

Q4 Laser-Scanner

Hardware Manual

for Programmers



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Connections for two plug type Scanners

Ethernet connection plug

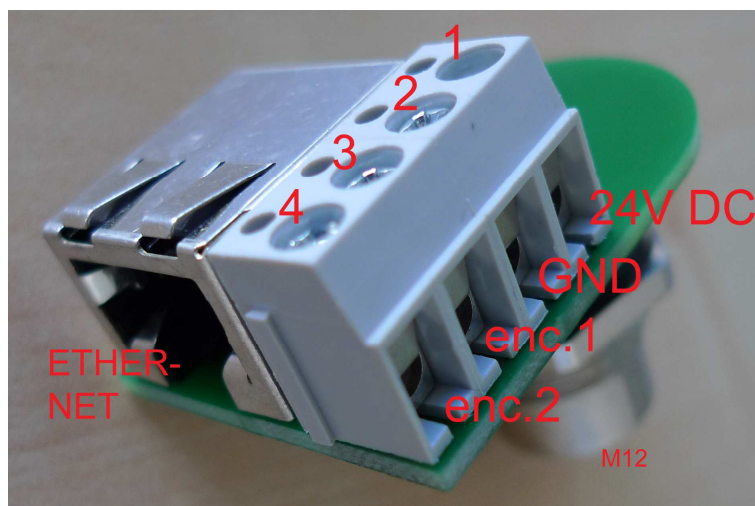
Connection	Pin-No.	Function	Cable colors	Note
M12 round 4-pol D-coded female	1	Tx+	green + white	Sending
	2	Rx+	red + white	Receiving
	3	Tx-	green	Sending -
	4	Rx-	red	Receiving -
	Shield			Connected with housing

Control cable plug (only 6 of 8 wires are used)

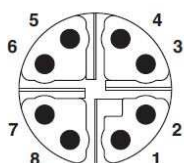
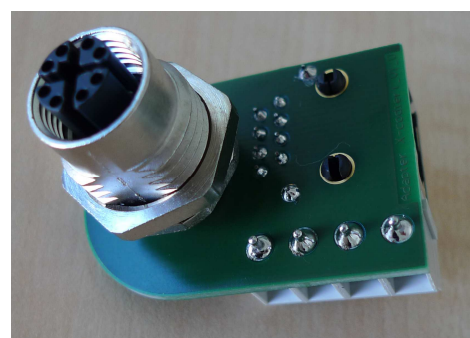
Connection	Pin-No.	Function	Cable colors	Note
M12 round 8-pol A- coded male	1	+12 - 24 V DC	white	Supply voltage, 24 V recommended, exceeding 30 V DC will kill internal fuse
	2	Digital input. 1	brown	encoder-input 1
	3	GND, 0V	green	Gnd,
	4	Digital input. 2	yellow	encoder-input 2
	5	Sync out	Grey	Sync output**
	6	Sync in	orange or pink*	Sync input**
			blue	Not used
			red	Not used
Shield				Connected with housing

* color pink or orange at pin6 depends on cable manufacturer, ** do not apply any external voltage

Connections for single plug type Scanners



Pin Out for Adapter for Scanners with single plugs



Pin assignment of M12 plug, 8-pos., X-coded, pin side view

M12 to M12 cables x-coded Cat 6 can be ordered in various lengths here:

<https://www.phoenixcontact.com/de/products/1408644>

Instructions for Quick Connect

1. Connect the Ethernet cable directly or via switch to a PC.
2. Connect the supply voltage 24V DC according to above scheme. (It is highly recommended to use a high quality power supply with high EMC robustness)
3. The default IP address of the scanner is 192.168.1.245. Port 1096, adjust the PC network settings accordingly.
4. Apply power and you should the diodes blinking.
5. Ping the scanner. If you see a response, ok, if not check the cable connections again, check the IP settings at the PC and the scanner. If necessary reset the scanner IP address by pressing the reset button for 5 sec.
6. Connect your measurement software and retrieve data, as soon as data connection is established, the laser line will come on. If the software stops receiving data, the FIFO will overflow and the laser will go off (safety). As soon as the data connection is established again, laser will go on again. For adjusting the laser you can press the reset button and this Laser-auto-off function will be inactive, the laser will stay on. Be aware that the laser will use the default IP 192.168.1.245 if the reset button is pressed.

General system description

Plug the scanner with a M12-D-coded standard industrial Ethernet connecting plug, as well as an 8-pin M12-A-coded control- and power supply plug.

On the plug surface 2 system indicators are integrated with the following features of function:

Status LED's	Meaning	color	OK when
System ok	Illuminates after self check	red	flashing
LAN act.	Ethernet Link sending data	yellow	flashing

The small recessed black button on the silver side of the scanner is the „reset IP“. If pressed for more than 5 s will provide the scanner with the default IP-address (192.168.1.245) in case the working IP address is not known.

