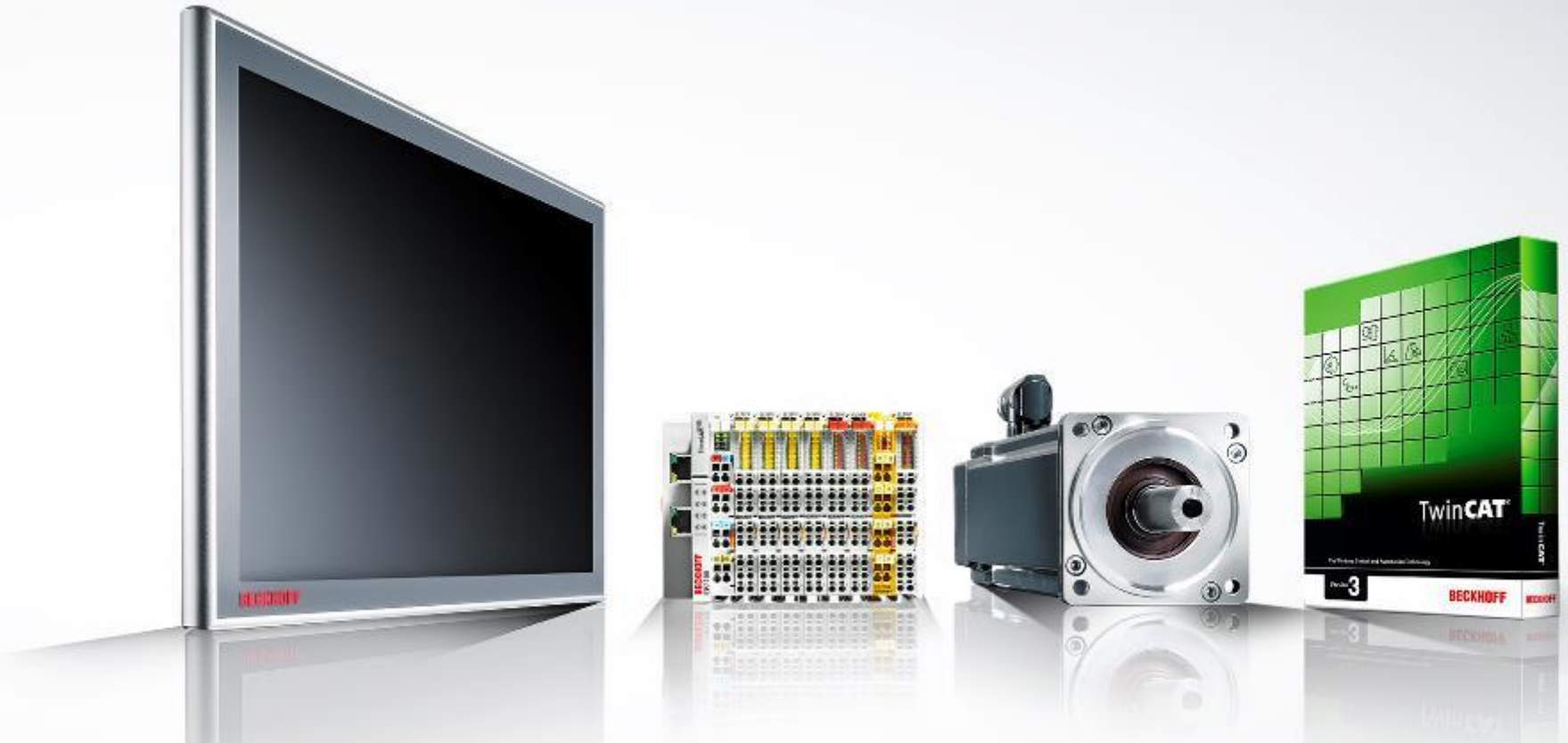
Beckhof 特色产品介绍 - IO组 —— PWM 输出模块

BECKHOFF



刘记忠

2016.12.05

本文档的适用范围：

EL2502	KL2502
EL2535	KL2512
EL2545	KL2535
EL2595	KL2545

Beckhof 特色产品介绍 IO组 —— PWM 输出模块

内　容

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1. 功能介绍
2. 推荐的应用场合
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4. 案例分析
5. 配套的Demo程序
6. FAQ

