

EtherCAT®

CANopen®

Instruction Manual

Kuhnke FIO

EtherCAT I/O Module in IP20

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Modifications

Modification history

Version	Description / comments / modifications
19/07/2016	Original version
07/09/2016	New Download link (4.1 Download)
11/10/2017	Some names have been adapted (Ventura-> Kuhnke, Skaleo-> FIO Controller)
28/01/2020	Design change

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1 Preface

1.1 Imprint

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1.2 About this Manual

This technical information is primarily directed to system designers, project engineers and device developers. It does not contain any availability information. We reserve the rights for errors, omissions and modifications. Pictures are similar.

Limitation of Liability

Specifications are for description only and are not to be understood as guaranteed product properties in a legal sense. Exact properties and characteristics shall be agreed in the specific contract. Claims for damages against us - on whatever grounds - are excluded, except in instances of deliberate intent or gross negligence on our part.

Terms of Delivery

The general conditions of sales and service of Kendrion Kuhnke Automation GmbH shall apply.

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Warranty

Warranty is subject to the provisions of the conditions of sale of Kendrion Kuhnke Automation GmbH or any contractual agreements between the parties.

2 Reliability, Safety

2.1 Intended Use

For reasons of personal safety and to avoid material damages when working with or handling this Kuhnke product, you are advised to take heed of the notes and information contained in this instruction manual.

2.2 Target Group of the Instruction Manual

This instruction manual contains all information necessary for the use of the described product (control device, control terminal, software, etc.) according to instructions. It is written for qualified design, project planning, servicing and commissioning experts. For proper understanding and error-free application of technical descriptions, instructions for use and particularly of notes of danger and warning, extensive knowledge of automation technology is compulsory.

2.3 Intended Use

Kuhnke's products are designed, developed and manufactured for standard industrial use. They must not be used for any other purposes than the ones specified in the catalogue or the associated technical documentation. Proper and safe operation depends on the products being transported, stored, lined up, mounted, installed, put into service, operated, and serviced correctly. Ambient conditions must be within the admissible limits. Notes and information in the associated documentation apply at all times.

2.4 Transport and Storage

At times of transport and storage, protect Kuhnke FIO Module against inadmissible exposure such as mechanical stress, temperature, humidity and/or aggressive atmospheres. Transport and store Kuhnke FIO Modules only in its original packaging if possible.

Verify that the contacts are neither soiled nor damaged when consigning the unit to stock or re-packaging it. Keep and transport Kuhnke FIO Modules in a container/packaging ensuring electrostatic discharge (ESD) compliance. Some parts of the units are sensitive to ESD and may be damaged if handled inappropriately. Thus, best transport practice is to place open assemblies in statically shielded transport bags with a metal coating which avoid contamination by amines, amides or silicone. When putting Kuhnke FIO Modules into service and performing any maintenance, you should also take the appropriate precautions against electrostatic discharge.



CAUTION

Electrostatic discharge

Destruction of or damage to the unit.

- ⇒ Transport and store FIO Safety I/O in its original packaging.
- ⇒ Ensure that the ambient conditions are as specified at all times during transport and storage.
- ⇒ Handle FIO Safety I/O in a well-earthed environment (persons, place of work, packaging).
- ⇒ Do not touch electrically conductive parts such as data contacts. Some of the electronic components may be destroyed if exposed to electrostatic discharge.



DANGER

Only use devices that are in perfect condition, ie that they do not show any transport damage, fluid effects or other damage

2.5 Reliability

Reliability of Kuhnke products is brought to the highest possible standards by extensive and cost-effective means in their design and manufacture.

These include:

- selecting high-quality components,
- quality agreements with our suppliers,
- actions to avoid static charges when handling MOS circuits,
- worst case planning and design of all circuits,
- visual inspections at various stages of fabrication,
- computer-aided tests of all assemblies and their interaction in the circuit,
- statistical assessment of the quality of fabrication and of all returned goods for the immediate taking of appropriate corrective actions.

2.6 Hazard and other Warnings

Despite the actions described in section 2.4, the occurrence of faults or errors in electronic control units - even if most highly improbable - must be taken into consideration.

Please pay particular attention to the additional notices which we have marked by symbols throughout this instruction manual. While some of these notices make you aware of possible dangers, others are intended as a means of orientation. They are described further down below in descending order of importance.


Every alert and hazard warning is made up as follows:


Type and source of risk


Potential consequences of non-observance

⇒ Preventive measures


	DANGER
A DANGER warning makes you aware of an immediately hazardous situation which WILL cause a serious or fatal accident if not observed.	

	WARNING
A WARNING makes you aware of a potentially hazardous situation which MAY cause a serious or fatal accident or damage to this or other devices if not observed.	

	CAUTION
A CAUTION alert makes you aware of a potentially hazardous situation which MAY cause an accident or damage to this or other devices if not observed.	



	NOTE
A NOTE makes you aware of a potentially hazardous situation which MAY cause damage to this or other devices if not observed.	

Other Notices

	Information
This symbol draws your attention to additional information concerning the use of the described product. This may include cross references to information found elsewhere (e.g. in other manuals).	

2.7 Safety

Our products normally become part of larger systems or installations. The information below is intended to help you integrate the product into its environment without dangers to humans or material/equipment.

	<p>DANGER</p> <p>Non-observance of the instruction manual</p> <p><i>Measures for the prevention of dangerous faults or errors may be rendered ineffective or new hazard sources created.</i></p> <ul style="list-style-type: none"> ▪ Thoroughly read the instruction manual ▪ Take particular heed of the hazard warnings
	<p>Information</p> <p><i>To achieve a high degree of conceptual safety in planning and installing an electronic controller, it is essential to exactly follow the instructions given in the manual because wrong handling could lead to rendering measures against dangers ineffective or to creating additional dangers.</i></p>

Project Planning

- Recommendation for 24V DC supply: Generate as electrically safely separated low voltage. Suitable devices include split-winding transformers built in compliance with European Standard EN 60742 (corresponds to VDE 0551).
- Power breakdowns or power fades: the program structure is to ensure that a defined state at restart excludes all dangerous states.
- Emergency-off installations must comply with EN 60204/IEC 204 (VDE 0113). They must be operative at any time.
- Safety and precautions regulations for qualified applications have to be complied with.
- Please pay particular attention to the notices of warning which, at relevant places, will make you aware of possible sources of dangerous mistakes or faults.
- Relevant standards and VDE regulations are to be complied with in every case.
- Control elements are to be installed in such a way as to exclude unintended operation.
- Lay control cables such that interference (inductive or capacitive) is excluded if this interference could influence controller operation or its functionality.

Maintenance and Servicing

- Precautions regulation VBG 4.0 to be observed when measuring or checking a controller after power-up. This applies to section 8 (Admissible deviations when working on parts) in particular.
- Repairs must be carried out by specially trained Kuhnke staff only (usually in the main factory in Malente). Warranty expires in every other case.
- Only use parts approved of by Kuhnke. Only genuine Kuhnke modules must be used in modular controllers.
- Modular systems: always plug or unplug modules in a power-down state. You may otherwise damage the modules or (possibly not immediately recognisably!) inhibit their functionality.
- Always dispose of (rechargeable) batteries as hazardous waste.

Disposal

- When disposing of the FIO modules, ensure that the modules are disposed of in accordance with the applicable environmental regulations.
- Treat the packaging as recyclable paper and cardboard.

2.8 Electromagnetic Compatibility


Definition

Electromagnetic compatibility is the ability of a device to function satisfactorily in its electromagnetic environment without itself causing any electromagnetic interference that would be intolerable to other devices in this environment.

Of all known phenomena of electromagnetic noise, only a certain range occurs at the location of a given device. These kinds of noise are specified in the applicable product standards.


The design and immunity to interference of programmable logic controllers are internationally governed by standard

IEC 61131-2 which, in Europe, has been the basis for European Standard EN 61131-2.

	Information
	<p><i>Refer to IEC 61131-4, User's Guideline, for general installation instructions to be complied with to ensure that hardware interface factors and the ensuing noise voltages are limited to tolerable levels.</i></p>

Interference Emission

Interfering emission of electromagnetic fields, HF compliant to EN 55011, limiting value class A, Group 1

	Information
	<p><i>If the controller is designed for use in residential areas, high-frequency emissions must comply with limiting value class B as described in EN 55011. Fitting the controller into earthed metal cabinets and installing filters in the supply lines may produce a shielding compliant to the above standard.</i></p>

General Notes on Installation

As component parts of machines, facilities and systems, electronic control systems must comply with valid rules and regulations, depending on their field of application.

General requirements concerning the electrical equipment of machines and aiming at the safety of these machines are contained in Part 1 of European Standard EN 60204 (corresponds to VDE 0113).

Electrical Immission Safeguard

To eliminate electromagnetic interference, connect the control system to the protective earth conductor. Practice best cable routing.

Cable Routing and Wiring

Keep power circuits separate from control circuits:

- DC voltages 60 V ... 400 V
- AC voltages 25 V ... 400 V

Joint laying of control circuits is allowed for:

- shielded data signals
- shielded analogue signals
- unshielded digital I/O lines
- unshielded DC voltages < 60 V
- unshielded AC voltages < 25 V

Location of Installation

Ensure that temperatures, contaminations, impact, vibration or electromagnetic interference are no impediment to the installation.

Temperature

Consider heat sources such as general heating of rooms, sunlight, heat accumulation in assembly rooms or control cabinets.

Contamination

Use appropriate enclosures / cabinets to ensure operation of the FIO modules in a suitable environment. It is designed to prevent possible adverse effects of moisture, corrosive gases, liquids and conductive dust. Operation of an impermissibly dirty module is not permitted. Cleaning the device is also prohibited.

Impact and Vibration

Consider possible influences caused by motors, compressors, transfer lines, presses, ramming machines and vehicles.

Electromagnetic Interference

Consider electromagnetic interference from various local sources: motors, switching devices, switching thyristors, radio-controlled devices, welding equipment, arcing, switched-mode power supplies, converters / inverters.

Particular Sources of Interference

Inductive Actuators

Switching off inductances (such as from relays, contactors, solenoids or switching magnets) produces surge voltages. It is necessary to reduce these extra voltages to a minimum. Throttling elements could be diodes, Z-diodes, varistors or RC elements. Their rating should conform to the specifications provided by the manufacturer or supplier of the actuators.

3 Introduction

Cam control units are used wherever control actions should depend on a machine position. They are used in machines running cyclically recurring processes.

A rotary encoder (in this case an incremental encoder) outputs the actual process values (axle position) to the control unit which then controls the machine according to the current switch cam set up in the program.

Electronic cam control units are not only intended to replace mechanical program control mechanisms but also designed to make their function more accurate, more generally applicable and more wear-resistant.

Operators benefit from the options of flexible manufacturing and shorter setup times. Latest electronic means facilitate both operation and programming.

Conventional applications include:

- Presses
- Fillers
- Glue application
- Paper or foil feeding
- Packaging machines

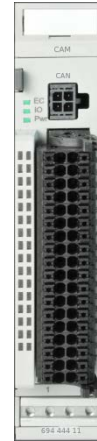


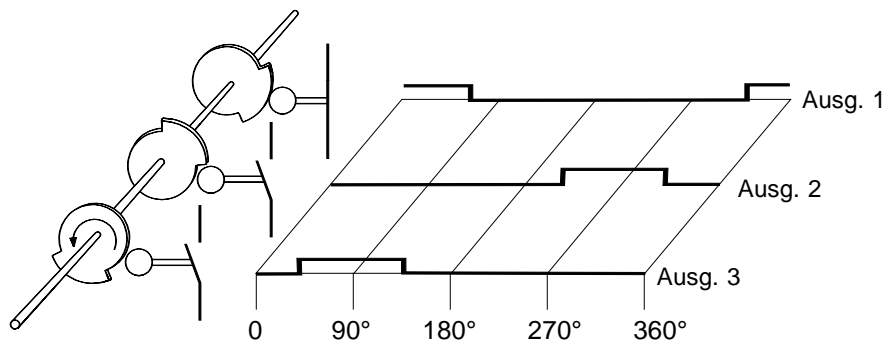
Figure 1: Kuhnke FIO CAM Control

3.1 Working principle of cam control units

When developing the electronic cam control unit, we referred to the working principle of mechanical cam control units in order to keep understanding the method of operation and programming simple.

3.1.1 From mechanical cam control units...

A mechanical cam control unit uses a section of a circular line to actuate a push-button. This section defines as a "cam". Reasons of construction very much restrict the number of circular lines.



3.1.2 ...to electronic cam control units

In terms of electronic cam control units, the mechanical methodology translates as: every output is a circular line. Thus, the number of parallel circular lines is equivalent to the number of outputs.

Programming a cam is therefore based on entering the tripping and releasing points of each section. The section between a tripping and a releasing point turns the output on.

3.1.3 Position detection

An incremental encoder picks up the current machine position.

Incremental encoders provide the angular momentum signals A and B.

Changes in position are identified by counting the momentum signals.

Checking the 180° offset of signals A and B allows you to establish the sense of rotation.

Since the absolute position is unknown when the system turns on, each incremental encoder needs to be referenced. (Meaning that changes in position cannot be recognised when the system is off.)

The absolute position is made known to the control unit by defining a home position which can be found either by means of marker switches or by means of the incremental encoder's reference impulse (index).

3.1.4 Further benefits of electronics

- A large number of cams with accurate trigger and release points can be programmed for every output.
- Once programmed, a cam can be easily changed or deleted.
- If a new cam overlaps an existing one, both cams are joined to make up a single cam.
- If a new cam is contained in a previous cam already, the new cam will be ignored.
- Once programmed, a cam can be copied to other cam control units.
- Physical dead times of actuators can be levelled out by the adjustable dead time compensation feature.
- Time cams enable the use of cams with constant times which solely depend on the triggering edge.

3.2 Programming

Programs can be created by various means, as appropriate. Use them to

- create, test and optimise programs,
- check them in online mode,
- copy them within the same cam control unit,
- copy them from one cam control unit to another,
- save them.

4 Hardware

4.1 Mechanical design

The picture below illustrates the basic layout of the Kuhnke FIO modules:

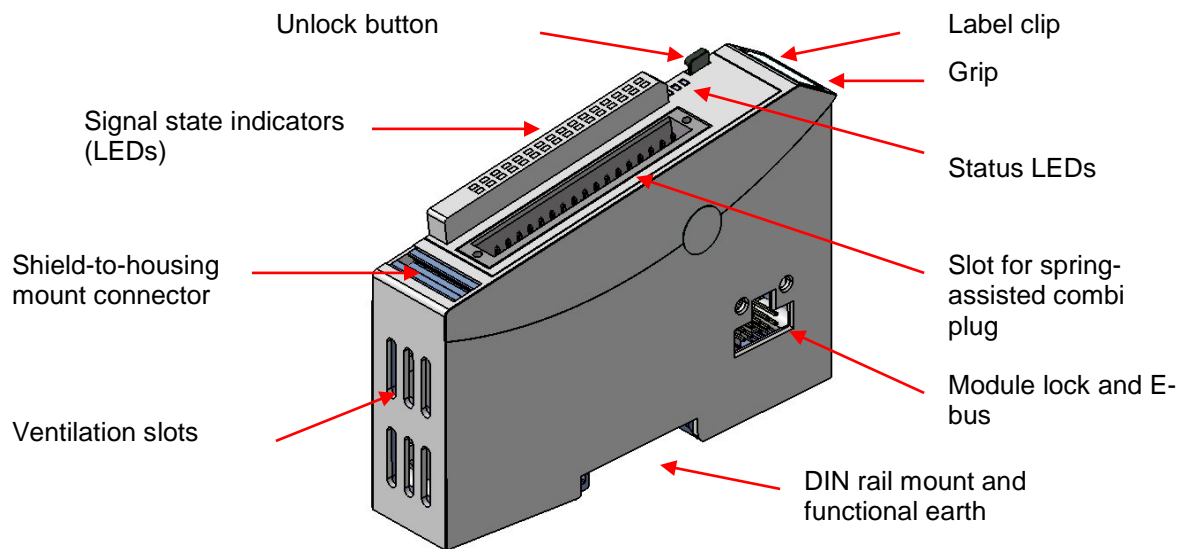


Figure 2 Module layout

The housing mount consists of an aluminium profile with an integral snap-on device used to snap the module to a 35mm DIN rail. The housing trough including the optical fibres for the status indicators, the side face and the front is made of plastic and contains the module. The optical fibres for the signal state indicators (LEDs) are located next to the spring-assisted combi plug. They slightly protrude from the housing and allow a clear diagnosis at a glance.

