDR parameter. Creates log folder after roll has changed. Deletes oldest saving data (folder) if max folders reached. Finds typical image of the roll. Saves roll image data to the image gallery and deletes oldest one (max = 8 gallery image). Reads scanning image data from the *./scannerX/mss/setup/image* data buffer 1.4 sent by the sensor. Saves scanning image data to the files. File names and folder are defined by the image data setup RTDR parameter. Executed once when Production EOS (Fwd, Rvs).
SP PFFx Pack Config Data to Versatile.vi	Reads configuration parameters, pack and write them to *./scannerX/mss/ssX optform/setup/versatile* data download RTDR parameter. Done in server startup. Executed once at server startup.

5.1.3. Save Images

Formation images and their values are saved to the hard disk at every end-of-scan, and to the image gallery when the roll is completed. Sample images are saved with the sample function.

Base path for saving images is *%MXRTDB%\CS Data\FotoForm* , where the default value for the environment variable MXRTDB = *C:\ProgramData\Honeywell\Experion MX\Database*.

5.1.3.1. Image Data Setup Parameters

Definitions for image saving are defined by the image data setup configuration parameter of the sensor processor (see Figure 5-2).

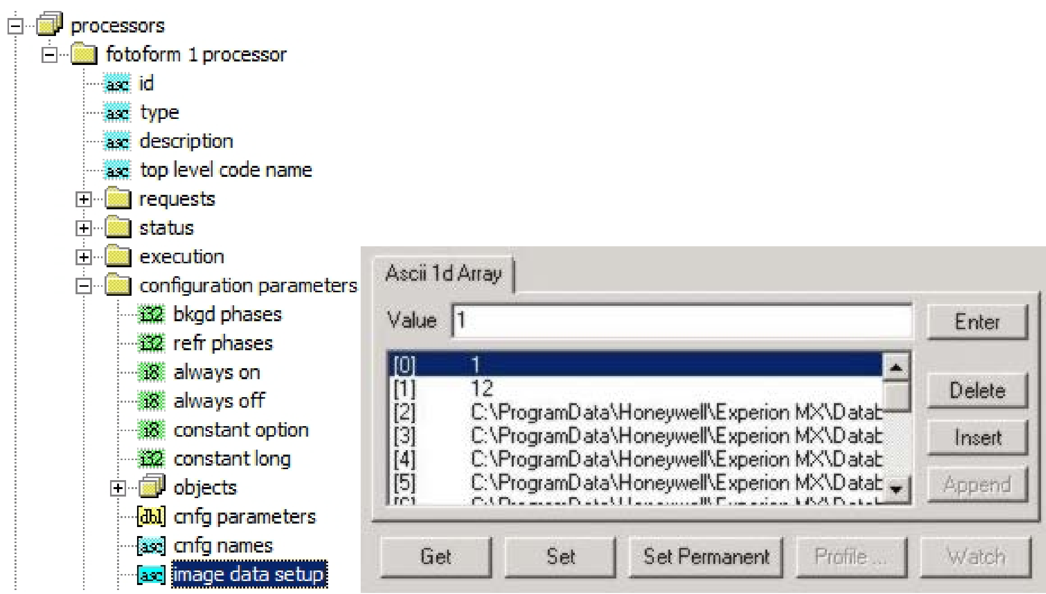


Figure 5-2 Image Data Setup

Table 5-5 lists and describes default values and image data parameters.

Table 5-5 Default Values for Image Data Setup Parameters

Idx	Parameter	Description	Default Value
0	Log ON/OFF (1/0)	Enable/disable image saving	1 = saving images
1	Max Folders to be Saved	Number of saved rolls	12

Idx	Parameter	Description	Default Value
2	Log Main Folder	Main folder name	*C:\ProgramData\ Honeywell\ Experion MX\ Database\ CS Data\ FotoForm\ PFF1_Data*
3	Log Saving Folder	Folder name for image history	*C:\ProgramData\ Honeywell\ Experion MX\ Database\ CS Data\ FotoForm\ PFF1_Saved_Data*
4	Main Folder\Image1FileName.ext	Image 1 file name	*C:\ProgramData\ Honeywell\ Experion MX\ Database\ CS Data\ FotoForm\ PFF1_Data\image1.jpg*
5	Main Folder\Image2FileName.ext	Image 2 file name	*C:\ProgramData\ Honeywell\ Experion MX\ Database\ CS Data\ FotoForm\ PFF1_Data\image2.jpg*
6	Main Folder\Image3FileName.ext	Image 3 file name	*C:\ProgramData\ Honeywell\ Experion MX\ Database\ CS Data\ FotoForm\ PFF1_Data\image3.jpg*
7	Main Folder\Image4FileName.ext	Image 4 file name	*C:\ProgramData\ Honeywell\ Experion MX\ Database\ CS Data\ FotoForm\ PFF1_Data\image4.jpg*
8	Main Folder\Image5FileName.ext	Image 5 file name	*C:\ProgramData\ Honeywell\ Experion MX\ Database\ CS Data\ FotoForm\ PFF1_Data\image5.jpg*
9	Main Folder\Data1FileName.ext	Slice data 1 file name	*C:\ProgramData\ Honeywell\ Experion MX\ Database\ CS Data\ FotoForm\ PFF1_Data\image1.dat*
10	Main Folder\Data2FileName.ext	Slice data 2 file name	*C:\ProgramData\ Honeywell\ Experion MX\ Database\ CS Data\ FotoForm\ PFF1_Data\image2.dat*
11	Main Folder\Data3FileName.ext	Slice data 3 file name	*C:\ProgramData\ Honeywell\ Experion MX\ Database\ CS Data\ FotoForm\ PFF1_Data\image3.dat*
12	Main Folder\Data4FileName.ext	Slice data 4 file name	*C:\ProgramData\ Honeywell\ Experion MX\ Database\ CS Data\ FotoForm\ PFF1_Data\image4.dat*
13	Main Folder\Data5FileName.ext	Slice data 5 file name	*C:\ProgramData\ Honeywell\ Experion MX\ Database\ CS Data\ FotoForm\ PFF1_Data\image5.dat*
14	Image Gallery Folder Name	Image gallery folder name	*C:\ProgramData\ Honeywell\ Experion MX\ Database\ CS Data\ FotoForm\ PFF1_Image Gallery*
15	Slice Data Mean Values File Name	Slice data file name	Mean Values.dat
16	Auto Reference Image ON/OFF (1/0)	Save/do not save reference images	0 (off)
17	Max Files in Log Saving Folder	# max files to be saved to	3000

5.1.3.2. Image Folders

Figure 5-3 is a screenshot of the image directory (under *%MXRTDB% \CS Data \FotoForm * directory by default).

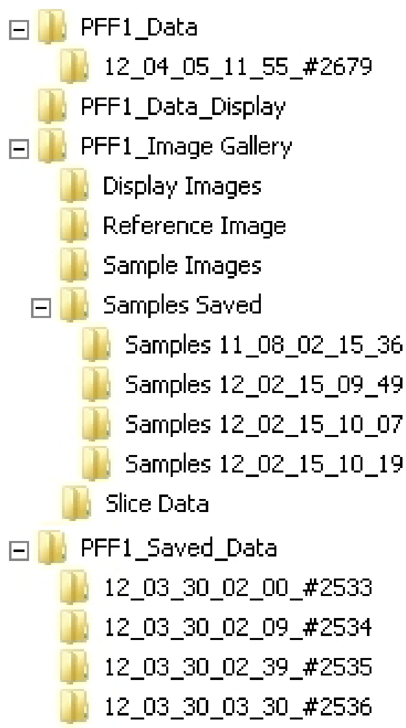


Figure 5-3 Image Directory

Table 5-6 describes the image directory contents.

Table 5-6 Image Directory Contents

Folder	Description
PFF1_Data	Storage for latest images and their data and current reel
PFF1_Data\ 12_04_05_11_55_#2679	Image folder of the current reel
PFF1_Data\ PFF1_Data_Display	Storage for current **FotoForm Display** images
PFF1_Image Gallery	Folder for the **FotoForm Image Gallery** display data
PFF1_Image Gallery\ Display Images	Images currently shown on the **FotoForm Image Gallery** display
PFF1_Image Gallery\ Reference Image	Reference image folder shown in the middle of the **FotoForm Image Gallery** display
PFF1_Image Gallery\ Sample Images	Current sample images
PFF1_Image Gallery\ Samples Saved	Saved sample image folders. Each folder contains maximum of nine samples.
PFF1_Image Gallery\ Slice Data	Formation data of images currently shown on the **FotoForm Image Gallery** display

Folder	Description
PFF1_Saved_Data	Folder for the reel history of image and formation data. Folders inside this folder each contain all saved images of one reel. If the number of images exceeds image data setup configuration parameter *Max Files in Log Saving Folder*, a new folder is created with the same reel number.

ATTENTION

Image and formation data history folders of the reels, for example, *06_11_16_17_48_#11* = Roll #11 started 16.11.2006 17:48. These folders are copied from the *PFFx_Data* folder when the reel is ready. The maximum number of reels, the images of which are saved, is defined by the image data setup parameter *Max Folders to be Saved*.

5.1.3.3. Folder and File Names

Figure 5-4 shows a screenshot of a folder hierarchy of the *PFF1 Data* directory.

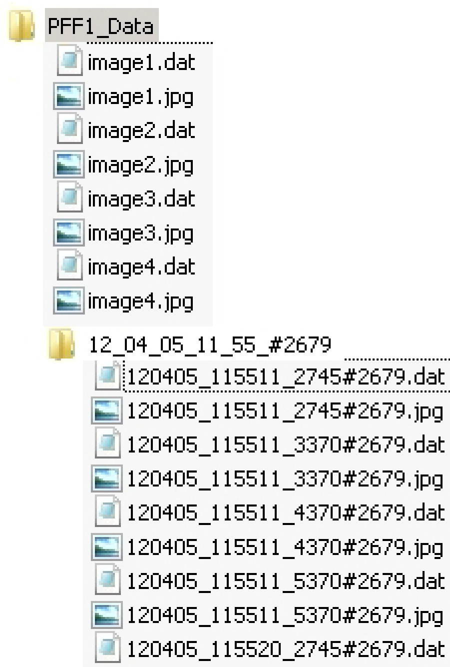


Figure 5-4 Folder Hierarchy: PFF1_Data

Table 5-7 lists and describes the folders shown in Figure 5-4.

Table 5-7 Folder Hierarchy Description: PFF1_Data

Folder	Description
Main folder (PFF1_Data)	Current Image files: ImageX.dat = Slice data file ImageX.jpg = Image X file name
Current reel image folder (12_04_05_11_55_#2679)	YY_MM_DD_hh_mm_#Reel, where YY = year, MM =month, DD = day, hh = hour, mm = minutes, #Reel = reel number
	Image and data files Inside Current Reel Image Folder: YYMMDD_hhmmss_Pos#Reel.ZZZ, where YY = year, MM = month, DD = day, hh = hour, mm = minutes, ss = seconds, Pos = Image position in mm, #Reel = reel number, ZZZ = filename extension (JPG for image, DAT for associated slice data).

Figure 5-5 is a screenshot of an expanded view of the *PFF1_Image_Gallery* folder.

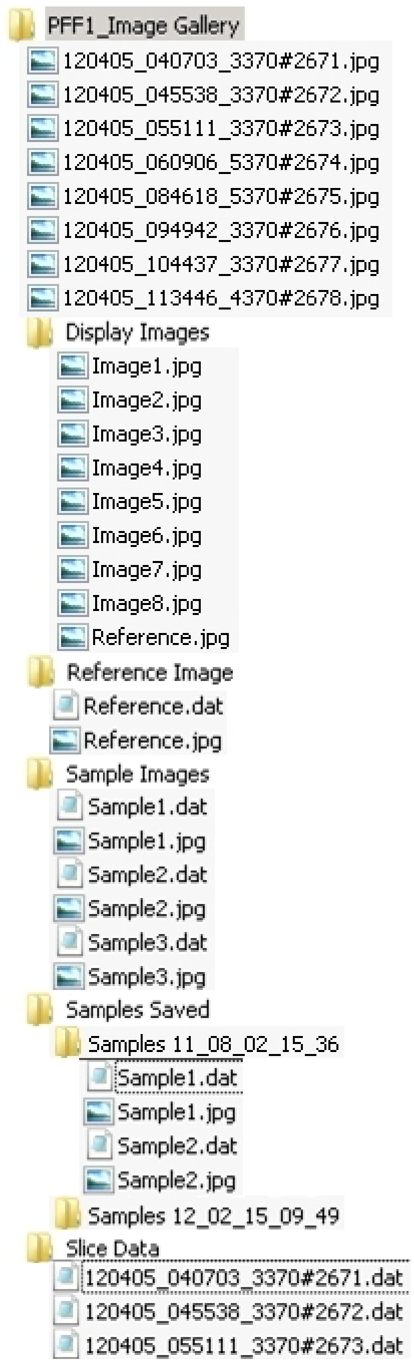


Figure 5-5 Folder Hierarchy: PFF1_Image_Gallery

Table 5-8 lists and describes the *PFF1_Image_Gallery* contents shown in Figure 5-5.

Table 5-8 Folder Hierarchy: PFS1_Image_Gallery

Folder	Description
PFF1_Image Gallery	Original saved image gallery files
	YYMMDD_hhmmss_Pos#Reel, where: YY = year, MM =month, DD = day, hh = hour, mm = minutes, ss = seconds, Pos = Image position in mm, #Reel = reel number
Display Images	Temporary storage of images for display purposes
Reference Image	Temporary storage of reference image for current grade for display purposes. Reference images are saved in RTDR records.
Sample Images	Current sample images: sample images are named in order of made samples. Maximum number of sample images to show at the same time is nine. If more needed, then images need to be saved.
Samples Saved	Sample images are saved by the SAVE function. The folder name format is: Samples YY_MM_DD_hh_mm, where YY = year, MM =month, DD = day, hh = hour, mm = minutes. Files are named as SampleN.ZZZ, where N=1…9, ZZZ = filename extension (JPG for image, DAT for associated slice data).
Slice Data	Slice data of original saved image gallery files (typical files of last eight reels).

5.2. System Configuration

FotoForm Measurement software is a standard feature of RAE, versions 610 and later.

FotoForm Measurement software can be added to these RAE versions by installing the add-on package:

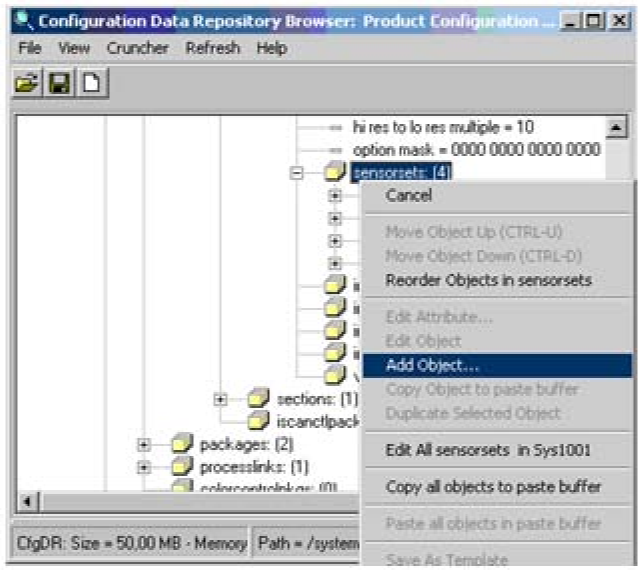
- RAE 600
- RAE 601
- RAE 602
- RAE 603

If your system is among the add-on compatible versions, contact Honeywell QCS Technical Assistance Center (TAC) for assistance to get the FotoForm add-on package.

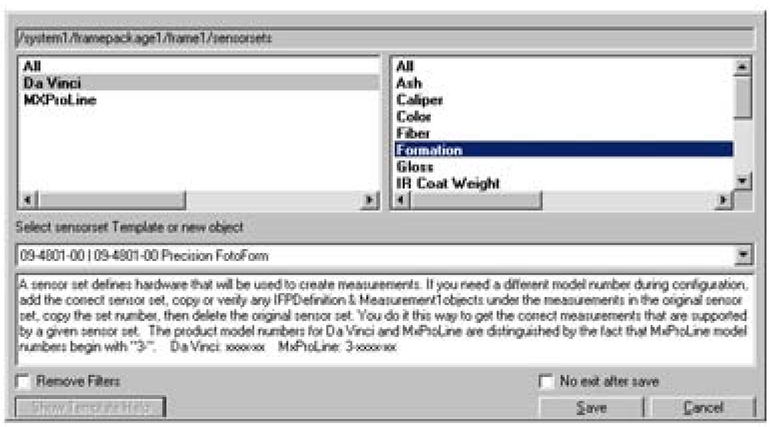
5.2.1. Add the Formation Sensor to the System

To add the Formation Sensor to the system:

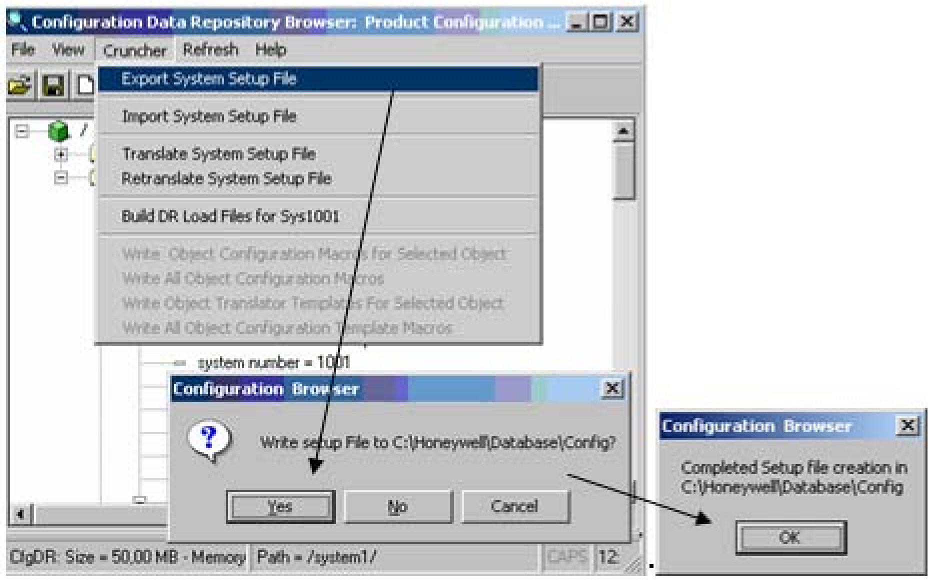
1. Open the **Configuration Data Repository Browser**.
2. Go to the */Systems/SysXxxx/framepackeges/Same*, or the similar *Spot/frames/scannerX/sensorsets/*.
3. Right-click on the *sensorsets* folder, and select **Add Object…**.



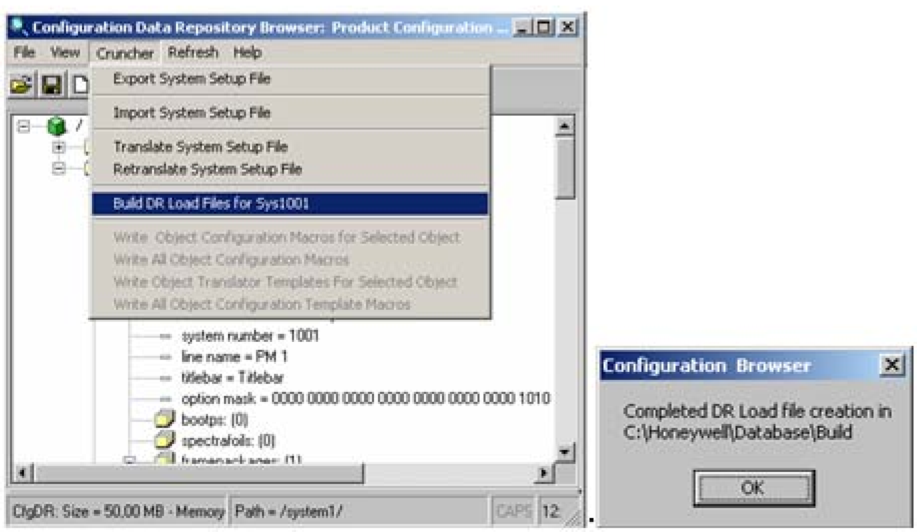
4. Select **Formation** from the sensor list and click **Save**. The Formation Sensor is added to the sensor set of the selected system.



5. Select **Cruncher**, then select **Export System Setup File**, click **Yes**, then click **OK**.



6. Select **Cruncher** again, then select **Build DR Load Files for Sysxxxx**, and click **OK**.



5.2.2. Set Configuration Parameters

5.2.2.1. Light Controller Type

The light controller type is defined by the *scannerX/mss/ssX fotoform /fotoform X processor/configuration parameters/cnfg parameters* RTDR parameter with index zero, where X = sensor set number. There are two choices:

- 1=PP810 (default)
- 2=PP880 (use only if explicitly instructed)

It is important to enter the correct Light Controller Type. Using wrong type may lead to failure of the illuminator. Unless explicitly instructed otherwise by a Honeywell Service Representative, always enter the default value 1 (= PP810).

5.2.2.2. Image Data Definitions

The image data folder and file names are defined with image data setup configuration parameters (see Figure 5-6). Default values are set by the build file (*BuildOFSP.mac*) and, except for the first two indexes, they do not need to change.

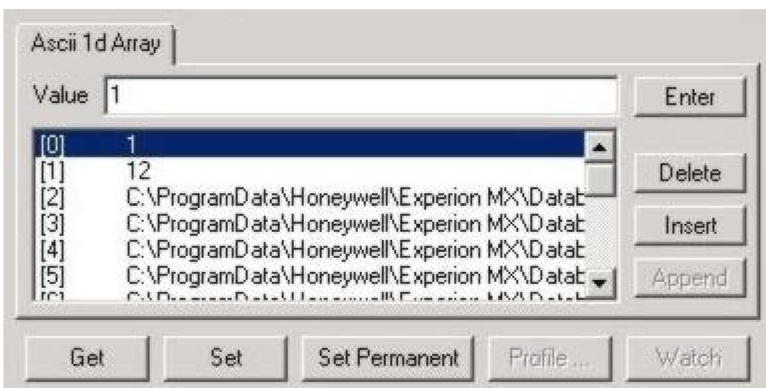


Figure 5-6 Ascii 1d Array

The first two indexes are for the start/stop image saving, and they define how many roll images are saved to the hard disc.

Table 5-9 lists and describes configuration parameters.

Table 5-9 Configuration Parameters

Idx	Parameter Name	Description
0	Enable/Disable Image Saving	Allows or inhibits history images saving to the files
		1 = save images (default)
		0 = do not save images
1	Number of Saved History Rolls	Defines number of rolls to be saved history. Default = 12
		Note that each scanning image saving file size is about 5 to 10 kB. If all four scanning images are defined and one scan lasts 10s and it takes one hour to finish each roll, the maximum hard drive space occupied will be 14400 kB. Make calculations relevant to the paper machine in question and take into account available disc space when determining how many are rolls to be saved.

To change the value:

1. Activate entering values by double clicking a value to be changed.
2. Enter the new value and click **Enter**.
3. Click **Set**.
4. Click **Set Permanent**.

5.2.3. Set Line Speed Scaling

The Formation Sensor needs to receive current line speed in units of meters per second from the QCS server for proper exposure adjustment. As the line speed available in RTDR parameter */scannerX/status/scan data/speed* may not always be in these units, a scaling is required:

Line Speed [m/s] = speed * speed slope + speed intercept

Parameters */calibration parameters/speed slope* and */calibration parameters/speed intercept* need to be configured in order to get correct scaling.

Reading, scaling, and writing the scaled line speed to */scannerX/mss/setup/process data buffer* RTDR parameter is performed by *SP PFFx Read Line Speed.vi* (see Table 5-4).

5.3. User Interface

The 4801 Precision FotoForm displays are located under the **FotoForm Display** category. There are three displays (see Figure 5-7):

- **FotoForm Engineering**
- **FotoForm Image Gallery**
- **FotoForm Display**

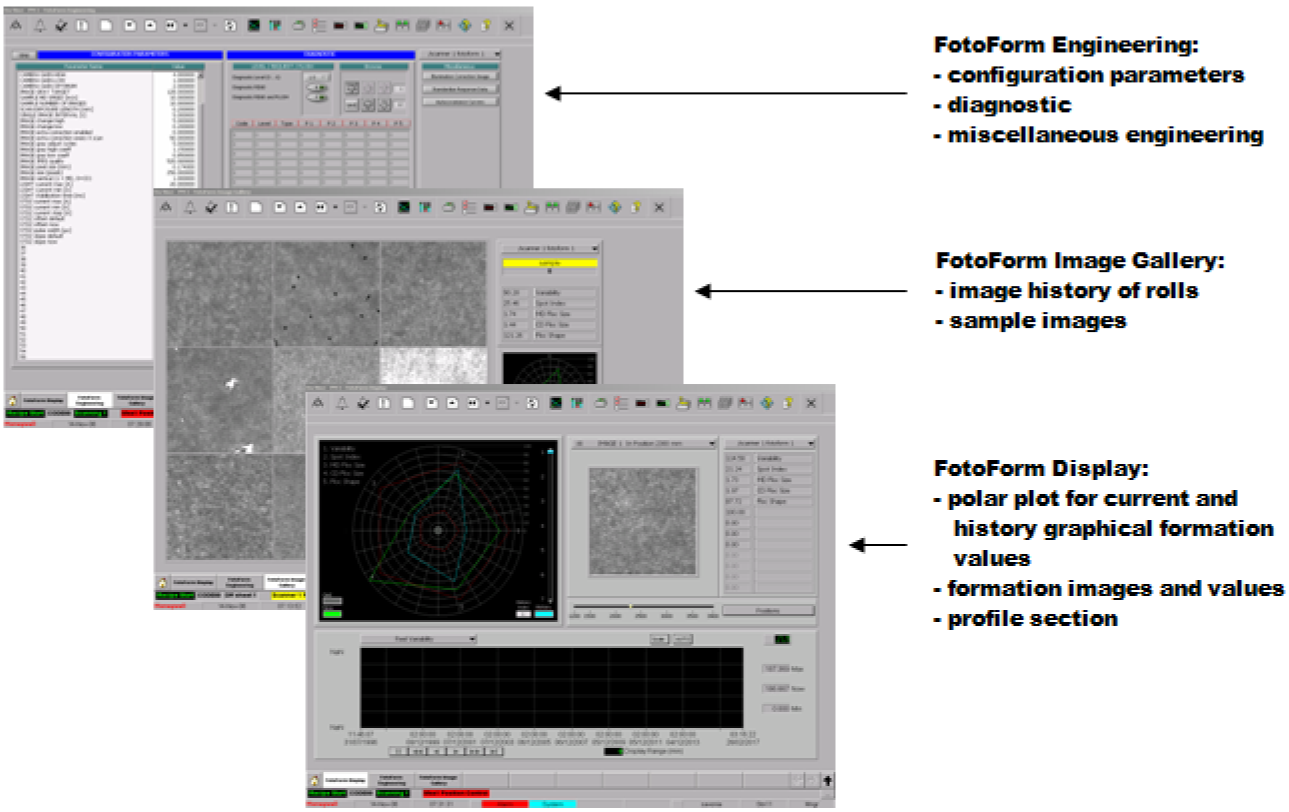


Figure 5-7 FotoForm Displays

The related VIs are listed in Table 5-10. The FotoForm displays are located at *C:\Program Files\ Honeywell\ Experion MX \Gauging\ Labview VIs\ Displauys\ Precision FotoForm*. The pop-ups are located at *C:\Program Files\ Honeywell\ Experion MX \Gauging\ Labview VIs\ Displauys\ Precision FotoForm\ Sub Level*.

Table 5-10 FotoForm Display VIs

Display	File Name	Type
FotoForm Display	*Precision FotoForm Display.vi*	Display
FotoForm Image Gallery	*Precision FotoForm Image Gallery.vi*	Display
FotoForm Engineering	*Precision FotoForm Engineering.vi*	Display
Image Positions	*PFF Image Positions.vi*	Pop-up
Polar Plot Scales	*PFF Polar Plot Scales.vi*	Pop-up
Illumination Correction Image	*PFF Illumination Correction Image.vi*	Pop-up
Standardize Response Data	*PFF Stdz Response.vi*	Pop-up
Auto Covariance Curves	*PFF Autocovariance Curvers.v*	Pop-up

5.3.1. FotoForm Display

The **FotoForm Display** (see Figure 5-8) is designed to provide thorough, real-time status of formation. Formation properties are displayed in numeric form, as a polar plot, and as a trend. In addition, on-line formation images are shown from up to four cross direction positions of the web. Scaling of the polar plot and cross direction positions of the on-line formation images are customizable on this display. The **FotoForm Display** is the most important display for analyzing the current state of formation and its recent history. Display items are presented in detail in Subsection 5.3.1.1 through to Subsection 5.3.1.9.