The scanner includes a CCD-sensor, a line laser and the electronics for the consolidation of the cloud of points..

The scanner provides a 2D scan of an object on the measurement range.

The width of the scan will be indicated with an X-value, the depth of the measurement will be indicated with a Z-value. The linearization of the scanner has been carried out in the factory. Profile data are send in metric values. A calibration by the user is not necessary. Therefore every scanner can be exchanged on-site, without any extensive new calibration necessary.

The profile will be composed of 290 profile points. An Ethernet interface will be used for the transmission of the profile data. For a normal operation of the scanner it is not necessary to send initialization data to the scanner. The evaluation electronics in the head of the scanner will carry out all settings automatically, in order to provide always the optimal profile.

The values in this description that are represented in hexadecimal format, will be represented in C++ format. Therefore 0x23 will be the hexadecimal value 23.

Heat Dissipation

The Scanner has a power consumption of 4 W. It should be operated mounted on a heat dissipating metal mount, Recommended materials are aluminum or steel.

The Scanner will switch of the laser output automatically above an internal temperature of 50°C to protect it from damage.

Idle Mode

The Scanner will shut the laser off as soon as there is no data transfer. As soon as the data transfer will pick up again from the PC Program, the laser will switch in again. For adjustment if no data transfer is made but the laser line will be needed to adjust the Scanner position you can press the reset button and the laser will go on. This feature was implemented to enhance the laser diode lifespan and enhance safety.

Maintenance

The Scanner has no moving parts inside, so the maintenance will be needed only outside. Especially the Scanner windows should be free of any dust, oil and other substances. Keep the scanner away from any airstream of pneumatically operated actuators, this air usually contains oil which will reside on the glass.

The windows can be cleaned with soft optical tissue and isopropanol. Do not use paper tissues, as they will eventually scratch the optical glass.

Recommendation for Programmers

It is strongly recommended to program a separate thread for the data retrieval with the scanner. Otherwise it can happen that the program is busy with other tasks and will not load the data form the IP Stack. This might lead to stack overflow. In this case the connection to the scanner has to be reset. .

Caution: All Registers which are not described here are either unused or for internal use only. It is strongly recommended not to alter any data in those undocumented registers

Data Formats of Sensor

Scanner data

Transmitted will be 2048 Bytes per Scan.

The composition of the packet is described in the following table.

Address	Bytes	Description		Factory setting
0..5	[6]	MAC address		
60	[1]	Id Byte	0x03 if Scanner data	
62	[1]	Image number		
66..1515	[1450]	Profile data	290 points with 5 Byte ea. = 1450 Byte	
1525..1528	[4]	Encoder data		

Info-Data (Info Telegram)

The Info-Data can be received by sending the command 0x21 to the scanner.

The packet described below will be received with 2048 Bytes.

In the field Status information 1 on address 60 will be the value 0x10, in order to identify the Info-Telegram.

It is not recommended to inquire the Info data continuously during continuous measurements, because it can slow down the scan rate.

Address	Bytes	Description		Factory setting
0..5	[6]	MAC address	Last 3 digits = serial No	00:08:DC:xx:xx:xx
60	[1]	Id Byte	0x10 if info telegram, if scan = 0x00	
66	[1]	Temperature		
70..74	[5]	Operating hours		
75..77	[3]	Switch-on cycles		
78	[1]	Inputs	Input 1+2 on Bit 0 and 1	
79	[1]	Output of exposure time	Bit 2..9 of Laserregulation	
102..104	[4]	Serial No		
106..107	[2]	Z Start range		in 0,1 mm steps
108..109	[2]	Z measurement range		in 0,1 mm steps
110..111	[2]	X Scan range start	At the beginning of the measurement range	in 0,1 mm steps
112..113	[2]	X Scan range end	At the end of the measurement range	in 0,1 mm steps
130..144	[14]	Version Firmware	ASCII String	Example: 5a00.666.X.831
145..176	[32]	Functionregister	readback of functionregister	Byte 0 bis 31

Data formats

Profile data

For every profile, 290 points will be send. Every point in the profile will be defined through an X- and a Z-value. The I-value refers to the intensity of a point and can be used to define points as valid or invalid.

The scanner provides default like linearized profile data.

Calculate a linearized point from the X- and Z-value as follows:

$$X = \frac{X\text{-value}[13..0]}{X\text{-max}} * X \text{ Scan range end} * 0.1 \quad [\text{mm}], X\text{-max} = 4096$$

$$Z = \frac{Z\text{-value}[13..0]}{Z\text{-max}} * Z \text{ Measurement range} * 0.1 \quad [\text{mm}], Z\text{-max} = 4096$$

The values X-max, Z-max, X Scan range end, Z Measurement range and Data resolution can be received with the Info-Telegram.