4.1.1 Earthing

Connect the Kuhnke FIO modules to earth by attaching the metal housing to functional earth.

Since the functional earth connector dissipates HF currents, it is of utmost importance for the module's noise immunity.

HF interference is dissipated from the electronics board to the metal housing. The metal housing therefore needs to be suitably connected to a functional earth connector.

You will normally have to ensure that

- the connection between module housing and DIN rail conducts well,
- the connection between DIN rail and switching cabinet conducts well,
- the switching cabinet is safely connected to earth.

In special cases you may attach the earth wire straight to the module.

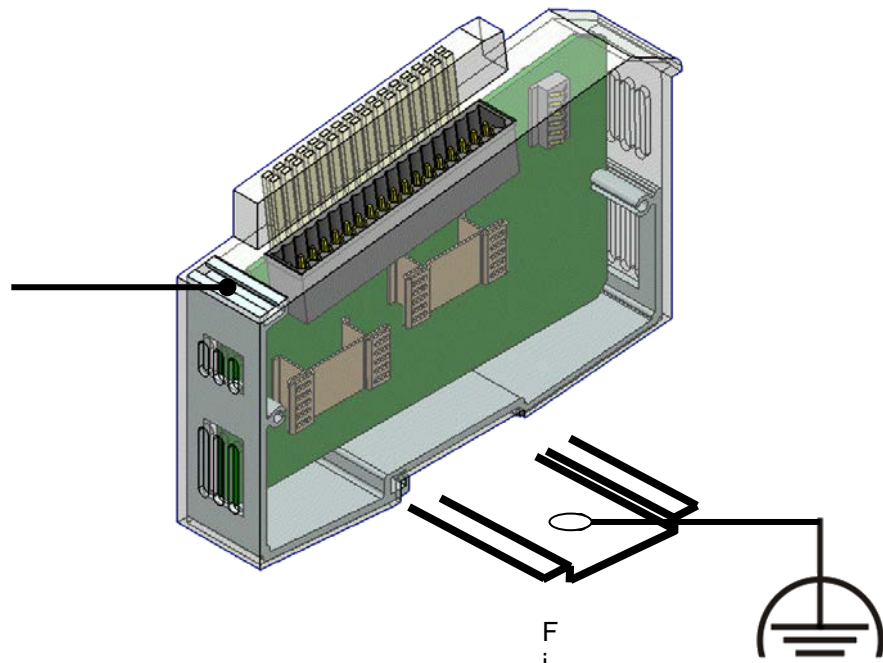


Figure 4: Aluminium profile



NOTE

Earth wires should be short and have a large surface (copper mesh). Refer to [http://de.wikipedia.org/wiki/ground_\(electronics\)](http://de.wikipedia.org/wiki/ground_(electronics)) or a similar source for further details

4.1.2 Mounting

Kuhnke's FIO modules are intended for mounting rail installation (DIN EN 50022, 35 x 7.5 mm).

4.1.2.1 To snap on a single module

1. Push up the module against the mounting rail from below, allowing the metal spring to snap in between mounting rail and mounting area as illustrated.
2. Push the top of the module against the mounting wall until it snaps in.

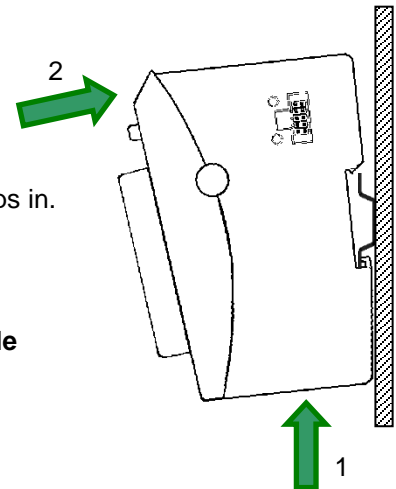


Figure 5: Rail mounting of module

4.1.2.2 To interconnect two modules

- After snapping on the first module to the rail, snap on the second module about 1cm away towards the right of the first module.
- Push the second module along the rail towards the first module until you hear the locking device snap in.

4.1.2.3 To disconnect two modules

- Push down the unlock button (see Figure6) of the module that you wish to disconnect from the module to the left of it.
- Push both module away from one another until they are about 1 cm apart.

4.1.2.4 To take down a single module

1. Push the module up and against the metal spring located on the underside of the rail guide.
2. Tip the module away from the rail as shown in the illustration.
3. Pull the module down and out of the mounting rail.

Unlock button

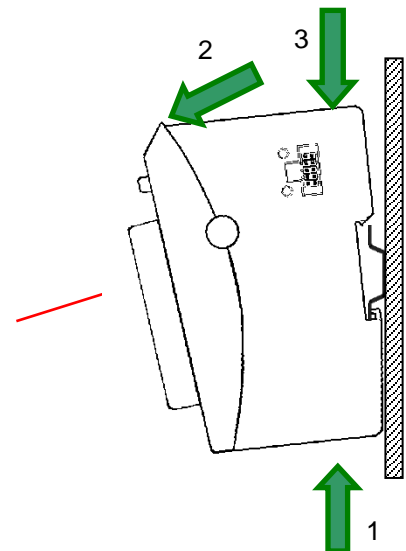


Figure6: Uninstalling a module

4.2 Ports

4.2.1 General information

The **spring-assisted PUSH-IN connector** allows you to quickly attach the wires by direct insertion without any tools. Just insert the connector sleeve end of the stripped solid or fine wire in the correct opening.

Wires: 320V / 13.4 A / 0.14 - 1.5 mm² (IEC)
 Nominal current: 300 V / 9.5 A / 26 - 16 AWG (UL)

Supported wires with connector sleeves:

Connector sleeve type	Wire cross section [mm ²]						
	0.14	0.25	0.34	0.50	0.75	1	1.5
Connector sleeve w/ collar to DIN 46 228/4	8 / 10	8 / 10	8 / 10	10 / 12	12 / 14	12 / 15	
Connector sleeve w/o collar to DIN 46 228/1							10 / 10
Stripped end [mm] / sleeve length [mm]							



NOTE

Do not connect the power supply lines through from one Kuhnke FIO to the next. To ensure that there is as little interference as possible, install a central power supply point and establish a star topology of as short wires as possible between the central point and Kuhnke FIO.

4.2.2 I/O connector

Both the system power supply and the I/Os connect to the same 36-pole module terminal block.

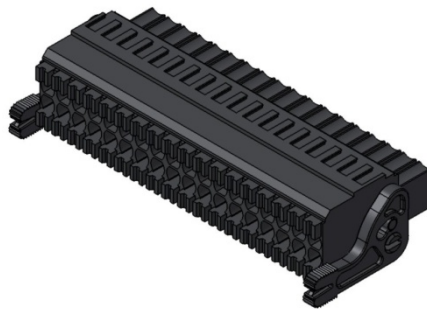


Figure 7: Two-row push-In connector with releasing lever

4.2.3 CAN connector

The CAN bus connects to the front of the module by means of a 4-pole Molex Micro-Fit Connector 3.0™. Connector (supplier: Farnell)

43025-0400: female Micro FIT 3.0

43030-0010: crimp socket PK100

MOLEX-79516-1043-MICRO-PASS 4WAY CABLE ASSEMBLY 3M

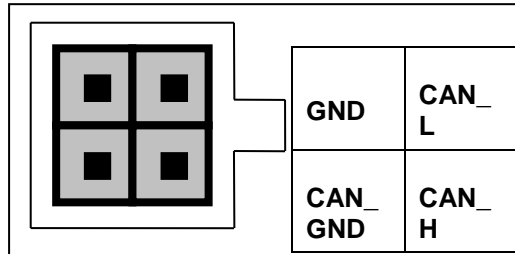


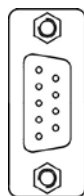
Figure 8: 4-pole male to female CAN connector

You may use a CAN to USB adapter to connect the CAN bus to the programming PC. (Source: <http://www.canusb.com/>)



Figure 9: CAN to USB adapter (Lawicel)

You may also need to adapt the D-SUB connectors to Micro-Fit.



Pin	Function
1	
2	CAN_L
3	CAN_GND
4	
5	
6	
7	CAN_H
8	
9	
Housing	Earth (GND)



Information

Please note that both ends of CAN cables require a 120Ω termination between CAN_L and CAN_H.

4.2.3.1 IO connector, left row

Pin	Signal	Explanation
1	DO1.0	Digital output 1.0 (track 9)
2	DO1.1	Digital output 1.1 (track 10)
3	DO1.2	Digital output 1.2 (track 11)
4	DO1.3	Digital output 1.3 (track 12)
5	DO1.4	Digital output 1.4 (track 13)
6	DO1.5	Digital output 1.5 (track 14)
7	DO1.6	Digital output 1.6 (track 15)
8	DO1.7	Digital output 1.7 (track 16)
9	DO2.0	Digital output 2.0 (track 17)
10	DO2.1	Digital output 2.1 (track 18)
11	DO2.2	Digital output 2.2 (track 19)
12	DO2.3	Digital output 2.3 (track 20)
13	DO2.4	Digital output 2.4 (track 21)
14	DO2.5	Digital output 2.5 (track 22)
15	DO2.6	Digital output 2.6 (track 23)
16	DO2.7	Digital output 2.7 (track 24)
17	+ 24V in/out	CAM Control Module power supply: 24 VDC
18	GND in/out	CAM Control Module power supply: GND

4.2.3.2 IO connector, right row

Pin	Signal	Explanation
19	DO0.0	Digital output 0.0 (track 1)
20	DO0.1	Digital output 0.1 (track 2)
21	DO0.2	Digital output 0.2 (track 3)
22	DO0.3	Digital output 0.3 (track 4)
23	DO0.4	Digital output 0.4 (track 5)
24	DO0.5	Digital output 0.5 (track 6)
25	DO0.6	Digital output 0.6 (track 7)
26	DO0.7	Digital output 0.7 (track 8)
27	DI 0.0 (0..10V)	Digital/analogue input 0.0 (0..10V)
28	DI 0.1 (0..10V)	Digital/analogue input 0.1 (0..10V)
29	DI 0.2 (0..10V)	Digital/analogue input 0.2 (0..10V)
30	DI 0.3 (0..10V)	Digital/analogue input 0.3 (0..10V)
31	DI 0.4 (interrupt)	Digital input (0.4 (interrupt))
32	DI 0.5 (A, 24V)	Incremental encoder input 0.5 (A, 24V)
33	DI 0.6 (B, 24V)	Incremental encoder input 0.6 (B, 24V)
34	DI 0.7 (Ref., 24V)	Incremental encoder input (Ref., 24V)
35	24 V DC power	24 V DC I/O power supply
36	GND	I/O GND

5 CAM Control

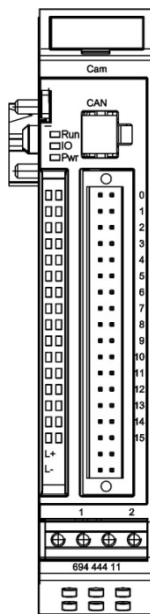


Figure 11: Front view of FIO CAM Control

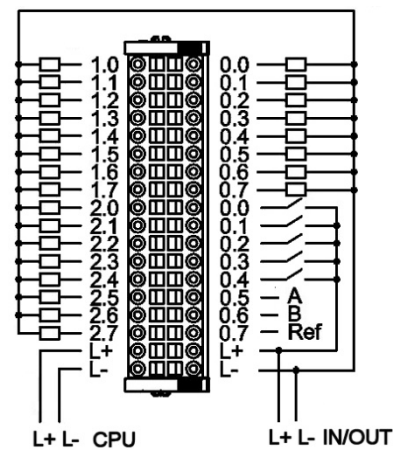


Figure 10: Connection of encoder, inputs, outputs and supply voltages

5.1.1 Supply voltage

Power supply to module I/Os

+ 24 VDC -20%+25%

L- 0 V

5.1.2 Status LEDs

5.1.2.1 "Run" LED

The "Run" LED indicates the state of the EtherCAT ASICs.

State	LED flash code	Explanation
Init	Off	Initialising, no data exchange
Pre-Op	Off/green, 1:1	Pre-operational, no data exchange
Safe-Op	Off/green, 5:1	Safe operation, inputs readable
Op	Green, on	Operational, unrestricted data exchange

5.1.2.2 "IO" LED

The LED labelled "IO" indicates the state of the module's I/Os.

State	LED flash code	Explanation
Ok	Off	No error
Error	Red, 1x	Short circuit of outputs
	Red, 2x	Low voltage (U load, CPU)
	Red, 4x	Bus system watchdog control failure

**NOTE**

The output drivers have a thermal fuse to automatically turn off any short-circuited outputs. In case the short circuit prevails, the outputs are allowed to cool down to be turned back on until the thermal fuse blows again.

5.1.2.3 "Power" LED

The LED labelled "Power" indicates the state of the I/O module's I/O power supply.

State	LED flash code	Explanation
On	Green, on	24 VDC supply ok
Off	Off	24 VDC supply not ok

**NOTE**

The module is not monitored for low voltage states.

5.1.2.4 "Channel" LEDs

State	LED	Explanation
On	Green, on	Input/output enabled
On	Yellow, on	Incremental encoder input enabled
Off	Off	Input/output disabled

5.1.3 Function

The CAM Control module features 24 digital outputs used for mapping cam tracks.

Run the "FIOCAM Creator" to write the cam program and save it on the fail-safe CAM Control module memory.

The CAM Control module supports the following operating options:

- Standalone
- Together with a Kuhnke FIO Controller, optional Kuhnke FIO modules and further EtherCAT slaves
- Together with an EtherCAT master, a Kuhnke bus coupler and optional Kuhnke FIO module plus further EtherCAT slaves
- Together with a CAN master and further CAN slaves

5.1.3.1 Input variables

Variable	Data type	Explanation
State1	USINT	Shows the selected cam program
State2	USINT	Status
Tracks ¹	UDINT	States of the outputs (tracks) (bits 0...32)
Digitalln	USINT	Digital inputs
reserved	USINT	Reserve
Position	UINT	Position
Speed	UINT	Velocity
AnalogIn1	UINT	Analogue inputs value 0.0
AnalogIn2	UINT	Analogue inputs value 0.1
AnalogIn3	UINT	Analogue inputs value 0.2
AnalogIn4	UINT	Analogue inputs value 0.3

State1

Shows the currently selected cam program, where 0 means that a cam program is not available.