5.3.1.1. FotoForm Display Pages

The **FotoForm Display** consists of two pages. The first page (see Figure 5-8) is the default page, which is called up when the **FotoForm Display** is launched. This page shows general status of formation and detailed information of a single selected position.

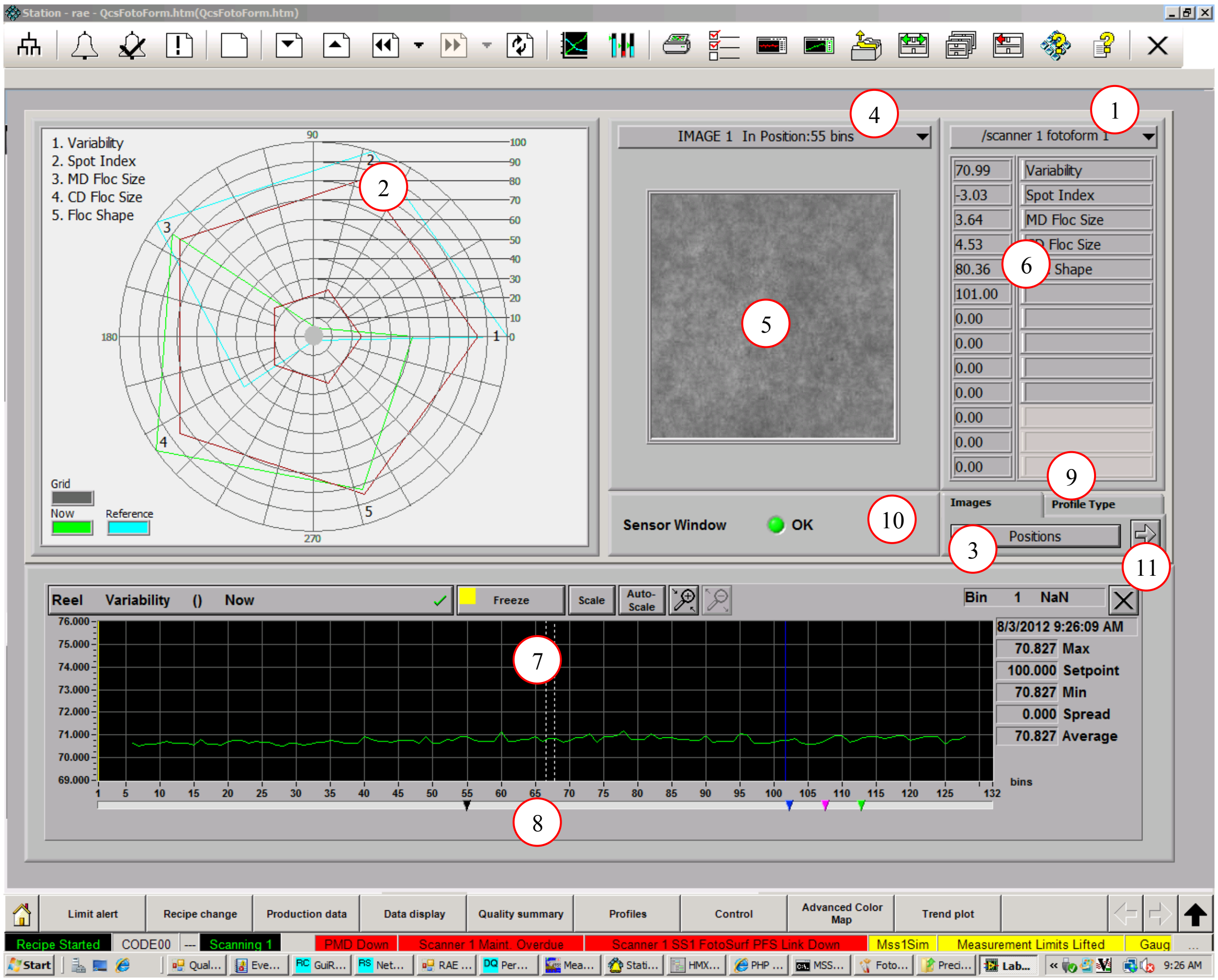


Figure 5-8 FotoForm Display (first page)

Table 5-11 lists and describes the items labeled in Figure 5-8.

Table 5-11 FotoForm Display (first page items)

Item	Description
1	Selection of the FotoForm sensor
2	Polar plot of formation characters
3	Configuration of cross direction positions of formation images
4	Selection of cross direction position for the on-line formation image
5	Single on-line formation image

Item	Description
6	Formation characters of single on-line surface image
7	Profile of selected measurement
8	Indicator of configured cross direction positions
9	Selection of profile type
10	Sensor window cleanliness indicator
11	Click arrow to display the second page of **FotoForm Display**

The second page (see Figure 5-9) shows live, on-line imagery from up to four cross direction positions. Formation properties are shown for each image. You can move between the pages by clicking the arrow button (item 6 in Figure 5-9).

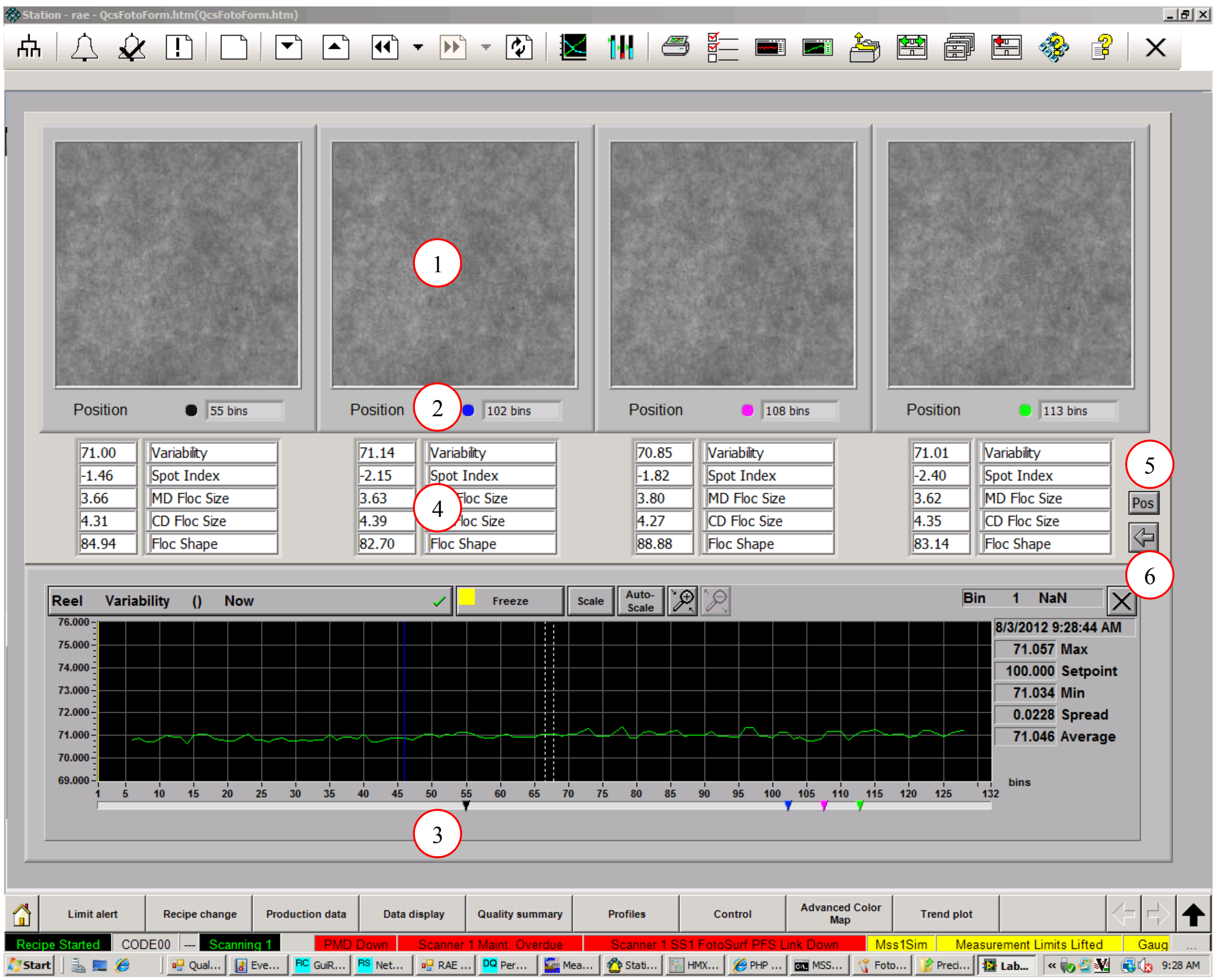


Figure 5-9 FotoForm Display (second page)

Table 5-12 lists and describes items labeled in Figure 5-9.

Table 5-12 FotoForm Display (second page items)

Item	Section/Subsection/Description
1	On-line formation images of the defined position
2	Numeric cross direction position indicator and color symbol
3	Indicator of configured cross direction positions
4	Formation characters of single on-line surface image
5	Configuration of cross direction positions of formation images
6	Click arrow to display first page of **FotoForm Display**

5.3.1.2. Formation Sensor Selection

All FotoForms installed to the system are listed in the FotoForm drop-down arrow menu (see Figure 5-10). Your system can have one FotoForm or multiple FotoForms on different scanners (maximum two per scanner). Select the one you want to monitor (you can change your selection at any time). Only one FotoForm can be monitored at a time.

Figure 5-10 Selection of FotoForm Sensor

5.3.1.3. Polar Plot of Formation Properties

The polar plot (see Figure 5-11, left) shows a graphical representation of current and history values of formation properties. The polar plot consists of several axes (all starting from the center), one for each of the five formation properties. The points representing current (or history) values of formation properties are connected with a line. In this way, the graph creates a pentagon. The distance from the center of the pentagon to the tip is proportional to the value of the formation property. The polar plot is useful for quickly identifying if any formation property is bad, for example, any of the axes increasing a lot. The smaller the pentagon is, the better the formation is overall.

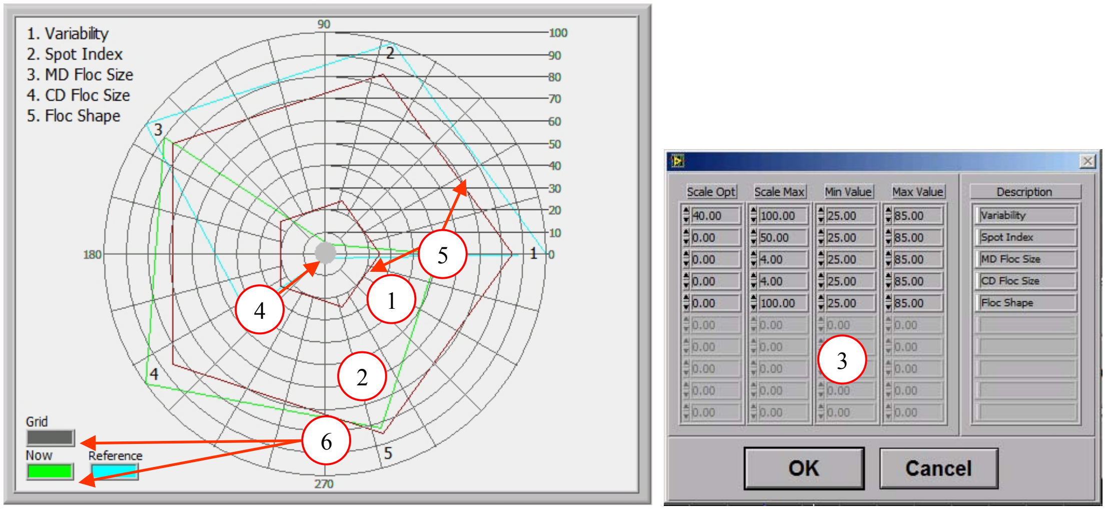


Figure 5-11 Polar Plot (left); Scale Configuration Pop-up (right)

Table 5-13 lists and describes the items labeled in Figure 5-11.

Table 5-13 Polar Plot and Scale Configuration Pop-up Items

Item	Element	Description
1	Now (current) plot of formation properties (green pentagon)	Average formation properties of the last scan. The plot is updated at the end of scan.
2	Reference plot of surface topography properties (cyan pentagon)	Typical formation properties of the reference image of the grade
3	Scale configuration pop-up	A pop-up in which the scales of axes of the polar plot are defined. This pop-up appears when you clicks the center of the polar plot, item 4.
4	Button to call up the scale configuration pop-up	Clicking the center of the polar plot outputs the scale configuration pop-up, item 3
5	Min and Max scale values (red pentagons)	Displays the reference values of scaled formation properties. Min and Max values are set in the scale configuration pop-up, item 3.
6	Color selection for the Grid, Now (current), and Reference plots	Clicking any of these rectangles outputs a color selection pop-up. The default colors are: Grid–gray, Now–green, Reference–cyan.

The current state of formation is shown as a green pentagon (item 1 in Figure 5-11). It represents the last scan average of formation properties, and is updated at each end-of-scan. The reference of formation for the current grade is shown as a cyan pentagon (item 2). The reference data is stored for the first reel of the grade or some later manually selected reel. Reference shows the most typical surface image of the reel.

The axes of the polar plot represent scaled values. Scaling of the axes can be defined in the scale configuration pop-up (item 3 in Figure 5-11), which appears when you click on the gray button (item 5 in Figure 5-11) in the middle of the polar plot. In this pop-up, the mapping of formation properties (typical scales, explained in Section 7.3) to scale 0–100% (polar plot units) is given. This is accomplished by giving two reference values, *ScaleMin* and *ScaleMax*, in the formation units and their corresponding *MinValue* and *MaxValue* in the polar plot units, and linearly interpolating between and extrapolating beyond the reference values.

Figure 5-11 shows an example where all the reference values are given with respect to 25% and 85% polar plot values. These reference values are also shown as red pentagons on the polar plot (item 6 in Figure 5-11). It is a good practice to scale all the properties so that the acceptable formation keeps all the tips of the polar plot within 50% value. In this way, any degradation of a formation property is seen as the corresponding tip going over the 50% threshold.

There are cases in which the scaled formation property value goes outside the 0–100% region. The *Spot Index* can sometimes be negative (see Section 7.3). That is why absolute values are always used for polar plot. On the other hand, it is possible for any of the properties to have a scaled value over 100%. In this case, the plot may extend outside the bounds of the polar plot window. To avoid this situation, the scales should be redefined as necessary. The color of **Grid**, **Now** (the current plot), and **History** can be customized by using the color picker pop-up (item 6 in Figure 5-11).

5.3.1.4. Configuration of Cross Direction Positions of Formation Images

The Formation Sensor can deliver up to four images per scan from different cross direction positions for visual assessment on the **FotoForm Display**. These positions are configured in the **Image Positions** pop-up (see Figure 5-12), which is called up by clicking **Positions** on the first page of the **FotoForm Display** (item 3 in Figure 5-8), or **Pos** on the second page of the **FotoForm Display** (item 5 in Figure 5-9).

Figure 5-12 shows valid image positions (left), and an error message after entering an invalid position (right). The error message appears if any of the values are outside the limits. In that case, enter valid values to the invalid fields and click **ENTER** in the pop-up.

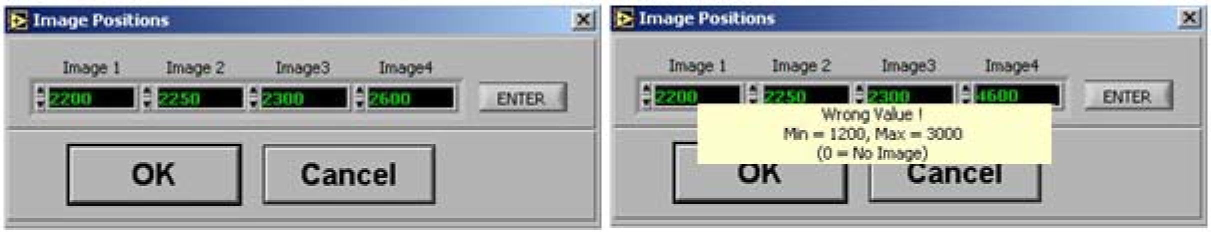


Figure 5-12 Image Positions Pop-up: Valid (left); Error Message (right)

The positions are given as distances, in millimeters, from the low end offset, and from the lowest value to the highest. The positions are fixed relative to the scanning frame, but not to the web if the web width or position change. If you do not want images from all four positions, zero must be entered as the distance for the image to be omitted. Values of cross direction positions are limited between the current web edges. The edges of the web are read from RTDR parameters:

- the lower limit: */scannerX/mss/unit info/low end offset mm*
- the upper limit: */scannerX/mss/hi other end/scan position*

5.3.1.5. Selection of Cross Direction Position for the On-line Formation Image

One preconfigured image position can be monitored at a time, on the first page of the **FotoForm Display**, as the on-line formation image. The drop-down arrow (item 4 in Figure 5-8) is used to select the image position, shown in Figure 5-13.

Figure 5-13 Cross Direction Position Selection

If a position is not defined, for example, zero is entered as the position (see Subsection 5.3.1.4), the text *IMAGE x In Position: No Image!* is shown in that row.

5.3.1.6. Single On-line Formation Image

The on-line formation image (see Figure 5-14 and item 5 in Figure 5-8) is derived from the original image from which the formation properties are computed.

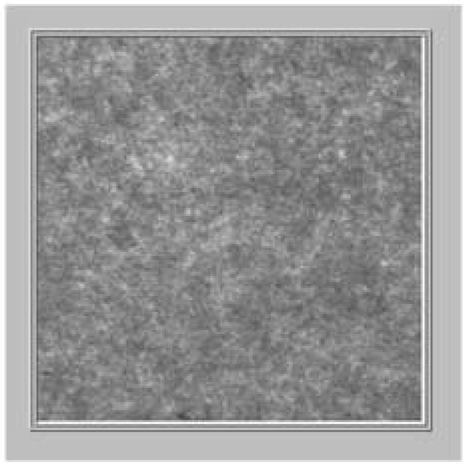


Figure 5-14 On-line Formation Image

The only difference is that the displayed image is a JPEG that has been compressed with a 1:10 compression ratio, whereas formation properties are computed from the uncompressed image. The compression is done in order to save bandwidth on the CSL. The compression factor can be controlled via the **FotoForm Engineering** display.

5.3.1.7. Single On-line Formation Image Properties

Formation image properties (see Figure 5-15 and item 6 in Figure 5-8) of the current on-line formation image (Figure 5-14) are shown as a table on the **FotoForm Display**.

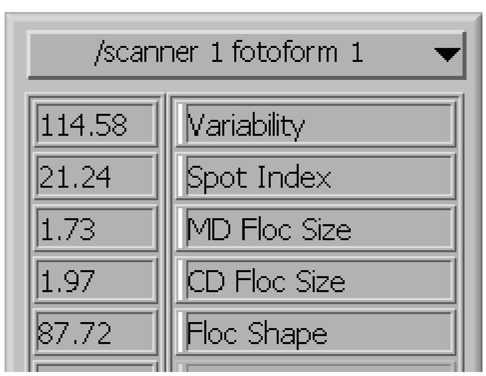


Figure 5-15 Current On-line Formation Image Properties

The five formation properties (**Variability**, **Spot Index**, **MD Floc Size**, **CD Floc Size**, and **Floc Shape**), and their typical ranges, are described in Section 7.3.

5.3.1.8. Display of Multiple On-line Formation Images and Data

On the second page of the **FotoForm Display**, on-line formation images of all defined positions (up to four) are shown side-by-side (see Figure 5-16). The images are updated live during scanning. Five selected formation properties are shown below each image. Selection of the five properties is performed in the **FotoForm Engineering** display (see Section 5.3.5.12).

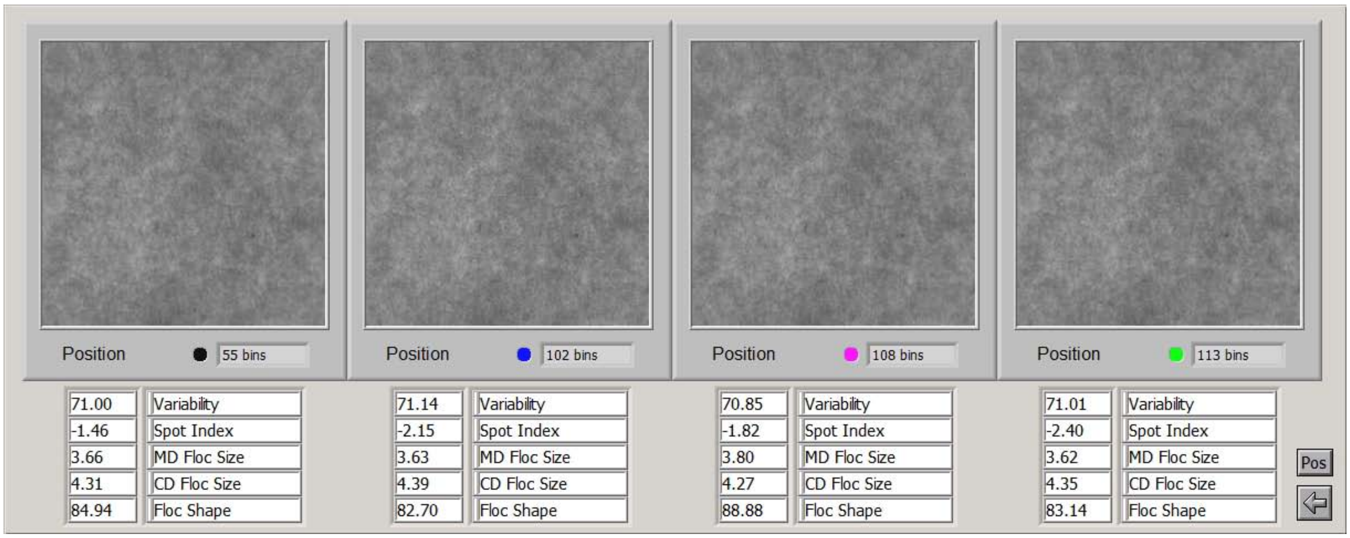


Figure 5-16 Multiple On-line Formation Images and Data

5.3.1.9. Profile and Cross Direction Position Indicator

The profile on the **FotoForm Display** can show any profile defined in the system. Typically, you may want to see one of the formation properties plotted as a profile. When there is a position which shows abnormal formation, one of the image positions can be defined at that cross direction position with the help of the profile. This is assisted by the indicator of configured cross direction positions, which is located below the profile (item 8 in Figure 5-8, and item 3 in Figure 5-9).

Each cross direction position is marked with a wedge with a color corresponding to the color of the circle to the left of the position data below the on-line image on the second page of the **FotoForm Display**.

5.3.2. FotoForm Image Gallery Display

The **FotoForm Image Gallery** display (see Figure 5-17) is a tool for comparing formation images and related formation properties. The display has two operating modes: *gallery mode*, and *sample mode*. The mode is selected by the gallery/samples switch, item 2 in Figure 5-17. Whenever you have new data coming in, and this display is open, it is useful to click **Refresh**, item 2 in Figure 5-17, to update the display with the latest data.

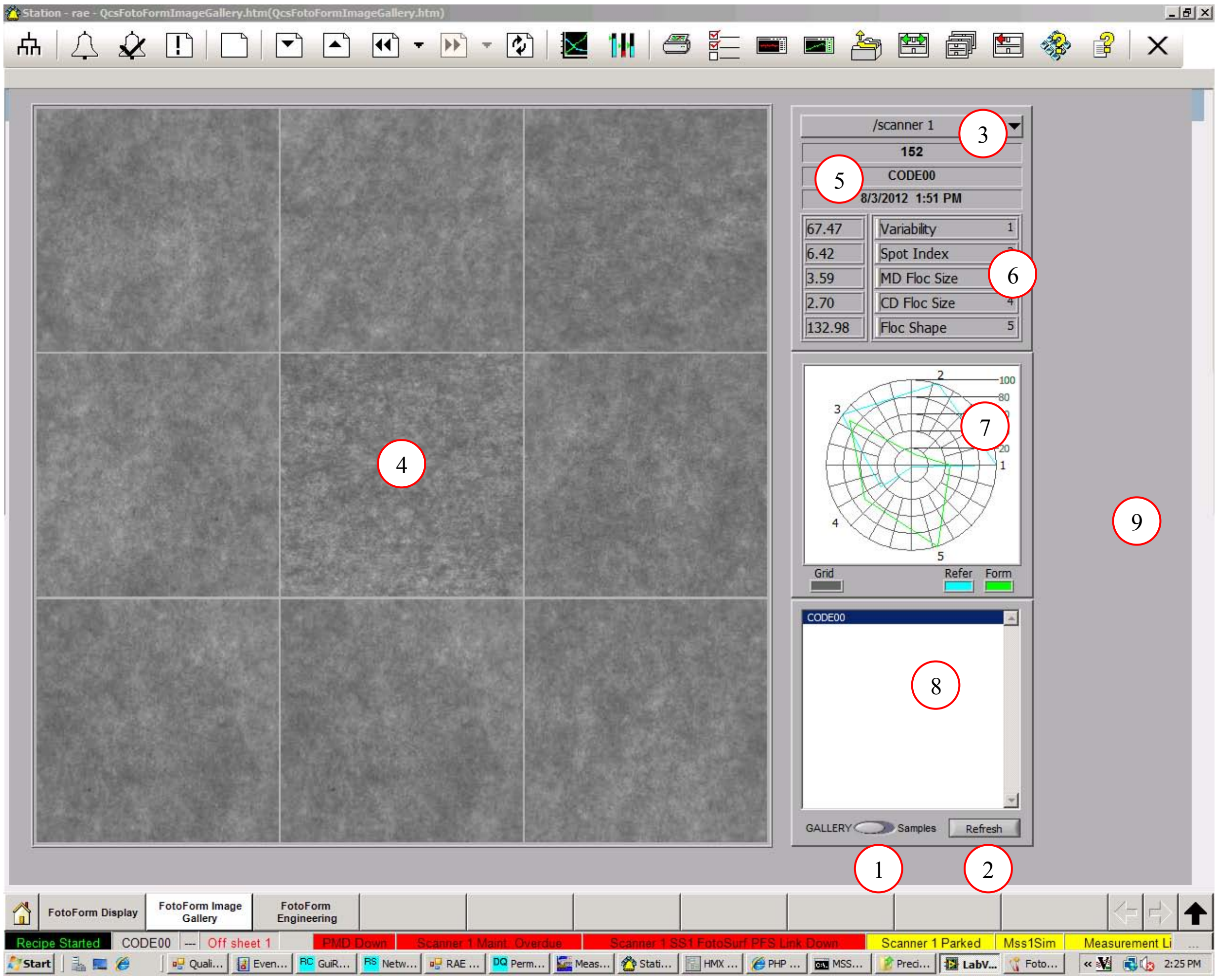


Figure 5-17 FotoForm Image Gallery Display

Table 5-14 lists and describes the items labeled in Figure 5-17.

Table 5-14 FotoForm Image Gallery Display Items

Item	Description
1	Mode selection: gallery/sample
2	Refresh display button
3	FotoForm sensor selection
4	Image grid: • gallery mode: roll images • sample mode: sample images

Item	Description
5	Gallery mode: roll (reel) number of the pointed image; sample mode: sample number of the pointed image
6	Formation properties of the pointed image
7	Polar plot of formation properties
8	Gallery mode: grade codes for temporary reference image selection
	Sample mode: sample gallery management buttons
9	Area to restore the Image selection mode

The Formation Sensor for this display is selected from the drop-down arrow (item 3 in Figure 5-17), as it is in the **FotoForm Display** (see Subsection 5.3.1.2).

Items number 4–8 of this display are mode dependent, and are described in Subsection 5.3.3 and Subsection 5.3.4.

5.3.3. FotoForm Image Gallery Display: Gallery Mode

In gallery mode, the **FotoForm Image Gallery** display shows historical data from the last eight rolls. Gallery mode is selected using the gallery/samples mode switch (item 1 in Figure 5-17, and in close-up in Figure 5-18).

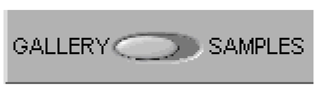


Figure 5-18 Mode Switch

5.3.3.1. Roll Data Collection

Historical formation data of rolls is collected based on up to four images collected during each scan. Image positions are defined in the **FotoForm Display** (see Subsection 5.3.1.4).

The images and the formation properties from all configured positions (positions with non-zero distance) are saved during the production of the current roll. This means, for example, that if there are four image positions configured, and the scanning frequency is two scans per minute, and the production of a roll lasts two hours, the system will save 4 * 2 * 120 = 960 formation images and their formation properties for the roll. If no image position is configured, for example, all the distances are zero (see Subsection 5.3.1.4), no data is saved.