Byte Number	Bit No.	
Profile Reg.1	6..0	X-value Bit 6..0
Profile Reg.2	6..0	X-value Bit 13..7
Profile Reg.3	6..0	Z-value Bit 6..0

Profile Reg.4	6..0	Z-value Bit 13..7
Profile Reg.5	7..0	I-value Bit 7..0 value range = 0x01(dark) to 0xFE(light)

Encoder data for position

The encoder data for position are only available when an incremental encoder is connected to the inputs 1+2. The position value is registered at the end of a scan, in order to receive for every profile the corresponding encoder data for position.

Values are in binary complement.

Encoder inputs:

Protocol Incremental Signal A+B 90° Phase shifted (HTL recommended)
 Input level Low = 0 ... 2 V High = 5 ... 30 V

Register	Bit No.	
Position encoder Reg.1	6..0	encoder Bit 6..0
Position encoder Reg.2	6..0	encoder Bit 13..7
Position encoder Reg.3	6..0	encoder Bit 20..14
Position encoder Reg.4	5..0 6	encoder Bit 26..21 Direction of movement

Sensor temperature

A temperature probe is a built-in part of the sensor. The temperature will be measured one time per second.

Register	Bit No.	Temperature	Value	
Temperature Reg.1	6..0	+126 C°	0x7E	In steps of 1 degree from -55 ... +126 C°
		+ 85 C°	0x55	
		+ 25 C°	0x19	
		+ 0 C°	0x00	
		- 1 C°	0x01	
	7	- 25 C°	0x19	if Bit 7 set, then temperature = +

Operating hours counter

The counter increases every 250 msec.

For the result in seconds, the operating hours counter [31..0] has to be divided into four.

Register	Bit No.	
Reg.1	6..0	operating hours Bit 6..0
Reg.2	6..0	operating hours Bit 13..7
Reg.3	6..0	operating hours Bit 30..14
Reg.4	6..0	operating hours Bit 27..21
Reg.5	6..0	operating hours Bit 31..28

Switch-on cycles counter

Every time the sensor is turned on, the value will increase to 1.

Register	Bit No.	Signification
Reg.1	6..0	No of Switch-on cycles Bit 6..0
Reg.2	6..0	No of Switch-on cycles Bit 13..7
Reg.3	2..0	No of Switch-on cycles Bit 16..14

Z and X values Info-Telegram address 106 to 113

Every one of the 4 values consists of a double register.

Register	Bit No.	
Reg.1	6..0	value Bit 6..0
Reg.2	6..0	value Bit 13..7

Scanner control

Data format for Register-addresses and Data

For the normal operation it is not necessary to write the registers. An initialization of the scanner is not necessary. The control commands are composed as follows:

	Bit No.		value = 0	value = 1
control command	6..0	Data		
	7	Identified	Data are address	Data are register value

In order to be able to write the register value, first the register address will be send, followed by the value.

The register address that was set, will be maintained until a new register address is send.

In cases of double registers, the value will be acknowledged only after writing to the highest significant register

In cases of control registers in which the column "Bit No." is marked with "***", it is sufficient to write the register address in order to perform the function.

Register of functions (write)

#Add Address offset to Address 145 (see page 5, Function register 145..176)

Address offset#	Bytes	Bit No.	Description		Default	
0..1	[2]	6..0	Exposure control	Manual exposure control		0
4	[1]	6..0	Limiting the field of view	min Z		0
5	[1]	6..0	Limiting the field of view	max Z	No of pixel vertically/8	
6..7	[2]	6..0	Gain manual setting	Gain setting for image amplifier		400
11	[1]	0	AGC (Auto Gain Control)	0 = off (recommended)	1 = on	0
12	[1]	0	Laser on/off	0 = off	1 = on	1
14	[1]		Reset encoder	encoder data for position will be set to "0"		X
15	[1]	0	Sync mode*	0 = simultaneous	1 = alternating	0
18	[1]	0	Scan rate	0 = 195 Hz	1 = 350 Hz	0
19	[1]	0				0
21	[1]	0	Exposure control	0 = Automatic	1 = Manual	0
25	[1]	6	Encoder Filter **	Default: Value = 1 = Filter on, fmax = 400kHz	Value = 0 = Filter off	1
25	[1]	2..0	Encoder Divider**	Default: Value = 0 Divider factors 0 = /1 1 = /2 2 = /4 3 = /8 4 = /16 5 = /32		0
28	[1]	***	Reset FIFO	Erases all data in the internal FIFO		X
30	[1]	***	Reset Sensor	All register values on Default value		X
33	[1]	***	Request Info-Data			X