State2

Bit no.	Explanation
0	Cam outputs enabled (U load connected)
1	Position referenced
2	Short-circuit of outputs (reset by Reset Error)
3	CPU low voltage (reset by Reset Error)
4	Low voltage on outputs (U load) (reset by Reset Error)
5	Bus system watchdog control failure (reset by Reset Error)
6	Anti-jitter enabled
7	Reverse

AnalogIn

Indicative of an analogue input voltage 0V – 10V, in CODESYS [UINT] 0...65535

¹ This variable is spread across 4 USINT-type variables in the CAN process image

5.1.3.2 Output variables

Variable	Data type	Explanation
Control1	USINT	Selects the cam program (currently not implemented.)
Control2	USINT	Control bits
PositionSet	UINT	Sets the position in slave mode
SpeedSet	UINT	Sets the velocity in slave mode

Control2	Bit no.	Explanation if TRUE
	0	Reset Error (if 1)
	1	Reference the position (0->1)
	2..7	Not used

5.1.3.3 Position referencing

An ON signal received by Ref input DI0.7 resets the counter reading to "0". This is referencing the position (if an incremental encoder is used).

State1.1 indicates the state of referencing.

5.1.3.4 Cam tracks

Cam tracks 0 .. 24 directly actuate digital outputs 0.0 to 2.7.

Cam tracks 25 .. 32 are software cams which the EtherCAT master, CAN master or other unit can read and output to other modules equipped with digital outputs (extension).

5.1.3.5 Slave mode

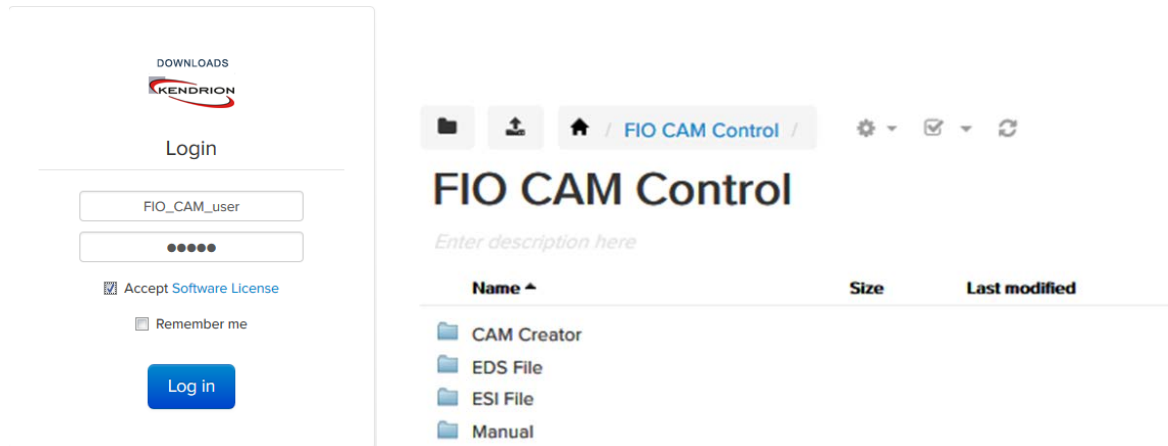
Only one encoder is required to run several CAM modules in a synchronised manner. The module that the encoder is connected to can use EtherCAT to transfer the position and velocity to the other modules.

6 Software

Run the FIOCAM Creator to write your cam programs and program the FIO CAM Control modules. This section describes how to start the FIOCAM Creator.

6.1 Download

All necessary programs, equipment descriptions and instructions are available in our download area.



Link to the download area:

<http://wp12324084.server-he.de/kuhnke-download/>

The necessary access are:

User: FIO_CAM_user
Password: Nocke

6.2 Installation

Installations involves running the Setups utility.

- Run the correct CAMCreator setup, e.g. "Setup_FIOCAM-Creator_V01000502.exe" (to install version 1.0.5.2).



- After accepting the license agreement, files
 - FIOCAM.exe for Windows XP, 7 ...
 - FIOCAM_01.DLL for the USB dongle (currently not implemented)
 - FIOCAM_02.DLL for CAN communication
 - FIOCAM_03.DLL for EtherCAT communication

are copied to folder

C:\Program Files (x86)\Kuhnke Automation\FIOCAM

6.3 Start/Exit

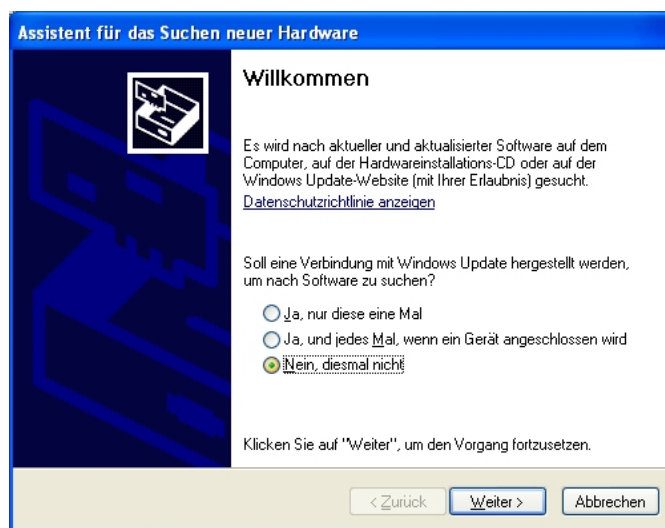
FIOCAM Creator starts by running FIOCAM.exe. The last project you used will be loaded.

6.4 CAN USB driver

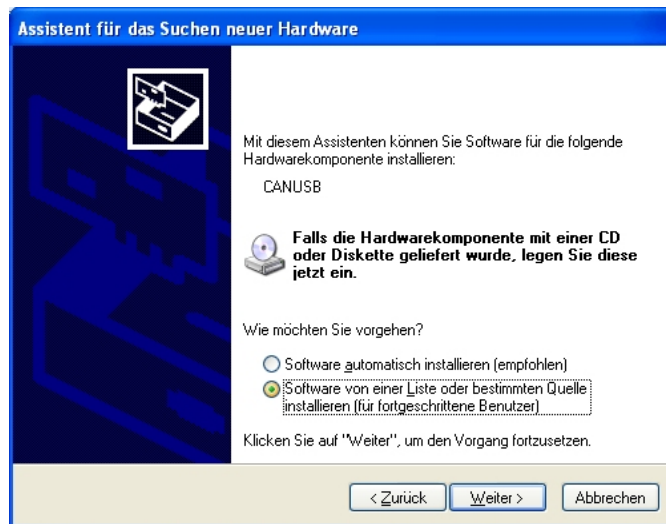
You will need drivers to operate the CAN to USB adapter supplied by Lawicel. We recommend proceeding as follows:

- Download the current drivers (e.g. CDM_2.08.14_CANUSB.zip) from <http://www.can232.com> and make a note of the directory that contains the unzipped drivers.
- Plug the USB cable of the CAN to USB adapter into a free USB slot of your PC.

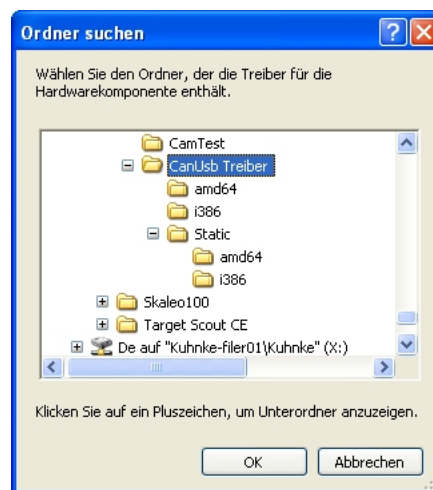
Your PC will detect the new hardware and run the New Hardware Wizard.



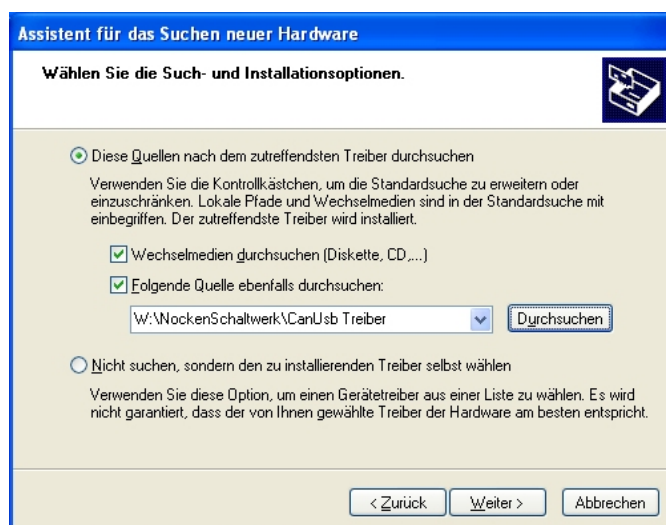
- Choose option "No, not this time".



- Choose "Install from a list or specific location (...)".
- Tick the box next to "Include this location in the search", then click on "Browse".



- Browse to the folder that you unzipped the downloaded drivers to after, then click on OK.



- Click on "Next" to start the installation process. Skip any security prompts that may appear.



You will see the following message shortly after the end of the installation.

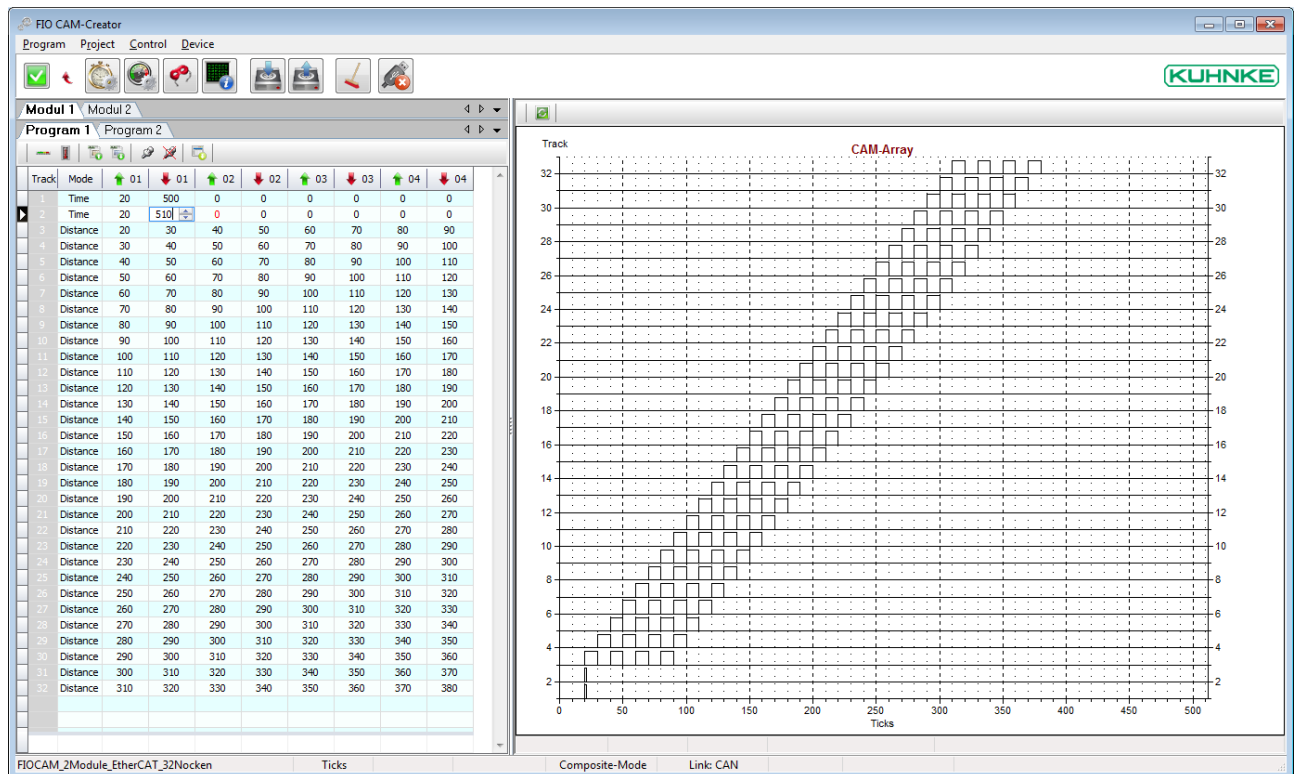


You can now establish an online link between FIOCAM Creator and the FIO CAM Control module via the CAN to USB adapter.

7 FIOCAM Creator

This section describes how to operate the FIOCAM Creator.

7.1 Cam programming



Once the application is up and running, you will see a table of cam programs on the left and the associated diagram - the CAM array - on the right-hand side of the screen.

7.1.1 Editing the cams

The cam program programs displays as an editable table.

(Refer to Project, Options, CAM to know more about the number of cams per track, the number of tracks per program, and the number of programs).

(Refer to Project, Options, Encoder and ...CAM for resolution details)



- Decide whether to edit the cams as number of increments (ticks) or angular degrees. (Changing between the two may produce non-integral values due to rounding differences.)

- Enter the values into the correct cells.
- Enable the tracks by ticking the boxes of the appropriate rows.



- Exports the cam programs to Excel sheets for documentation or reuse at a later time.



- Imports cam programs from Excel sheets you previously exported and edited, as appropriate.



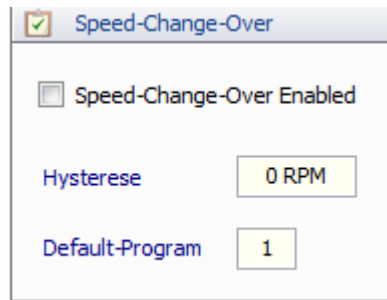
- Enables/disables all cams



- Changes the cam settings online

**NOTE****Online Change**

You may change the cams during operation. This requires you to disable the speed change-over first, see 5.4.4.5



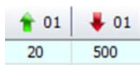
Define a default program to be able to make online changes to any of your programs.



- This column shows the number of enabled cam tracks which you can set under Control/Options/Module/CAM, see 5.4.4.3



- This column allows you to pick one of the operating models, i.e. 'Time' (time cam) or 'Distance'.

- Time cams enable the use of cams with constant times which solely depend on the triggering edge.
 - The application currently supports 5 time cams per cam program
 - Set the starting time and duty cycle, in [ms],
 e.g. start after 20 ticks for 500 ms cam time.

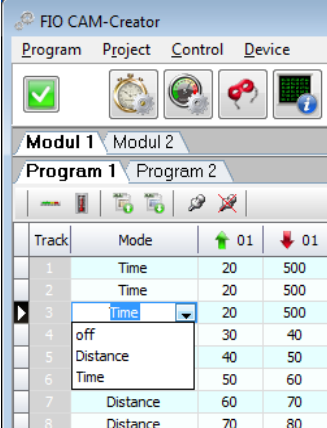
- Distance cams:



Enter the starting and end time in ticks or angular degrees (depends on setting)



- Used to show/set the start and end of CAM 1.