The images are saved temporarily to the directory created at the start of the roll in the base path defined by the image data setup parameter *Log Main Folder* (see Subsection 5.1.3 and Table 5-5) at every end-of-scan.

When the roll is complete (and the software creates or gets a new roll number), the roll data is summarized and saved. This is accomplished by selecting the most representative formation image of the roll from among the saved images.

The selection criterion is: the most representative formation image of the reel is the image whose squared deviation of formation properties from the mean formation properties of all the images of the reel.

This means that, for example, one image out of 960 images will be selected to represent the entire roll. Both the formation image and its formation properties will be saved as the historical representation of the roll. The image and the data are saved to the path defined by image data setup parameter *Image Gallery FolderName* (see Subsection 5.1.3.1). After the history data is archived, the temporary images and data are removed.

5.3.3.2. Roll Images

The most representative images of the last eight rolls are displayed on the edge slots of the nine-slot image grid (item 4 in Figure 5-17) on the **FotoForm Image Gallery** display. When a roll is completed, its most representative image is placed in the upper left corner of the grid (see Figure 5-19). Images of older rolls are moved clockwise around the center slot, and the oldest image is discarded.

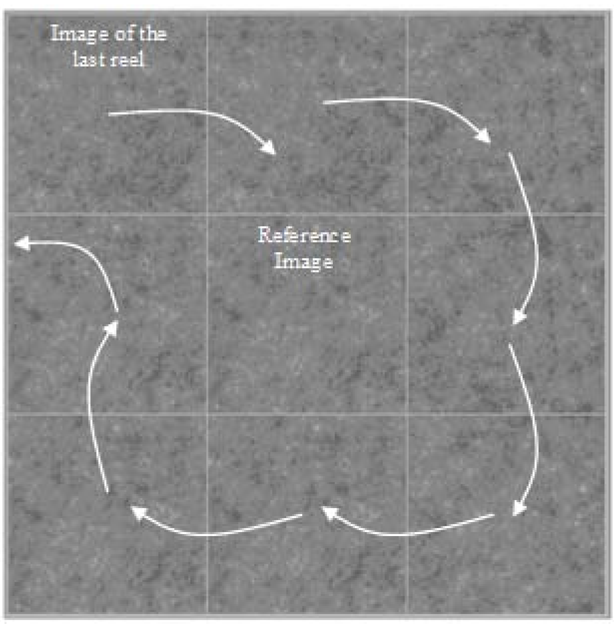


Figure 5-19 Roll History Images

The center slot is reserved for the reference image of current paper grade. The reference image is an image that is selected to represent typical formation of the grade (see Subsection 5.3.3.3). When there is a long production run (several rolls of a single paper grade), the reference image is ideally located in the center of the grid to facilitate visual comparison.

At the grade change, the reference image is changed immediately, which means that from then on the relevant comparison can be done only between the reference image and new roll images.

Any image on the grid can be selected for inspection simply by rolling the mouse pointer over it (without clicking). Items 5–7 in Figure 5-17 are updated and show data for the selected image. If you click any of the images, the reference image selection pop-up appears (see Subsection 5.3.3.3). After closing the pop-up, click somewhere in the blank gray area (item 9 in Figure 5-17) on the right side of the **FotoForm Image Gallery** display to restore image selection mode. If you do not click there, the selection mode remains disabled.

5.3.3.3. Reference Image of Paper Grade

Formation may vary quite a lot between different paper grades produced on the same paper machine. For example, a newsprint machine can produce grades, whose fiber composition varies: low-grammage grades may need long softwood fibers, which give rise to large flocs, for reinforcement, while higher grammage grades could be free of softwood. That is why the optimum formation of these grades will look very different with respect to each other. It is evident that formation of these grades should be assessed individually. To facilitate the visual assessment, the reference image of the current grade is shown in the center slot of the image grid.

At the first occurrence of a paper grade, for example, when FotoForm is newly deployed, there are no reference images saved in the system and the center slot is blank. At the end of the first roll of each grade, the most representative image of the roll will be saved automatically as the reference image of the grade. Subsequent rolls of the same grade will not change the reference image automatically.

ATTENTION

The automatic reference image feature is disabled by default. It can be activated by setting the value of *Image Data Setup Parameter* number 16 (Auto Reference Image) to 1 (instead of default value 0).

5.3.3.4. Roll Number

When the mouse pointer is rolled over the image grid, the roll number of the rolled-over image is shown in the **FotoForm Image Gallery** display by item 5 in Figure 5-17. The roll number is updated as the mouse pointer rolls over the images. When the reference image (center of the image grid) is rolled over, the **Roll Number** field shows the text *Reference*.

5.3.3.5. Image Formation Properties

When the mouse pointer is rolled over the image grid, the formation properties of the rolled-over image are shown in the **FotoForm Image Gallery** display by item 6 in Figure 5-17. Typical data is shown in Figure 5-20.

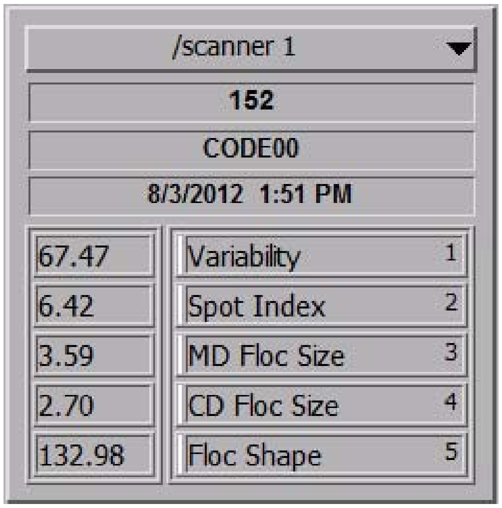


Figure 5-20 Formation Properties

5.3.3.6. Polar Plot of Formation Properties

Formation properties of the rolled-over image are shown as a polar plot in the **FotoForm Image Gallery** display (item 7 in Figure 5-17). Polar plot details are shown in Figure 5-21.

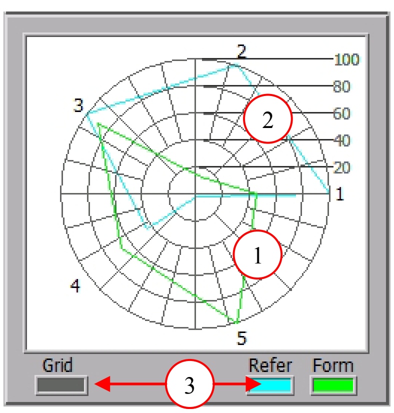


Figure 5-21 Polar Plot of Formation Properties

The polar plot shown in Figure 5-21 is related to the polar plot on the **FotoForm Display** (see Subsection 5.3.1.3). The differences are that last scan data is replaced by data of the rolled-over image, and the current grade reference data is replaced by the reference image data in the center slot of the gallery. The scales of the axes that are defined on the **FotoForm Display** apply to this polar plot on the **FotoForm Image Gallery** display. If there is any need to change the scales, it can be performed only on the **FotoForm Display**.

Table 5-15 lists and describes the items labeled in Figure 5-21.

Table 5-15 Polar Plot of Formation Properties Items

Item	Description
1	Formation properties of the rolled over image (green pentagon). This plot is updated as mouse pointer is moved over the images.
2	Formation properties of the reference Image (cyan pentagon): represents current grade
3	Color selection buttons for the grid, reference image pentagon, and rolled-over image pentagon. Clicking on the button outputs the color selection pop-up. **Grid**: color of the polar plot grid, default color gray. **Refer**: color of the of reference image, default color cyan. **Form**: color of the pointed image, default color green

5.3.3.7. Temporary Reference Image Selection

In addition to the method described in Subsection 5.3.3.3, there is one more method to select the reference image to the image grid on the FotoForm Gallery display. The existing reference images are shown as a list (item 8 in Figure 5-17, and Figure 5-22) by their grade codes.

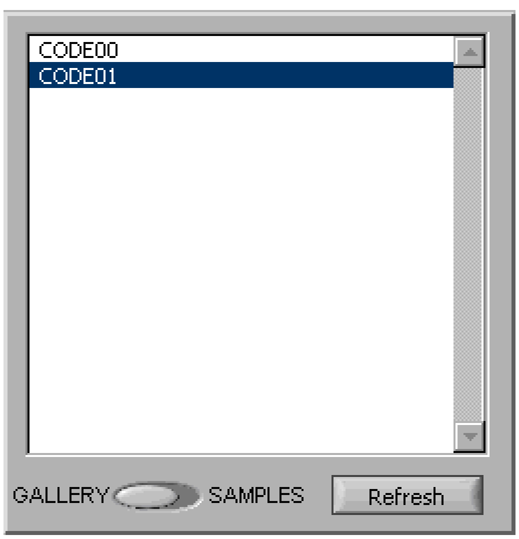


Figure 5-22 Temporary Reference Image Selection

Double-clicking any code in the list will copy the reference image of that grade to the center slot of the image grid. The selection is temporary, and is replaced at the next grade change by the reference image of the new grade. That function allows comparison between the gallery images and the reference image of any grade whenever needed.

5.3.4. FotoForm Image Gallery Display: Sample Mode

In sample mode, the **FotoForm Image Gallery** display shows sample measurement data. Sample mode is selected using the gallery/samples switch (see Figure 5-18).

5.3.4.1. Sample Data Collection

Detailed instructions on performing sample measurement are presented in Section 4.6.

5.3.4.2. Sample Images

Sample measurement images are shown in the image grid of the **FotoForm Image Gallery** display (item 4 in Figure 5-17). Sample images are arranged in the measurement order, starting from upper left corner and ending at the lower right corner, as shown in Figure 5-23. This arrangements differs from the arrangement in gallery mode (see Figure 5-19).

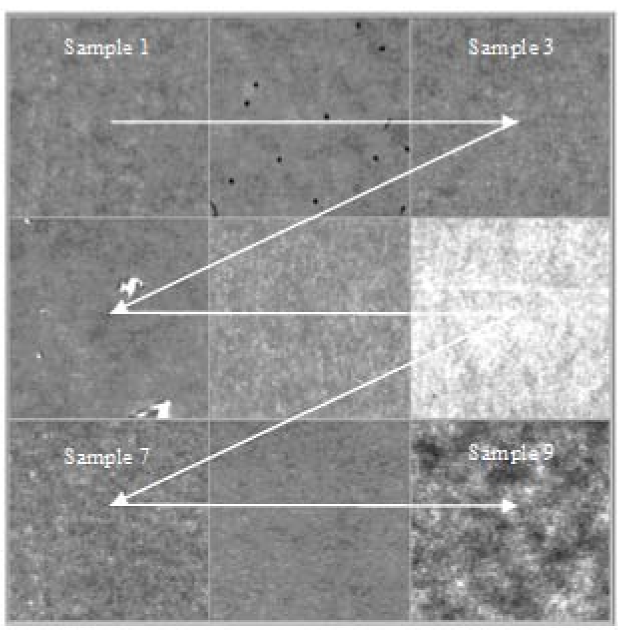


Figure 5-23 Sample Image Arrangement

There is no reference image in sample mode, so up to nine sample measurement images can be displayed at a time. If you need to view more samples, save the samples and *clean* the sample gallery (see Subsection 5.3.4.5).

Using the image grid in sample mode is similar to gallery mode (see Subsection 5.3.3.2). For example, images on the grid are selected for inspection by rolling the mouse pointer over them without clicking.

5.3.4.3. Sample Number and Formation Properties of Selected Image

When the mouse pointer is rolled over the image grid, the sample number (not the reel number) of the rolled-over image and its formation properties are shown in the **FotoForm Image Gallery** display by items 5 and 6 in Figure 5-17. The order of sample images in the sample gallery is shown in Figure 5-23.

5.3.4.4. Polar Plot of Formation Properties

Formation properties of the rolled-over image are shown as a polar plot on the **FotoForm Image Gallery** display by item 7 in Figure 5-17.

Polar plot details are shown in Figure 5-21. This plot is related to the polar plot on the **FotoForm Display** (see Subsection 5.3.1.3). The differences are that last scan data is replaced by data of the rolled-over image and there is no reference image data (reference pentagon and its color selection button are not shown). The scales of the axes that are defined on the **FotoForm Display** apply to this polar plot as well. If there is any need to change the scales, that can be done only on the **FotoForm Display**.

5.3.4.5. Sample Gallery Management Buttons

In sample mode, the **FotoForm Image Gallery** display contains sample gallery management buttons (see Figure 5-24), instead of a temporary reference image selection list. When the sample gallery is full, a notification appears above the buttons.

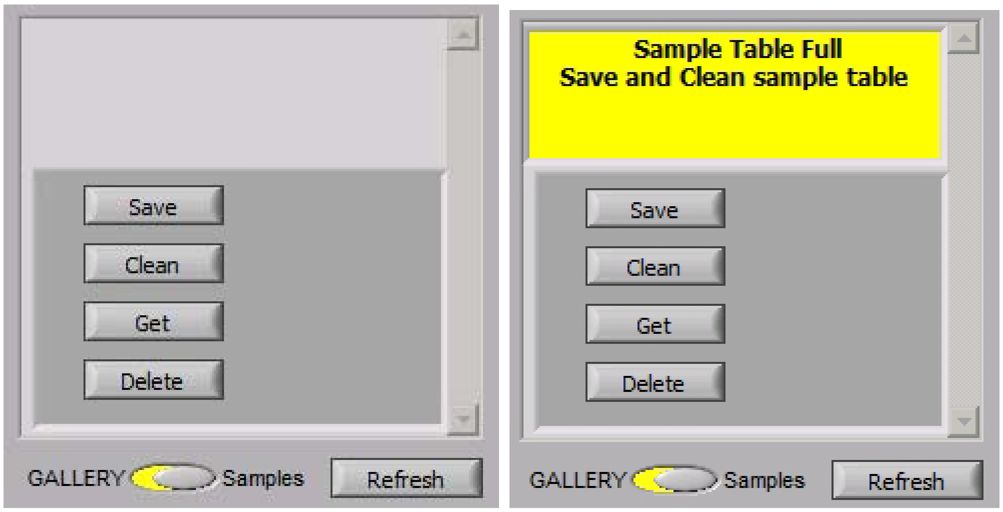


Figure 5-24 Sample Gallery Management Buttons (left); Gallery Full (right)

Click **SAVE** to save the images currently shown in the gallery. Images are saved to the path *Image Gallery Folder Name \Samples Saved*, which is defined by the image data setup parameter 14 (see Subsection 5.1.3). The file name format is *Samples YY_MM_DD_hh_mm,* where YY = year, MM = month, DD = day, hh = hour, and mm = minutes

The file save is confirmed in the **Boolean Panel** pop-up shown in Figure 5-25.

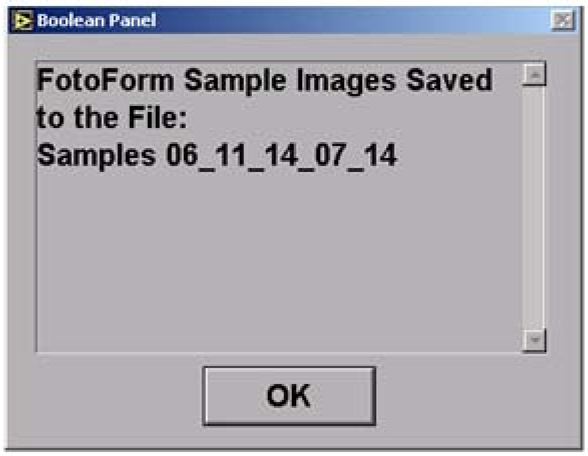


Figure 5-25 Boolean Panel Pop-up

The saved samples can later be reloaded into the gallery by clicking **GET**, which brings up the **File Dialog** dialog shown in Figure 5-26, where the sample directory can be selected.

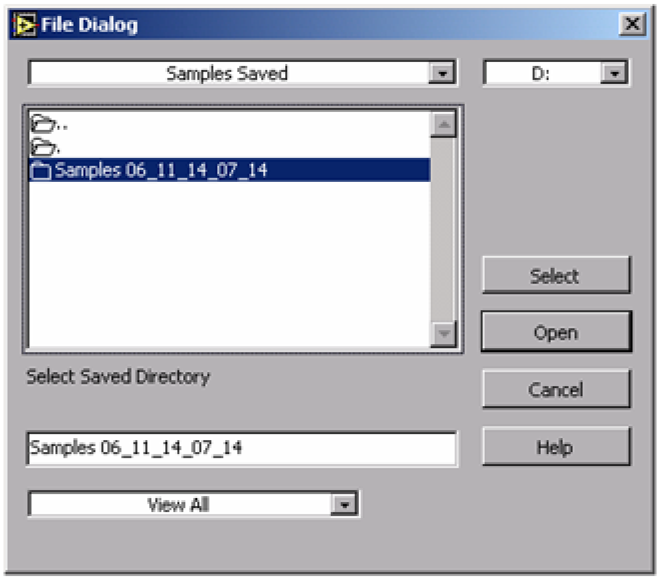


Figure 5-26 File Dialog, Dialog

If you want to do more than nine sample measurements, the gallery has to be cleaned after saving the current gallery contents. To clean the gallery, click **CLEAN**. If you want to delete one of the saved galleries, click **DELETE**.

5.3.5. FotoForm Engineering Display

The **FotoForm Engineering** display (see Figure 5-27) is a tool for configuring and diagnosing the Formation Sensor. The sensor to be configured or diagnosed is selected for this display from the drop-down arrow (item 1) in the same way it is selected on the **FotoForm Display** (see Section 5.3.1).

Items 2 and 3 handle FotoForm configuration through customizing and uploading configuration parameters. Items 4–7 deal with legacy CSL data (obsolete in Experion MX system). Advanced diagnostic and configuration of sensor operation can be performed using controls under item 8, the **Miscellaneous**, and **Definitions** sub-tabs.

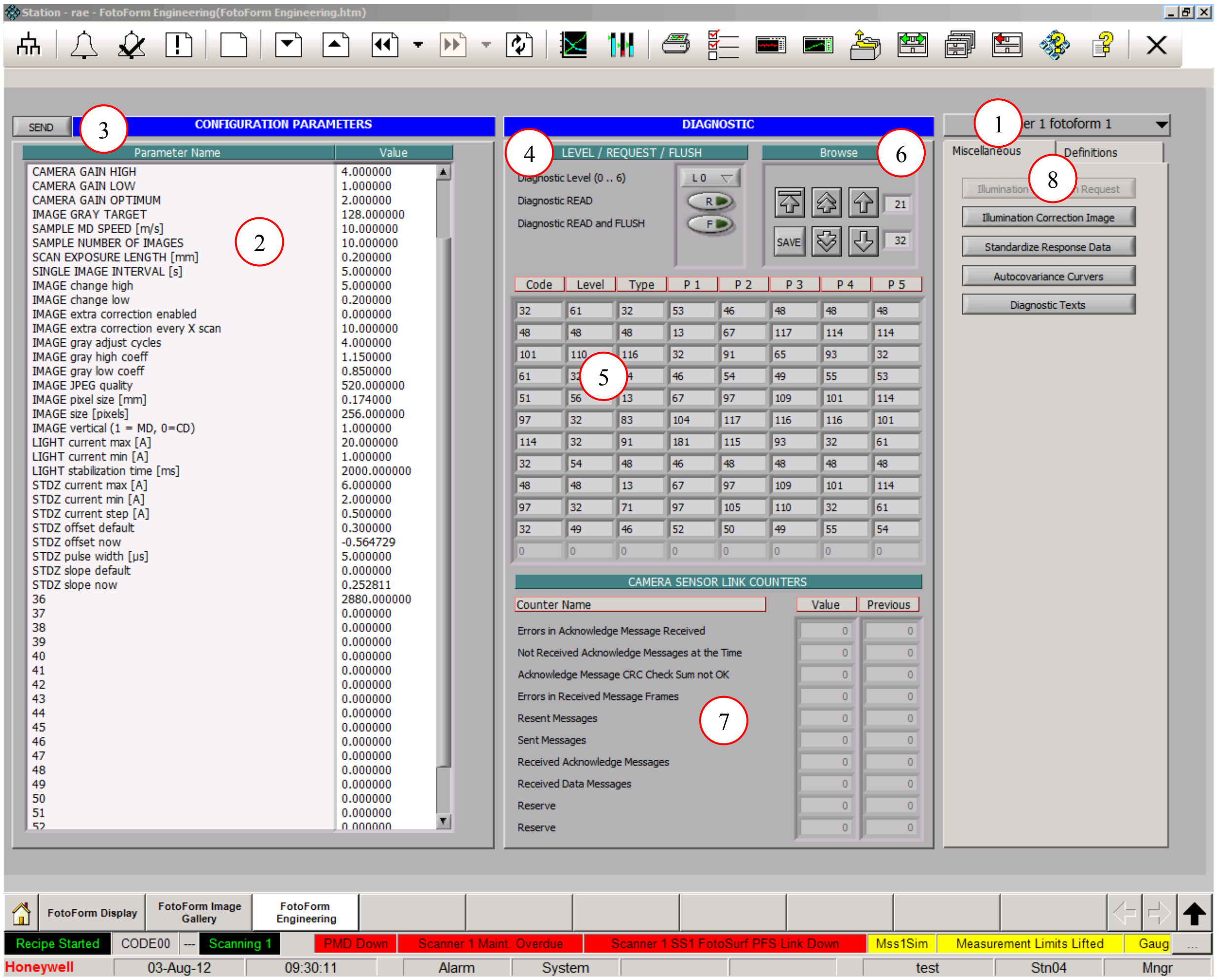


Figure 5-27 FotoForm Engineering Display

Table 5-16 lists and describes the items labeled in Figure 5-27.

Table 5-16 FotoForm Engineering Display Items

Item	Description
1	Formation Sensor selection drop-down arrow
2	Configuration parameters
3	The configuration parameters **SEND** button
4	Diagnostic **LEVEL**, **REQUEST**, and **FLUSH** controls (legacy, obsolete in Experion MX)
5	Diagnostic data (legacy, obsolete in Experion MX)
6	Diagnostic **Browse** directional buttons and the **SAVE** button (legacy, obsolete in Experion MX)
7	CSL counters (legacy, obsolete in Experion MX)
8	**Miscellaneous**, and **Definitions** sub-tabs

The **Miscellaneous**, and **Definitions**, sub-tabs are shown in Figure 5-28.

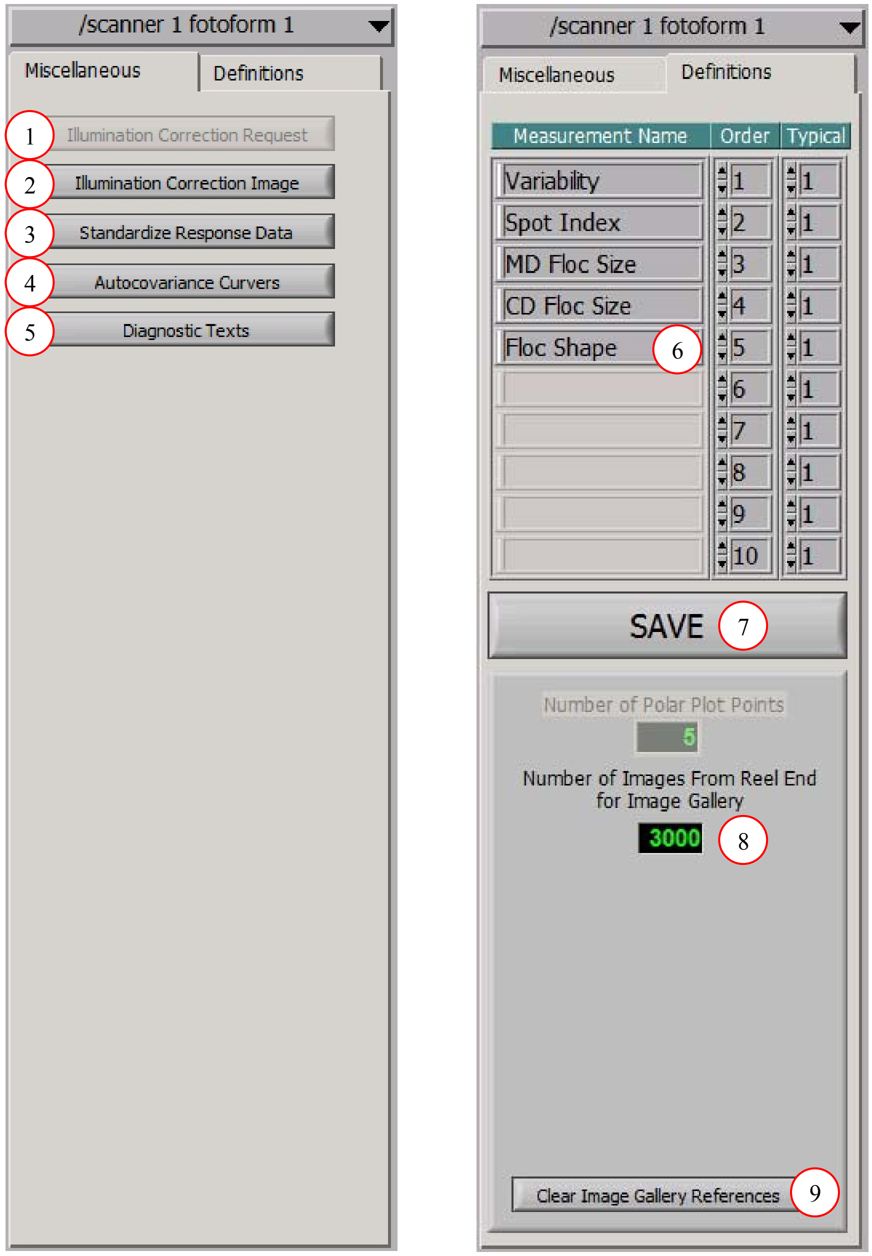


Figure 5-28 FotoForm Engineering Display: Miscellaneous, and Definitions Sub-tabs

Table 5-17 lists and describes items labeled in Figure 5-28.

Table 5-17 FotoForm Engineering Display: Miscellaneous and Definitions Sub-tabs Items

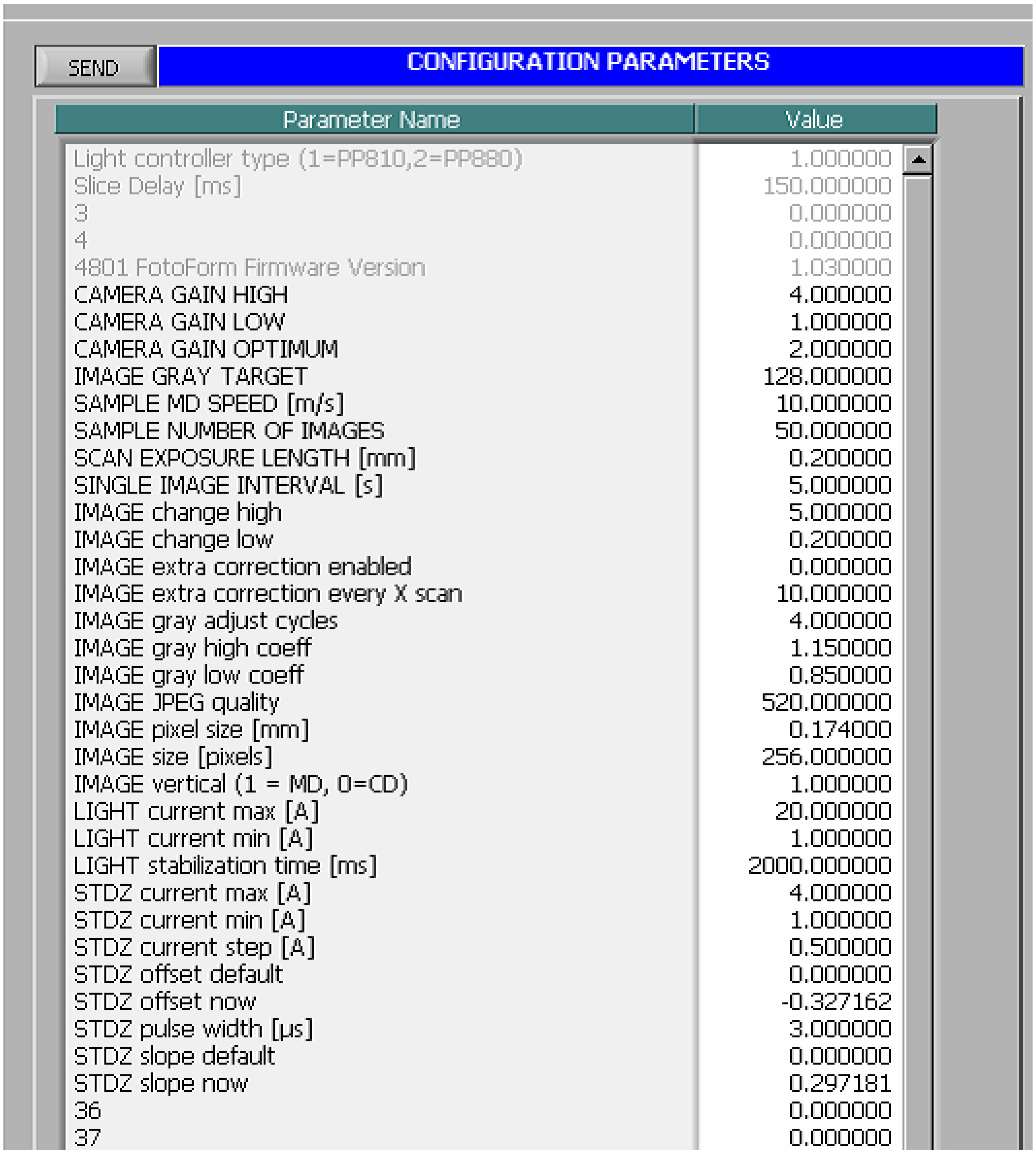
Item	Description
1	**Illumination Correction Request** button
2	**Illumination Correction Image** button
3	**Standardize Response Data** button
4	**Autocovariance Curves** button
5	**Diagnostic Texts** button
6	**Measurement** / **Order** / **Typical** image criterion definition table
7	The definitions **SAVE** button
8	**Number of Images From Reel End for Image Gallery** to typical Image selection
9	**Clear Image Gallery References** button

5.3.5.1. Configuration Parameters

FotoForm functionality can be adapted and customized under **CONFIGURATION PARAMETERS** on the **FotoForm Engineering** display (item 2 in Figure 5-27). Configuration parameters are sent to the sensor automatically during Formation Measurement startup. When FotoForm is already running, configuration parameters can be sent to the sensor by clicking **SEND**. This is required after making changes to the parameters.