X = any value, set 0 or 1 will reset this register

*only single plug scanner: due to single plug this model needs a special instruction after power to the be able to use the inputs 3+4 as sync inputs instead of encoder inputs. Default setting is encoder input for pins 3+4 (see page 3 for pinout). To use pins 3+4 for sync, send:

{0x13, 0x81}; // to Register 19 enable synchronous measuring with slave scanner

{0x0F, 0x81}; // to Register 15 enable asynchronous measuring with slave scanner

Encoder Filter + Divider

**If the Register 25 is set, the Encoder Counter value is set to 0

Register	Bit No.		
25 (Encoder Filter + Divider)	2..0	Divider factor	0 = /1 1 = /2 2 = /4 3 = /8 4 = /16 5 = /32
	6	Filter	Value = 0 = off Default: Value = 1 = on Fmax 400kHz

Description of the control commands

Exposure control

This register is for the sensors manual control of exposure (=Laser on time).

It has only an effect when register exposure control mode is on 1 = switched on manual.

Register	Bit No.		
Reg.1	6..0	value Bit 6..0	0x000 = maximum exposure time and brightness.
Reg.2	2..0	value Bit 9..7	0x3FF = minimum exposure time and brightness.

Calculation of the exposure time

The sensor works with 200 half images per second.

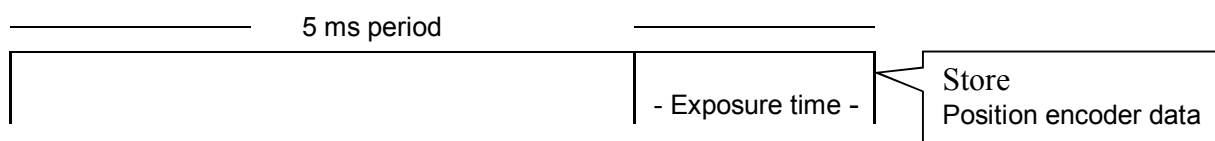
This are 5 ms period terms.

The maximum exposure time is 1ms

The exposure time can be keyed in 1024 steps.

Based on this, the minimum exposure time can be calculated = maximum exposure time/1024=1 μs

In order to identify from which position on the exposure was carried out, it is required that a position encoder is plugged to the scanner. The position will be saved at the end of an image.



Limiting the field of view

The registers limiting the field of view Z define the area in which the sensor is being read out. A profile cannot be generated outside of a defined window.

With this function it is possible to put a shield in front of the sensor, in order to limit the Z-measurement range at front and back.

Amplification

The amplification of the sensor signal can be influenced. In cases of very dark and reflecting surfaces, the value can be increased here. (default value 500)

Register	Bit No.		
Reg.1	6..0	value Bit 6..0	0x000 = minimum amplification.
Reg.2	2..0	value Bit 9..7	0x3FF = maximum amplification.

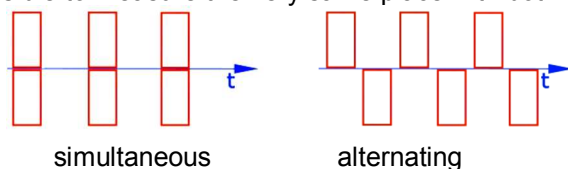
AGC (Automatic Gain Control)

This function should be only activated if the Laser profile looks on a highly reflective target and a highly absorbing or transparent material simultaneously. When this function is activated, the scanner controls the amplification of the sensor signal automatically. This has the effect of very good results in cases of very different brightness distribution in surfaces. On normal surfaces this feature should remain in the default position, i.e. off.

Synchronization Mode

This mode is to set up how two scanners should work together when connected with the help of synchronal inputs and Outputs.

The function „alternative“ is for the performance of two scanners that do not see each other. This way it is possible to measure the very same place with both scanners, having as result a doubling of the measuring rate.



Set up this function by connecting the Sync-Out Output of scanner 1 with the Sync-In input of scanner 2. The GND Pins of both scanners have to be connected with each other. The external Trigger function is not available, when the scanners are being synchronized.