Beckhof 特色产品介绍 IO组 —— PWM 输出模块

1. 功能介绍

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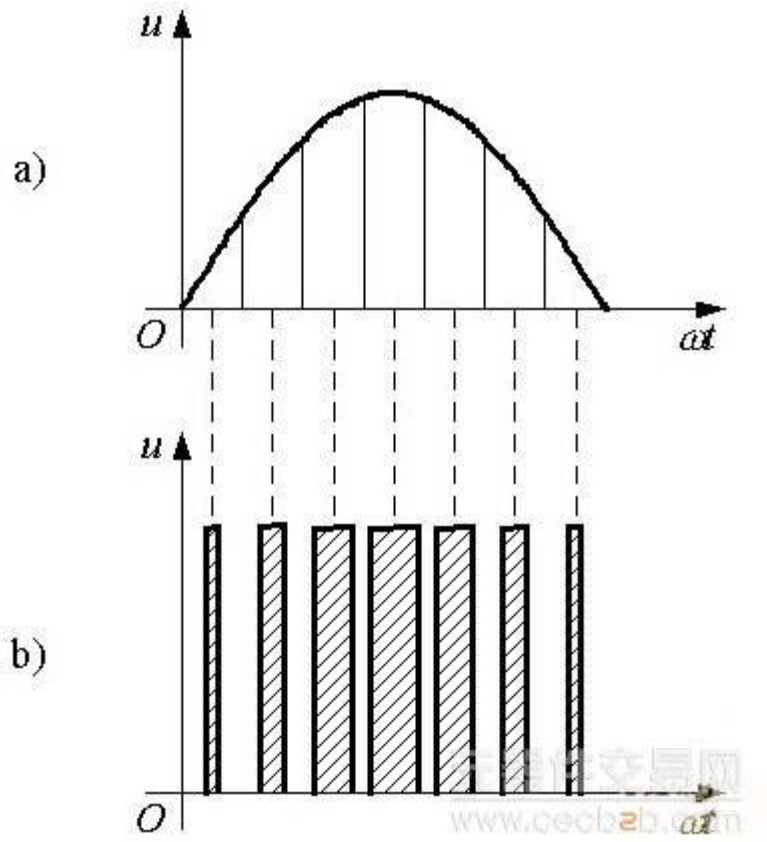
➢ Pulse Width Modulation 脉冲宽度调制