A closer look at configuration parameters is shown in Figure 5-29. There are 50 parameters that can be configured in this window. FotoForm uses the first 35 of them. The first five parameters on the list are not shown when you call up the **FotoForm Engineering** display, but you can scroll up the list to show all of them. The first five parameters cannot be configured in this window. All the other values can be changed by double-clicking the value field, which launches a pop-up where the new value can be entered.

FotoForm configuration parameters are listed in detail in Table 5-18. The parameters are divided into four categories and are described in Subsection 5.3.5.2 through Subsection 5.3.5.5.


SEND

CONFIGURATION PARAMETERS

Parameter Name	Value
Light controller type (1=PP810,2=PP880)	1.000000
Slice Delay [ms]	150.000000
3	0.000000
4	0.000000
4801 FotoForm Firmware Version	1.030000
CAMERA GAIN HIGH	4.000000
CAMERA GAIN LOW	1.000000
CAMERA GAIN OPTIMUM	2.000000
IMAGE GRAY TARGET	128.000000
SAMPLE MD SPEED [m/s]	10.000000
SAMPLE NUMBER OF IMAGES	50.000000
SCAN EXPOSURE LENGTH [mm]	0.200000
SINGLE IMAGE INTERVAL [s]	5.000000
IMAGE change high	5.000000
IMAGE change low	0.200000
IMAGE extra correction enabled	0.000000
IMAGE extra correction every X scan	10.000000
IMAGE gray adjust cycles	4.000000
IMAGE gray high coeff	1.150000
IMAGE gray low coeff	0.850000
IMAGE JPEG quality	520.000000
IMAGE pixel size [mm]	0.174000
IMAGE size [pixels]	256.000000
IMAGE vertical (1 = MD, 0=CD)	1.000000
LIGHT current max [A]	20.000000
LIGHT current min [A]	1.000000
LIGHT stabilization time [ms]	2000.000000
STDZ current max [A]	4.000000
STDZ current min [A]	1.000000
STDZ current step [A]	0.500000
STDZ offset default	0.000000
STDZ offset now	-0.327162
STDZ pulse width [µs]	3.000000
STDZ slope default	0.000000
STDZ slope now	0.297181
36	0.000000
37	0.000000

Figure 5-29 CONFIGURATION PARAMETERS Display

Table 5-18 FotoForm Configuration Parameters

Number	Name	Value	Range	Note
1	Light controller type (1=PP810,2=PP880)	1		Always use value 1 if not instructed otherwise
2	Slice Delay [ms]	150		Copied from MSS Job Set IO Setup
3	Not in use			Not in use
4	Not in use			Not in use
5	4801 FotoForm Firmware version	N/A	N/A	Updated by FotoForm
6	CAMERA GAIN HIGH	4	1–15	
7	CAMERA GAIN LOW	1	1–15	
8	CAMERA GAIN OPTIMUM	2	1–15	
9	IMAGE GRAY TARGET	128	0–255	
10	SAMPLE MD SPEED [m/s]	10	0–35.0	
11	SAMPLE NUMBER OF IMAGES	10	0–50	
12	SCAN EXPOSURE LENGTH [mm]	0.2	0.2–1.0	
13	SINGLE IMAGE INTERVAL [s]	5	5–6	
14	IMAGE change high	5	2–10	
15	IMAGE change low	0.2	0.1–0.5	
16	IMAGE extra correction enabled	0	0 or 1	
17	IMAGE extra correction enabled every X scan	50	1–100	
18	IMAGE gray adjust cycles	5	1–10	
19	IMAGE gray high coeff	1.15	1–2	
20	IMAGE gray low coeff	0.85	0–1	
21	IMAGE JPEG quality	520	0–1000	
22	IMAGE pixel size [mm]	0.174	0—10	
23	IMAGE size [pixels]	256	256, 512, or 1024	
24	IMAGE vertical (1=MD, 0=CD)	1	0 or 1	
25	LIGHT current max [A]	20	0–20	
26	LIGHT current min [A]	1	0–20	
27	LIGHT stabilization time [ms]	2000	0–5000	
28	STDZ current max [A]	4	0–20	
29	STDZ current min [A]	2.5	0–20	
30	STDZ current step [A]	0.25	0–20	
31	STDZ offset default	0	Not in use	
32	STDZ offset now		-1.0–1.0	Updated by FotoForm
33	STDZ pulse width [μs]	3	3–10	
34	STDZ slope default	0		Not in use
35	STDZ slope now		0.2–0.4	Updated by FotoForm

5.3.5.2. Grade and Scanner Adaptation Parameters

This Subsection describes in detail some of the parameters listed in Table 5-18.

Configuration parameters number 6–13 are the ones that may need to be adjusted in order to make FotoForm work properly with the paper grades that have high light absorbency.

6: CAMERA GAIN HIGH

Maximum camera signal amplification factor to be used. Making this parameter higher amplifies the signal (doubling the value doubles the signal), but also adds image noise.

7: CAMERA GAIN LOW

Minimum camera signal amplification factor to be used. There is usually no need to change this from the default.

8: CAMERA GAIN OPTIMUM

The optimum (control target) camera signal amplification factor to be used. Assign this parameter a value, which is between CAMERA GAIN LOW and CAMERA GAIN HIGH. Preferably these ratios should be equal:

$$\frac{\text{CAMERA GAIN HIGH}}{\text{CAMERA GAIN OPTIMUM}} = \frac{\text{CAMERA GAIN OPTIMUM}}{\text{CAMERA GAIN LOW}}$$

9: IMAGE GRAY TARGET

Goal for mean graylevel of the image. May be lowered if light absorbency is too high (halving the value doubles the signal).

10: SAMPLE MD SPEED [m/s]

Virtual machine direction speed in meters per second to control light output in sample measurement. Make this value close to the actual machine direction speed of the paper machine that produced the paper.

11: SAMPLE NUMBER OF IMAGES

Number of images to be used in sample measurement averaging.

12: SCAN EXPOSURE LENGTH [mm]

The length that the web can move in the machine direction during image exposure (the default is approximately one pixel). This parameter fixes the amount of motion blur for all the machine direction speeds of the web. If an acceptable signal level cannot be reached, and larger machine direction blur is tolerable, this parameter can be made larger (doubling this parameter doubles the signal level).

13: SINGLE IMAGE INTERVAL [s]

On-line image update interval in single mode for the **FotoForm Display**.

24: IMAGE vertical (1=MD, 0=CD)

Orientation of the Formation Sensor with respect to the machine direction. It is strongly recommended that the Formation Sensor always be mounted in a way that the machine direction coincides with the vertical direction of the image. However, if it is only possible to mount the sensor in the perpendicular direction (cross direction coincides with the vertical direction of the image), this parameter must be adjusted.

5.3.5.3. FotoForm Reporting Parameters

This Subsection describes in detail some of the parameters listed in Table 5-18.

Parameters 2, 5, 32, and 35 are used for reporting rather than configuration.

2: Slice Delay [ms]

This parameter value is automatically copied from **MSS Job Set IO Setup** (see Subsection 3.3.1.3. for more information).

5: FotoForm Firmware version

This is the version number of FotoForm firmware. This parameter is received from FotoForm at every standardize. The value of this parameter can not be edited.

32: STDZ offset now

Offset of linear fit of light intensity vs. current in standardization. This parameter is received from FotoForm at every standardize. If you change this value and send the configuration parameters to the sensor, the new value is used from the next scan until the next standardize, where FotoForm determines a new value for it.

35: STDZ slope now

The slope of linear fit of light intensity versus current in standardization. This parameter is received from FotoForm at every standardize. If you change this value and send the configuration parameters to the sensor, the new value is used from the next scan until the next standardize, where FotoForm determines a new value for it.

5.3.5.4. FotoForm Internal Parameters

This Subsection describes in detail some of the parameters listed in Table 5-18.

Parameters 1, 14–23, 25–30, and 33 control internal processing of the Formation Sensor. In normal conditions these parameters should not be changed. Changes to them would be necessary only in special situations such as temporary fixes in the case of hardware malfunction, upgrade of hardware, or in-depth troubleshooting.

1: Light controller type (1=PP810,2=PP880)

This parameter tells FotoForm which strobe controller it has. Always use a value of 1 unless instructed otherwise. Wrong values may damage the FRIM. The default value of this parameter is set at the build of the RTDR to the record (*/scannerX/mss/ssX fotoform X processor/configuration parameters/cnfg parameters: index*, 0 = Light controller type).

14: IMAGE change high

Maximum relative change of graylevel in one light control step. This parameter limits the change in the instance of a very large absorbency decrease of paper (required amount of light intensity increases a lot) to reduce oscillation (*hunting*) in light control. For example, if IMAGE change high = 3, one light control step can triple the light intensity at maximum.

15: IMAGE change low

Minimum relative change of graylevel in one light control step. This parameter limits the change in the instance of a very large absorbency decrease of paper (required amount of light intensity increases a lot) to reduce oscillation (hunting) in light control. For example, if IMAGE change low = 0.5, one light control step can halve the light intensity at minimum. The following rule should usually be employed:

$$\text{IMAGE change low} = \frac{1}{\text{IMAGE change high}}$$

16: IMAGE extra correction enabled

Zero = disable (default), 1 = enable extra illumination correction updates. This parameter must be set to 1 (enabled) if illumination correction image has to be updated more regularly than once between two standardizations. This would be needed only in the case of extremely rapid dirt accumulation.

17: IMAGE extra correction enabled every X scan

Number of scans between extra illumination correction updates. This parameter has an effect only if IMAGE extra correction enabled = 1. For example, if IMAGE extra correction enabled every X scan = 3, the illumination correction image will be recalculated at the end of every third scan.

18: IMAGE gray adjust cycles

Upper limit of the number of graylevel adjustment cycles in sample measurement and in entering single point mode. If the current graylevel does not meet validity limits defined by IMAGE GRAY TARGET, IMAGE change high, and IMAGE change low, up to this many control steps are performed.

19: IMAGE gray high coeff

Upper relative validity limit of mean graylevel. If mean graylevel of scan exceeds this limit, a light control action is performed at end-of-scan. For example, if IMAGE GRAY TARGET = 128 and IMAGE change high = 1.15, the highest valid mean graylevel is 128 * 1.15 = 147.2. If the dead zone of light control has to be widened or narrowed, change the value of this parameter.

20: IMAGE gray low coeff

Lower relative validity limit of mean graylevel. If mean graylevel of the scan is below this limit, a light control action is performed at end-of-scan. For example, if IMAGE GRAY TARGET = 128 and IMAGE change low = 0.85, the lowest valid mean graylevel is 128 * 0.85 = 108.8. If the dead zone of light control has to be widened or narrowed, change the value of this parameter.

21: IMAGE JPEG quality

The quality of JPEG images sent from FotoForm to the QCS server. The compression of JPEG images is done to save CSL bandwidth and storage space on the QCS server. The default value 520 means 1:10 compression, which is still not visually noticeable in formation images. Higher values mean higher quality and less compression; lower values mean lower quality and more compression. Using very high quality may congest the CSL.

22: IMAGE pixel size [mm]

Scale of pixel in formation image. This parameter is measured in the factory test and its value can be found in the *Factory Test Report* shipped with the sensor. Floc size measurement in millimeters is based on this parameter.

23: IMAGE size [pixels]

Size of image in pixels. The formation image has equal dimensions in both machine direction and cross direction. The default value is 256, which should always be used in normal operation of the sensor. However, if higher resolution images are needed, for example, when making special reports, and so on, this value can be changed temporarily to 512 (image size must be a power of 2). Higher values are not recommended. Notice that when you change IMAGE size parameter, you must also scale the IMAGE pixel size parameter in order to get right floc size measurement results.

25: LIGHT current max [A]

Maximum allowed current supplied by the light pulse driver (specific to the pulse driver type).

26: LIGHT current min [A]

Minimum allowed current supplied by the light pulse driver (specific to the pulse driver type).

27: LIGHT stabilization time [ms]

Stabilization time of pulse characteristics of the light pulse driver (specific to the pulse driver type). Important for sample and single point modes.

28: STDZ current max [A]

Maximum current used in standardization to drive the light source. Lower this value if the standardization curve saturates.

29: STDZ current min [A]

Minimum current used in standardization to drive the light source. Tune this value if initial nonlinearity of the standardization curve is encountered.

30: STDZ current step [A]

Current step used in standardization procedure. Choose this value to make steps match also the STDZ current max. For example:

OK: STDZ current min = 1, STDZ current max = 3, STDZ current step = 0.5 ➔ currents used in standardization = 1.0, 1.5, 2.0, 2.5, 3.0

NOT OK: STDZ current min = 1, STDZ current max = 3, STDZ current step = 0.7 ➔ currents used in standardization = 1.0, 1.7, 2.4

33: STDZ pulse width [μs]

Width of light pulse in standardization. This parameter depends both on the pulse driver type and age of the light source. If the standardization curve saturates with small currents, lower the pulse width. If the curve is badly nonlinear, try increasing the pulse width.

5.3.5.5. Unused Parameters

Parameters 3, 4, 31, and 34 are currently not in use.

5.3.5.6. Legacy Sensor Diagnostic

Legacy sensor diagnostic functions of the **FotoForm Engineering** display (items 4–7 of Figure 5-27) are obsolete in the Experion MX system.

5.3.5.7. Illumination Correction Request button

The **Illumination Correction Request** button under the **FotoForm Engineering** display **Miscellaneous** sub-tab (item 1 in Figure 5-28) is enabled only in maintenance mode (otherwise disabled). Clicking this button in maintenance mode makes the next FotoForm sample measurement be requested as *Illumination Correction Image update*. The normal sample result will not be generated in this case. FotoForm will calculate an average of images during sample processing and use that as the illumination correction image. It is good practice to update the illumination correction image every time before starting a sample measurement session.

For successful illumination correction update, it is important to use a paper sample that is roughly in the same grammage range as the samples to be measured. The sample must be moved around during illumination correction update in order to make it represent unevenness of illumination, and not any local features of the sample.

5.3.5.8. Illumination Correction Image

Clicking on **Illumination Correction Image** on the **FotoForm Engineering** display **Miscellaneous** sub-tab (item 2 in Figure 5-28) calls up the **Illumination Correction Data** pop-up (see Figure 5-30).

Figure 5-30 Illumination Correction Data Pop-up

The current illumination field is shown as an image in this pop-up. The illumination field is the average spatial distribution of light coming to the CCD sensor of the camera. Darker areas in this image receive less light than the lighter areas. Uneven light distribution is caused by several effects, such as unevenness of light source, or vignetting of the lens, and dirt accumulation on the FRMM window.

FotoForm automatically compensates for the unevenness by using illumination correction data in order to get high-quality images and data. This helps to reduce maintenance work in the case of paper grades that produce dust and dirt. Manual cleaning of the window is needed less often.

The amount of correction that can be automatically made by the Formation Sensor is limited to 200% compensation in signal level (graylevel). This maximum amount of compensation is in use when graylevel of the darkest areas is 50% of the lightest areas. If this level is exceeded (correction is saturated), the images and formation characters will not be fully corrected. Percentage of the saturated area is shown in the **Illumination Correction Data** pop-up. If this value deviates from zero, the FRMM window should be cleaned manually as soon as possible. If a corner of the illumination correction image is dark, and the saturated area value is high, even after cleaning the window, there might be a light source failure, in which case you should consult service.

5.3.5.9. Standardize Response Data

Standardization determines slope and offset of linear fit of light intensity (mean graylevel of image) vs. pulse current. Accurate values of the slope and the offset help light control to settle faster in case of large grade changes (the amount of needed light changes significantly).

At the end of standardization, the Formation Sensor sends standardize response data to the QCS server. The latest data can be seen by clicking **Standardize Response Data** on the **FotoForm Engineering** display (item 3 in Figure 5-28), which calls up the **Stdz Response Data** display.

The graph in the **Stdz Response Data** display shows normalized graylevel (graylevel divided by the maximum graylevel of the standardize sequence) as a function of current driving the light source (white squares) and linear fit (solid red line). The measured points should fall neatly on the fitted line. An ideal case of standardize response data is shown in Figure 5-31.

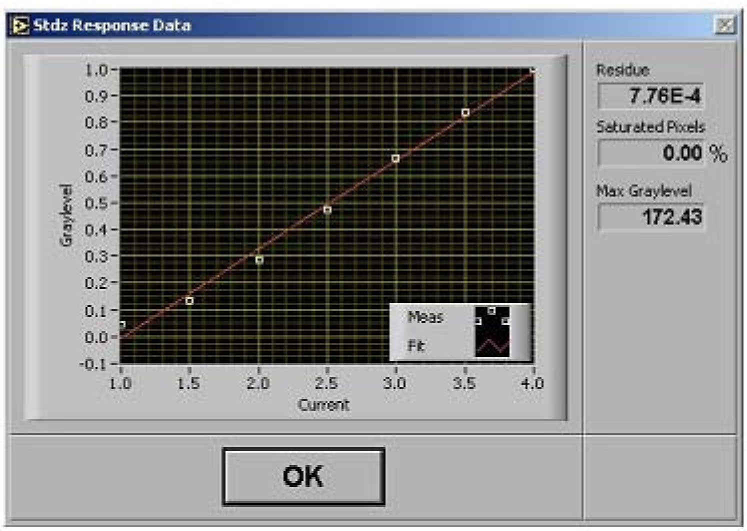


Figure 5-31 Stdz Response Data: Ideal

If there is significant nonlinearity in the graylevel vs. current plot, as shown in Figure 5-32, or if the graylevel seems to saturate to value 1.0, as shown in Figure 5-33, check the following standardization parameters: STDZ current max [A], STDZ current min [A], and STDZ current step [A] (see Subsection 5.3.5.4).

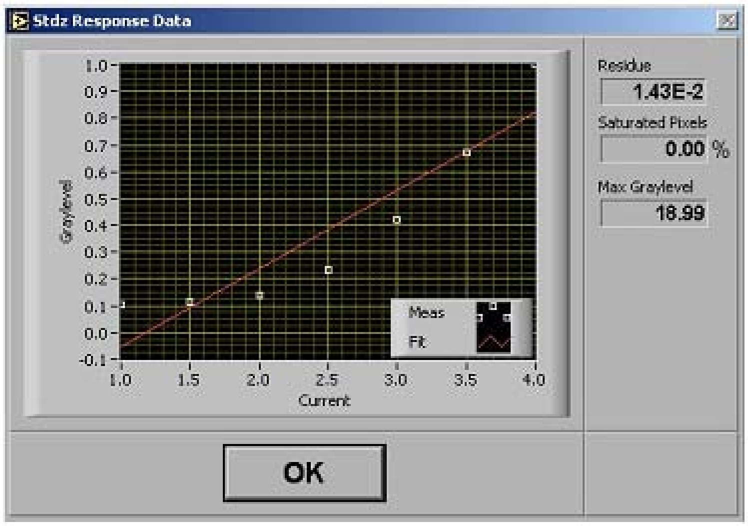


Figure 5-32 Stdz Response Data: Nonlinear

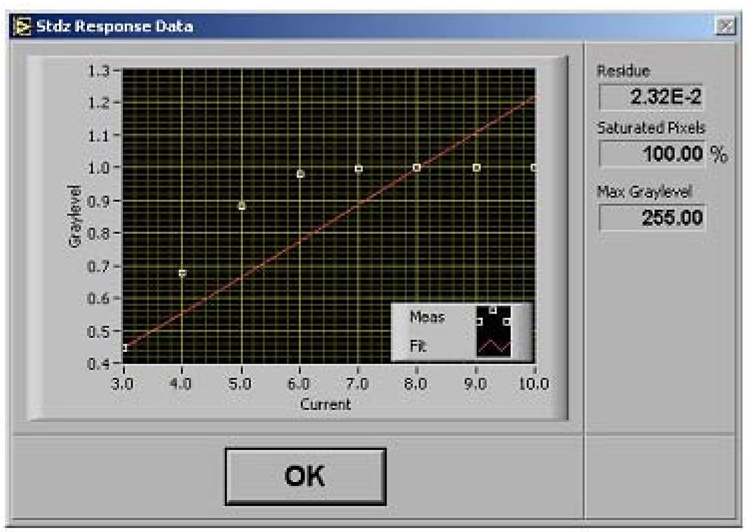


Figure 5-33 Stdz Response Data: Saturated

The residue of the fit indicates the goodness of the linear fit.

A saturated pixels value in the pop-up indicates saturation (overexposure) during the standardization. This value should not exceed 0.0%.

The maximum graylevel indicator shows the maximum graylevel (not normalized) of the image taken with the highest light intensity (highest current) during the standardization.

5.3.5.10. Autocovariance Curves

Accurate calculation of machine direction and cross direction floc size requires paper-grade-dependent parameters to be set up properly. These parameters control linear fits of autocovariance curves, which are important for the calculation. These curves can be studied in the **FotoForm Engineering** display by clicking **Autocovariance Curves**, which calls up the autocovariance curves pop-up shown in Figure 5-34.

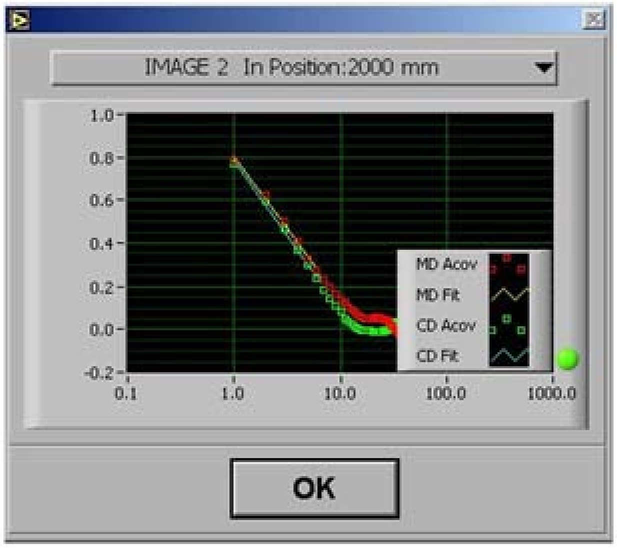


Figure 5-34 Autocovariance Curves

The autocovariance curves pop-up shows the machine direction and cross direction autocovariance curves together with the fitted values. The fitted lines should neatly track the initial linear part of the curve. If the curves are nonlinear right from the beginning, there is probably some problem with the illumination correction image, or it has not yet been calculated for the first time after FotoForm power-up.

The curves legend can be turned on and off by clicking the green button.

If the curves have a linear part, but the fitting starts or ends at the wrong part of the curve, adjust *Acov Start Fit Point*, *Acov Nbr of Fit Point*, or *Acov Fit Level* grade-based configuration parameter values in the **Recipe Maintenance** display. In normal conditions there is no need to change these parameters, but some tweaking may be necessary for exotic grades. Their default values are listed in Table 5-19.

Table 5-19 Grade Parameter Default Values

Grade Parameter	Default Value
Acov Start Fit Point	1
Acov Nbr of Fit Point	6
Acov Fit Level	0.0

5.3.5.11. Diagnostic Texts

Diagnostic messages sent by the Formation Sensor can be read by clicking **Diagnostic Texts** under the **Miscellaneous** sub-tab on the **FotoForm Engineering** display (item 5, Figure 5-28). This will call up **Diagnostic Texts** pop-up window (see Figure 5-35). Update interval and content of the diagnostic messages is dependent on the firmware version of the Formation Sensor. These messages are useful for troubleshooting performed by service.

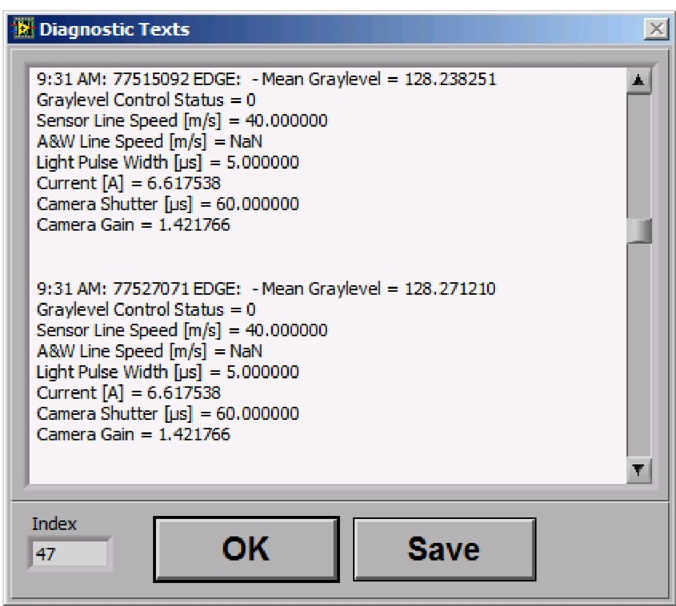


Figure 5-35 Diagnostic Texts Pop-up

5.3.5.12. Measurement Order and Typical Criteria

There is a definition table on the upper part of the **Definitions** sub-tab of the **FotoForm Engineering** display (see Figure 5-28). Measurement names are listed in the first column.

The second column contains the display order of the measurements as ordinals from 1 to 10. This order is used to show all measurements on the **FotoForm Display**, single on-line formation properties (see Subsection 5.3.1.7). In addition, measurements with ordinals 1–5 are selected for displaying data on the polar plot on the **FotoForm Display** (see Subsection 5.3.1.3) and the **FotoForm Image Gallery** (see Subsection 5.3.3.6). The same five measurements are also shown in the display of multiple on-line formation images and data (see **FotoForm Display** second page, Subsection 5.3.1.8).

The third column contains flags for inclusion (value = 0 ⇔ do not include, 1⇔ include) of measurement into the most typical image calculation at the end of roll (see Subsection 5.3.3.1). This means that only those measurements are taken into account for which the value in the **Typical** column is 1.

5.3.5.13. The Save Definitions Button

All values entered on the **Definitions** sub-tab of the **FotoForm Engineering** display can be saved by clicking **SAVE** (item 7, Figure 5-28). Remember to click **SAVE** before exiting the display if you want your changes to take effect.

5.3.5.14. Number of Images From Reel End for Image Gallery Control

Sometimes you may want to select the typical image of the roll near roll end (not based on the whole roll) in order to better link Formation Sensor measurements to laboratory measurements, which are only taken from roll-end cross direction strips of the web. This can be achieved by entering a suitable value to **Number of Images From Reel End for Image Gallery** control (item 8, Figure 5-28). If four imaging positions are defined (see Subsection 5.3.1.4), setting this value to 40 means that only 10 last scans of the roll are taken into account when the most representative image is selected.

5.3.5.15. Clear Image Gallery References

When the automatic grade reference feature is enabled (see Subsection 5.3.3.3), the QCS system saves the most representative image of the first roll of a grade as the reference image of the grade. Sometimes it may be desirable to reset all grade references, for example, after a major overhaul of the paper machine, which may change formation of all grades dramatically. Image gallery references can be reset by clicking **Clear Image Gallery References** (item 9, Figure 5-28).

6. Detailed Sensor Structure

This chapter gives a detailed description of the Formation Sensor structure (electronics, pneumatics, and software), and describes the National Instruments CVS-1456 processor module DIP switch configuration.