The Program which is controlling the scanners has to send 1 to Register 15 (see above) to set the scanners into asynchronous mode

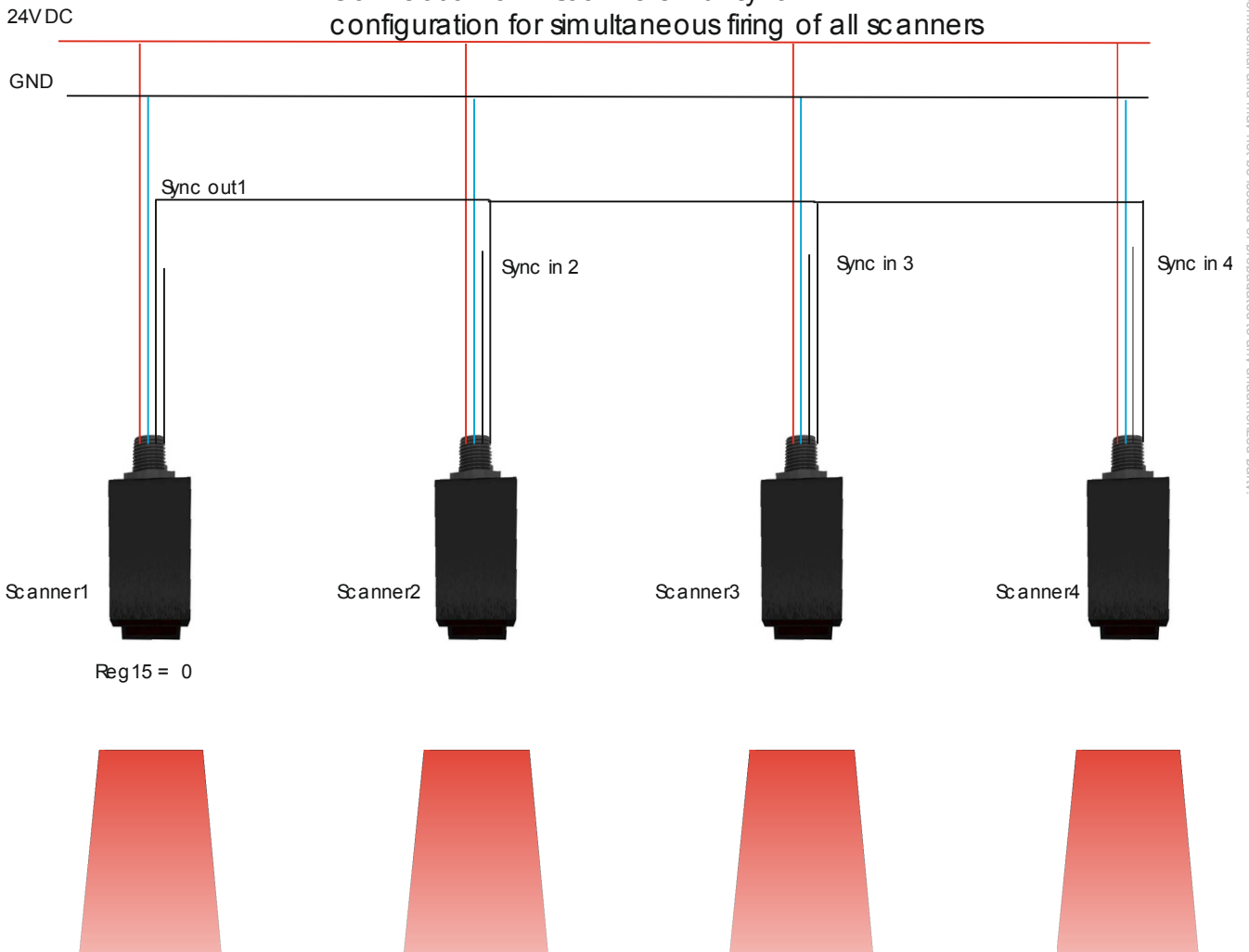
These are these sequences in Hex

- 0x0F to adress Register 15
- 0x81 to set Register to "1"