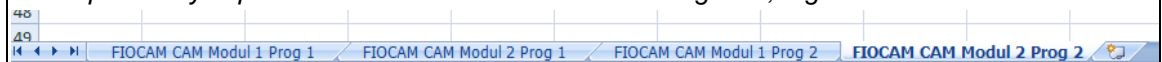
Track	Mode	↑ 01	↓ 01
1	Time	20	500
2	Time	20	500
3	Time	20	500
4	off	30	40
5	Distance	40	50
6	Time	50	60
7	Distance	60	70
8	Distance	70	80

**NOTE****Time cam**

The application currently supports 5 time cams per cam program

**NOTE**


The import utility expects an Excel sheet with the following tabs, e.g.



Assuming you previously exported the cam table, you can save it as an Excel worksheet, open another Excel worksheet and import it to FIOCAM Creator.

Assuming you did not export a cam table before, the following prompt will pop up when you run Excel:



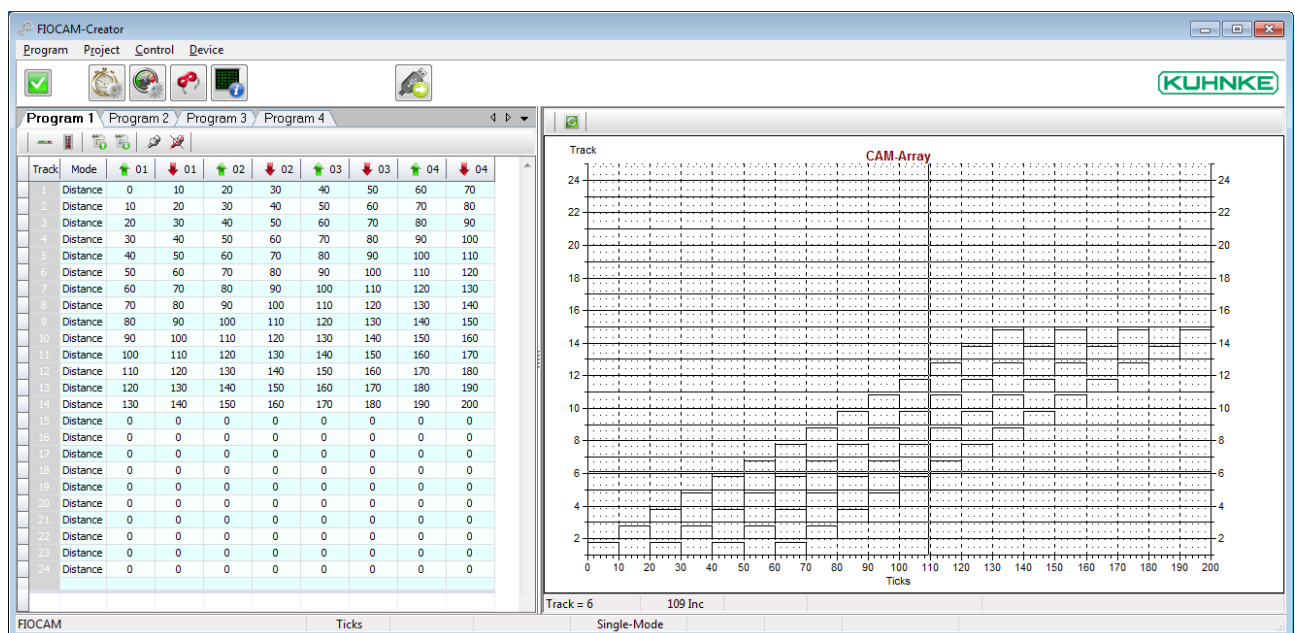
- OK acknowledges the prompt.
- Open the Excel worksheet and display the sheet containing the cam table.
- In FIOCAM Creator, again click on import from Excel 

The table will now be imported into the open project. The data quantities will consider the project settings.

7.1.2 Diagram view

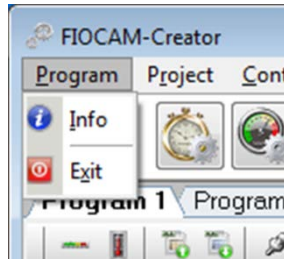
Displays the cams of the enabled tracks as a CAM array.

Assuming "Cross-Hair" is enabled under Project, Settings, System, pressing and holding the left mouse button and moving the mouse over the cams will display the coordinates of each cam.



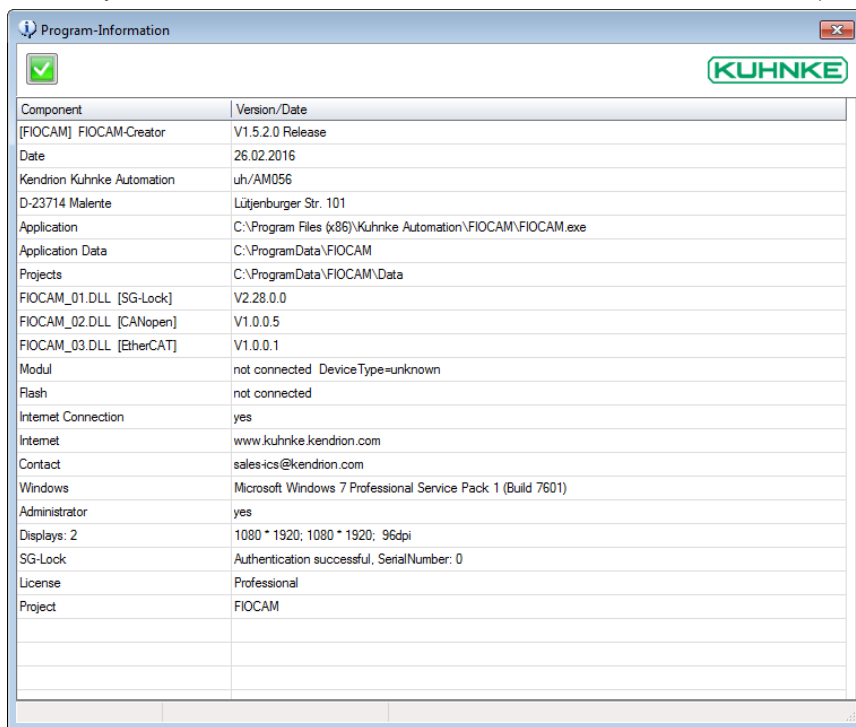
- The CAM array's Refresh button only serves to refresh the display.

7.2 Program



7.2.1 Info

Info display information of your FIOCAM Creator installation and the FIO CAM module (while online).

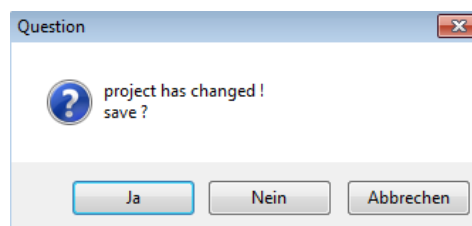


NOTE

FIOCAM Creator stores all its projects in the above folder. If you wish to use the projects elsewhere, please copy them from this folder and/or return them there when you are finished.

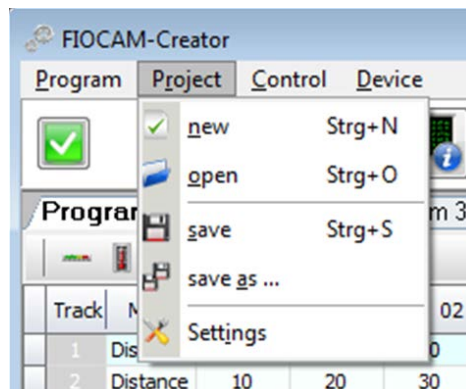
7.2.2 Exit

Exits FIOCAM Creator. A Save Changes prompt will pop up if you changed the project in any way.



7.3 Project

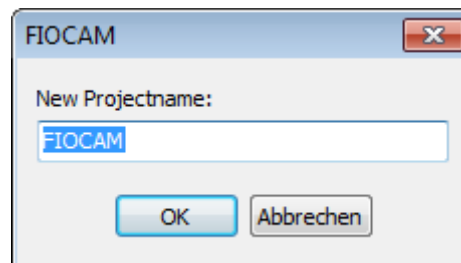
This section details the project management features.



7.3.1 new

Creates a new project.

- Assign a name to the new project.



7.3.2 open

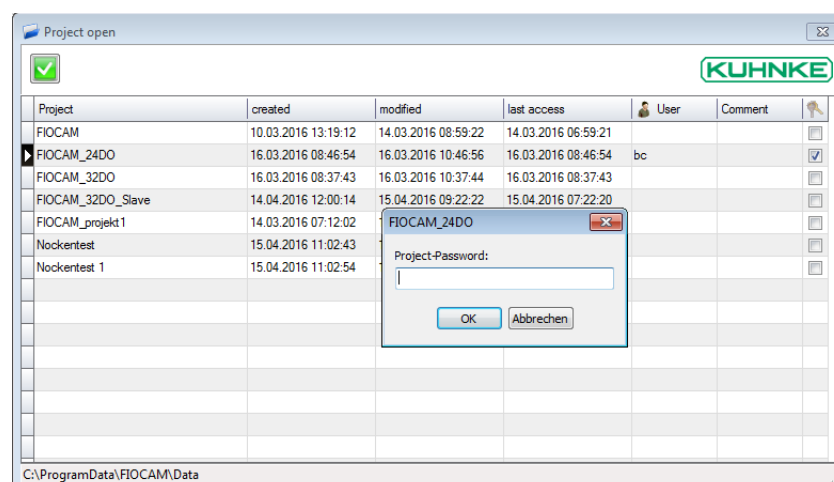
Opens a projects and closes the previous project.

- Pick a project from the list.



in the column with the key icon marks password-protected projects.

- If so, enter the password and click on OK to confirm.



7.3.3 save

Saves the open project

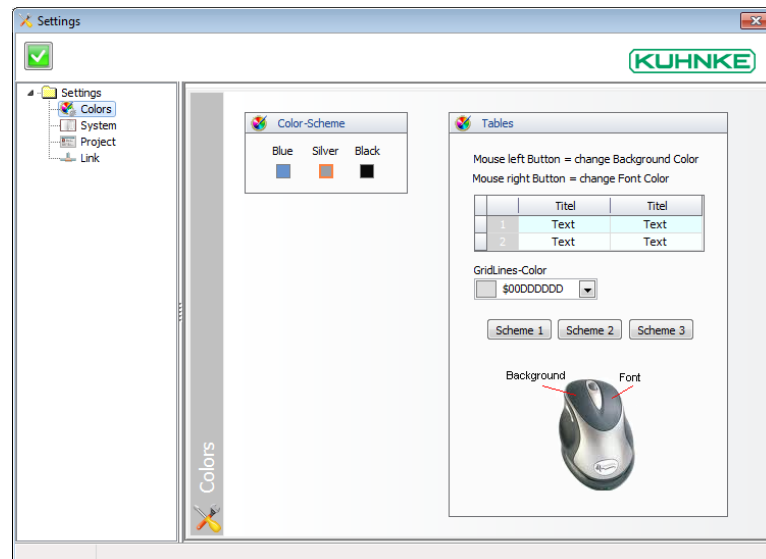
7.3.4 save as ...

Saves the open project under a different name (creates a copy).

7.3.5 Settings

7.3.5.1 Colors

Use these settings to re-design the appearance of your FIOCAM Creator:



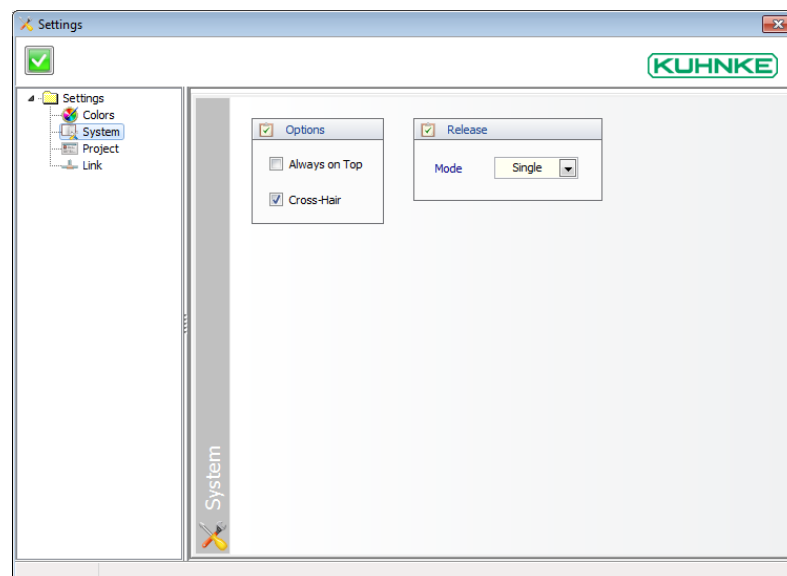
Color Scheme:

- Choose from Blue, Silver and Black to change the appearance of dialog boxes to your preferences.

Tables:

- Choose a background colour and font colour for your tables. Either choose from Schemes 1, 2 or 3 or take your own pick.

7.3.5.2 System



Options:

- Always on Top:
 - Tick this option to always show FIOCAM Creator on top of all other items on the screen.

- Cross-Hair:
 - Tick this option to be shown coordinates when left-clicking and moving the mouse across the CAM array.

Release:

- Choose between Single or Composite mode.
 - Single: Project containing a single FIO CAM Control module
 - Composite: Project containing up to 8 FIO CAM Control modules

7.3.5.3 Project

Choose this menu item to enter your user name, project password and a comment.

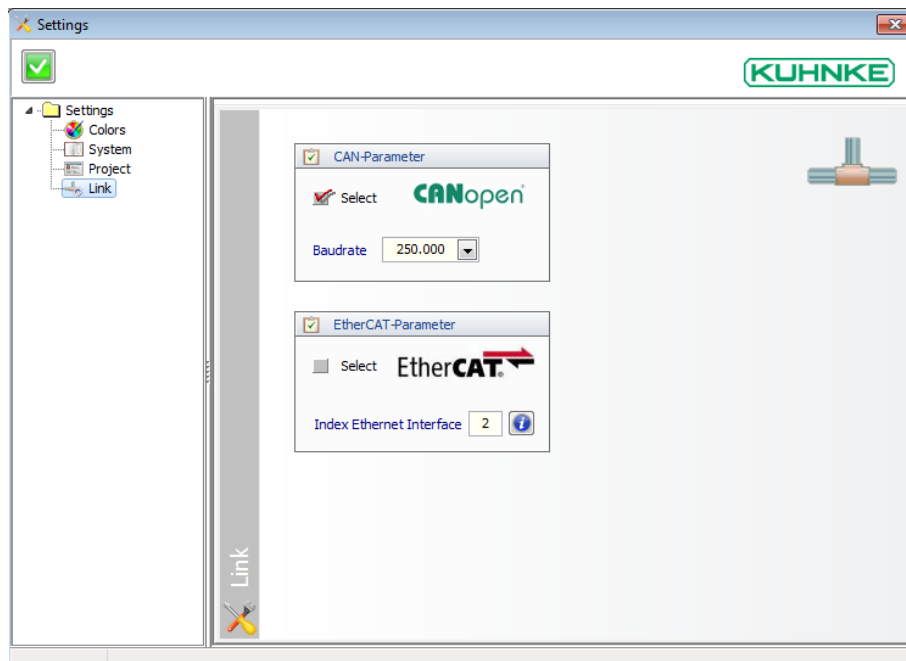
These details will be shown when you open the project.