6.1. Electronics

The FRMM electronics comprise:

- National Instruments CVS-1456 processor module
- camera
- signal converters
- cabling

The sensor internal operation is controlled by the processor module. It handles imaging and computation of formation properties, control of camera and light source, and communication between the sensor, the sensor EDAQ and the Measurement Sub System (MSS).

Images are taken, and a simultaneous light pulse is fired, when the processor module outputs a trigger signal 10 times per second. Both the camera and the strobe parameters are managed by the processor module through a serial link. The camera captures images of the web.

The processor module calculates formation properties of each image, and sends them as normal slice data to the QCS server (trends and profiles are possible).

The FRIM electronics comprise:

- strobe controller
- signal converter
- cabling

The FRIM acts as a slave unit of the FRMM. The strobe controller accepts pulse controls and trigger signals from the FRMM transmitted through the Power track. The role of the FRIM is to output a bright, uniform flash of light at the right time with given properties.

6.1.1. The CSL

The communication between the formation sensor and MSS is handled by the CSL, which uses the 100 Mbit/s sensor LAN Ethernet.

6.1.2. CVS-EDAQ Control Link

The communication between the FRMM sensor and the FRMM EDAQ board is handled by the CVS-EDAQ control link, which is a fast serial link using CSL protocol. The link is full-duplex, and the communication speed is 115200 bit/s. The processor module output signal is TTL-level (0–5 V) which is converted first to RS232 level and then to RS422. The RS422 is a four-wire connection, which means two wires for transmitted data and two wires for received data. Output signals are isolated from the sensor power supply.

6.1.3. Time Synchronization

The internal time of the sensor must be synchronized with the system time. The timestamp is part of the slice measuring data of the sensor. The MSS needs timestamps to maintain profiles. Also, the starting points of measurement and image positions are triggered by time. The timestamp signal is enabled at the edges of the sheet, sample measurement, single-point measurement, and idle mode. Time synchronization has the following steps (also see Figure 6-1):

1. EDAQ is synchronized by the system time. It sends a future time specification via CVS-EDAQ control link (serial) to the CVS once per second.

2. CVS reads the future time specification and waits for the trailing edge of the Time Synch Line.

3. EDAQ sets the Time Synch digital output line, and then resets it precisely at future time.

4. CVS initializes the Internal Time Counter, and starts to process the monotonic clock.

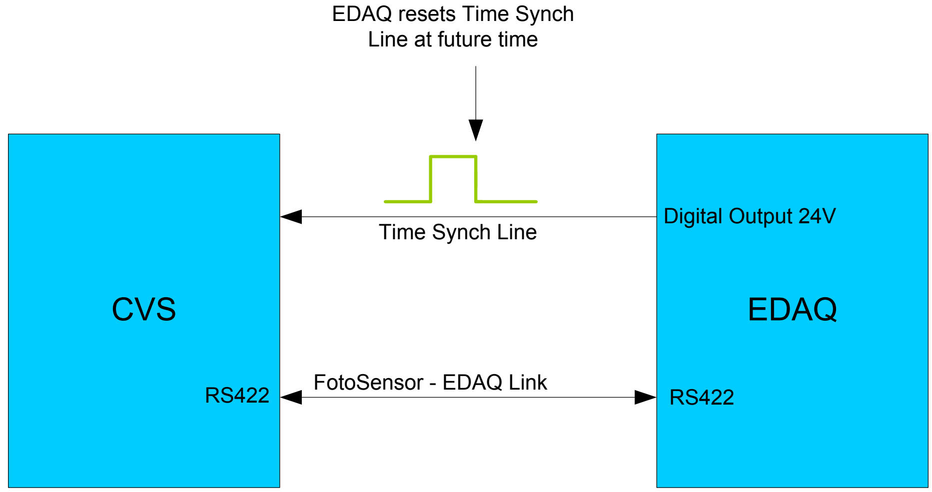


Figure 6-1 Formation Sensor Time Synchronization

6.1.4. Light Control Link

The processor module can control FRIM light parameters via the light control link. Typical parameters are light intensity and length of the light pulse. The link is serial at the end-points, but is converted to/from the Ethernet by the FRMM and the FRIM EDAQ boards.

The link is half-duplex, and the communication speed is 9600 bit/s. Only the transmitting mode is in use. The strobe controller can only receive data. The processor module output signal is RS232 level, which is converted to RS485. Only two wires are needed for communication. The output signal is isolated from the sensor power supply. At the FRIM module, the RS485 signal is converted back to an RS232 signal.

6.1.5. Light Trigger

The processor module triggers the light on via a triggering line. The trigger signal is a very short pulse, with a typical duration of 50 µs. The light pulse duration is controlled by the strobe parameters. The trigger signal is TTL-level (0–5 V) which is converted to 24 V isolated signal. Signal is fed through the Power track to the FRIM module. Only two wires are needed for the light trigger signal.

6.1.6. Camera Trigger

The camera exposure is triggered by the processor module. The signal is TTL level (0–5 V) with a very short pulse duration of, typically, 50 µs. The camera trigger is fired simultaneously with the light trigger.

6.2. Fuses and LEDs

The FRMM and the FRIM have their own fuses for power supply protection. All signal converters have LEDs for diagnostic purposes.

6.2.1. Fuses

Table 6-1 lists and describes the FRMM and FRIM fuses.

Table 6-1 Fuses

Fuse	Device	Description
F1	FRMM	Module power supply protection: 2 A, fast, 5x20 mm
F2	FRIM	Module power supply protection: 2 A, fast, 5x20 mm

6.2.2. Signal Converter LEDs, Ja Jumper Settings

Signal flow through FotoForm electronics can be observed through LEDs of the signal converters. Table 6-2 lists descriptions of different LED states.

Table 6-2 Formation Sensor Signal Converter LEDs

LED	Device	Signal	Description
Yellow	FRMM, TTL25A (A4)		LED is on when 24 power supply is OK
Green	FRMM, TTL25A (A4)	CSL between sensor and MSS	LED is blinking when TTL25A (A4) converter is receiving data from the XP422 (A5) converter
Red	FRMM, TTL25A (A4)	CSL between sensor and MSS	LED is blinking when TTL25A (A4) converter is sending data to the XP422 (A5) converter
Yellow	FRMM, XP422 (A5)		LED is on when 24 power supply is OK
Green	FRMM, XP422 (A5)	CSL between sensor and MSS	LED is blinking when XP422 (A5) converter is receiving data from the MSS
Red	FRMM, XP422 (A5)	CSL between sensor and MSS	LED is blinking when XP422 (A5) converter is sending data to the MSS
Yellow	FRMM, XP485 (A6)		LED is on when 24 power supply is OK
Green	FRMM, XP485 (A6)	Light control link between FRMM and FRIM	LED is blinking when XP485 (A6) converter is receiving data from the FRIM module
			This LED is always off because data from Strobe Controller is ignored
Red	FRMM, XP485 (A6)	Light control link between FRMM and FRIM	LED is blinking when XP485 (A6) converter is sending data to the FRIM module
Yellow	FRMM, DKE-DE (A2)	Light trigger from FRMM to FRIM	LED is blinking when the processor module is triggering FRIM lights
			Trigger pulse is very short, and it is very difficult to see LED blinking
Yellow	FRIM, XP485 (A7)		LED is on when 24 power supply is OK
Green	FRIM, XP485 (A7)	Light control link between FRMM and FRIM	LED is blinking when XP485 (A7) converter is receiving data from the FRMM module
Red	FRIM, XP485 (A7)	Light control link between FRMM and FRIM	LED is blinking when XP485 (A7) converter is sending data to the FRMM module
			This LED is always off because data from Strobe Controller is ignored

Locations of the LEDs and correct jumper settings of the converters are shown in Figure 6-2 through Figure 6-6.

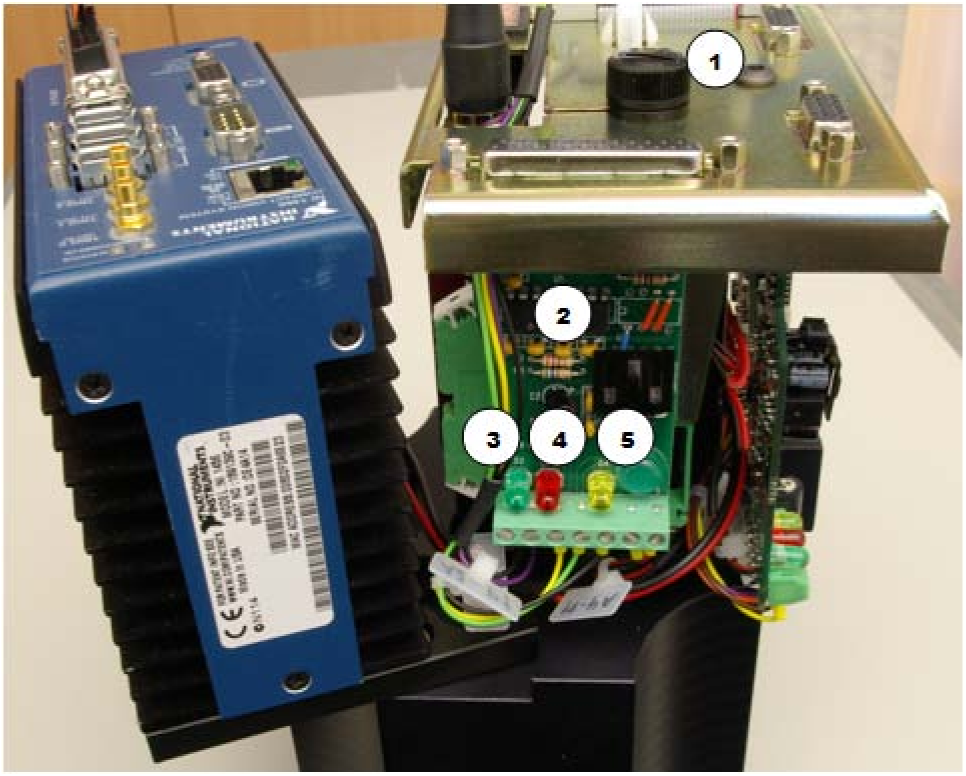


Figure 6-2 FRMM LEDs and Fuses (1 of 3)

Table 6-3 lists and describes the items labeled in Figure 6-2.

Table 6-3 FRMM LEDs and Fuses (1 of 3) Items

Item	Description
1	Fuse F1, I=2A
2	TTL25A (A4): TTL / RS232 converter
3	Green LED: received data, XP422 (A5) → TTL25A (A4)
4	Red LED: transmitted data, TTL25A (A4) → XP422 (A5)
5	Yellow LED: 24 V power on

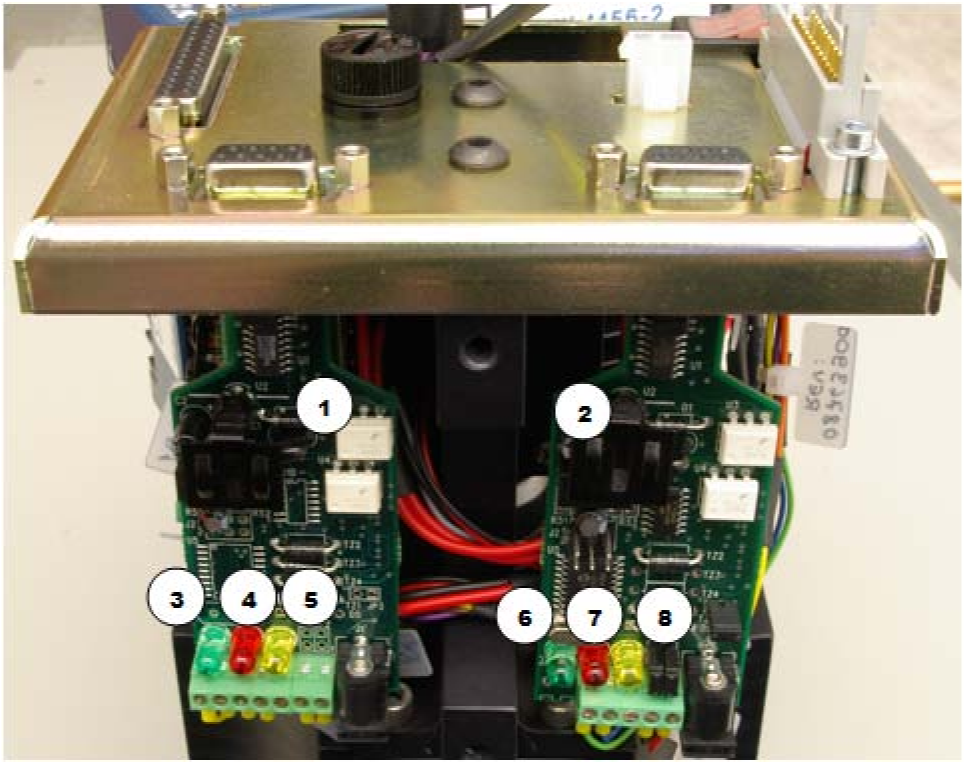


Figure 6-3 FRMM LEDs and Fuses (2 of 3)

Table 6-4 lists and describes the items labeled in Figure 6-3.

Table 6-4 FRMM LEDs and Fuses (2 of 3) Items

Item	Description
1	XP422 (A5): RS232 / RS422 converter
2	XP485 (A6): RS232 / RS485 converter
3	Green LED: transmitted data, XP422 (A5) to FRIM
4	Red LED: received data TTL25A (A4) to XP422 (A5)
5	Yellow LED: 24 V power on
6	Green LED: received data FRIM to XP485 (A6)
7	Red LED: transmitted data XP485 (A6) to FRIM
8	Yellow LED: 24 V power on

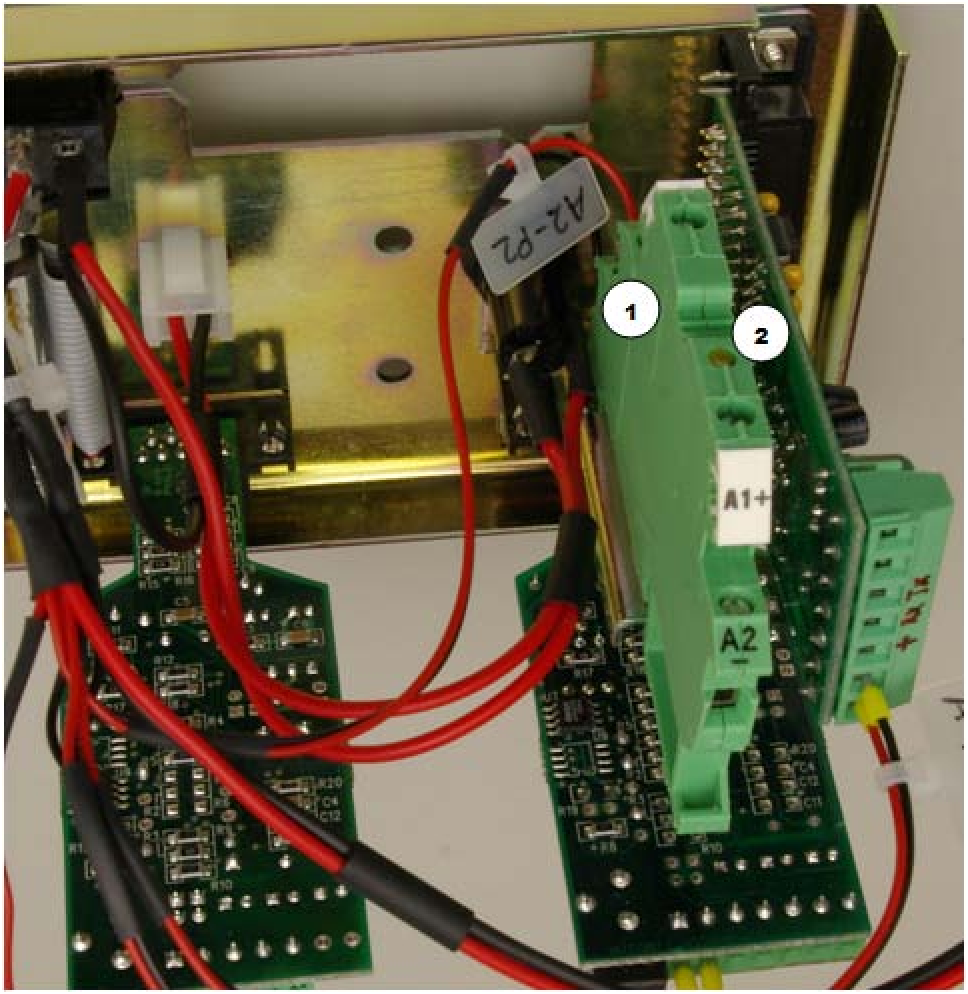


Figure 6-4 FRMM LEDs and Fuses (3 of 3)

Table 6-5 lists and describes the items labeled in Figure 6-4.

Table 6-5 FRMM LEDs and Fuses (3 of 3) Items

Item	Description
1	DKE-DE (A2)
2	Yellow LED: light trigger FRMM to FRIM

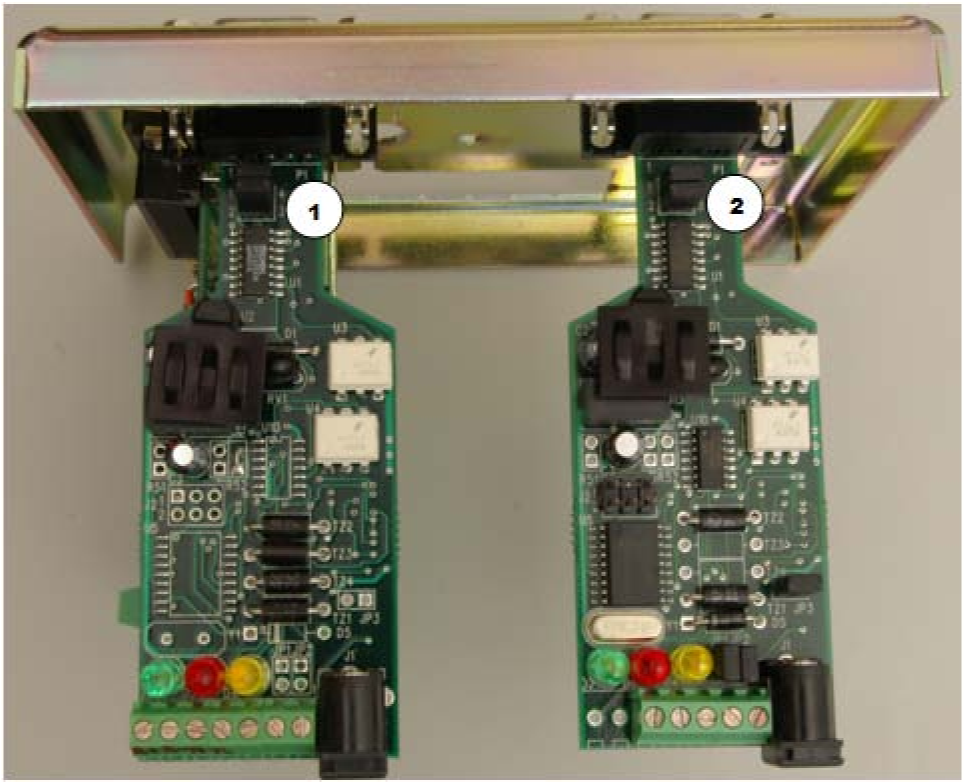


Figure 6-5 FRMM Jumpers

Table 6-6 lists and describes the items labeled in Figure 6-5.

Table 6-6 FRMM Jumpers

Item	Description
1	XP422 (A5); jumpers 1-4 and 2-3 closed
2	XP485 (A6); jumpers 1-4 and 2-3 closed

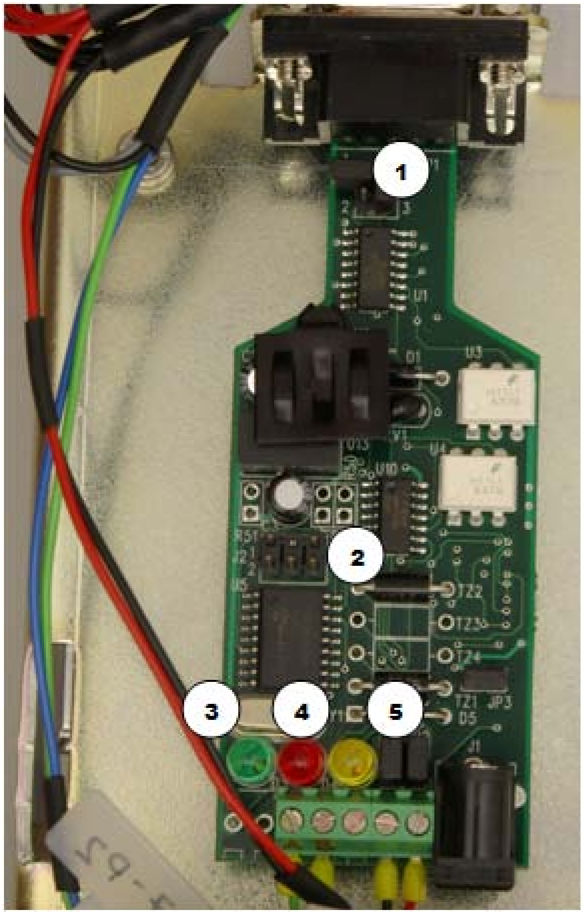


Figure 6-6 FRMM Jumpers and LEDs

Table 6-7 lists and describes the items labeled in Figure 6-6.

Table 6-7 FRMM Jumpers and LEDs

Item	Description
1	XP485 (A7); jumpers 1-2 and 3-4 closed
2	XP485 (A7) RS232 / RS485 converter
3	Green ED: received data, FRMM → XP485 (A7)
4	Red LED: transmitted data, XP485 (A7) → FRMM
5	Yellow LED: 24 V power on

6.3. CVS-1456 LEDS and DIP Switches

This section describes the appearance and function of the LEDs and DIP switches on the National Instruments CVS-1456 processor module (see Figure 6-7).

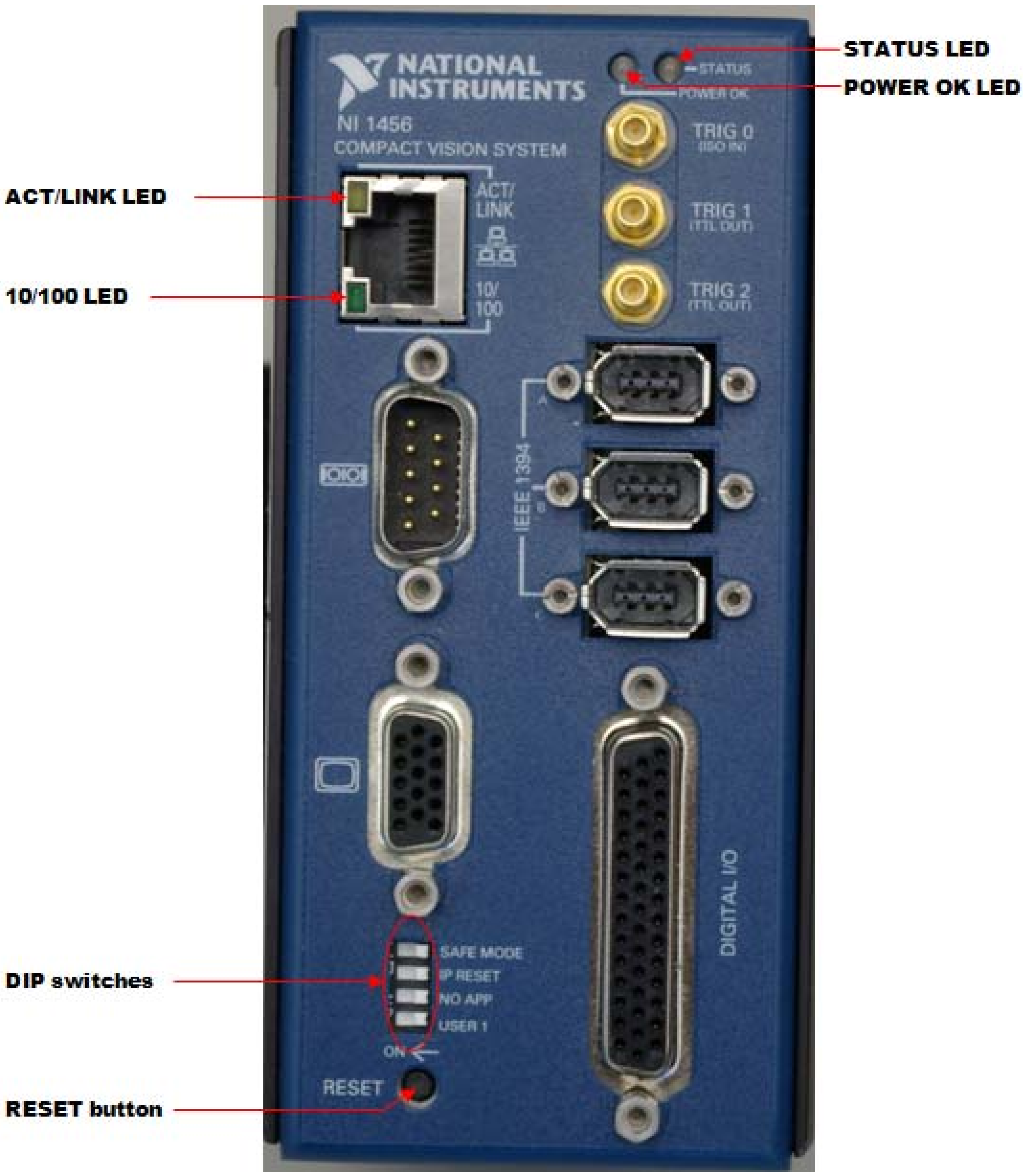


Figure 6-7 CVS-1456 Processor Module: LEDs and DIP Switches

6.3.1. STATUS LED

Under normal operating conditions, the orange **STATUS** LED remains *off*. The LED flashes a specific number of times to indicate certain error conditions or specific DIP switch settings. The LED remains *on* if the processor module detects an internal error.

6.3.2. POWER OK LED

Under normal operating conditions, the **POWER OK** LED remains green while the processor module is powered on. When green, the LED indicates that the processor module is receiving power and is not in a fault state. The LED turns red to indicate that the processor module has shut down because of a fault state. A fault state occurs when user shutdown input is set, the processor overheats, or the watchdog timer expires.

ATTENTION

The **POWER OK** LED does not indicate the status of the isolated power (Viso).

6.3.3. ACT/LINK LED

The orange **ACT/LINK** LED blinks when the processor module receives data from or transmits data to the network through the Ethernet connection. Unrelated network activity causes the LED to blink occasionally even when the processor module is inactive.

6.3.4. 10/100 LED

The green **10/100** LED is on when the network provides 100 Mbit/s support and the processor module is communicating at 100 Mbit/s. If the LED is off, the processor module is *not* operating at 100 Mbit/s.

6.3.5. DIP Switches

The Formation Sensor has four DIP switches on the processor module in the FRMM (see Figure 6-7).

To enable a DIP switch, move it to the left to the *on* position, then reset the processor module by pressing and holding the **RESET** button for at least two seconds (otherwise the DIP switch does not change the mode of the processor module).

Table 6-8 lists the processor module DIP switch default settings.

Table 6-8 DIP Switch Settings

DIP switch	Setting
SAFE MODE	OFF
IP RESET	OFF
NO APP	OFF
USER 1	OFF

SAFE MODE: The **SAFE MODE** DIP switch is used to reconfigure TCP/IP settings, and to download or update software from the development computer. Downloading incorrect software to the processor module may cause it to hang during restart, or become inaccessible over the network. Powering on or resetting the processor module in safe mode starts the processor module, but does not start the embedded LabVIEW RT engine. To resume normal operations, restart the processor module with the **SAFE MODE** switch in the *off* position.

IP RESET: The **IP RESET** DIP switch is used to clear the processor module IP settings. Move the **IP RESET** switch to the *on* position, and reset the processor module. Use the **IP REST** switch to reset the TCP/IP settings when moving the system from one subnet to another, or when the current TCP/IP setting is invalid. Resetting the processor module with the **IP RESET** switch in the *on* position resets the IP address to 0.0.0.0. You can then set up a new network configuration for the processor module from a development machine on the same subnet, or you can use an Ethernet crossover cable to connect the processor module directly to the development computer.

NO APP: The **NO APP** DIP switch is used to prevent the processor module from automatically running programs at startup. Move the **NO APP** switch to the *on* position and reset the processor module. If the processor module becomes inaccessible because of the startup program, enable the **NO APP** switch, and reset the processor module. Enable this switch to prevent the processor module default startup program or vision builder AI from running at startup.

USER 1: The **USER 1** DIP switch is user-configurable and has no default functionality.

7. Introduction to Measurement

This chapter defines and explains paper formation and how it is measured. Factors having an influence on formation are described. Measurement results produced by the Formation Sensor are explained in detail with examples.