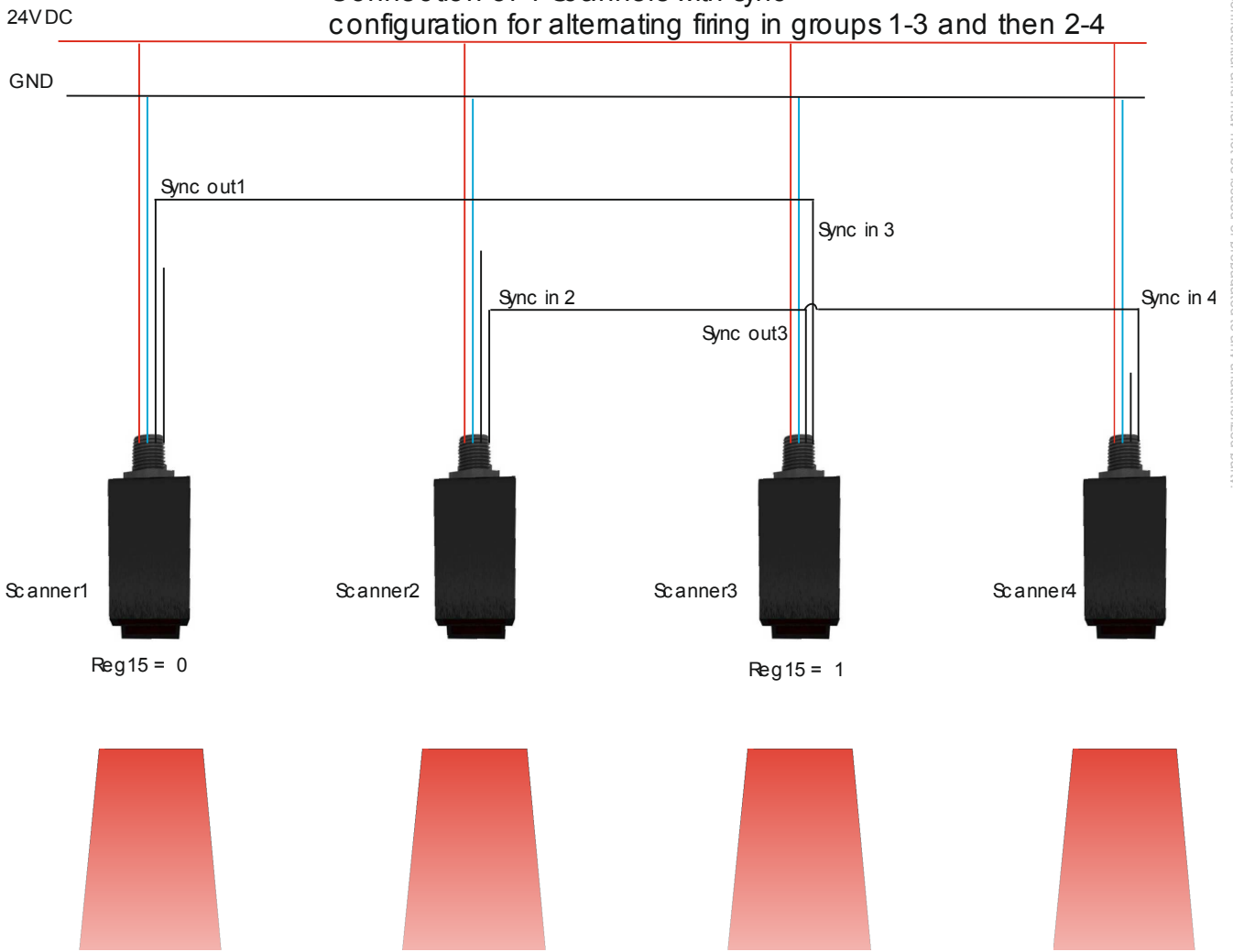
15	[1]	0	Sync	0 = simultaneously	1 = alternately	0
----	-----	---	------	--------------------	-----------------	---

The scanners will not remember the settings, after power up they will come on with the default setting which is simultaneous synchronization, so after each power up the program has to set the scanners to asychrone mode if required.