If you set a password, you will have to enter that password before the project actually opens. Furthermore, a cam program can only be retrieved if it is opened in a project protected by this password.

7.3.5.4 Link

Used to define the project's online links.

- Choose between CAN and EtherCAT by ticking the appropriate Select box.
-



CAN Parameter:

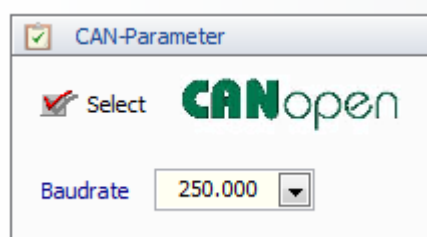
Sets the CAN transfer rate

The transfer rate needs to be set to allow the FIO CAM Control module to operate in a CANopen network.

The transfer rate you set in this dialog will be stored in the module when you open the project.

To program FIO CAM Control module:

- Choose the baud rate your FIO CAM Control module has been set to, e.g. 250,000 bps.

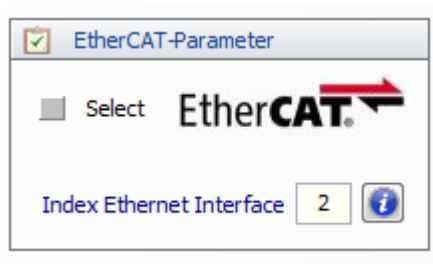


To use the FIO CAM Control module in a CANopen network:

- Choose the baud rate your CANopen network has been set to.

EtherCAT Parameter:

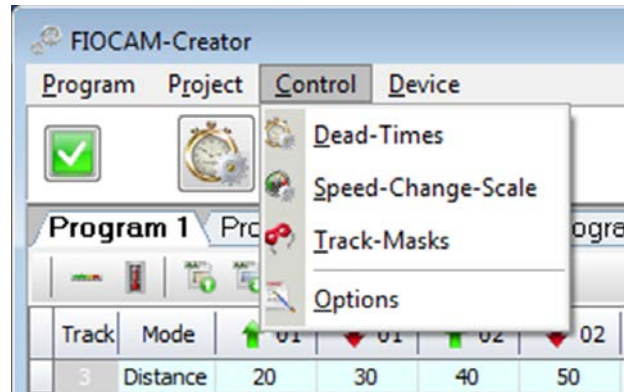
- Click on the Info icon to see which index no. has been allocated to the Ethernet port you wish to use on your PC.



- Enter that number into the box next to Index Ethernet Interface.

7.4 Control

This section tells you how to program flexible cam programs

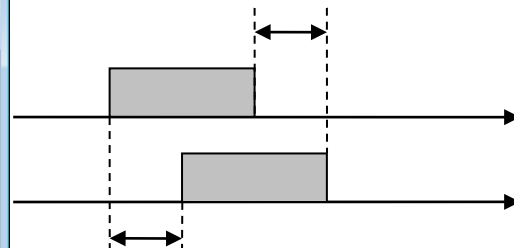
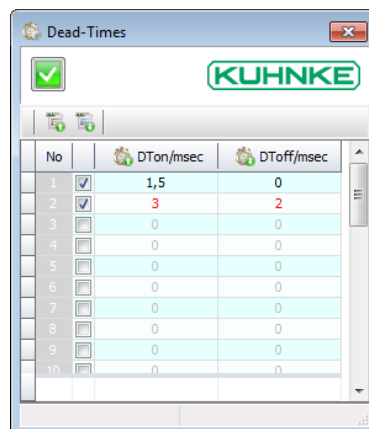


7.4.1 Dead-Times



Dead time corrections:

Assuming a dead time has been assigned to a response to switching operations, the operation needs to occur sooner or later with reference to the actual speed, i.e. cams have to be moved.



Example of an encoder with 360 increments / revolution:

(One revolution is equivalent to 360 increments)

A cam triggers at 25° and releases at 50°. (This is the program.)

Set both DTon and DToff of this cam to 1 sec.

A speed of 1 rpm is the same as 6 increments/sec.

A speed of 2 rpm is the same as 12 increments/sec.

If dead time compensation is on, this will result in:

at 1 rpm: The cam triggers at 19° and releases at 44°.

at 2 rpm: The cam triggers at 13° and releases at 38°.

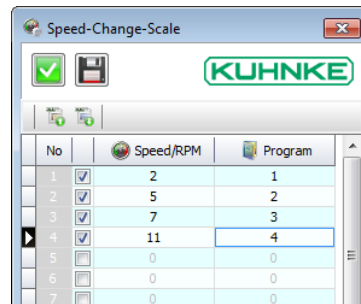
7.4.2 Speed Change Scale



Program change-over table

Pick Control, Options, CAM, Programs from the menu to set the number of cam programs to run on a FIO CAM Control module.

A change between programs should occur with reference to the actual speed.



- Tick the boxes in the table rows you use.
- Set the speeds at which a change of program should occur.
- Allocate the programs.

The picture below is just an example of the following settings:

No	Speed/RPM	Program
1	2	1
2	5	2
3	7	3
4	11	4

Row 1: At a speed of 2 or higher, the program changes from 1 to 2.

Row 2: At a speed of 5 or higher, the program changes from 2 to 3.
If the speed drops to anything between 2 and 5, the program will go back to 2.

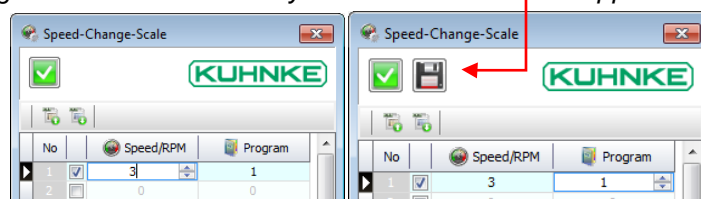
Please note that programs can only change in a linear manner, i.e. from 1 to 2 to 3 but not in any other way, i.e. from 1 to 3.



NOTE

Press Enter to confirm your entries

Any change you make to your program sequence table will have to be confirmed by pressing Enter or by moving on to another field. Only then will the Save icon appear.



A general recommendation is to press Enter every time you enter a value into the table.

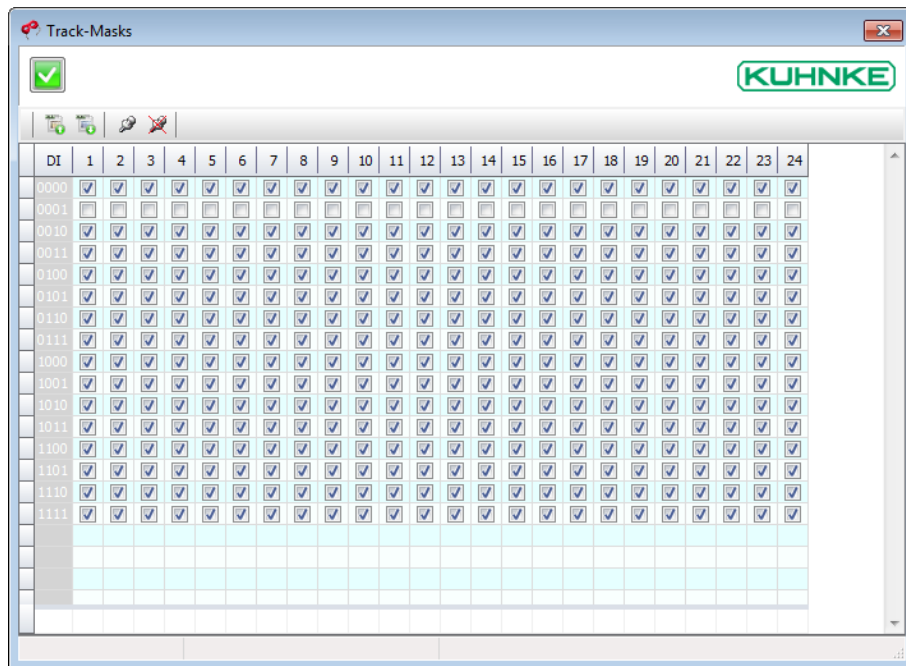
7.4.3 Track Masks



To mask tracks

You may use a module's digital inputs to disable (mask) any of the tracks. In other words, if the digital inputs "DI" have been allocated appropriately (see first column), the tracks whose boxes are ticked will be actuated by the cam program.

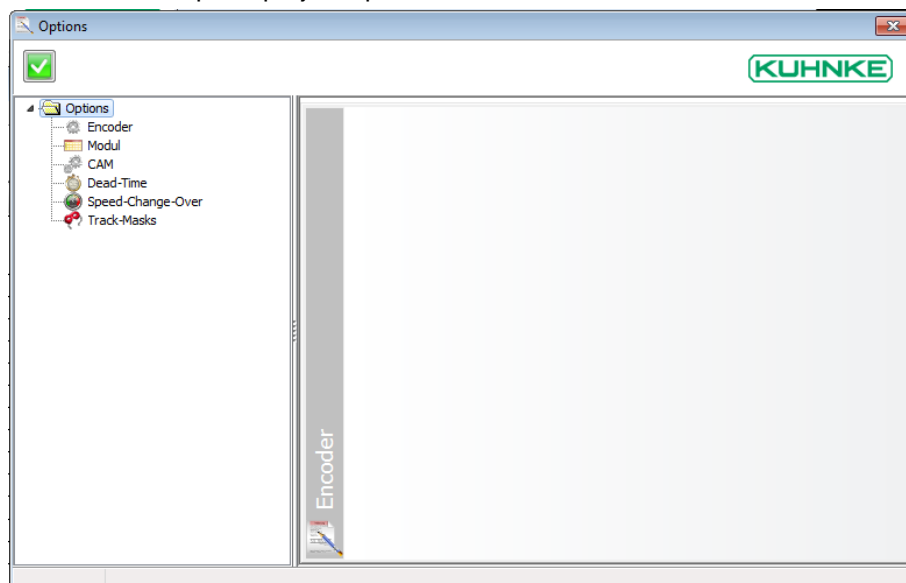
Example: In the picture below, all cams will be disabled when DI 0.0 detects a high signal. You must also enable the "Track Masks" mode. See 5.4.4.6 Track Masks.



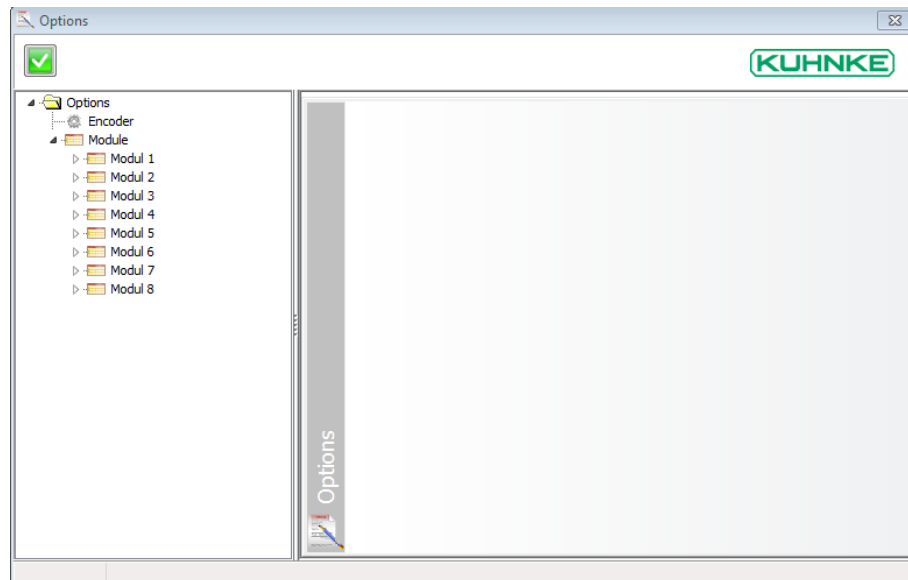
- Tick the appropriate boxes.
- And enable the option as described in section 5.4.4.6 Track Masks.

7.4.4 Options

This section details how to set up the project options.

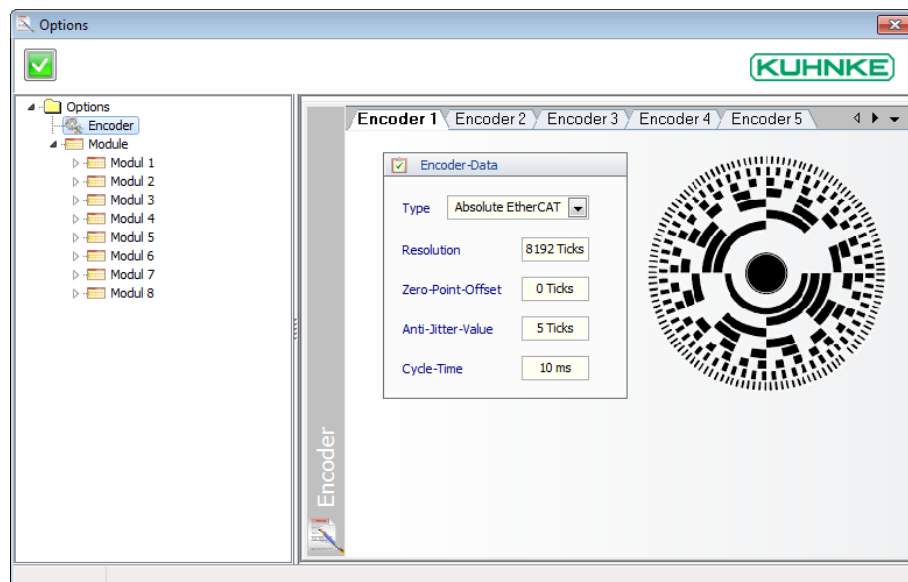


The screen looks like the example below if you set option Project/Setting/System/Release to "Composite" (see 5.3.5.2).



7.4.4.1 Encoder

Used to set up the incremental encoder.



Term	Explanation	Values
Type ²	24V, CAN, on-board (digital inputs)	
Resolution	Resolution	1...8192 ticks
Zero-Point Offset	Zero point offset	0 .. 4096 ticks
Anti-Jitter-Value	Stabilisation of output	0.. 50 ticks
Cycle-Time	Time the controller needs to detect the speed.	10...1000 ms

You may set up up to eight different encoders. Encoder examples include "Absolute EtherCAT" or "Absolute CAN" (currently not implemented). See section 6 for an example.

² The module currently supports 24V incremental encoders only

**NOTE****Absolute CAN**

Remember that an Absolute CAN Encoder always connects to the CAN master and that the FIO CAM Control modules then need to link in via EtherCAT.

Resolution

Sets the encoder resolution, in increments (ticks).

Assuming your incremental encoder's resolution is 1000 (see name plate) and you are running a 4-fold interpretation, you will be able to interpret 4000 ticks.

That is to say: When it receives the first pulse, the FIO CAM Control module will reset the reading at its Ref input to 0. Then it will keep counting up from 0 to 3999 and reset to 0 again at 4000.

- Enter the encoder's resolution (name plate).
(See Project Options CAM for the usable resolution)

Zero-Point-Offset

Zero point offset

This is the counter reading after referencing.

Anti-Jitter-Value

You may enter an offset to suppress any output jitter at the cam edges.

It allows you to stabilise the cam output. When the FIOCAM module detects a change of rotation, it will suppress the output of the cams for the set number of ticks.