7.1. Paper Formation

The purpose of the forming process in a paper machine is to produce a thin, uniform sheet out of water/fiber suspension. The degree of achieved uniformity is often called the *formation* of paper. In International Standard ISO 4046-3:2002, formation is defined as “the manner in which the fibers are distributed, disposed and intermixed to constitute the paper”. This definition is quite broad, because it includes virtually the whole fiber network structure, including planar and Z-directional fiber orientation, in addition to spatial grammage distribution.

No ISO or TAPPI standard is defined for the measurement of formation.

In paper physics, it is very common to define formation as small-scale grammage variation, which includes fines, fillers, and other constituents of paper as well as fibers.

In paper mills it is very common to use the term formation as a synonym for the look-through of paper, which is defined in ISO 40446-5:2002 as “structural appearance of a sheet of paper observed in diffused transmitted light”. This is an indication of formation (see Figure 7-1).

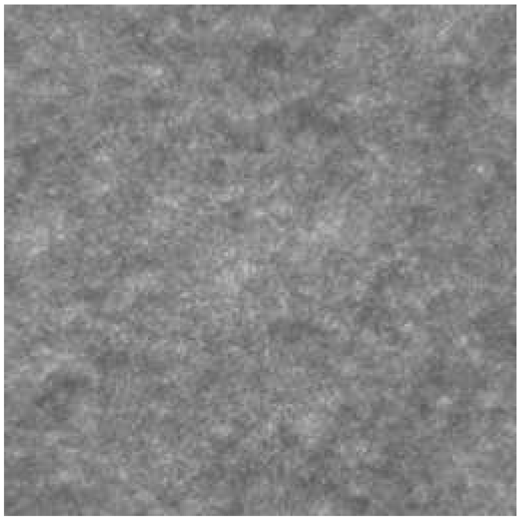


Figure 7-1 Paper Illuminated With Diffuse Transmitted Light

Look-through is usually related to small scales. However, these definitions of formation differ fundamentally from each other. Light transmission through a small local area of paper is not always unambiguously defined by its grammage. For example, calendering can change the optical properties much more than changing grammage, which makes it impossible to correlate local basis weight and light transmission with each other. In most cases look-through is a fairly good indication of grammage distribution. Scale information, such as floc size, is almost identical in both cases. Conversely, the *aesthetic appearance* of paper relates directly to look-through and it cannot be deduced directly from grammage distribution.

Very often formation scale is considered to be from 0.1–100 mm (< 0.01–3.94 in.). A more detailed description is given by B. Norman and D. Söderberg. Their scale definition is shown in Table 7-1. For more information on these references, see *Related Reading* in the Introduction chapter of this manual.

The 4801 Precision Formation Sensor has been designed to analyze the scale from 0.2–44.5 mm (0.01–3.94 in.), which mostly corresponds to small scale as defined in Table 7-1.

Table 7-1 Scales of Paper Structure Variation

Scale	Size	Origin
Micro scale	scale < 0.1 mm (< 0.01 in.)	Particle size, micro flow, colloidal forces
Small scale	0.1 mm (< 0.01 in.) < scale < 40 mm (1.57 in.)	Fiber flocculation, forming hydrodynamics
Medium scale	40 mm (1.57 in.) < scale < 10 m (32.81 ft)	Instabilities in headbox flow and wire section dewatering
Macro scale	scale > 10 m (32.81 ft)	Variability in the incoming stock flow

7.2. Evolution of Formation Paper Making

7.2.1. Raw Materials

7.2.1.1. Fibers

The most important factor that influences formation of paper or paperboard is the choice of raw materials. Fibers are very long objects (up to several millimeters) compared to their width. When these flexible *strings* rotate in non-laminar flows in the headbox and the forming section, they tend to get wound around each other, for example, flocculate. The tendency of fiber suspension to flocculate can be described by Crowding Factor N, which is defined as

$$N = \frac{2}{3} c_v \left(\frac{L}{d} \right)^2 ,$$

Equation 7-1

where *L* is fiber length, *d* is fiber diameter (assume cylindrical fibers), and c_v is volume concentration of the suspension (refer to *Kerekes, R. and Schell, C., "Characterization of Fibre Flocculation Regimes by a Crowding Factor", J. Pulp Pap. Sci., 18(1): p. J32-38 (1992)*). According to Equation 7-1, the Crowding Factor *N* is equal to the number of fibers in a spherical reference volume, whose diameter is fiber length L. When N << 1, fibers do not often meet each other because there are hardly any neighbors to an individual fiber. Collisions and subsequent entanglements of fibers with each other (flocculation) are rare. When N << 1 there are many fibers within the reach of any fiber. Fibers collide and entangle with each other all the time, which leads to strong flocculation. Equation 7-1 can be interpreted in practical terms: increasing consistency c_v, or using long, slender fibers (high L/d ratio) increases flocculation of pulp. In order to reduce flocculation, fiber length can be reduced by refining. Different levels of N are explained in Table 7-2 (refer to *B. Norman and D. Söderberg, "Overview of Forming literature, 1990-2000", in Proceedings of 12th Fundamental Research Symposium, Oxford, p. 431-558 (2001)*).

Table 7-2 Crowding Factor Levels

Crowding Factor *N*	Concentration	Type of Fiber Contact
$N < 1$	Dilute	Rare collisions
$1 < N < 60$	Semi-concentrated	Frequent collisions
$N > 60$	Concentrated	Continuous contact

Paper samples are often produced using a laboratory sheet mold in order to determine the formation potential of the pulp to be used in production. The forming process in the sheet mold takes place in very low concentration ($N < 1$). That is why the fibers settle down onto the wire without much interacting with each other. Flocculation does not take place, and the resulting formation will become optimal for the pulp. On a paper machine, such a low concentration can not be used due to limitations in dewatering at a given production speed. The concentration c_v will be higher ($N >> 1$), therefore flocculation is quite common. An image of flocculation of softwood kraft pulp is shown in Figure 7-2.

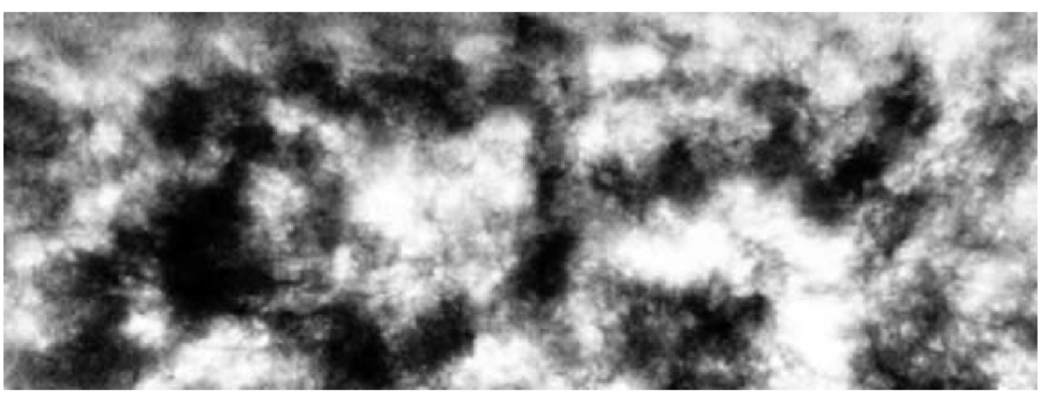


Figure 7-2 Flocculation of Softwood Pulp in Pipe Flow

Fiber dimensions set the typical scale of flocculation in fiber suspension flow (refer to *Karema, H., Kataja, M., Kellomäki, M., Salmela, J. And Selenius, P., "Transient fluidisation of fibre suspension in straight channel flow", in*

Proceedings of TAPPI International Paper Physics Conference, San Diego, USA, p. 369-379 (1999)). Using hardwood pulp (shorter fiber length) will make the flocs smaller than using softwood pulp (longer fiber length).

7.2.1.2. Chemicals and Mineral Fillers

During web forming, most of the flow through the head box is removed on the wire section, and only around 2% of the flow continues further to the press section. Wire retention expresses to what extent the suspension is retained in the web while the water is removed. This phenomenon consists of two mechanisms:

- mechanical retention
- chemical retention

Mechanical retention means the natural tendency of fibers and fiber fines to attach to each other and build a network.

Other particles in the suspension, such as mineral fillers, need to be bound to fibers with retention chemicals. This phenomenon is called chemical retention. Mistakes in retention chemical feeding may also bind fibers to each other and help them form larger and tighter flocs, which directly deteriorates formation of paper. Therefore, an optimization of these chemicals and their feeding is essential for preserving good formation while yielding good retention.

Most other chemicals that are fed to the short circulation also leave some sort of fingerprint to the formation, for example, contents of coated broke, biocides, and contaminants caused by closed water circulations can cause various formation changes. The presence and effects of these chemicals must be known and under control.

7.2.2. Headbox

One task of the paper machine headbox is to produce a thin, smooth jet of fiber suspension with even solids content and flow field for forming section. Another task is to minimize flocculation of the fiber suspension by turbulent shear forces and elongational flow by acceleration. By using turbulence generators in a hydraulic headbox, the flocs can be effectively torn apart. Unfortunately, the fibers tend to reflocculate quite rapidly further downstream where turbulence level has decayed (refer to *Karema, H., Kataja, M., Kellomäki, M., Salmela, J. And Selenius, P., "Transient fluidisation of fibre suspension in straight channel flow", in Proceedings of TAPPI International Paper Physics Conference, San Diego, USA, p. 369-379 (1999)*). That is why the achieved state has to be utilized as soon as possible. One way of improving formation is to raise jet speed in order to minimize the time between breaking the flocs and drainage.

7.2.3. Forming Section

The forming section is critical in terms of formation. This is the phase of process where fiber suspension is transformed to the planar fiber network. Water is removed through one wire (Fourdrinier), or two wires (gap former). The most important parameter in regard to formation is the rush/drag ratio. In rush conditions the jet is decelerated by the wire; in drag conditions it is accelerated by the wire. In both cases shear forces are generated, which have a large effect on formation.

The formation optimization strategy is quite different on Fourdrinier and gap former. In Fourdrinier there is usually quite a lot of pulsation and activity on the wire. Figure 7-3 illustrates the filtration process of the fiber mat. When water is removed, new fibers are deposited on top of the already formed layers of the web. With wire activity, the filtration can be made more homogeneous and formation will be better as a result. The role of the headbox is to loosen flocs and to produce a good raw material for table activity where the actual formation is created.

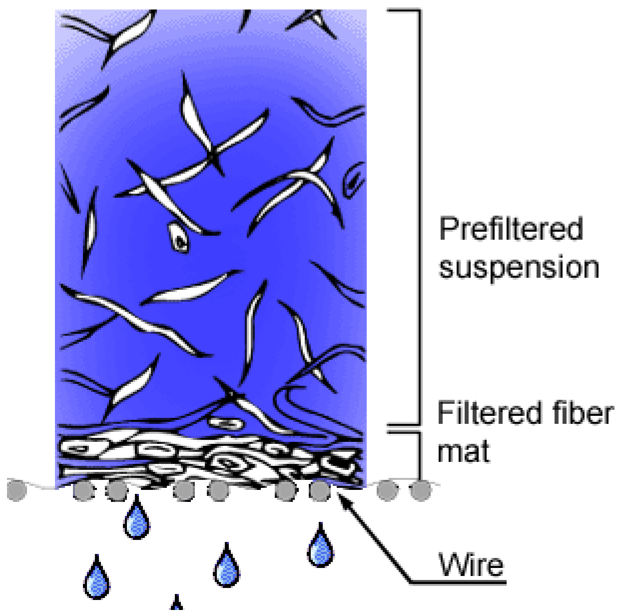


Figure 7-3 Filtration Process

In gap former, the jet is captured between two wires. The initial water removal is much more rapid, which emphasizes the role of the headbox. Flocculation is more easily copied from the slice jet because the time from jet to web is much smaller, and the movement of fiber suspension is more confined between two wires than on the single wire of Fourdrinier. Balance between initial and further water removal is one of the key issues in getting the best formation.

Jet impingement is one of the critical issues for formation in the forming section. The impingement angle has to be correct so that generation of harmful vortices is avoided. These vortices may easily result in poor formation.

Wire marking might be introduced during forming. It can consist of both periodic basis weight distribution and/or segregation of materials, for example, uneven filler distribution. Strong wire marking is usually perceived as bad formation.

7.2.4. Press Section

Press section binds fibers together as a network. Spatial grammage distribution does not change very much, but some defects can be introduced, for example, felt marking, or marking of the suction roll holes. Look-through changes more than basis weight distribution during the press section.

7.2.5. Drying, Coating, and Calendering

In the dryer section, solids do not move within the paper. The spatial basis weight distribution should therefore remain unchanged. However, drying shrinkage can cause changes in the spatial basis weight distribution, for example, floc shapes and periodic markings, especially near sheet edges, can change.

Coating adds a very smooth layer of minerals onto the paper. The coating layer decreases local grammage variations as it tends to fill the holes. Optically the changes are dramatic: fine-particle minerals scatter light very effectively making look-through of the paper much more uniform. This, in turn, gives an impression that formation would be much better than for the uncoated paper. However, the non-uniformity of the fiber network structure, which determines the non-uniformity of various properties of the paper, for example, in the printing process, remains the same. The tendency of paper for mottling in offset printing is directly related to formation of the base paper. That is why formation should be assessed before coater.

Calendering compresses paper significantly. Grammage variation before the calender turns into density variation after the calender. This does not change spatial grammage distribution, but the optical properties change a lot. Light transmission of high-density areas rises while light transmission of low-density areas remains unchanged. Also, gloss of paper surface increases, which leads to reduced transmission of light. These effects can change look-through significantly, while spatial grammage distribution remains unchanged.

7.3. Formation Properties

In most of the current off-line and on-line formation analyzers, the state of formation is expressed as a single index. Either small, such as AMBERTEC Beta Formation Tester, or large, such as Metso Automation's IQFormation Online formation measurement, value of the index is said to represent good formation. However, as explained in Chapter 6, the state of formation is generated by a large number of process steps and furnish properties. That is why formation tends to be a multi-dimensional property. There is no single bad or good state to be pursued. The question of optimizing formation is to look at different phenomena in formation separately, and optimize those.

Figure 7-4 further illustrates the measurement challenge. These images show that formation is not just a single phenomenon, therefore a single formation index approach is inadequate. The analysis must be able to decompose formation into its components.

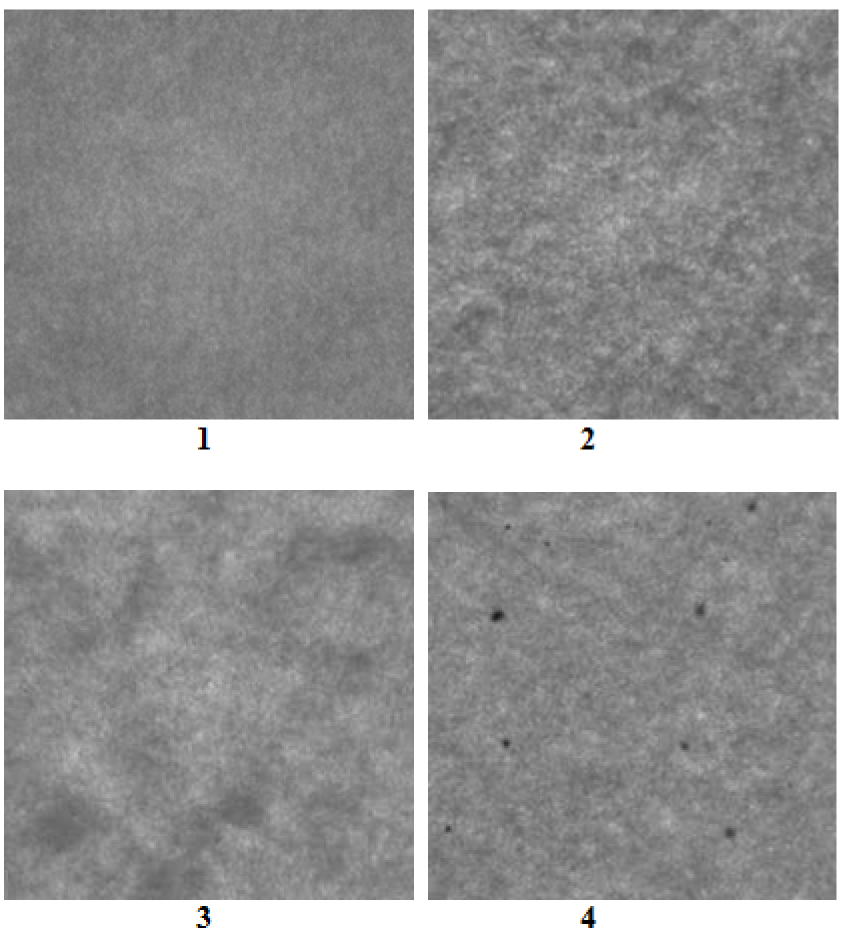


Figure 7-4 Formation Examples

In Figure 7-4 the sample images represent:

1. Good formation.
2. Large variability.
3. Large floc size.
4. Dark spots.

Figure 7-4, image 1, shows an example of a good formation, whereas images 2–4, show examples of bad formation, where *badness* originates from different causes.

Figure 7-4, image 2, shows an example where large variability (large peak-to-peak variation) of image brightness is evident. This is a typical type of formation defect and may result from insufficient table activity (Fourdrinier), or balance of water extraction (gap former).

Figure 7-4, image 3, shows an example of large flock size, which leads to cloudy look-through of the paper. In combination with large variability, this kind of formation can also be less appealing and lead to printability problems. This phenomenon can arise from an overdose of retention chemicals, misaligned jet, and very long fiber fractions.

Figure 7-4, image 4, shows an example of impurities in the furnish that may lead to dark spots in the look-through. It is evident that these types of defects are a serious problem for most paper grades.

These examples show that formation is not just a single phenomenon and a single formation index approach is inadequate. The analysis must be able to decompose formation into its components.

The Honeywell Q4221-50 Formation Measurement provides powerful tools for analyzing paper formation. State of formation is characterized by a carefully selected set of intuitive descriptors, called formation properties. These properties efficiently handle the described examples. The properties are summarized, along with range and typical values, in Table 7-3.

Table 7-3 Formation Properties

Formation Character	Units	Typical Values	Range	Visual Appearance: Low Value	Visual Appearance: High Value
Variability	0.1%	40–200	0–1000	Uniform look-through	Large difference between light and dark areas
Spot Index	-	-20–20	-100–100	Zero: balance between light and dark areas	Positive: light spots dominate
				Negative: dark spots dominate	Large positive: holes (for example, pinholes)
MD Floc Size	mm	1.0–3.0	0.0–40.0	Small flocs (grainy)	Large flocs (cloudy)
CD Floc Size	mm	1.0–3.0	0.0–40.0	Small flocs (grainy)	Large flocs (cloudy)
Floc Shape	%	70–150	0–1000	100: isotropic flocs	> 100: flocs are larger in machine direction (for example, rush/drag < 1)
				< 100: flocs are larger in cross direction (for example, rush/drag > 1)	

7.3.1. Variability

Variability is the most important formation character. It describes the amplitude of light transmission variation. The value of variability is calculated from image intensity matrix *I* as follows:

$$Variability = 1000\frac{\sigma_I}{\langle I \rangle} = 1000\frac{\sum_{i,j}\left(I_{ij} - \langle I \rangle\right)^2}{\frac{1}{N}\sum_{i,j} I_{ij}}$$

Equation 7-2

In this instance, variability is defined as the coefficient of variation of the image pixels multiplied by 1000. In other words, this character tells how much light transmitted through the paper varies relatively. The larger the variability is, the more there is relative variation of light absorption (optical density).

Figure 7-5 shows examples of variability. The left-hand example shows lower variability and appears more even. The difference between the lightest and the darkest areas is small.

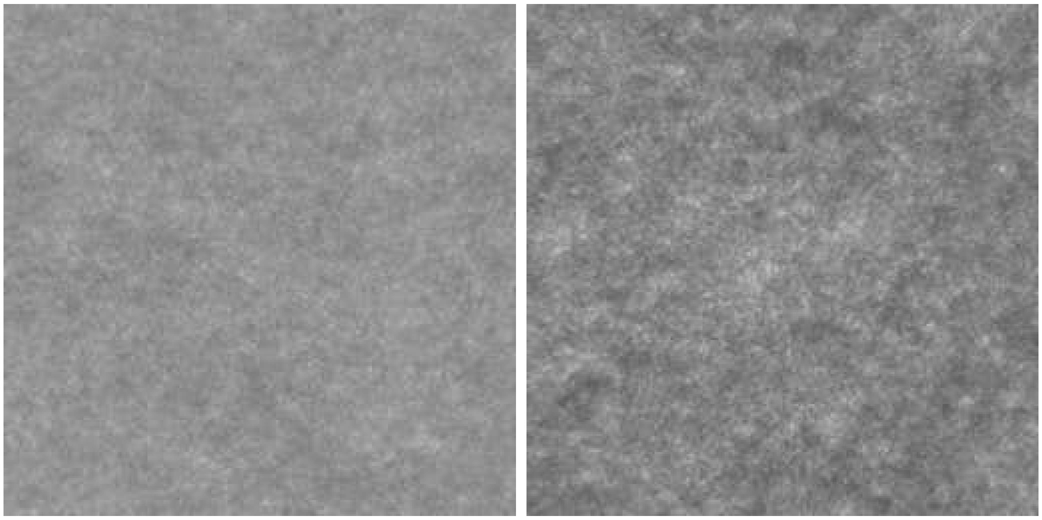


Figure 7-5 Low Variability (left); High Variability (right)

The right-hand example shows higher variability and appears less even. The difference between the lightest and the darkest areas is high.

Variability can be understood intuitively as *the relative contrast of formation texture*. To improve formation, make changes to the process that minimize variability.

Due to its mathematical definition, variability correlates best with the floc intensity parameter of a previous product, SpectraForm. Refer to the *Precision Formation Sensor User Manual* (p/n 46024900). This relationship is useful to know when migrating from SpectraForm to Q4221-50 Formation Sensor for Experion MX.

ATTENTION

One of the goals of optimization is to make variability as small as possible to minimize the contrast of formation. This is the most important quality characteristic of formation.

7.3.2. Spot Index

Variations in formation are much more complex than just changes of relative contrast. One such case is the appearance of light or dark spots. Figure 7-6 presents examples of three different cases of spottiness: negative (dark spots), zero (no spots), and positive (white spots).

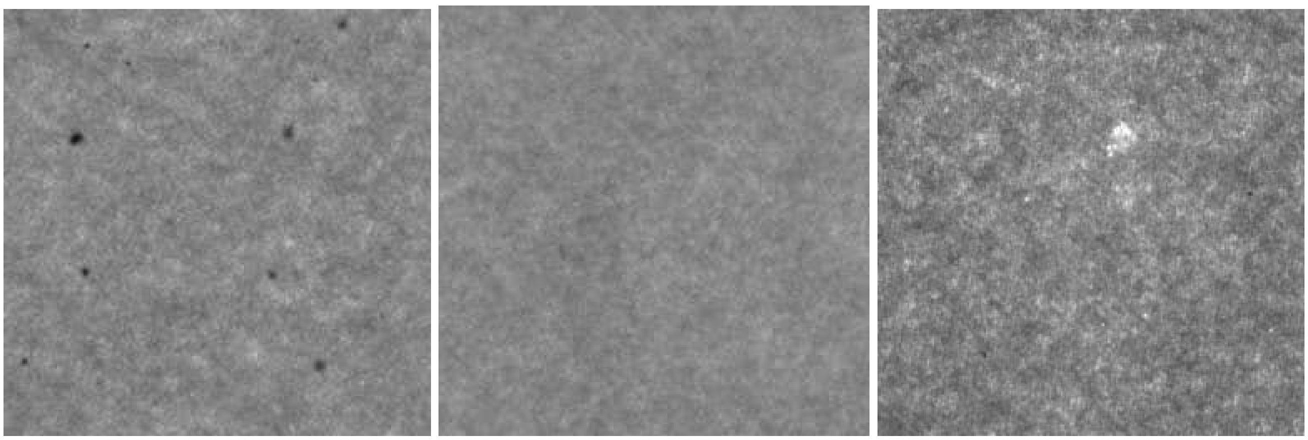


Figure 7-6 Spot Index: Negative (left), Zero (center), Positive (right)

These cases can be identified with spot index, which is defined as:

$$spotindex = \frac{\sum_{i,j}\left(g_{ij} - \langle g \rangle\right)^3}{(N-1)\sigma^3}$$

Equation 7-3

where g is defined as:

$$g_{ij} = \log_{10} I_{ij}$$

Equation 7-4

where I_{ij} is the image pixel intensity

In other words, spot index is defined as the amount of skew of a logarithmic intensity distribution. This distribution is in many cases, though not always, proportional to grammage distribution (when transmitted intensity is exponentially related to grammage). In other words, spot index is related to the balance between low-grammage areas (voids) and high-grammage areas (flocs).

Negative values of spot index define situations where there is an excess of heavy or dark spots/flocs compared to thin or light spots. Negative values arise, for example, due to dirt particles in the stock or excessively high rush-to-drag ratio (hard deceleration of stock causes dense flocs to be created).

If spot index is positive, the amount of light spots exceeds the number of dark spots. An extreme case of large positive values is found, for example, when there are pinholes in the paper. This sometimes happens with lightweight newsprint grades.

In the case of no spots at all, or balancing dark and light spots, the value of spot index is zero. This is usually the optimum to which the formation is attempted to be optimized. If dark and light spots are in balance with each other, and they are both strong, the value of variability becomes very high.

ATTENTION

> One of the goals of optimization is to make spot index as close to zero as possible to minimize spotted formation.

7.3.3. Floc Size

It is evident to anyone who has looked at paper formation that not only does the contrast or spottiness of the texture vary, it is quite common that the scale (or floc size) also varies. Sometimes flocs tend to form large *clouds*, and sometimes small *grains*. Figure 7-7 shows images of two paper samples: one with large flocs, and one with small flocs.

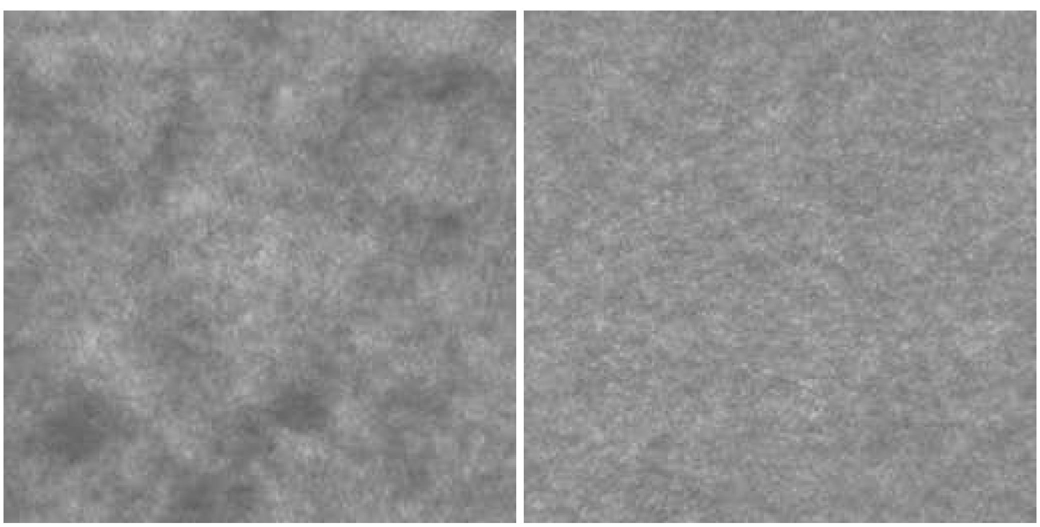


Figure 7-7 Large Flocs (left); Small Flocs (right)

To quantify the floc size from the images, it is mathematically equivalent to the method published in *Kellomäki, M. and Jetsu, P., "Graininess of formation", in Proceedings of TAPPI International Paper Physics Conference, Victoria (BC),* *Canada, p. 193-199 (2003)*. Floc size can be independently analyzed both for machine direction and cross direction. Values are reported in millimeters.

Floc size depends mostly on the mean fiber length of the stock used (refer to *Karema, H., Kataja, M., Kellomäki, M., Salmela, J. And Selenius, P., "Transient fluidisation of fibre suspension in straight channel flow", in Proceedings of TAPPI International Paper Physics Conference, San Diego, USA, p. 369-379 (1999)*).

Floc size is typically 1–3 fiber lengths. If fiber length is of the order of 4 mm (0.16 in.), the floc size is in the range of 4–12 mm (0.16–0.47 in.). If the fiber length is 0.7 mm (0.03 in.), floc size varies from 0.7–2.1 mm (0.03–0.08 in.). Wet end chemistry has a great effect on floc size. A high amount of retention aid can glue together very large flocs, while some other chemicals can make formation extremely uniform.