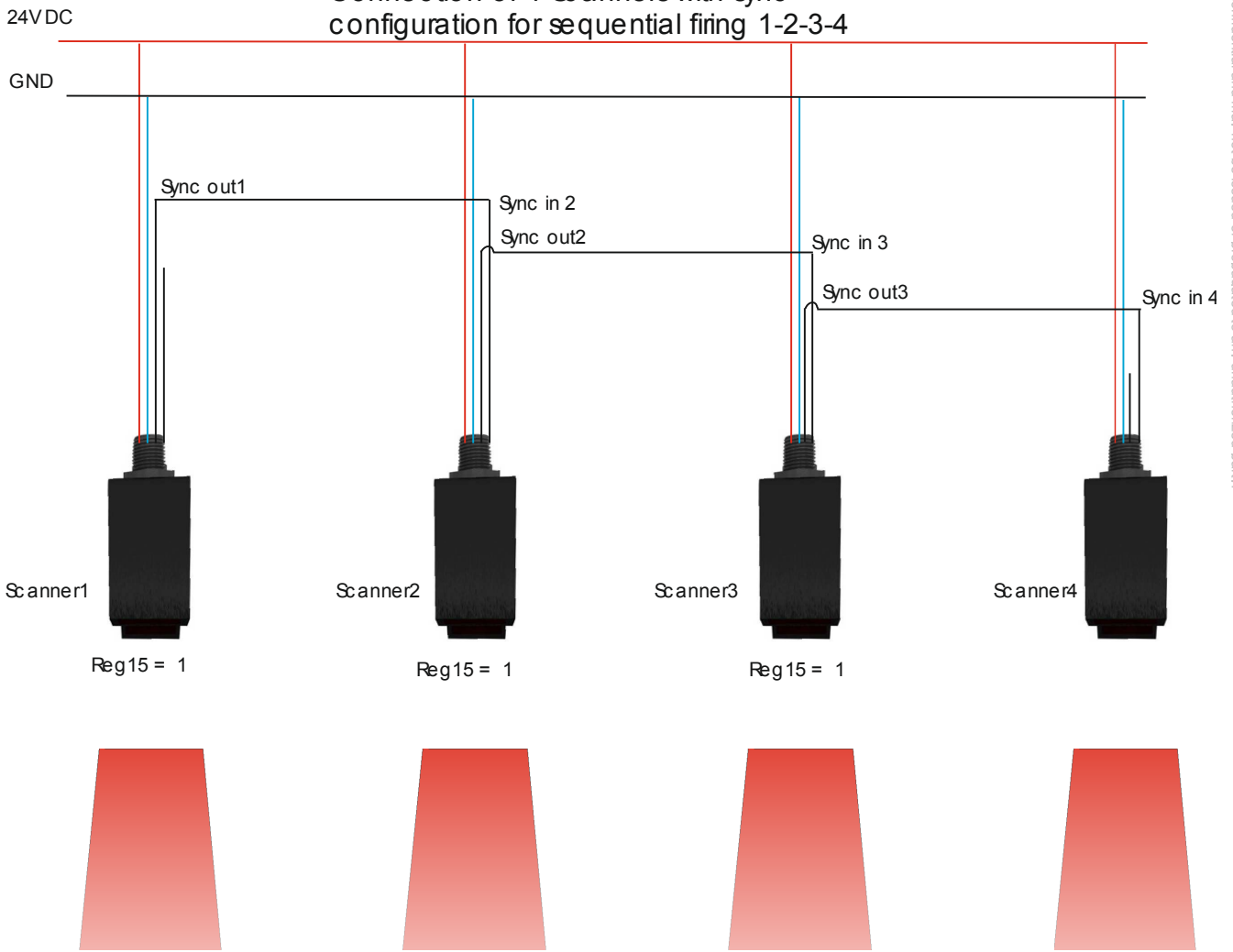
Connection of 4 Scanners with sync configuration for simultaneous firing of all scanners



Connection of 4 Scanners with sync configuration for alternating firing in groups 1-3 and then 2-4



Connection of 4 Scanners with sync configuration for sequential firing 1-2-3-4



Technical Specifications

Ethernet Interface:

Default IP-address	192.168.1.245
Default Port	1096
Default Subnet mask	255.255.255.0
Transmission rate	10/100 Mbit
Protocol	TCP/IP-Protocol
Auto MDIX	yes
DHCP	no

Encoder inputs:

Protocol	Incremental Signal A+B 90° Phase shifted, max 0,4 MHz input.
Input level	Low = 0 ... 2 V High = 5 ... 30 V

Other:

Temperature probe	Value range -55°C to +126°C in 1 grade steps
Operating hours counter	counting interval = 250 ms
Switch-on counter	Every time the sensor is turned on, the value will increase to 1.
Power	24V DC, 4W

Description of Web-Interface

Address the scanner by using the integrated Web-Interface with the help of a web-browser. Input the Scanners IP address into the web-browsers address field.

The parameters as well as the scan profile will be indicated.

A scan profile update will not be performed automatically. A scan profile update will only be indicated new after having updated the website.

Additionally, the access with the web-browser allows the possibility to set up directly the working IP-address, the Port and the Subnet mask.