是利用微处理器的数字输出来对模拟电路进行控制的一种非常有效的技术，广泛应用在从测量、通信到功率控制与变换的许多领域中。

简而言之，**PWM是一种对模拟信号电平进行数字编码的方法。**

方波的占空比被调制用来对一个具体模拟信号的电平进行编码。

PWM信号仍然是数字的，电压或电流源是以一种通(ON)或断(OFF)的重复脉冲序列被加到模拟负载上去的。
只要带宽足够，任何模拟值都可以使用PWM进行编码。

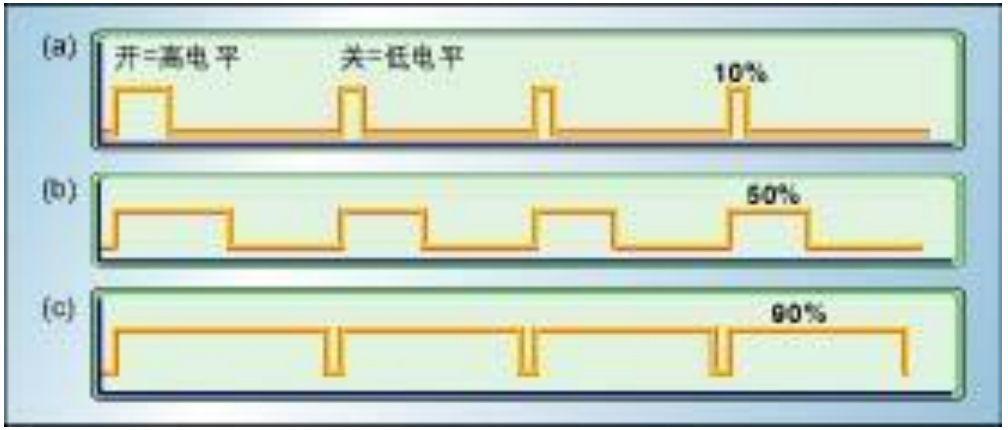


1. 功能介绍

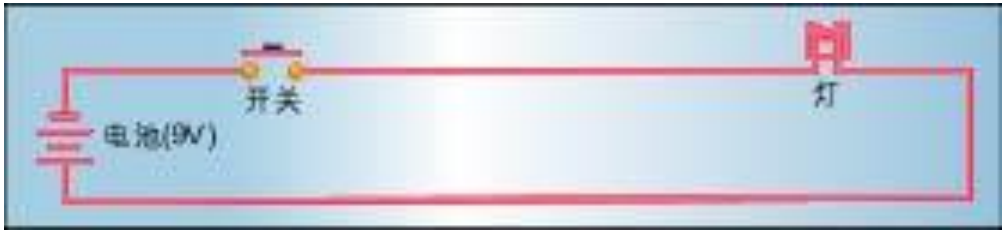
- 基本控制要素

占空比

调制频率



三种不同的PWM信号



使用PWM进行驱动的简单电路

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1. 功能介绍 EL2502附加功能

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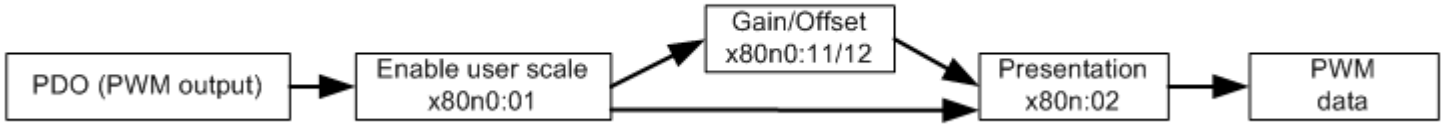
➢ 附加功能

The parameters are considered in the following order:



- Presentation

In the CoE a channel parameter *Presentation* (x80n0:02) can be set. This affects the consideration of the PWM-PDO (16 bit):

- signed (default): value range 0...$7FFF_{hex}$/32767_{dec} for 0..100% duty factor
- unsigned: value range 0...$FFFF_{hex}$/65535_{dec} for 0..100% duty factor
- Absolute value with MSB as sign
- Absolute value

- User scaling
- Channel synchronization (from firmware10) 通道同步功能

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1. 功能介绍 EL2502附加功能

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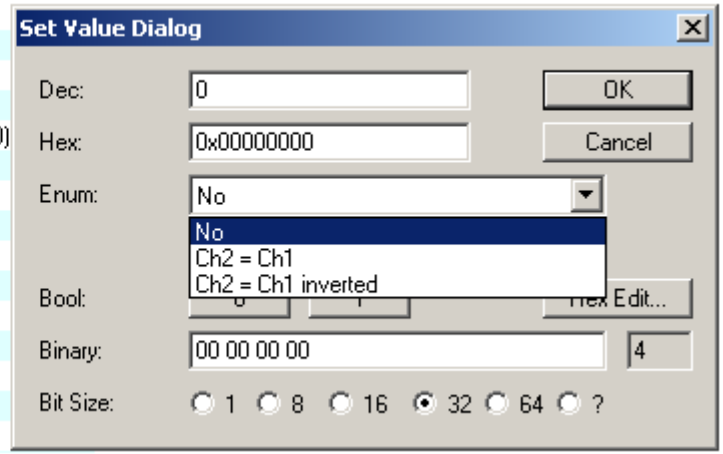
➢ 附加功能