**NOTE**

Try to keep the number of ticks as small as possible with reference to the mechanical conditions, resolution and rotational speed of your application.

Cycle-Time

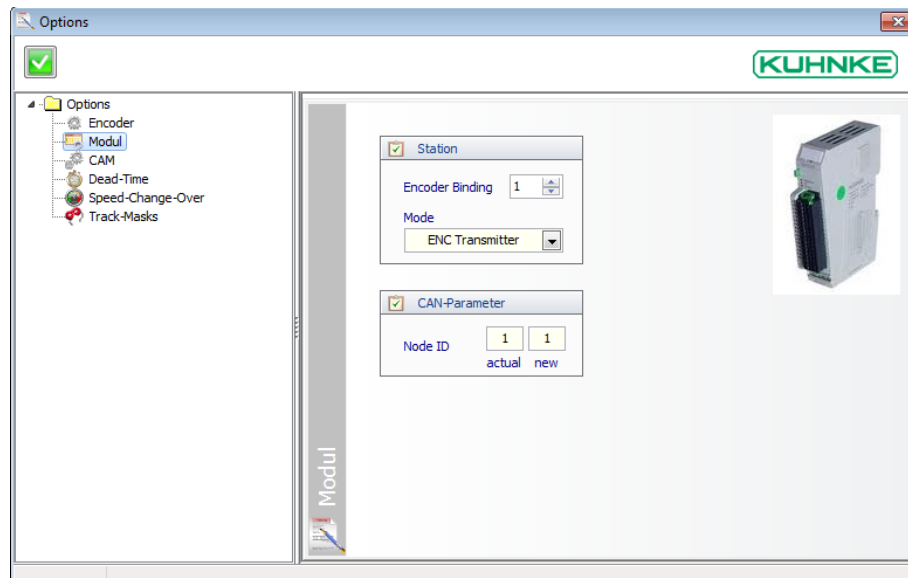
Time the controller needs to detect the speed. You can set the time to anything between 10 ms and 1000 ms.

The module counts the ticks per cycle time you set and uses them to calculate the speed.

This time is also used to calculate the set dead times.

7.4.4.2 Module**Station**

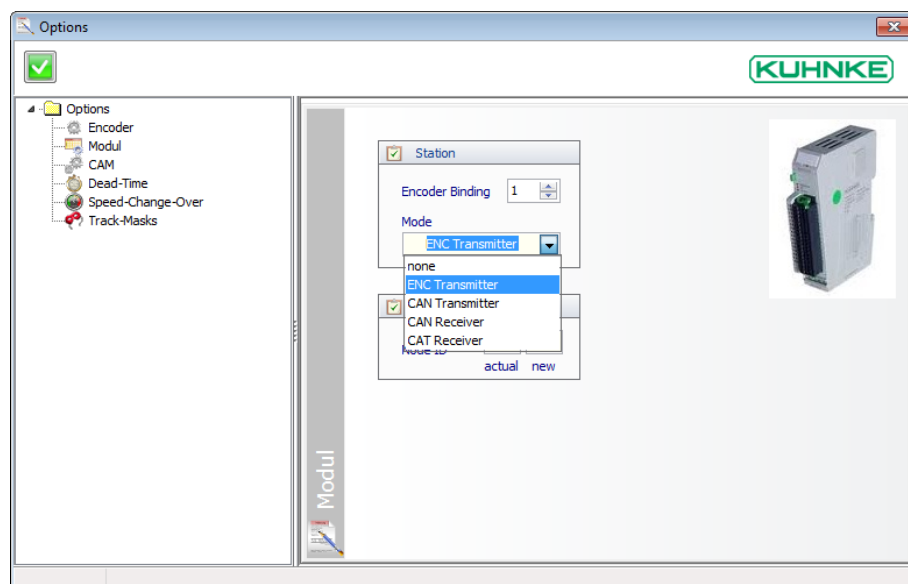
Encoder Binding allocates one of the 8 possible encoders to this module.



Pick one of the five Mode options:

none	No mode selected
ENC Transmitter	Incremental encoder (AB-Ref) - EtherCAT transmitter
CAN Transmitter	CAN transmitter (currently not implemented)
CAN Receiver	CAN receiver (currently not implemented)
CAT Receiver	EtherCAT receiver

The CAN/CAT Receiver mode apply to "Composite Mode", see 5.3.5.2, i.e. to running several CAM modules connected to one encoder.



CAN Parameter:

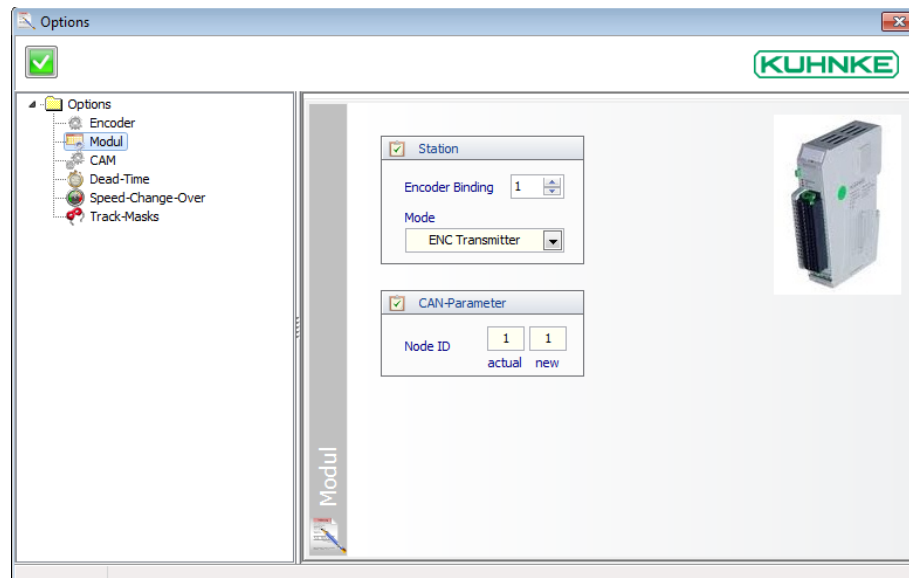
Sets the node ID

You need to assign a node ID (CAN address) to the FIO CAM Control module before you can add it to a CANopen network.

The node ID you set in this dialog will be stored in the module memory when you upload the cam program.

Enter the unit's current node ID into the box above "actual".

Enter another node ID into the box above "new".



NOTE

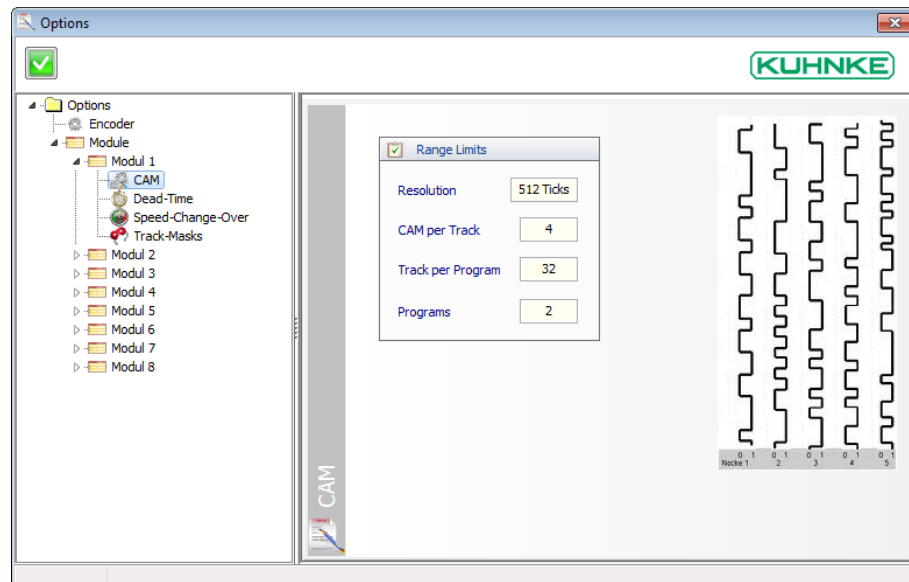
The set node ID will not be used until you upload the program and complete a power cycle (turn the module off and back on again).

7.4.4.3 CAM

Sets the range limits

The panel on the left-hand side of the FIOCAM Creator screen is used for writing the cam programs.

Use the Range Limits dialog to set up the cam program tables for cam creation on the left.



Term	Explanation	Max.
Resolution	Number of ticks/revolution for cam programming	4096
CAM per Track	Cams per track	8
Track per Program	Tracks per cam program	24
Programs	Number of cam programs	32

**NOTE**

Adapt the figures to your needs and try to minimise them.

Resolution

The CAM resolution is the number of ticks per revolution as used for cam programming. It sets the CAM array's X-axis.

The encoder resolution is the number of pulses or encoder positions per revolution. Incremental encoders internally always apply a 4-fold resolution.

Incremental encoder example:

The incremental encoder's resolution is 1000.

- Go to Project, Options, Encoder, Resolution and enter "1000 Ticks".

This will enable the FIO CAM Control module to count 4000 ticks per revolution.

Every encoder pulse received sets off the module's interrupt processing routine.

You may wish to apply a speed reduction in order to reduce the interrupt load on the FIO CAM Control module.

- Go to Control, Options, Module x, CAM, Resolution and enter "500 Ticks".

This will set cams between 0 and 499 ticks for the cam program and CAM array's X-axis will end at 500.

In this case, the FIO CAM Control module will process every 8th encoder pulse.

**NOTE**

Aim for an integral ratio of 4-fold encoder resolution and CAM resolution.

Thus, best practice is to first set the minimum resolution required for programming (CAM resolution).

This is equivalent to the minimum number of ticks per revolution.

Divide this number by 4 and you will get the required encoder resolution.

**NOTE****Absolute EtherCAT encoder**

If you are using an Absolute EtherCAT encoder, changing the module resolution will just affect the view of the CAM Creator's CAM array.

To set the CAM module to actually process every xth value, you must run CODESYS and divide its encoder setting by x.

In the example below, you would have to divide by 16:

The screenshot shows two configuration windows side-by-side. The left window is titled 'Encoder-Data' and has a checked checkbox. It contains a 'Type' dropdown menu set to 'Absolute EtherCAT' and a 'Resolution' text box containing '8192 Ticks'. The right window is titled 'Range Limits' and also has a checked checkbox. It contains a 'Resolution' text box containing '512 Ticks'.

CAM per Track

Number of cams per track.

Track per Program

Number of tracks per cam program.

Programs

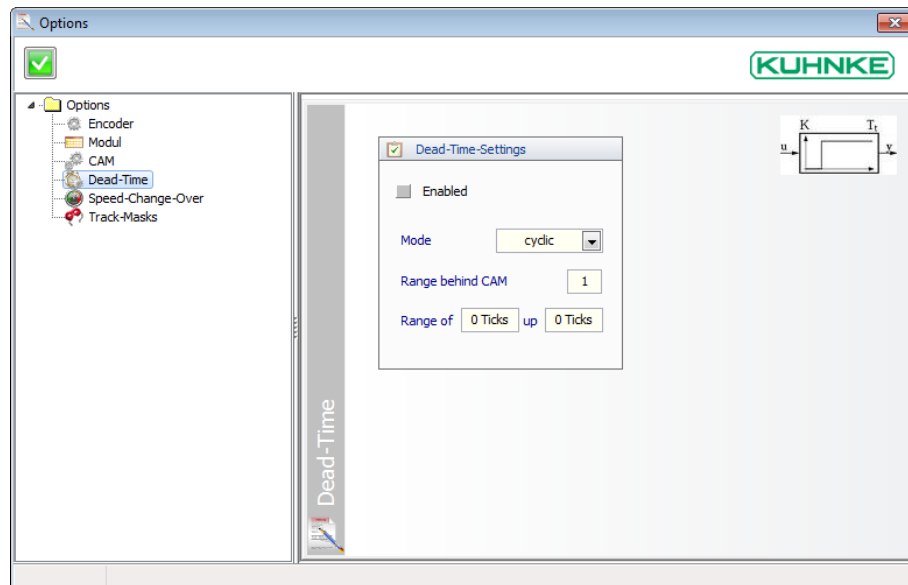
Number of cam programs.

7.4.4.4 Dead-Time

Sets the limits and effects of dead time compensation.

Go to Control/Dead-Times to separately set the dead times of each track (5.4.1 Dead-Times).

Dead times are computed cyclically; section 5.4.4.1 Encoder explains how to set the cycle time for computation.



Enabled:

- Tick this box to enable dead time compensation.

Mode :

Dead time compensation mode

- **cyclic** cyclic calculation of dead times, i.e. after every clock pulse (see Options/Encoder/Cycle-Time; 5.4.4.1 Encoder)
- **in the range** (currently not implemented).
Range behind CAM No.
Dead time calculation in the range after cam no.
- **synchronized** (currently not implemented).
All dead times are calculated at the zero point

Range behind CAM

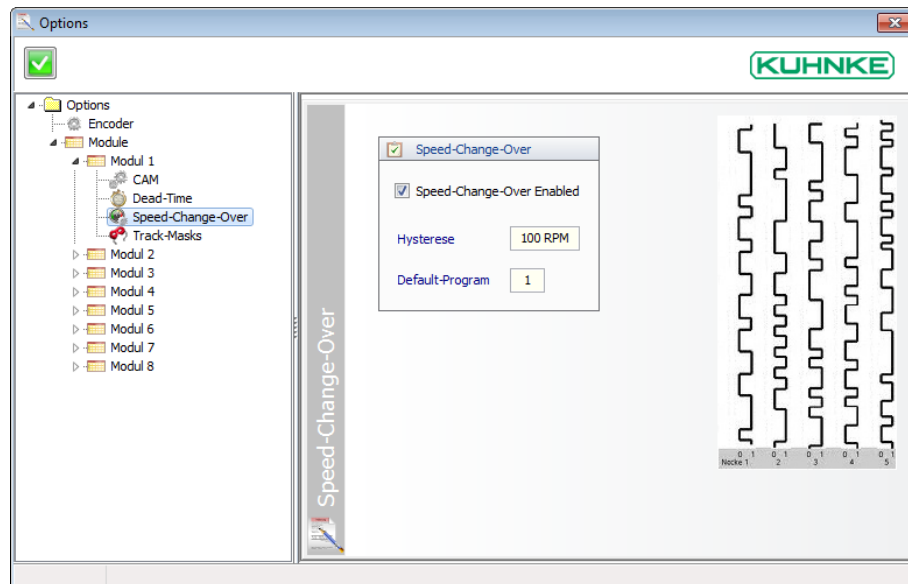
Dead time calculation in the range after cam no. x.

Range ... of ... up.

Dead time calculation in the range from ... to ... ticks after the cam selected above.

7.4.4.5 Speed-Change-Over

Properties for a speed-dependent change of program:



You may run various cam programs triggered at different speed limits.
Go to Control / Speed-Change-Scale (see 5.4.2 Speed Change Scale) to set up this table.

Use the Speed-Change-Over dialog to set the basic properties:

Speed-Change-Over Enabled:

- Tick this box to run the cam programs with reference to the actual speed.