ATTENTION

One of the goals of optimization is to make floc size smaller if you want to avoid large cloudlike structures (make floc size larger, if you want to avoid small granular structures).

7.3.4. Floc Shape

The flocs have size *and* shape. The floc shape definition is:

$$flocshape = 100\frac{MDF}{CDF},$$

Equation 7-5

where *MDF* is floc size in machine direction and *CDF* in cross direction.

In other words, floc shape means how what percentage the machine direction floc size is of the cross direction floc size. Values over 100 mean flocs are elongated in the machine direction, for example, drag condition. Values under 100 mean flocs are elongated in the cross direction, which can happen in rush conditions. Values equal to 100 mean flocs have similar size in both the machine direction and the cross direction.

ATTENTION

One of the goals of optimization is to make floc shape as close to 100 as possible, unless your goal is to make anisotropic paper, for example, high degree of fiber orientation.

7.4. Formation Effects on Material Properties

Formation is an indication of the level of non-uniformity and the scale of non-uniformity of the constituents of paper or paperboard. It could be viewed as a perturbation to the ideal case where, for example, grammage would have only one value, the mean grammage, everywhere.

Deviation from ideal formation does not usually change mean values of other properties; however, in some cases, even the mean value can be affected. For example, light transmission of a uniform sheet is lower than transmission of a non-uniform sheet with the same mean grammage. This is due to the nonlinear (exponential) decay of transmission as a function of grammage.

7.4.1. Strength Properties

Strength properties of paper are greatly affected by formation. When the paper web experiences high stress it sometimes breaks, causing a loss of production and an increase in costs.

The crack propagation in paper usually starts from a weak point. When the initial crack is formed, it starts to propagate very rapidly across the web. Low-grammage areas have less than average strength and they are often the points from which the rupture starts. If formation is very bad, there are lots of potential points for starting the fracture (and subsequent propagation), and therefore, web breaks are more probable.

Conversely, if formation is very good, there are far fewer points available where stress could exceed local breaking threshold, which increases the strength of the web.

7.4.2. Surface Properties

Formation is mainly caused by variation of local basis weight of the paper or paperboard. Local thickness correlates with local basis weight especially for uncoated and uncalendered low-grammage paper. This implies that topography of the paper is a function of formation. Floc size is an important scale of the topography as well, and roughness of the surfaces is affected by variability. For roughness, the fiber dimensions are always a very important scale. In some cases, such as mottling in offset printing, floc scale emerges as the root cause of printability problems.

7.4.3. Optical Properties

Formation can have an effect on many optical properties of paper. For uncoated and uncalendered paper the local light transmission coefficient *c* is exponentially related to local grammage *g*:

$$I = \exp(-\alpha g) I_0 =: c I_0$$

Equation 7-6

where I_0 is the incident intensity of light, α is the grade-dependent absorption coefficient, and I is the transmitted intensity of light.

Relation shown in Equation 7-6 is usually true only if the density of the paper is constant. The calendering process tries to squeeze paper to a constant thickness, which causes the density of high-grammage areas to rise, while some of the low-grammage areas might be intact (no force exerted due to lacking contact). As higher density areas transmit light more effectively, Equation 7-6 does not hold any more.

Another optical phenomenon is related to formation due to Equation 7-6. The total light transmission through paper is dependent on formation. The greater the grammage variation is, the higher the total transmission will be. This is due to the exponential relation shown in Equation 7-6: low-grammage areas transmit more extra light than the high-grammage areas absorb. In other words, low-grammage areas, for example, holes, dominate the transmission. One of the consequences is that opacity of a paper with bad formation can be lower than that of a paper with good formation.

7.4.4. Porosity

As with light transmission, low-grammage areas dominate on fluid flow through paper. The flux always goes through the easiest areas. This means that bad formation can make paper more porous (in terms of mean permeability). Also, density variations due to calendering can introduce non-uniformity of porosity.

7.4.5. Printability

Bad formation can give rise to density and porosity fluctuations. In printing, areas with higher density and lower porosity do not absorb ink as easily as areas with lower density and higher porosity. This in turn can lead to uneven print quality.

Another mechanism deteriorating print quality is the varying coating layer thickness. This type of variation is possible in the case of blade coated paper, where base paper formation is bad. When grammage varies a lot, and consequently thickness, the blade coater fills the valleys while leaving only little coating color on the hills.

The mechanical properties, for example, Z-directional elastic modulus, of the areas in which there is a lot of fiber and a little coating (hill) differ very much from the areas in which there is less fiber and more coating (valley). This leads to varying pressure against paper in the pressing nip of an offset or a *flexo* printing machine. Print density is affected by this non-uniformity leading to mottling of large uniformly colored areas.

7.5. Laboratory Methods and Standards

No ISO or TAPPI standard is defined for the measurement of formation. There are many laboratory methods for formation, which are each defined separately. While it is possible to correlate FotoForm properties to most of the existing methods, FotoForm offers much better accuracy due to its high sampling rate and optimized formation properties.

8. Preventive Maintenance

The frequency of preventive maintenance procedures for the Formation Sensor may need to be adjusted depending on your operating environment.

In Table 8-1, *X* indicates recommended maintenance intervals.

Table 8-1 Preventive Maintenance Internal Checklist

Procedure	Daily	Weekly	Months		Years			Task Details
			1	6	1	2	5	
Clean the Outer Side of the FRMM Window	X							Subsection 9.1.1
Clean the Outer Side of the FRIM Window	X							Subsection 9.2.1

9. Tasks

This chapter contains procedures for maintaining optimal performance of the Formation Sensor. Tasks are organized based on mechanical and functional viewpoints.

9.1. FotoForm Measurement Module

9.1.1. Clean the Outer Side of the FRMM Window

Dirt build-up on the FRMM window may impact Formation Sensor performance. It is advisable to clean the window regularly. For example, if the moisture measurement sensor is installed to the same scanner head, it is useful to clean the windows of both sensors at the same time.

Mild build-up is digitally canceled by the FRMM. When dirt build-up is moderate, the FRMM turns on the **Clean Soon** indicator on the **FotoForm Display**. When even more dirt builds up, the indicator changes to **Clean Now**. In this mode, dirt build-up starts to have a significant impact on measurement results, and immediate cleaning is mandatory.

Activity Number:	Q4221-50-ACT-001	**Applicable Models:**	Q4221-50
Type of Procedure:	Maintain	**Expertise Level:**	Operator
Priority Level:	Average	**Cautions:**	None
Availability Required:	Scanner offsheet	**Reminder Lead Time:**	
Overdue Grace Period:		**Frequency (time period):**	Once per shift up to 1 week
Duration (time period):	5 minutes	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	

Required Parts:	Part Number	Quantity	Lead Time
Required Tools:	Part Number	Quantity	Lead Time
	• clean cloth • window cleaner fluid		

To clean the outer side of the FRMM window:

1. Command the scanner to offsheet.
2. Separate the heads.
3. Clean the window using a clean cloth and window cleaning fluid.
4. Close the heads.
5. Set the scanner back to scanning.
6. Look at the **FotoForm Display** on the QCS system.
7. Wait until the scanner head has performed a standardization and a minimum of five scans.
8. Verify that the **Clean Soon** or **Clean Now** status changes to **Sensor Window OK**. When the OK status appears, the procedure is complete.
9. If the cleaning status does not change to OK, repeat Steps 1–8. If that still does not help, proceed to Step 10.
10. Look at the illumination correction image on the **FotoForm Engineering** display. Observe where the dirt particles are on the window. If they cannot be cleaned outside, proceed to Subsection 9.1.2.

9.1.2. Clean the Inner Side of the FRMM Window

If the dirt build-up cannot be cleaned on the outside of the FRMM window, it is likely that the dirt particles are on the inside of the window.

Activity Number:	Q4221-50-ACT-002	**Applicable Models:**	Q4221-50
Type of Procedure:	Maintain	**Expertise Level:**	Technician
Priority Level:	Average	**Cautions:**	None

Availability Required:	Scanner offsheet	**Reminder Lead Time:**	
Overdue Grace Period:		**Frequency (time period):**	
Duration (time period):	30 minutes	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
Required Parts:	Part Number	Quantity	Lead Time
Required Tools:	Part Number	Quantity	Lead Time
	• 3/32" hex wrench • clean cloth • window cleaner fluid		

To clean the inner side of the FRMM window:

1. Power off the FRMM.
2. Unmount the FRMM from the sensor head.
3. Unscrew the four hex screws holding the FRMM window assembly.
4. Unmount the FRMM window assembly.
5. Clean the inner side of the window using a clean cloth and window cleaning fluid.
6. Mount the FRMM window assembly and tighten the four hex screws.
7. Mount the FRMM on to the sensor head.
8. Power up the FRMM.
9. Set the scanner back to scanning.
10. Look at the **FotoForm Display** on the QCS system.
11. Wait until the scanner head has performed a standardization and a minimum of five scans.
12. Verify that the **Clean Soon** or **Clean Now** status changes to **Sensor Window OK**. When the OK status appears, the procedure is complete.

13. If the cleaning status does not change to OK, repeat Steps 1–12. If that still does not help, proceed to Step 14.

14. Look at the illumination correction image on the **FotoForm Engineering** display. Observe where the dirt particles are on the window. If they cannot be cleaned inside, proceed to Subsection 9.1.1.

9.1.3. Replace the FRMM Window Assembly

If there are any cracks in the FRMM window, it must be replaced immediately to prevent any glass fragments getting into paper production, and to properly protect the sensor. Fracturing the window is almost impossible in normal operation, but careless use of tools such as a hammer can cause a fracture.

Severe scratches on the window make replacement important because measurement accuracy might be compromised.

Activity Number:	Q4221-50-ACT-003	**Applicable Models:**	Q4221-50
Type of Procedure:	Replace	**Expertise Level:**	Technician
Priority Level:	Low	**Cautions:**	None
Availability Required:	Scanner offsheet	**Reminder Lead Time:**	
Overdue Grace Period:		**Frequency (time period):**	
Duration (time period):	1 hour	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	Check distance calibration
Required Parts:	Part Number	Quantity	Lead Time
Required Tools:	Part Number	Quantity	Lead Time
	• 3/32" hex wrench		

To replace the FRMM window:

1. Command the scanner to offsheet.

2. Power off the FRMM.

3. Unmount the FRMM from the sensor head.

4. Unscrew the four hex screws holding the FRMM window assembly.

5. Replace the FRMM window assembly with a new one and tighten the four hex screws.
6. Mount the FRMM on to the sensor head.
7. Power on the FRMM.
8. Set the scanner back to scanning.

9.1.4. Replace the FRMM Fuse

The FRMM fuse should not blow during normal operation. After changing the fuse, check whether or not it blows again. If it does, send the FRMM to Honeywell service.

Activity Number:	Q4221-50-ACT-004	**Applicable Models:**	Q4221-50
Type of Procedure:	Replace	**Expertise Level:**	Technician
Priority Level:	Low	**Cautions:**	None
Availability Required:	Scanner offsheet	**Reminder Lead Time:**	
Overdue Grace Period:		**Frequency (time period):**	
Duration (time period):	1 hour	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
Required Parts:	Part Number	Quantity	Lead Time
	51000438: fuse		
Required Tools:	Part Number	Quantity	Lead Time
	• flat screwdriver		

To replace the fuse:

1. Command the scanner to offsheet.
2. Power off the FRMM.
3. Open the fuse holder and replace the fuse.
4. Power on the FRMM.

5. Observe whether or not the FRMM powers up. If not, power the FRMM off, unmount it from the sensor head, and send it to Honeywell service.

6. Set the scanner back to scanning.

9.2. FotoForm Illumination Module

The Formation Sensor is not very sensitive to dirt build-up on the FRIM. Clean the FRIM only when dirt build-up starts to attenuate illumination, and/or when the paper web is very thin. It is advisable to clean the FRIM window at the same time you clean the FRMM window.

9.2.1. Clean the Outer Side of the FRIM Window

Activity Number:	Q4221-50-ACT-005	**Applicable Models:**	Q4221-50
Type of Procedure:	Maintain	**Expertise Level:**	Operator
Priority Level:	Average	**Cautions:**	None
Availability Required:	Scanner offsheet	**Reminder Lead Time:**	
Overdue Grace Period:		**Frequency (time period):**	Once per shift up to 1 week
Duration (time period):	5 minutes	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
Required Parts:	Part Number	Quantity	Lead Time
Required Tools:	Part Number	Quantity	Lead Time
	• clean cloth • window cleaner fluid		

To clean the window:

1. Command the scanner to offsheet.

2. Separate the heads.

3. Clean the FRIM window using a clean cloth and window cleaning fluid.

4. Close the heads.

5. Set the scanner back to scanning.

9.2.2. Replace the FRIM Window Assembly

If there are any cracks in the FRIM window, it must be replaced immediately to prevent any glass fragments getting into paper production, and to properly protect the sensor. Fracturing the window is almost impossible in normal operation, but careless use of tools such as a hammer can cause a fracture.

Normally, scratches on the FRIM window are not important, but measurement accuracy may be compromised if scratches are extremely severe and/or the paper web is very thin.

Activity Number:	Q4221-50-ACT-006	**Applicable Models:**	Q4221-50
Type of Procedure:	Replace	**Expertise Level:**	Technician
Priority Level:	Low	**Cautions:**	None
Availability Required:	Scanner offsheet	**Reminder Lead Time:**	
Overdue Grace Period:		**Frequency (time period):**	
Duration (time period):	1 hour	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	Check distance calibration
Required Parts:	Part Number	Quantity	Lead Time
Required Tools:	Part Number	Quantity	Lead Time
	• 3/32" hex wrench		

To replace the window:

1. Command the scanner to offsheet.

2. Power off the FRIM.

3. Unmount the FRIM from the sensor head.

4. Unscrew the four hex screws holding the FRIM window assembly.

5. Replace the FRIM window assembly with a new one and tighten the four hex screws.

6. Mount the new FRIM on to the sensor head.

7. Power on the FRIM.

8. Set the scanner back to scanning.

9.2.3. Replace the FRIM Fuse

The FRIM fuse should not blow during normal operation. After changing the fuse, check whether or not it blows again. If it does, send the FRIM to Honeywell service.

The FRIM fuse may also blow, over time, if the illuminator current is high all the time and pulses are very wide. Consult Honeywell TAC for a slower replacement fuse and proper configuration parameters if this happens.

Activity Number:	Q4221-50-ACT-007	**Applicable Models:**	Q4221-50
Type of Procedure:	Replace	**Expertise Level:**	Technician
Priority Level:	Low	**Cautions:**	None
Availability Required:	Scanner offsheet	**Reminder Lead Time:**	
Overdue Grace Period:		**Frequency (time period):**	
Duration (time period):	1 hour	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
Required Parts:	Part Number	Quantity	Lead Time
	51000438: fuse		
Required Tools:	Part Number	Quantity	Lead Time
	• flat screwdriver		

To replace the fuse:

1. Command the scanner to offsheet.

2. Power off the FRIM.

3. Open the fuse holder and replace the fuse.

4. Power on the FRIM.

5. Observe whether or not the FRIM powers up. If not, power the FRIM off, unmount it from the sensor head, and send it to Honeywell service.

6. Set the scanner back to scanning.

10. Troubleshooting

This chapter is divided into two sections listing possible issues with the Formation Sensor:

- Section 10.1 Alarm Based Troubleshooting, listing steps to be taken in response to a specific alarm generated in the Experion MX system.
- Section 10.2 Non-alarm Based Troubleshooting, listing steps that may not be related to a specific alarm in the Experion MX system.

10.1. Alarm Based Troubleshooting

Depending on system configuration, your Experion MX system may display only some of these alarms.

10.1.1. FotoForm Link Down

Symptom	Possible Causes	Solutions
Formation Measurement does not communicate with MSS	FRMM fuse blown	Replace the FRMM Fuse

10.2. Non-alarm Based Troubleshooting

10.2.1. FotoForm Clean Soon Indicator

Symptom	Possible Causes	Solutions
Indicator below **FotoForm Display** formation is yellow	FRMM window dirty	Clean the Outer Side of the FRMM Window
		Clean the Inner Side of the FRMM Window

10.2.2. FotoForm Clean Now Indicator

Symptom	Possible Causes	Solutions
Indicator below **FotoForm Display** formation is red	FRMM window dirty	Clean the Outer Side of the FRMM Window
		Clean the Inner Side of the FRMM Window

10.2.3. Formation Image Too Dark

Symptom	Possible Causes	Solutions
Formation image in **FotoForm Display** is too dark to be seen	Wrong line speed to FotoForm	Check line speed (see Subsection 5.2.3.)
	Bad standardize curve	Check standardize curve (see Subsection 5.3.5.8)
	Wrong configuration parameters	Check parameters (see Subsection 5.3.5.1)
	FRMM-to-FRIM link down	Inspect cables, connectors and boards
	FRIM fuse blown	Replace the FRIM Fuse
	FRIM window too dirty, blocks too much light	Clean the Outer Side of the FRIM Window

10.2.4. Formation Image Too Bright

Symptom	Possible Causes	Solutions
Formation image in **FotoForm Display** is too bright (details are washed out)	Wrong line speed to FotoForm	Check line speed (see Subsection 5.2.3)
	Bad standardize curve	Check standardize curve (see Subsection 5.3.5.8)
	Wrong configuration parameters	Check parameters (see Subsection 5.3.5.1)
	FRMM and/or FRIM link down	Inspect cables, connectors and boards

11. Storage, Transportation, and End of Life

This chapter summarizes Honeywell policy regarding storage and disposal of the Formation Sensor.

11.1. Storage and Transportation Environment

In order to maintain integrity of system components, storage and transportation of all equipment must be within the parameters shown in Table 11-1.

Table 11-1 Storage and Transportation Parameters

Duration of Storage	Acceptable Temperature Range	Acceptable Humidity Range
Short term (less than one week)	-20–60 °C (-4–140 °F)	10–90% non-condensing
Long term	-10–50 °C (14–122 °F)	10–90% non-condensing

11.2. Disposal

Honeywell supports the environmentally conscious disposal of its products when they reach end of life or when components are replaced.

All equipment should be reused, recycled, or disposed of in accordance with local environmental requirements or guidelines.

This product may be returned to the Honeywell manufacturing location, and it will be disposed of using environmental friendly methods. Contact the factory for further details and instructions.

Except where identified in this chapter, the Formation Sensor does not contain hazardous or restricted materials.

Guidelines for disposal of equipment by Honeywell or the customer for sensor-specific materials are described in Subsection 11.2.1.

11.2.1. Solid Materials

- remove all non-metallic parts (except plastic) from the Formation Sensor and dispose of them through the local refuse system
- recycle plastic parts
- wires and cables should be removed and recycled (copper may have value as scrap)
- electrical and electronic components should be recycled or handled as special waste to prevent them from being put in a landfill, because there is potential for lead and other metals leaching into the ground and water
- metals should be recycled (in many cases they have value as scrap)

12. Glossary

Bin (or Measurement Bin)	The smallest measurement zone on the frame. Also called bucket or slice.
Bucket	See Bin.
Cable End	Location of the electronics and/or the entry point for communications and power on the scanner.
C-frame	The C-shaped metal support for the sensor head.
Code or Code Name	See Recipe. Alternately, another name for alloy.
Cross Direction (CD)	Used to refer to those properties of a process measurement or control device that are determined by its position along a line that runs across the paper machine. The cross direction is transverse to the machine direction that relates to a position along the length of the paper machine.
Cross Direction Bin	A unit representing an element in a measurement profile at the cross direction bin resolution.
Cross Direction Bin Resolution	A user-defined resolution, usually lower than the scanner resolution, which all measurement profiles are mapped down to after the profiles have been verified and before they are processed further in performance cross direction.
Cross Direction Effect Profile	An *error* profile of a measurement in cross direction bin resolution used for management information system (MIS) reporting. The profile is generated by subtracting the exponential-filtered cross direction bin measurement profile from the cross direction bin target profile. From the cross direction effect profile, a cross direction effect spread is calculated and reported in the MIS as an indication of cross direction control performance on a particular measurement.
Cross Direction Spread	Variation in the profile data equal to twice the standard deviation of the measured variable.
CVS	Compact Vision System by National Instruments
Data Storage and Retrieval (DSR)	A mechanism provided in real-time application environment (RAE) for storing recipe- or grade-dependent data, such as tuning, calibration, and setup values, and retrieving them when a recipe is loaded. The recipe- or grade-dependent data are saved to a database known as the *Recipes* database.
Distant End	The end of the scanner opposite the cable end.
Drive Side (DS)	The side of the paper machine where the main motor drives are located. Cabling is routed from this end. Also called back side.

Error Profile	A profile in cross direction bin resolution that is the difference between the target profile and the current profile of a measurement, both in cross direction bin resolution.
Floc Shape	Relative machine direction/cross direction ratio of floc size. Units: %.
Floc Size	Length scale of formation texture. Large value ⇔ cloudy texture, small value ⇔ grainy texture, measured in both machine direction and cross direction. Units: mm.
Formation	Unevenness of mass distribution of paper
FotoForm	Other name of the Formation Sensor
FRIM	FotoForm Illumination Module
FRMM	FotoForm Measurement Module
High End Calibrate Distance	The distance from a fixed point on the sensor head to the closest vertical member of the scanner when it is located at the high end limit switch. This position is determined during scanner calibration.
High End Calibrate Position	The value of the head position when the sensor head reaches the high end calibration position. This is only updated during a scanner calibration procedure.
HMI/UPI	Human/machine interface. Interface at endbell for controlling sensors and scanner movement.
Look-through	Unevenness of light transmitted through paper. Also called as optical formation.
Low End Calibrate Distance	The value of the head position (in millimeters) when the sensor head reaches the low end calibration position.
Low End Calibrate Position	This position is only updated during a scanner calibration procedure.
Low End Offset	The distance in millimeters from the cable end of the scanner to where bucket zero is located.
Machine Direction (MD)	The direction in which paper travels down the paper machine
Management Information System (MIS)	A mechanism provided in RAE to accumulate and manipulate production data, and to generate reports for mill wide management.
Measurement Sub System (MSS)	CPU responsible for binning data before sending to the QCS server.
Motor End	Location of the motor on the scanner.
Motor End Support	Formed steel channel welded to the upper and lower box beams at the motor end.
Multivariable Controller	The new controller in performance cross direction that performs multivariate control based on some prior knowledge (model) of the process.
MXOpen	Software quality control system. See QCS.
MXProLine	MXProLine™ system is a measurement and control solution designed for flat sheet applications in plastics, rubber, aluminum, and non-woven processes.

Optical formation	See: look-through
Permanents Database	A database provided by RAE to store the last values of certain process parameters such that these values can be restored when the QCS starts up from a previous shutdown.
PHD	Honeywell Uniformance Process History Database (PHD)
Quality Control System (QCS)	A computer system that manages the quality of the product produced.
Real-Time Application Environment (RAE)	The system software used by MXProLine, Da Vinci, and Experion QCS to manage data exchange between applications.
Real-time Data Repository (RTDR)	The database managed by RAE to store system data and data for individual applications.
Recipe	A list of pulp chemicals, additives, and dyes blended together to make a particular grade of paper. Also called codes.
Remote PMP	(MSS) remotely mounted precision measurement processor.
Scan Position	A constant position (in millimeters) measured from the cable end.
Sensor Set	The term used in the **Sensor Maintenance** display to describe a set of sensors working together on a scanner to perform one measurement.
Setpoint (SP)	Target value (desired value). Setpoints are defined process values that can be modified by entering new values through the monitor, loading grade data, and changing a supervisory target.
Slice	See Bin.
Smoothing Width	A value that determines the amount of averaging that will be applied to a measurement bin.
Spot Index	Balance between light and dark spots: Units: dimensionless.
Standardize	An automatic periodic measurement of the primary and auxiliary sensors taken offsheet. The standardize measurements are used to adjust the primary sensors' readings to ensure accuracy.
Streak	A narrow cross-directional section of paper where a measured quality deviates significantly from the average of the entire width of the paper, or an area in an array of cross directional measurements that deviates more than a certain amount from its surroundings. The amount of allowed deviation can be set up as an absolute number or as a percentage.
Target Profile	The desired absolute cross direction profile in cross direction bin resolution a sheet property should be controlled to.
Tending Side (TS)	The side of the paper machine where the operator has unobstructed access. Also called front side.
Trend	The display of data over time.
Variability	Relative variation of light transmitted through paper, most important formation measurement. Units: dimensionless.

A. Part Numbers

Table A-1 lists part numbers and part descriptions for the Formation Sensor.

Table A-1 Part Numbers

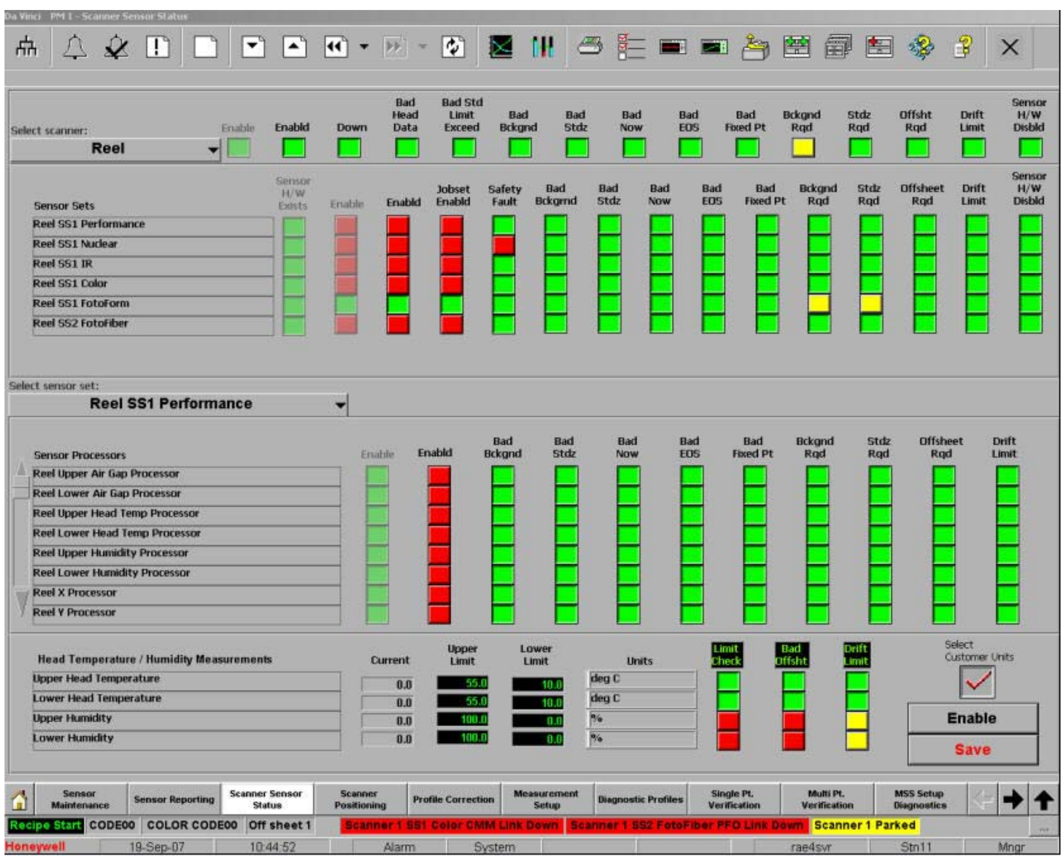
Part	Description	Qty	Spare Part Kit
08762900	Light source assembly, FRIM	1	(X)
08763200	Cable assembly, Signal Gender Changer FotoForm	1	
08763800	Harness assembly, FRMM Power supply	1	
08763900	Harness assembly, FRMM Serial and Trigger Interconnect	1	
08764000	Harness assembly, FRMM Processor IO	1	
08764100	Cable assembly, FRMM Illumination CTRL	1	
08764200	Cable assembly, FRMM Camera Sensor Link	1	
08764300	Harness assembly, FRIM Power supply	1	
08764400	Harness assembly, FRIM Serial and Trigger Interconnect	1	
08764500	Cable assembly, FRIM Illumination Control	1	
08764600	Window assembly, FRIM	1	X
08764700	FotoForm Processor Module W/Firmware	1	
08764800	Window assembly, FRMM	1	X
08764900	Cable assembly, FRMM, FIREWIRE, IEEE1394A	1	
20001068	Converter, RS-232/485, isolated	1	X
20001069	RS232 TO TTL Logic converter	1	X
20001076	Converter, RS-232/422, isolated	1	X
22000185	Controller, LED light	1	
28104079	SCR,4-40 x 1.125 in., CAPSOC,SS	8	X
38002004	Camera, IEEE 1394, CCD, B/W, XGA	1	
38002005	Lens, C-MOUNT FL 12.5	1	
51000438	Fuse, 2 AMP EURO FA 250V IEC SHT 2	2	X
55000432	Optocoupler, 5DC/24DC/100 kHz	1	X
X: to be obtained when the Formation Measurement is purchased. (X): recommended to be obtained when the Formation Measurement is purchased.			