- Channel synchronization (from firmware10) 通道同步功能

7010:0	PWM Outputs Ch.2	RO	> 19 <
8000:0	PWM Settings Ch.1	RW	> 22 <
8000:01	Enable user scale	RW	FALSE
8000:02	Presentation	RW	Signed Presentation (0)
8000:05	Watchdog	RW	Default Watchdog value (0)
8000:07	Operation mode	RW	PWM 20Hz...20kHz (0)
8000:09	Channel synchronisation	RW	No (0)
8000:11	Offset	RW	0
8000:12	Gain	RW	65536
8000:13	Default output	RW	0x0000 (0)
8000:14	Default output ramp	RW	0xFFFF (65535)
8000:15	Period PWM 20Hz..20kHz[µs]	RW	0x0FA0 (4000)
8000:16	Period PWM 1Hz..20kHz [µs]	RW	0x000186A0 (100000)
800E:0	PWM Internal data Ch.1	RO	> 2 <
8010:0	PWM Settings Ch.2	RW	> 22 <



Function:

- No: no dependence of channel 2 on channel 1
- Ch2 = Ch1: Frequency and duty factor of channel 1 are also applied to channel 2.
  The phase angle is 0, i.e. the rising/falling edges of channels 1 and 2 arrive at the same time and channel 2 outputs the same as channel 1.
- Ch2 = Ch1 inverted: Frequency and duty factor of channel 1 are also applied to channel 2, but the duty factor is inverted.
  The phase angle is 0, i.e. a rising edge of channel 1 arrives at the same time as a falling edge of channel 2 etc.

Notes

- the *ChannelSynchronisation* setting is also present in channel 2, but has no effect there or rather is not to be used.
- on activating or deactivating the function in the CoE, an invalid phase angle briefly occurs (naturally) on channel 2.

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2. 推荐的应用场合（１）EL2502

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➢ 应用领域

通信与控制

PWM的一个优点是从处理器到被控系统信号都是数字形式的，无需进行数模转换。让信号保持为数字形式可将噪声影响降到最小。噪声只有在强到足以将逻辑1改变为逻辑0或将逻辑0改变为逻辑1时，也才能对数字信号产生影响。

对噪声抵抗能力的增强是PWM相对于模拟控制的另外一个优点，而且这也是在某些时候将PWM用于通信的主要原因。从模拟信号转向PWM可以极大地延长通信距离。在接收端，通过适当的RC或LC网络可以滤除调制高频方波并将信号还原为模拟形式。

➢ PWM硬件控制器

许多微控制器内部都包含有PWM控制器。例如，Microchip公司的PIC16C67内含两个PWM控制器，每一个都可以选择接通时间和周期。

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2. 推荐的应用场合（2） EL2595

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单通道 LED恒电流模块EL2595

- 特别适用于LEDs灯光控制
- 单个或多个串联的LED灯
- 超短时间的闪烁功能，脉宽长度可从1微秒到无限
- LED闪烁时机控制可以通过分布式时钟的时间戳功能实现

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3. 技术参数 型号列表

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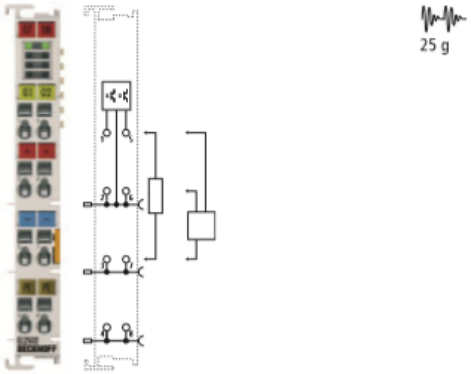
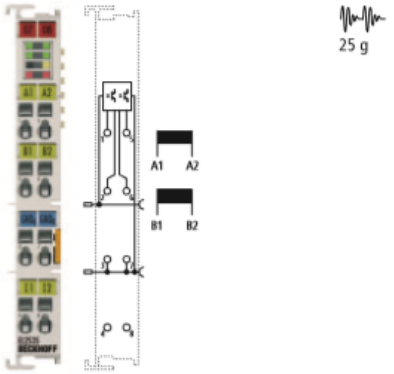
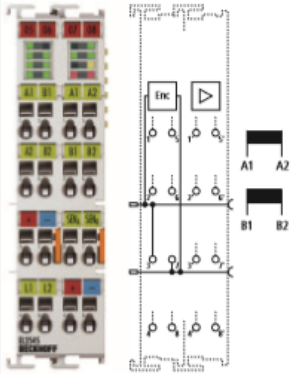
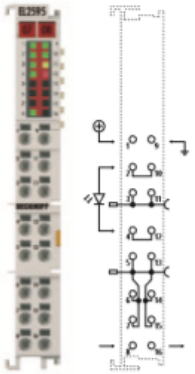
E-Bus模块