Hysteresis

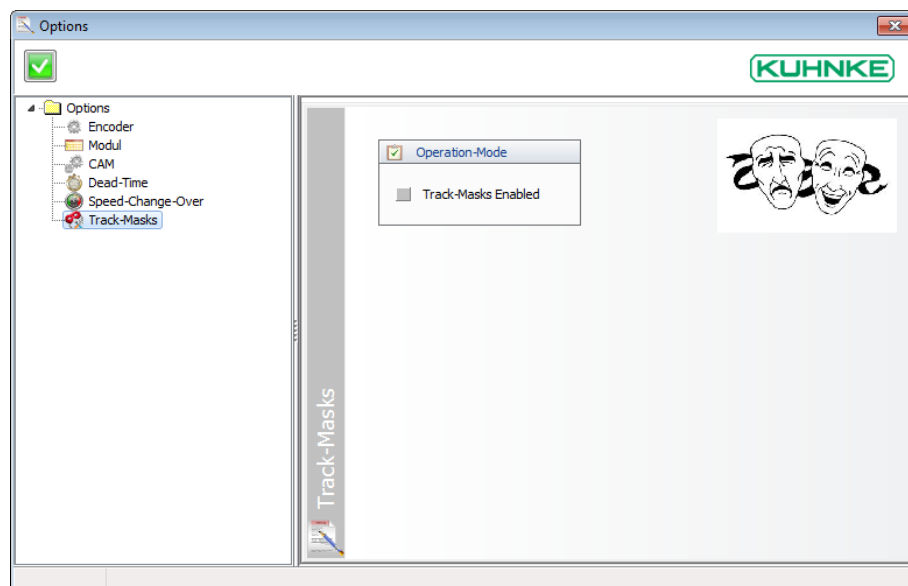
Permanent changes of cam program while the speed is near the change-over limit can be avoided by setting a hysteresis (input range: 0 ... 100 rpm)

Default-Program

This function is not available when the Speed-Change-Over is enabled. If it is not, you can use this setting to specify the cam program to be started with by default. This is required to use the Online-Change feature.

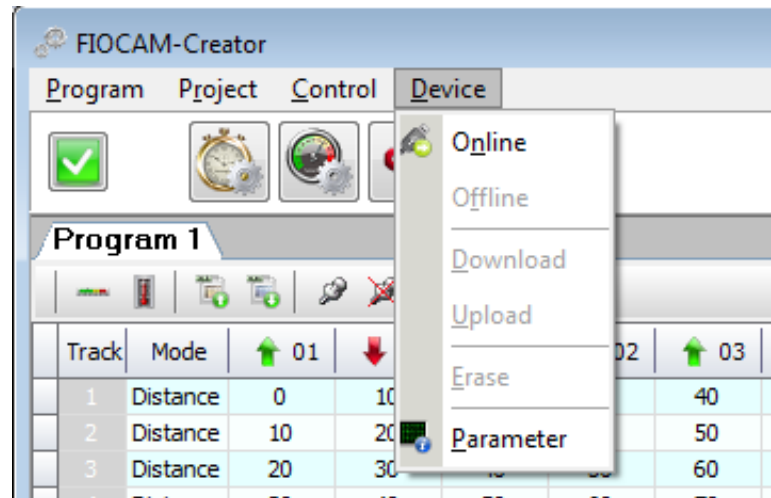
7.4.4.6 Track Masks

Enables the track masking table set up under Control/Track-Mask (5.4.3 Track Masks).



7.5 Device

This section details the FIOCAM Creator's online functions.



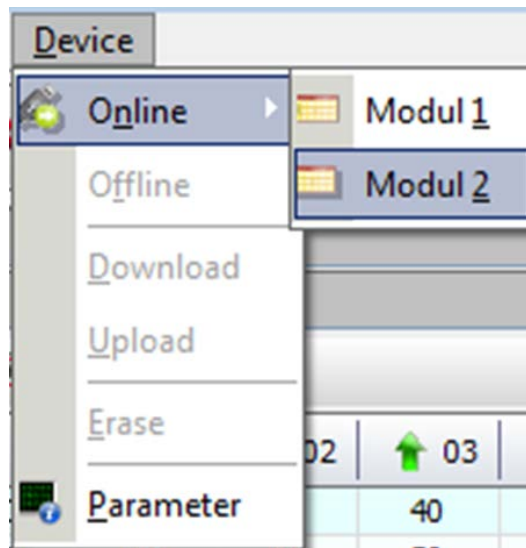
7.5.1 Online



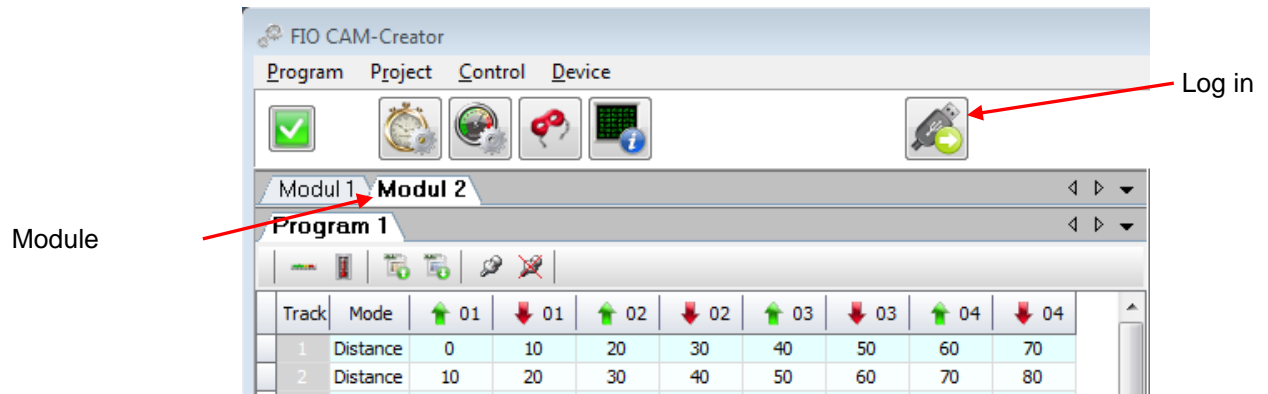
Use this option to enable the online connection you selected at Project/Settings/Links (5.3.5.4 Link).

Module selection

Used for option Online/Module x to log in to the set module.



Another method is to click on the appropriate module tab and log in from there.



7.5.2 Offline



Use this option to disable the online connection you selected at Project/Settings/Links (5.3.5.4 Link)

7.5.3 Download



This function uses the online link to download the cam project from the programming PC to the FIO CAM Control module.

7.5.4 Upload

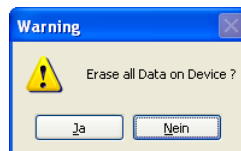


This function uses the online link to upload the cam project from the FIO CAM module to the programming PC.

7.5.5 Erase



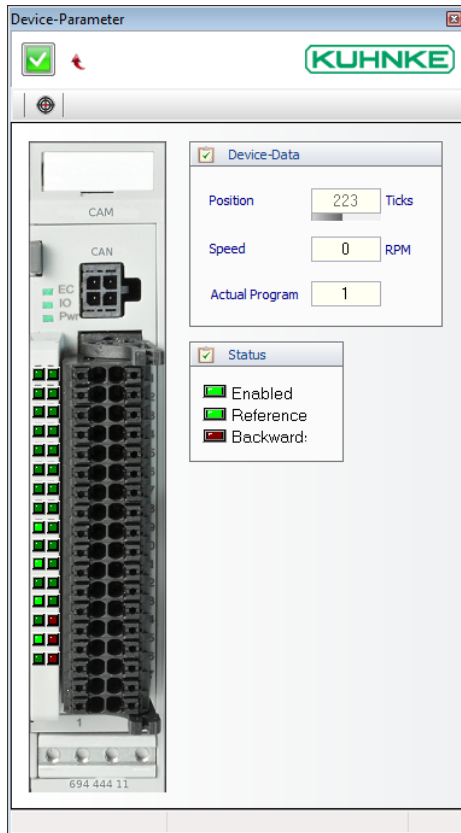
Choose to remove the cam program from the FIO CAM Control module. You will have to confirm a security prompt before the program is actually removed.



7.5.6 Parameter



The "Device Parameter" screen display the online status of the FIO CAM Control module.



Set Reference:



Click on this icon to set the position to "zero".

Device Parameter, module LED status:

Term	Explanation
Enabled	Outputs enabled
Referenced	Counter referenced
Backwards ³	Encoder runs in reverse

Device Data:

Term	Explanation
Position	Current position, in ticks
Speed	Speed, in revolutions per minute
Actual Program	Number of program that is currently running

³ In reverse, all FIOCAM module calculations are off

8 Examples

8.1 CODESYS software solution

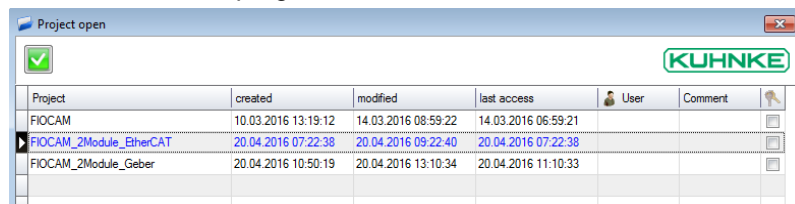
The example discussed in this section tells you how to set up two FIO CAM Control modules in "PositionSet" mode in conjunction with an Absolute EtherCAT encoder. Both modules will run in slave mode. Make the following settings:



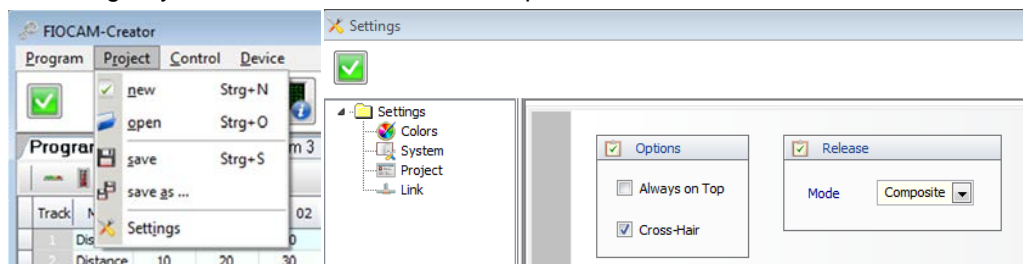
NOTE

*If you set the position in CODESYS only, interim values will not be interpolated, i.e. cams might be skipped. This can only be avoided by setting the speed.
Remember to set the speed in ticks per cycle time.*

Run FIOCAM Creator and select a cam program, here: FIOCAM_2Module_EtherCAT.

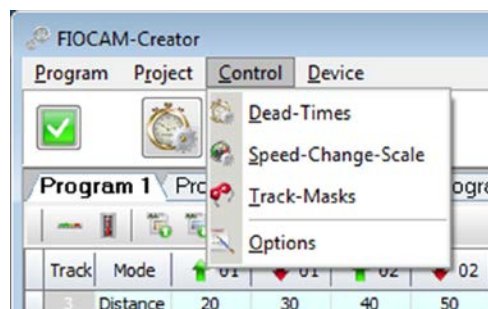


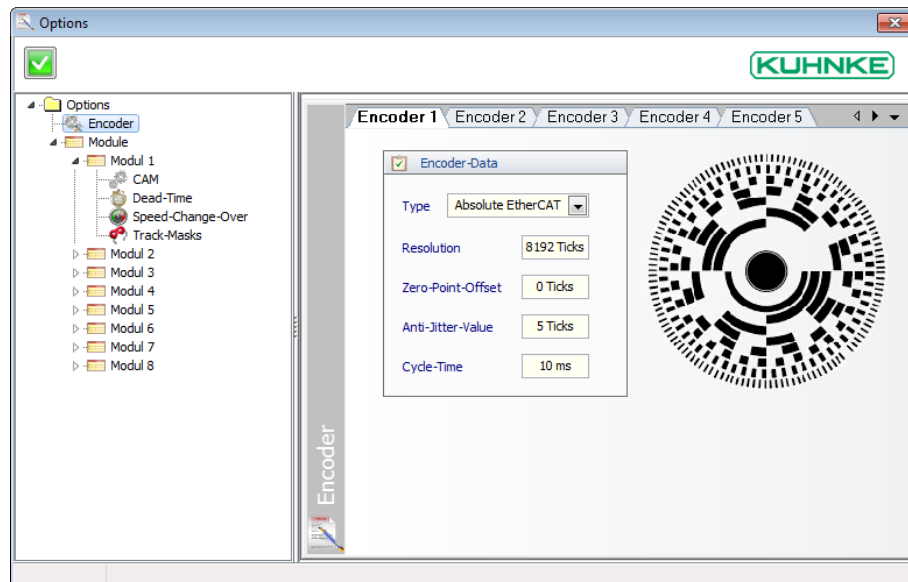
Go to Project/Settings/System and set Release to Composite



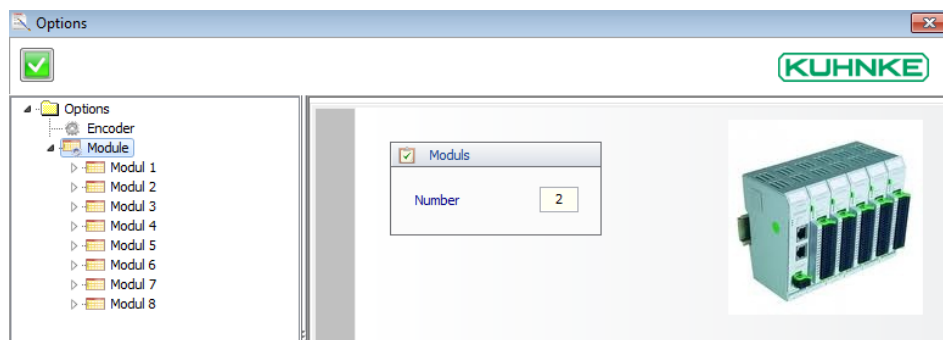
Pick the link from section 5.3.5.4 Link.

Absolute EtherCAT encoder settings. This example uses Encoder1 set to Absolute EtherCAT and 8192 ticks.



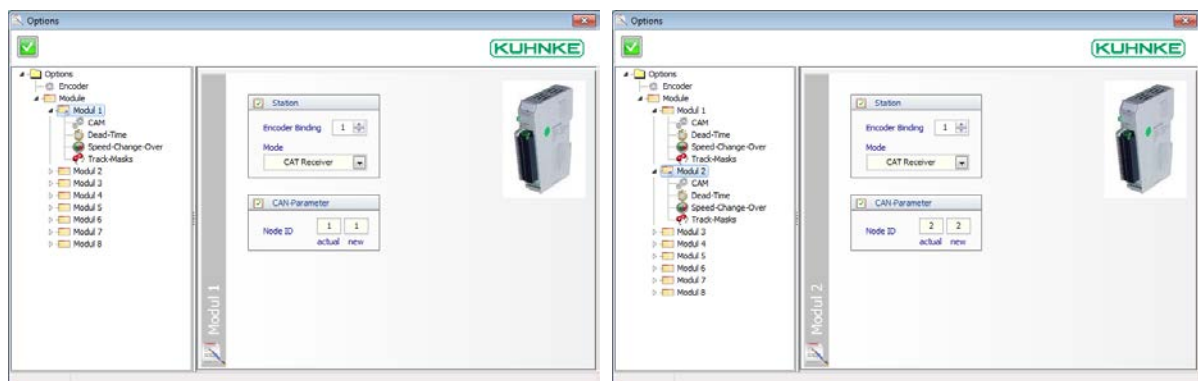


Number of FIO CAM Control modules: two



You will still see all 8 modules but only two of them will be needed for the remaining settings.