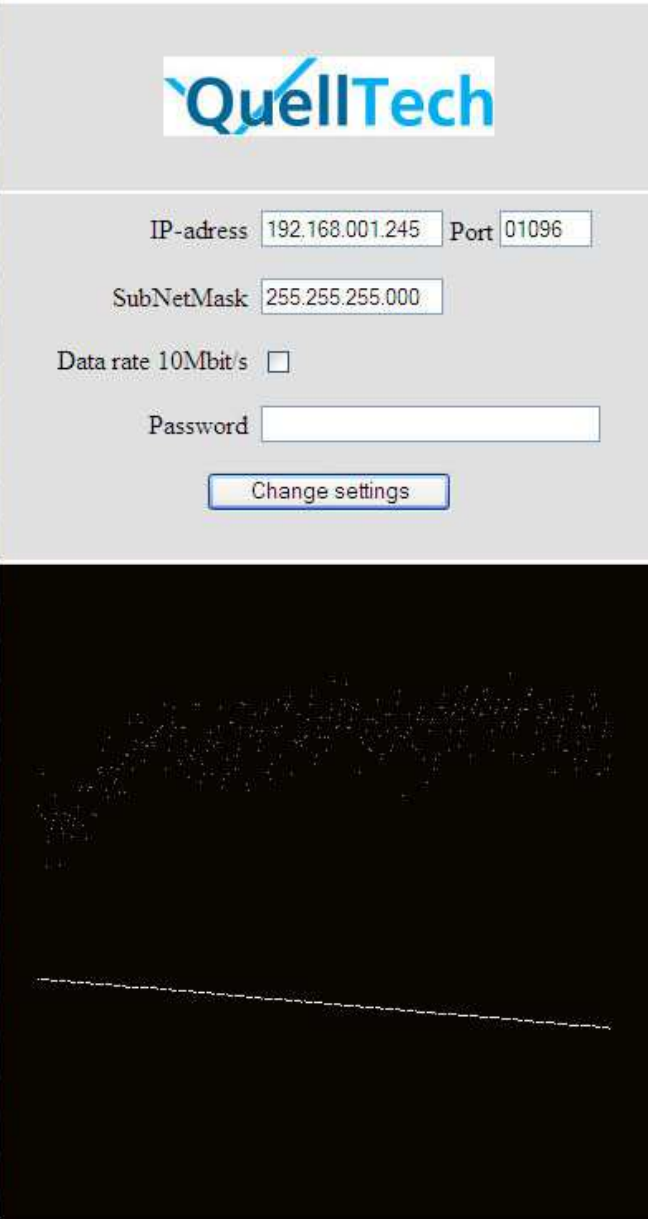
Changing the IP-address

In order to be able to change the IP-address, include the new data into the entry mask.

The password is: **q4**

After having sent the data with „Change IP-address“, the scanner will provide a report with a new screen page on which the new data are being confirmed. Do not forget to set your PCs address accordingly.

Version info	
Firmware	5a00.666.X.831
Serial number	0414380
MAC	00:08:DC:06:52:AC
Default settings	
IP-address	192.168.001.245
Port	01096
SubNetMask	255.255.255.000
Working settings	
IP-address	192.168.001.245
Port	01096
SubNetMask	255.255.255.000
Scanner connected to	000.000.000.000
Data rate	100Mbit/s
Scanner parameter	
Power on hours count	622 hour 11 min 46 sec
Laser on time > 35°C	15 hour 10 min 24 sec
Power cycles count	563
Sensor head temp	+ 34°C
Encoder	+ 0
Standoff	220 mm
Range z	240 mm
Range x beginn	120 mm
Range x end	160 mm

Laser Safety

Laser Safety Disclaimer

A condition of a QuellTech product use is the acceptance of the following statement:

It is a condition of use that the customer/user accepts complete responsibility for all and every aspect of Laser Safety associated with the use of QuellTech Scanners supplied and/or suggested by QuellTech and/or its distributors, consultants and associates.

It is YOUR PERSONAL RESPONSIBILITY to address laser safety in conjunction with the person or people responsible for laser safety within your organization.

IMPORTANT:

- The customer is deemed responsible for implementing all appropriate laser safety precautions for the reflected and transmitted beams.
- All higher laser powers > Laser Class 2M must be dealt with by using laser protection glasses when inside the reach of the laser beam.

Useful starting points may be:

- The laser classification label on your laser scanner
- **ANSI Z136**
- **IEC 60825**
- http://en.wikipedia.org/wiki/Laser_safety

Class 2M

A Class 2M laser is safe because of the blink reflex if not viewed through optical instruments. As with class 1M, this applies to laser beams with a large diameter or large divergence, for which the amount of light passing through the pupil cannot exceed the limits for class 2.

**LASER RADIATION
DO NOT STARE INTO BEAM OR VIEW
DIRECTLY WITH OPTICAL INSTRUMENTS
CLASS 2M LASER PRODUCT**

Class 3R

A Class 3R laser is considered safe if handled carefully, with restricted beam viewing. With a class 3R laser, the MPE can be exceeded, but with a low risk of injury. Visible continuous lasers in Class 3R are limited to 5 mW. For other wavelengths and for pulsed lasers, other limits apply.

**LASER RADIATION
AVOID DIRECT EYE EXPOSURE
CLASS 3R LASER PRODUCT**

Class 3B

A Class 3B laser is hazardous if the eye is exposed directly, but diffuse reflections such as those from paper or other matte surfaces are not harmful. The AEL for continuous lasers in the wavelength range from 315 nm to far infrared is 0.5 W. For pulsed lasers between 400 and 700 nm, the limit is 30 mJ. Other limits apply to other wavelengths and to ultrashort pulsed lasers. Protective eyewear is typically required where direct viewing of a class3B laser beam may occur.

**LASER RADIATION
AVOID EXPOSURE TO BEAM
CLASS 3B LASER PRODUCT**

Example for Laser Class 3 B area with Laser Scanner Q4-1000 (other Scanner models on demand):