2-channel pulse width output terminal, 24 V DC, 0.5 A	2-channel pulse width current terminal, 24 V DC, 1 A, current-controlled	2-channel pulse width current terminal, 50 V DC, 3.5 A, current-controlled, with incremental encoder	1-channel LED constant current terminal, 2-wire, adjustable
EL2502 | ES2502	**EL2535** | ES2535	**EL2545** | ES2545	**EL2595**
PWM output, push-pull outputs			2-wire
ohmic, inductive, lamp load	ohmic, inductive > 1 mH	inductive	ohmic
0.5 A (short-circuit-proof) per channel	1 A	3.5 A (short-circuit-proof, thermal overload-proof) per channel	700 mA steady load (short-circuit-proof)
2	2	2	1
			
24 V DC (-15 %/+20 %)	24 V DC (-15 %/+20 %)	8…50 V DC	2…48 V DC (controlled automatically)

Beckhof 特色产品介绍 IO组 —— PWM 输出模块

3. 技术参数 型号列表

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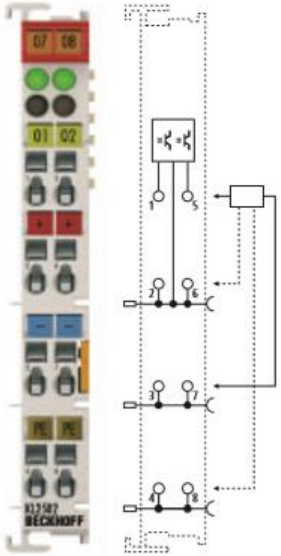
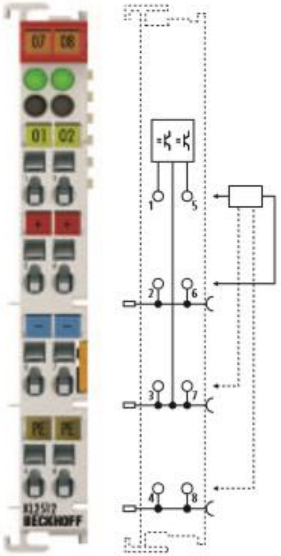
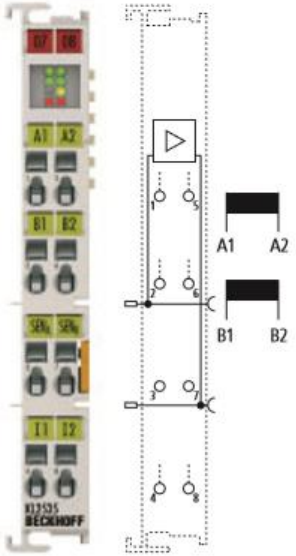
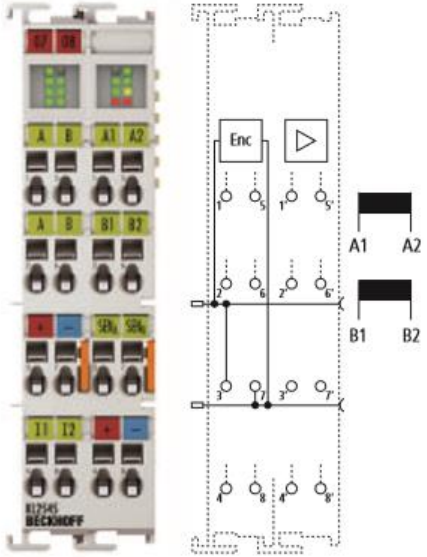
K-Bus模块