B. Installation Test

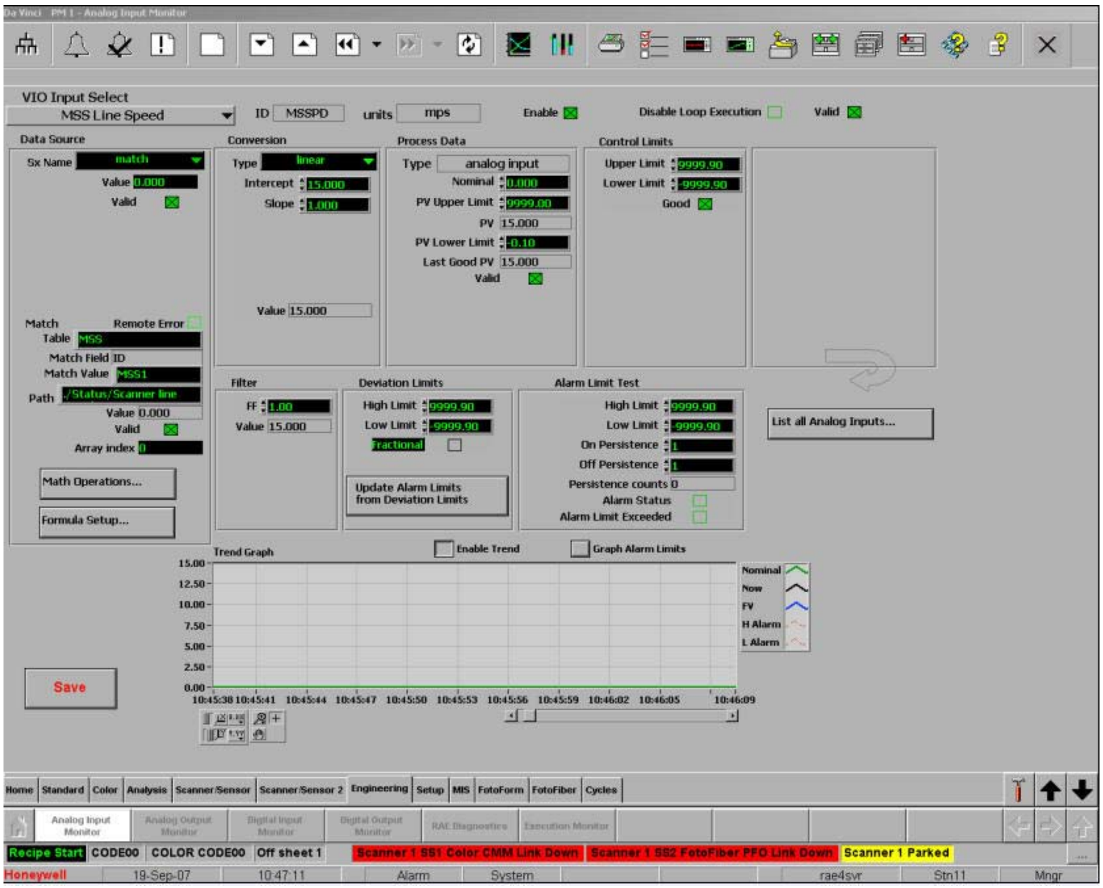
B.1. Confirming Formation Sensor Installation

To confirm Formation Sensor installation:

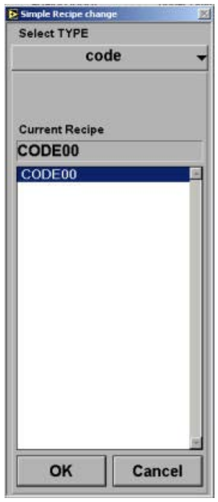
1. Log in to your QCS system as administrator.
2. Access the **Scanner Sensor Status** display, and check that the Formation Sensor is enabled.



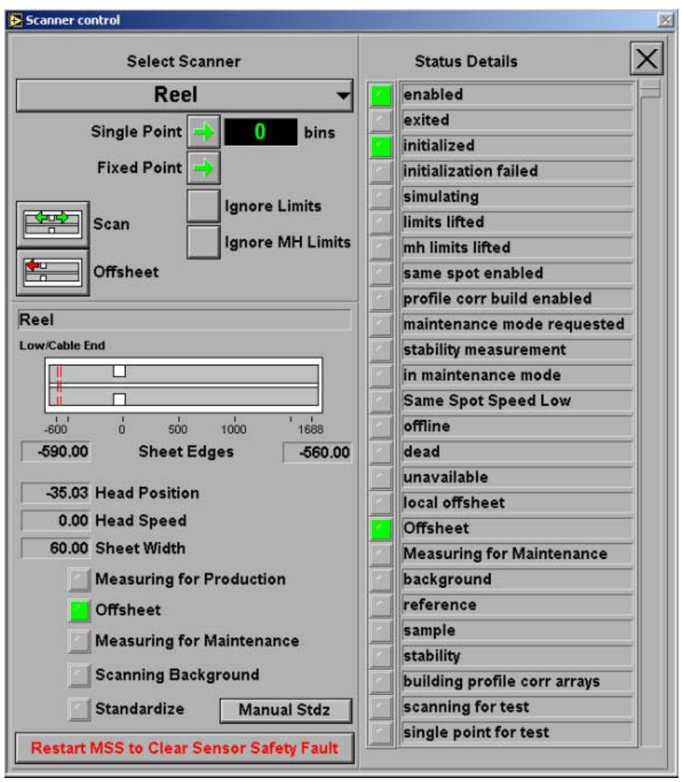
3. Access the **Analog Input Monitor** display, and check that there is speed. If there is no speed, it can be simulated using the **Intercept** field (value 15 means 15 m/s). If you use **ENTER** to save the value, it is not saved to a permanent file but is used as speed for the system. This value must be set to zero when the installation test is done.



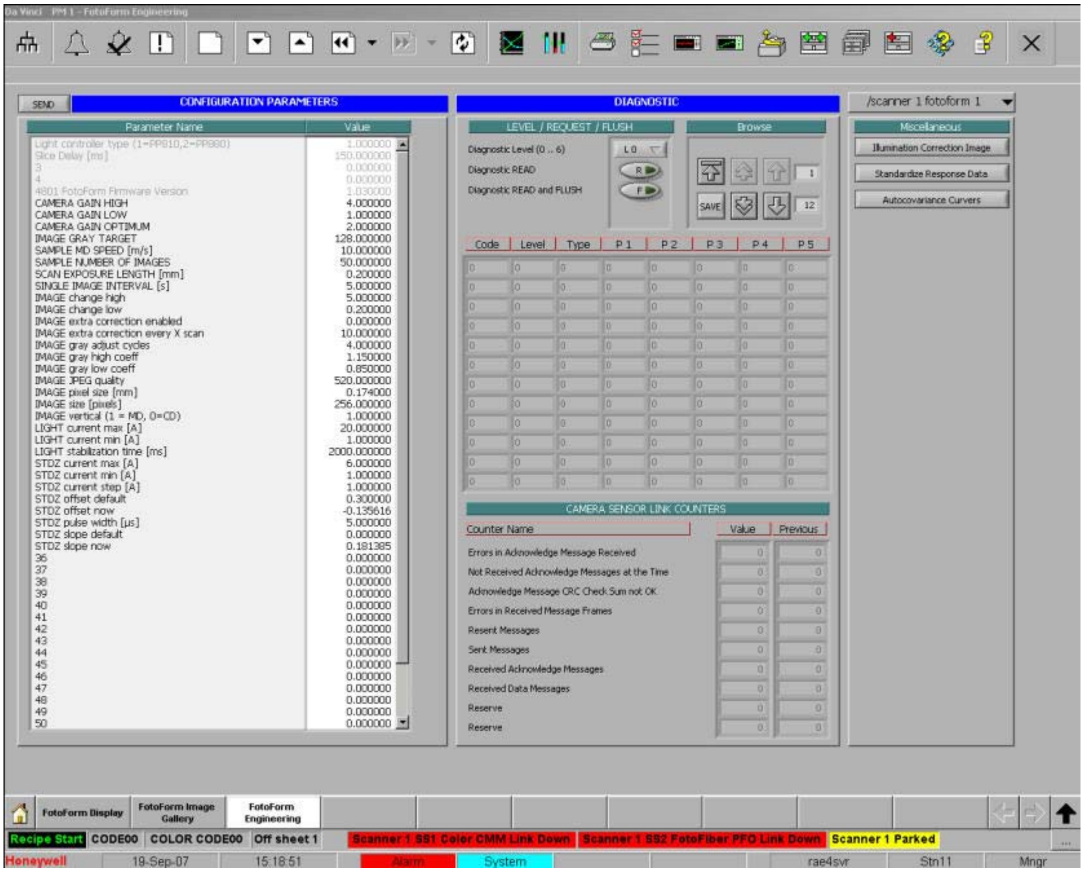
4. Select a recipe from the **Sample Recipe change** pop-up to load correct scanner positioning parameters. If no sheet edge information is available, the fixed edges must be defined.



5. Access the **Scanner control** dialog, select **Manual Stdz**, and check that there is white light flashing from the FRIM to the sensor gap.



6. Access the **FotoForm Engineering** display.



7. Click **Standardize Response Data** to open the **Stdz Response Data** pop-up.

Saturated Pixels must be < 1.0%, and **Max Graylevel** must be between 80 and 220, otherwise standardization must be done again. If the values are not within these limits after a retrial, the parameters used in standardization must be changed.

If **Max Graylevel** is less than 80:

Access the **FotoForm Engineering** display and change the **STDZ current max [A]** to 6 A.

When the parameter is changed, send it to the sensor by clicking **SEND**.

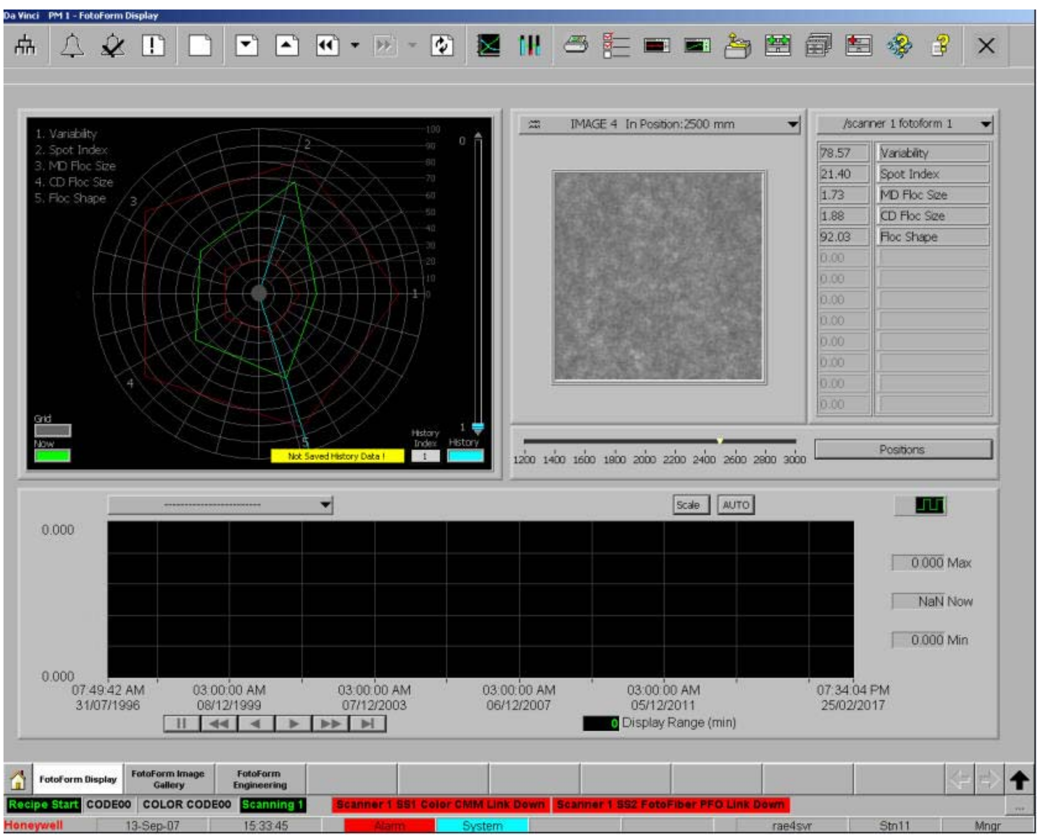
Repeat standardization.

If **Max Graylevel** is still less than 80, you can continue changing the **STDZ current max [A]** up to maximum of 10 A.

If the standardization is OK, but the curve in the **Standardize Response Data** display is not straight, decrease the current and increase **STDZ pulse width [µs]** one step to 4 µs. Repeat standardization and, if not OK, continue so long as the max pulse width is 6 µs. If still not working, consult QCS TAC.

When the standardization is ok, insert a sample to the sensor gap and fix it in place with adhesive tape.

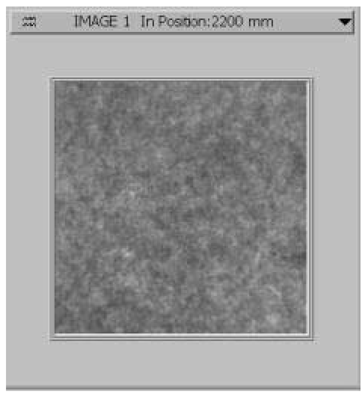
8. Access the **FotoForm** display.



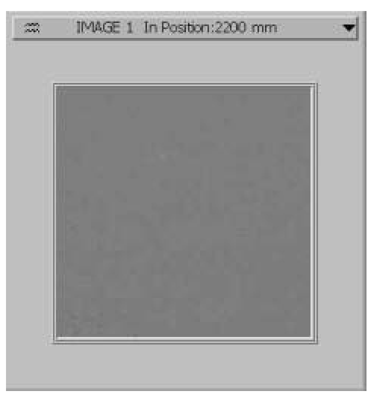
9. Click **Positions** to open the **Image Positions** pop-up.

10. Insert the cross direction positions from where you want to get images. The positions are given as distances from low end offset in millimeters from the smallest value to the highest.

11. Start scanning and look at the on-line formation image display. After the first scan you should see formation of the sample.



12. Wait two or three scans (needs 100 images), and check that the illumination correction image has been generated.



The purpose of illumination correction is to remove any stationary defects from the image. When the sample is fixed (stationary), the formation of the sample is interpreted as defective. When the illumination correction works correctly, the image of the fixed sample should become totally smooth because all of its unevenness has been removed by the algorithm.

B.2. Illumination Image Generation for Sample Measurement

The illumination correction image generated in Section B.1, with a fixed sample, is used for validating the illumination correction function. It cannot be used as a calibration for sample measurement because it includes not only the unevenness of the illumination but also the unevenness of the sample.

To generate a valid illumination correction image for sample measurement you have to scan with the Formation Sensor in one of two ways:

- make an Illumination Correction sample measurement according to Section 5.3.5.7. (preferred method if there is no paper web available)
- scan a paper web (actual running web or a test web spanned across the scanner)

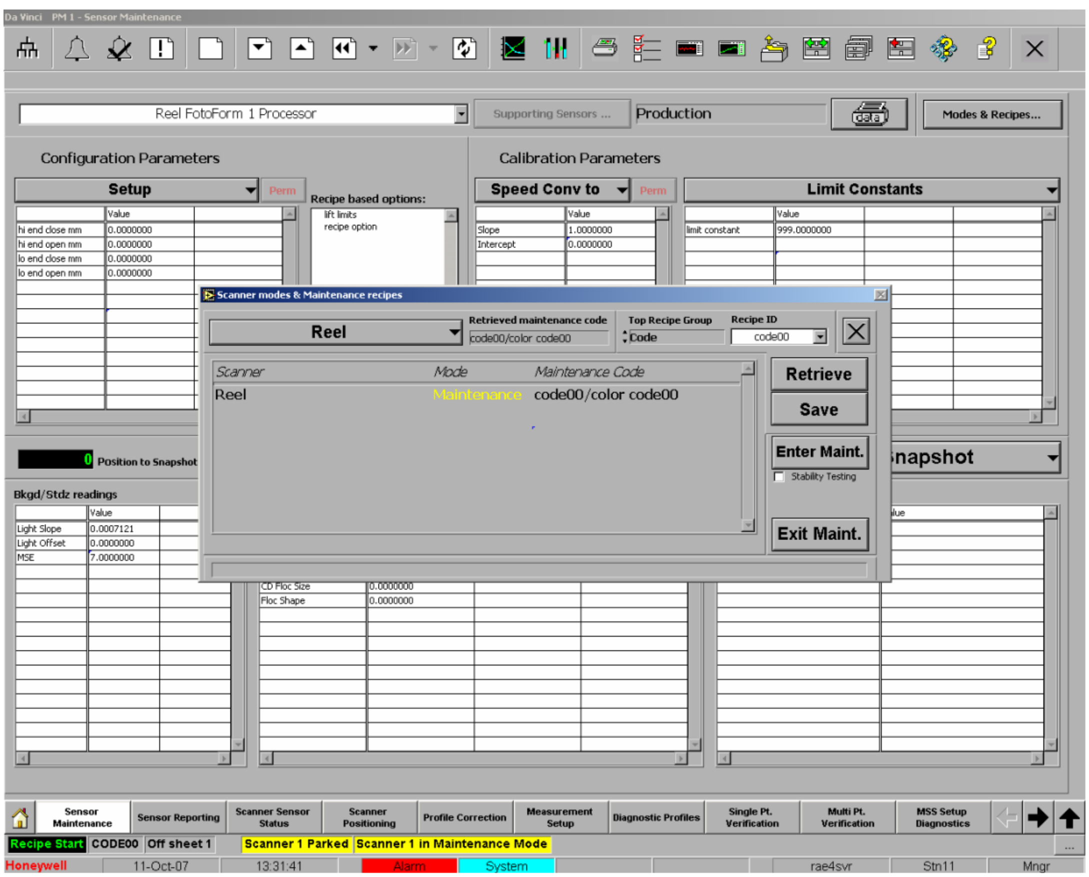
If you choose the second method you have to scan until the illumination correction image has been automatically generated. Typically this takes two to three scans. A sign of the automatic generation is a 1–2 second extra pause of the sensor head at end-of-scan. After generation, check that the illumination correction image has been updated in the **FotoForm Engineering** display.

C. Sample Measurement Procedure

To perform a sample measurement:

1. Access the **FotoForm Engineering** display to ensure that the Formation Sensor has generated an up-to-date illumination correction image. See Section B.2 for details on how to generate illumination correction data if it is missing.

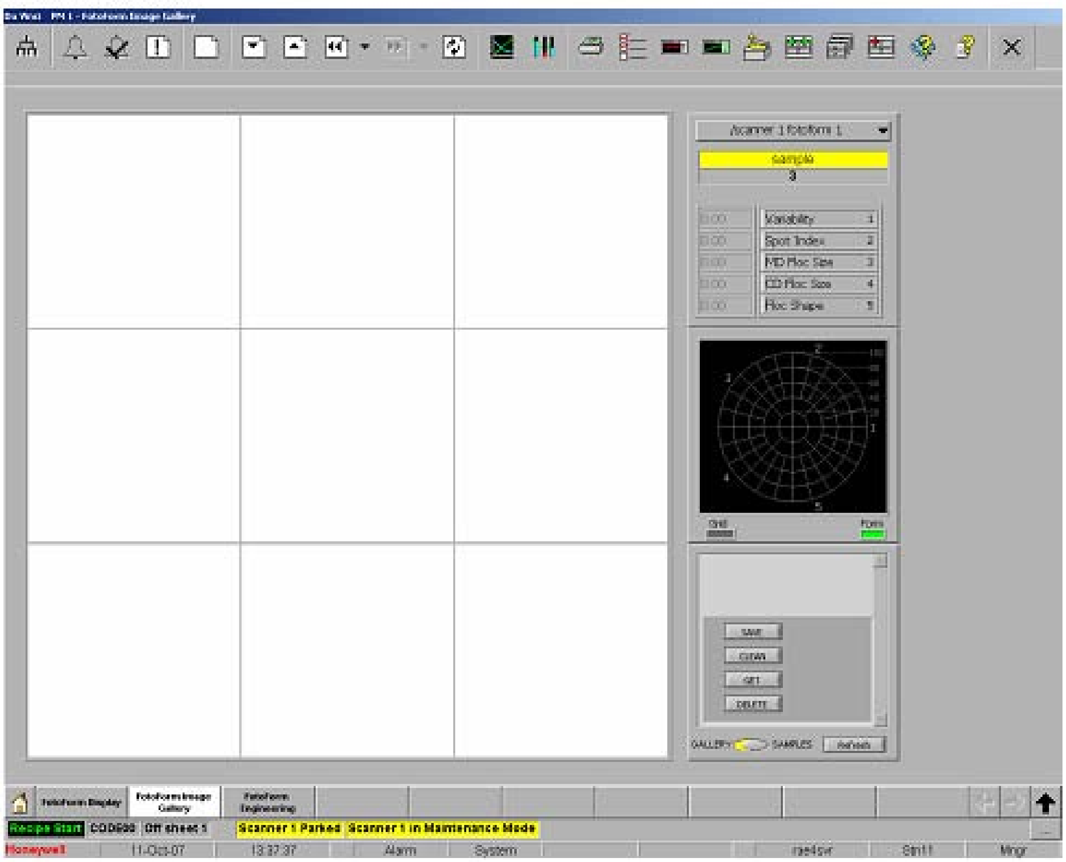
2. Access the **Sensor Maintenance** display and click **Modes & Recipes** to open the **Scanner modes & Maintenance recipes** dialog.



3. Retrieve recipe(s) and enter maintenance mode from the dialog, then close the dialog.

4. Set **Sampl. Integr. Time** to at least 40.00 seconds if configuration parameter IMAGE gray adjust cycles = 5. If its value is larger, increase the sample integration time.

5. Access the **FotoForm Image Gallery** display, select **Sample** mode, then refresh the display. If there are any unsaved samples, save them. You may continue an earlier sample measurement, or make room for new samples by cleaning the gallery (see Subsection 5.3.4 for instructions). Refresh the display after cleaning.



To measure samples:

1. Insert a sample into the sensor head gap so that the sample completely covers the FotoForm window.

2. Press the **Sample** button on the scanner, or click **Sample** on the **Sensor Maintenance** display. The light in the **Sample** button lights up and the sample indicator is shown.

3. Wait until the light in the **Sample** button goes out (and the sample indicator disappears).

4. Remove the sample.

5. You can see data of the latest sample on the **Sensor Maintenance** display, and the accumulating images and data of the whole sample measurement session on the **FotoForm Image Gallery** display when you refresh the display.

6. Repeat Steps 1–4 until all samples are measured. Save the samples and clean the gallery every nine samples (there are nine slots in the image grid). The saved samples can later be loaded-in for analysis.

You can study the sample measurement results in the **FotoForm Image Gallery** display (see Figure C-1), or in the **Sensor Reporting** display (see Figure C-2).

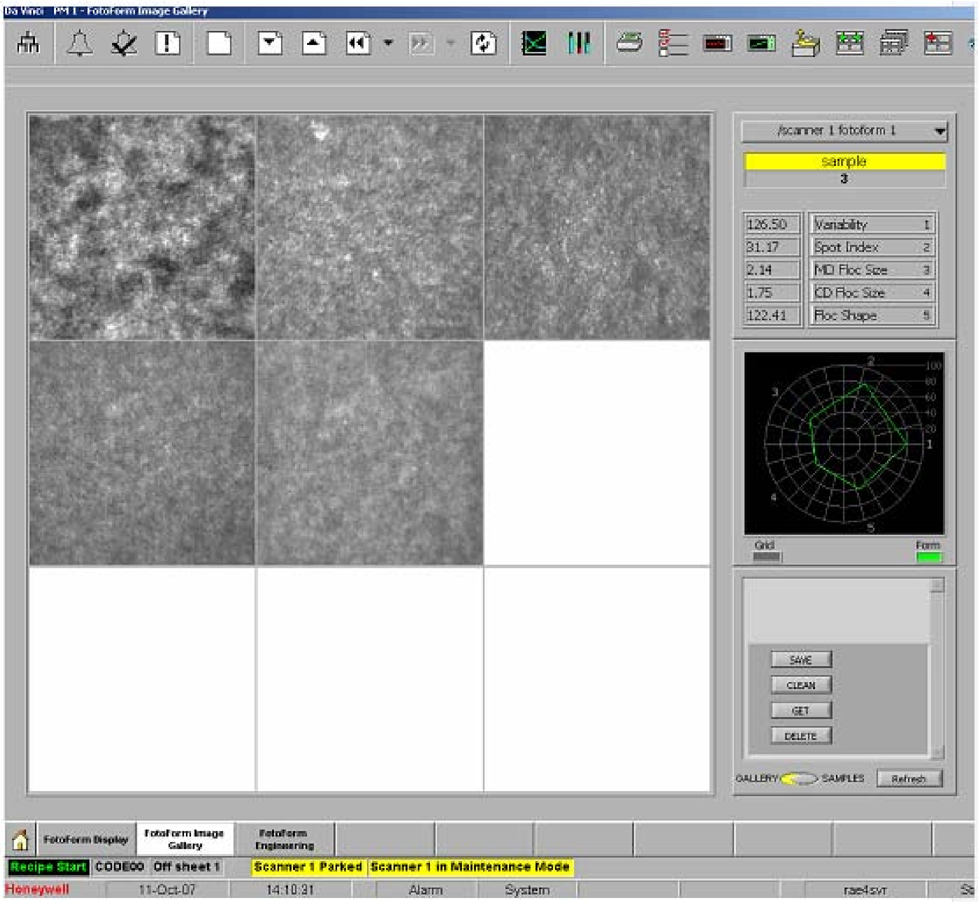


Figure C-1 FotoForm Image Gallery Display

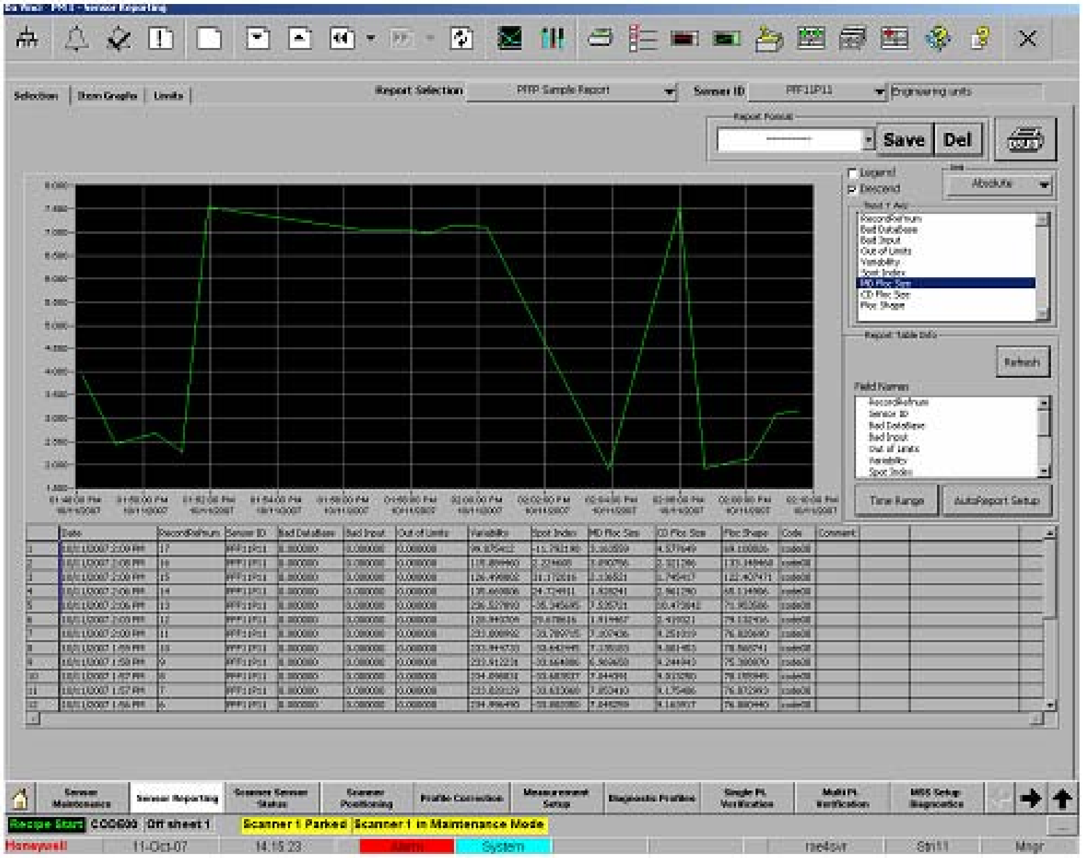


Figure C-2 Sensor Reporting Display