Set both FIO CAM Control modules' Encoder Binding to 1 and the Mode to "CAT Receiver". Set the Node IDs to 1 and 2, respectively.



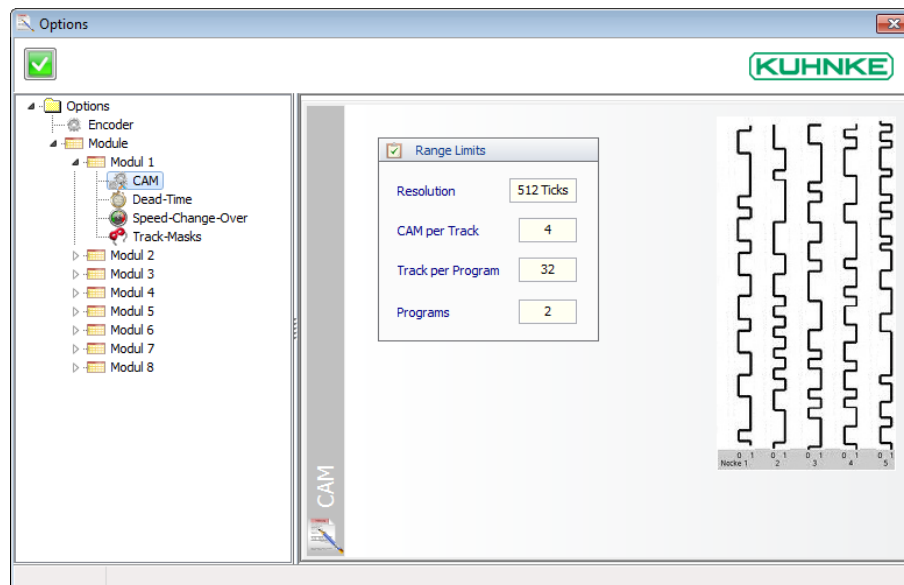
Set the resolution of both CAM modules to <= 4096 (5.4.4.3 CAM)

**NOTE****Absolute EtherCAT encoder**

If you are using an Absolute EtherCAT encoder, changing the module resolution will just affect the view of the CAM Creator's CAM array.

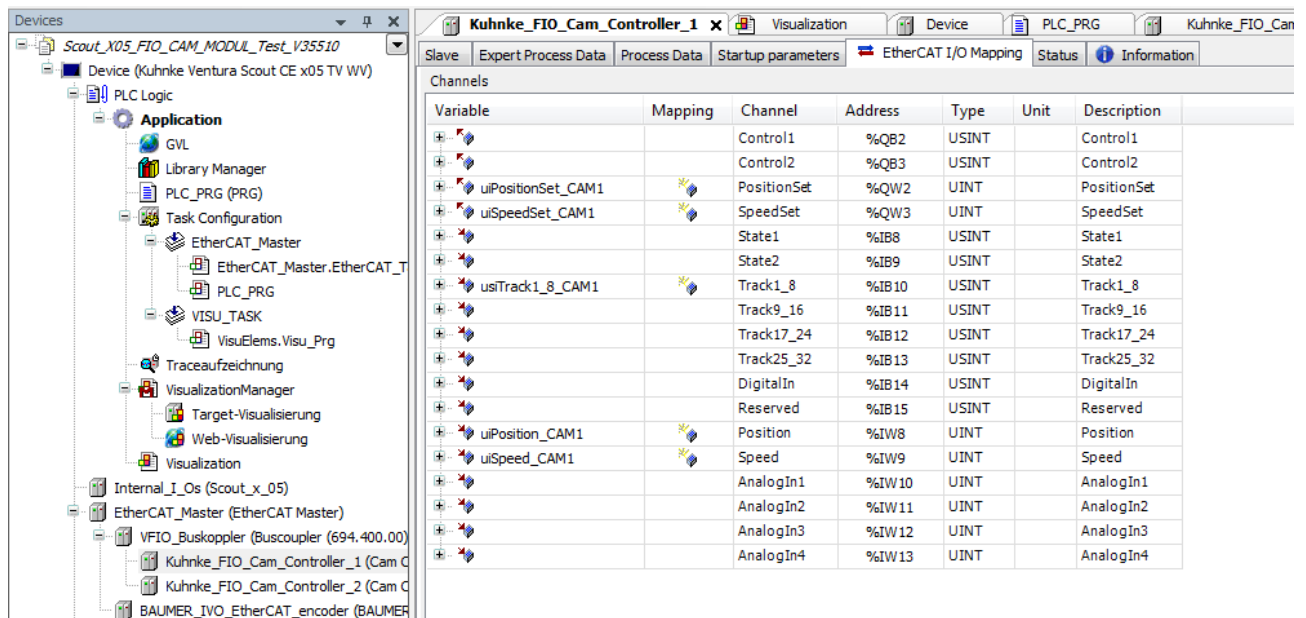
To set the CAM module to actually process every xth value, you must run CODESYS and divide its encoder setting by x.

In this case, the resolution is set to 512 ticks, which means that you will also have to divide CODESYS' encoder value by 16.



Now download the cam program to the modules (see 5.5.3Download).

The last item you need is a CODESYS project which might look as follows:



Use output variable "uiPositionSet_CAM1" to set the position and "uiPosition_CAM1" to display the actual position, e.g.:

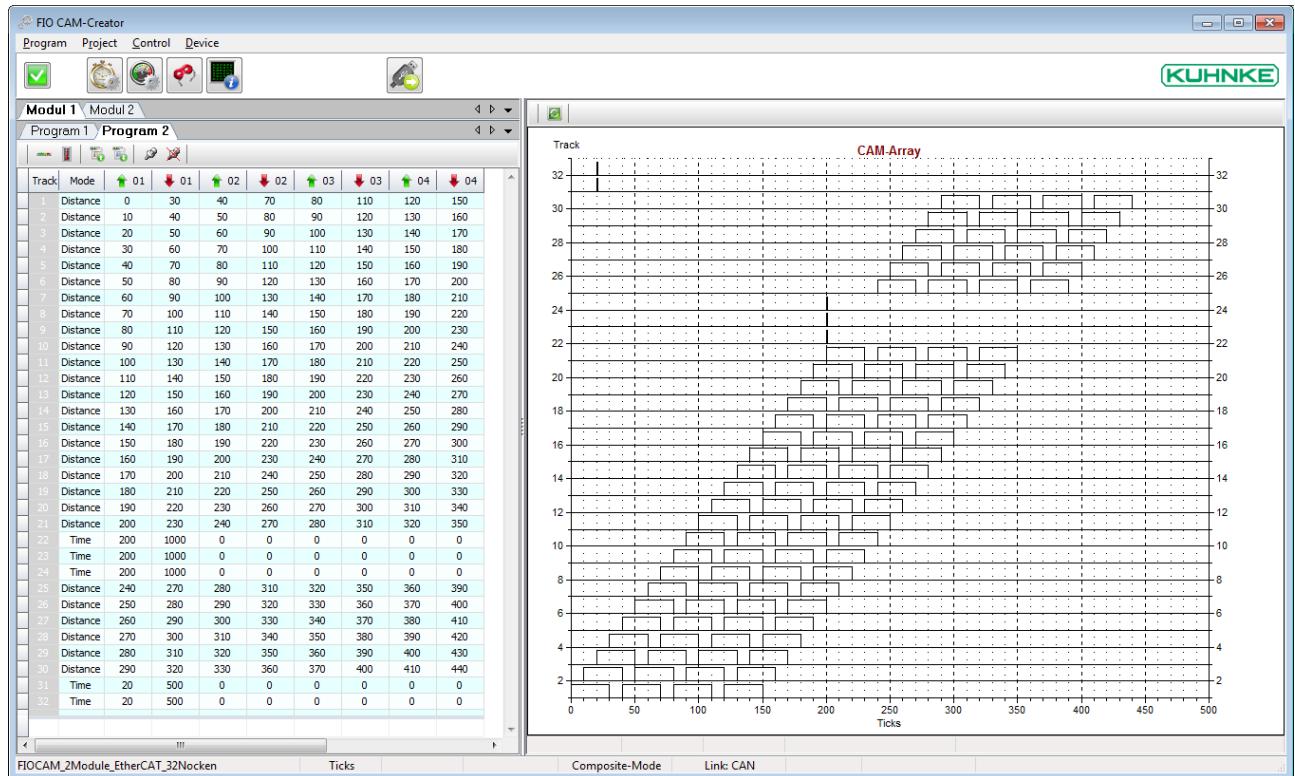
```
uiPositionSet_CAM1[466] := uiPositionSet_CAM2[466] := UDINT_TO_UINT(udintEtherCatGeberPosition[7457] / uiGearReduction_AbsolutEtherCATEncoder[16])
```

8.2 Time cam example

Time cams enable the use of cams with constant times which solely depend on the triggering edge.

The application currently supports 5 time cams per cam program

The example below uses time cams on tracks 22-24, 31 and 32. The time cams on tracks 31 & 32 start at 20 ticks and go on for 500 ms. The time cams on tracks 22 to 24 start at 200 ticks and go on for 1 sec. The CAM array only shows the starting points because the rest of the time curve depends on the encoder speed.



9 Appendix

9.1 Technical data

Function

Digital Outputs (Tracks)..... 8x0,5A (DO0..DO7)
 16x0,1A (DO8..DO23)

Total current 6A

Digital inputs 1 x 24 VDC, 1 ms

Dig./analogue inputs 4 x 24 VDC or 0..10 V

Incremental encoder 24 VDC A, B, Ref

Cams / track 8

Dead time compensation..... 1 to 5000 ms

Cam programs..... 32

CAM module response time 20 µs

Max. speed 1000 rpm

(at 1° resolution)

Controller TMS 320F28234

ASIC ET1200

Fieldbus1 (system) EtherCAT 100 Mbps

EtherCAT file: KuhnkeEtherCATModulesAll.xml

Connector 10-pole system plug in side wall

Terminating module not required

Power supply from EtherCAT coupler via E-bus connector

E-bus load..... 215 mA

Electrical insulation module/module and modules/bus

Fieldbus2 CAN max. 1 Mbps

EDS file: CamModule.eds

Electrical insulation..... yes

General

Power supply 24 VDC -20% +25%

WxHxD..... 25x120x90 [mm]

Installation..... 35 mm DIN rail

Storage temperature..... -25 ...+70 [°C]

Working temperature 0...+55 [°C]

Relative humidity 5...95 [%], non-condensing

Protection IP20

Immunity zone B

Part no. 694.444.11

9.2 Order specifications

Name	Part no.	ID no.	Technical data	IO/power connector
Kuhnke FIO IO modules				
Kuhnke FIO CAM Control	694.444.11	186.682	Page 22	36-pole

Name	Part no.	ID no.	Technical data
Kuhnke FIO connector			
FIO connector, 36-pole, 1x	694.101.36.01	178.642	Push-in, releasing lever
FIO connector, 36-pole, 20x	694.101.36.20	178.643	Push-in, releasing lever

9.3 References

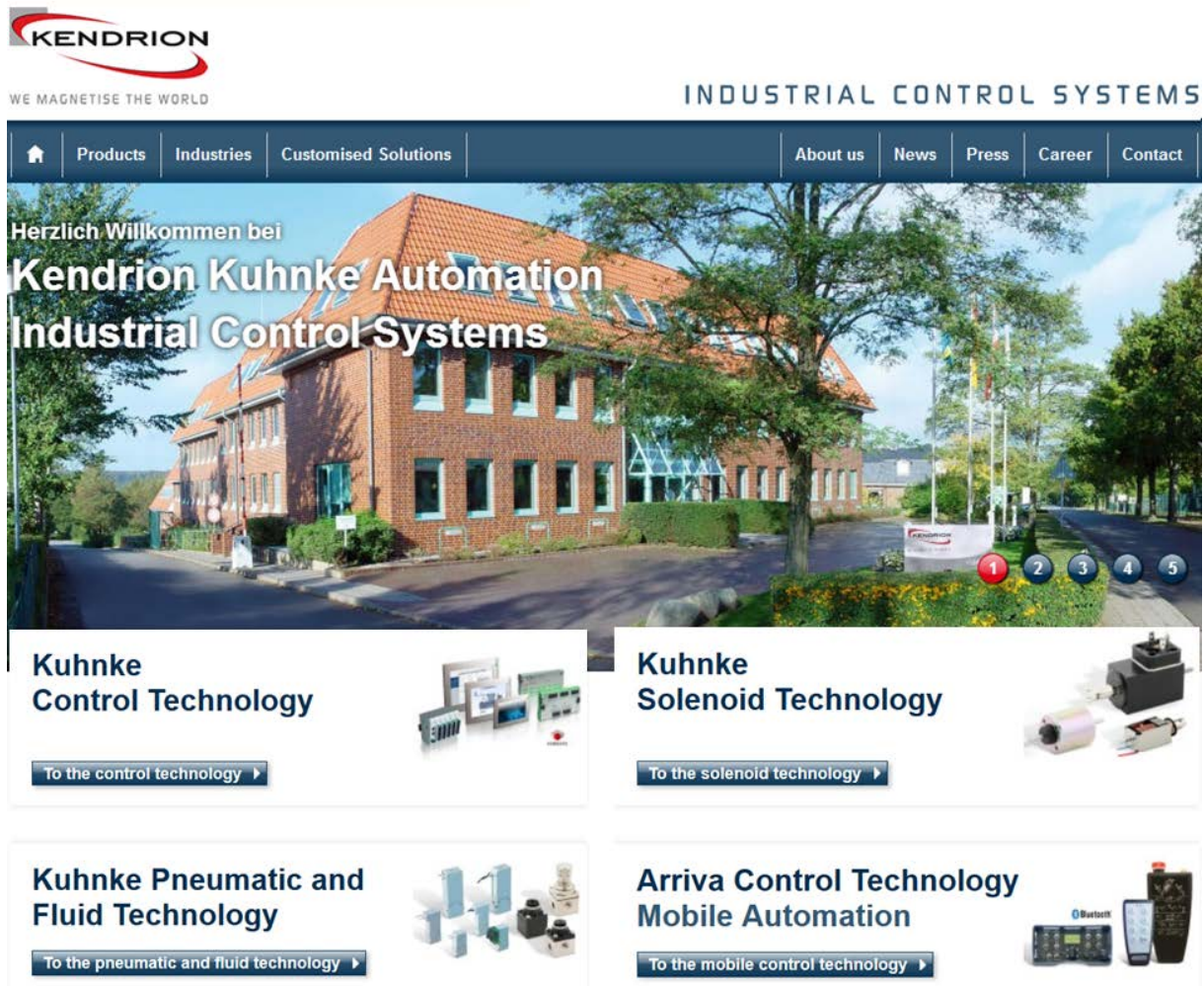
<i>Title / Subject</i>	<i>Number</i>	<i>Source</i>
Kuhnke FIO Instruction Manual	E 747 GB	http://productfinder.kuhnke.kendrion.com/
Kuhnke Scout Manual	E 804 GB	http://productfinder.kuhnke.kendrion.com/
EtherCAT, Technology, FAQs, Downloads		http://www.ethercat.org
CANopen, Technology, FAQs, Downloads		http://www.can-cia.org

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10 Sales & Service

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