2-channel pulse width output terminal, 24 V DC	2-channel pulse width output terminal, 24 V DC	2-channel pulse width current terminal, 24 V DC	2-channel pulse width current terminal, 50 V DC
KL2502 | KS2502	KL2512 | KS2512	KL2535 | KS2535	KL2545 | KS2545
ohmic		inductive > 1 mH, valves, coils	
0.1 A (1 A driver component) per channel	1.5 A per channel	2 x 1 A (short-circuit-proof, thermal overload-proof for both channels together)	2 x 3.5 A (short-circuit-proof, thermal overload-proof for both channels together)
2	2	2	2
			

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3. 技术参数 EL2502

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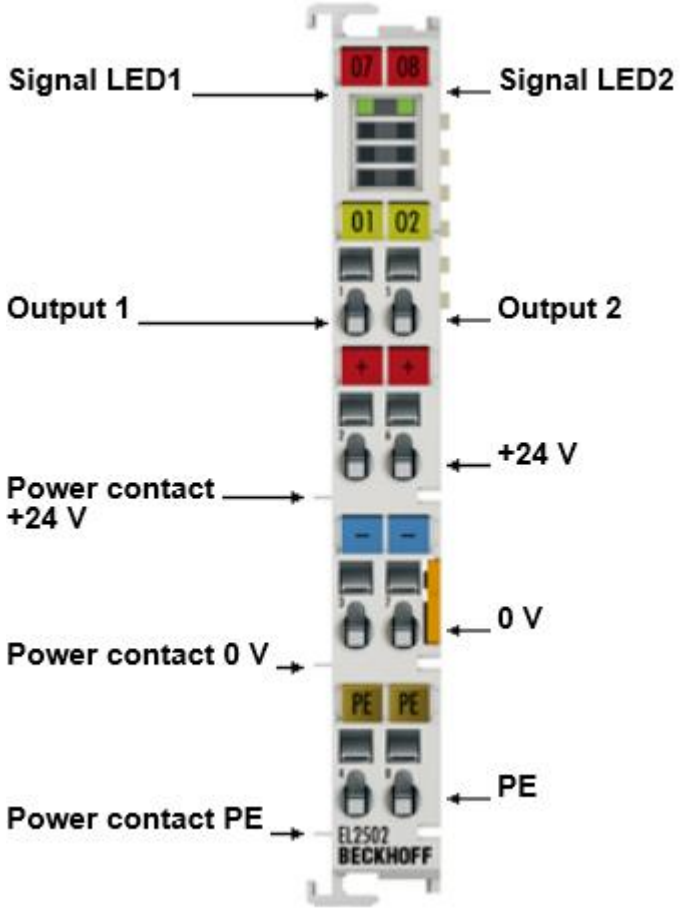
双通道脉冲宽度输出端子模块
24V DC，0.5A



Technical data	EL2502 | ES2502
Connection technology	PWM output, push-pull outputs
Number of outputs	2
Rated load voltage	24 V DC (-15 %/+20 %)
Load type	ohmic, inductive, lamp load
Distributed clocks	–
Max. output current	0.5 A (short-circuit-proof) per channel
Short circuit current	typ. < 1.5 A
PWM clock frequency	20 Hz…20 kHz, 250 Hz default
Base frequency	1…20 kHz, 250 Hz default
Duty factor	0…100 % (T_{ON} > 750 ns, T_{OFF} > 500 ns)
Resolution	10 bit
Reverse voltage protection	yes
Current consumption E-bus	typ. 150 mA
Electrical isolation	500 V (E-bus/field potential)
Current consumption power contacts	typ. 30 mA + load
Bit width in the process image	2 x 16 bit PWM output
Configuration	via TwinCAT System Manager
Special features	separate frequency can be set for each channel
Weight	approx. 50 g
Operating/storage temperature	0…+55 °C/-25…+85 °C
Relative humidity	95 %, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27
EMC immunity/emission	conforms to EN 61000-6-2/EN 61000-6-4
Protect. class/installation pos.	IP 20/variable

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3. 技术参数 EL2535

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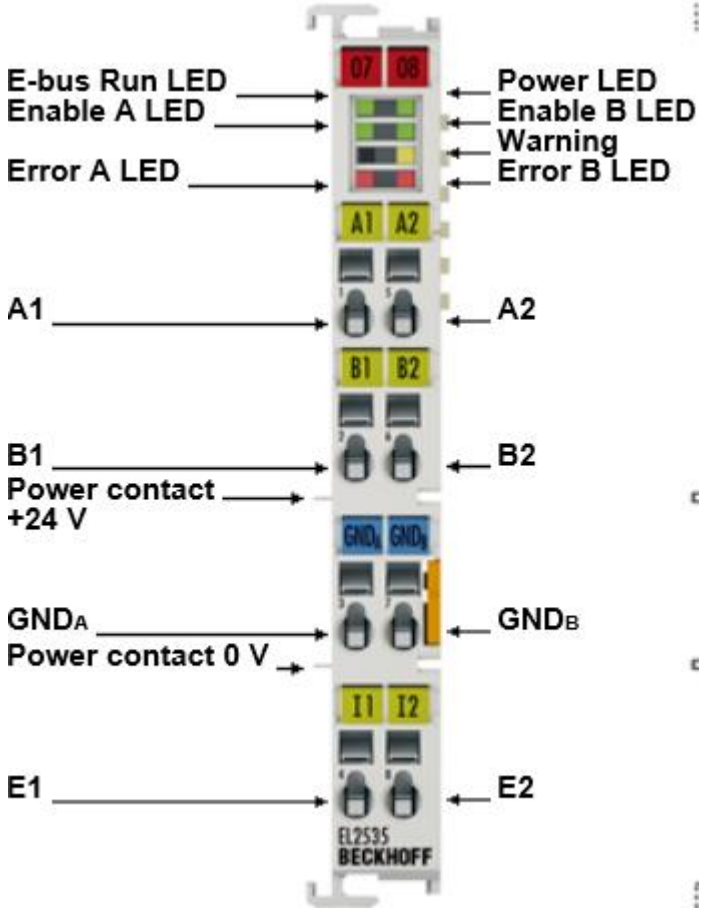
双通道脉冲宽度电流输出端子模块
24V DC， ± 1A



Technical data	EL2535 | ES2535	EL2535-0002	EL2535-0050
Connection technology	PWM output, push-pull outputs		
Number of outputs	2		
Rated load voltage	24 V DC (-15 %/+20 %)		
Load type	inductive > 1 mH		
Distributed clocks	–		
Max. output current	±1 A per channel	±2 A	±50 mA
Short circuit current	typ. < 2 A	< 4 A typ.	< 500 mA typ.
PWM clock frequency	30 kHz default		
Duty factor	0…100 % (current-controlled)		
Resolution	10 bit		
Reverse voltage protection	yes		
Current consumption E-bus	typ. 110 mA		
Electrical isolation	500 V (E-bus/field potential)		
Current consumption power contacts	typ. 30 mA + load		
Bit width in the process image	48 inputs/outputs: 2 x 16 bit data, 2 x 8 bit control/status		
Special features	2 digital 24 V inputs		
Weight	approx. 50 g		
Operating/storage temperature	0…+55 °C/-25…+85 °C		
Relative humidity	95 %, no condensation		
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27		
EMC immunity/emission	conforms to EN 61000-6-2/EN 61000-6-4		
Protect. class/installation pos.	IP 20/see documentation		
Pluggable wiring	for all ESxxxx terminals		
Approvals	CE	CE	CE, Ex

Beckhof 特色产品介绍 IO组 —— PWM 输出模块

3. 技术参数 EL2545

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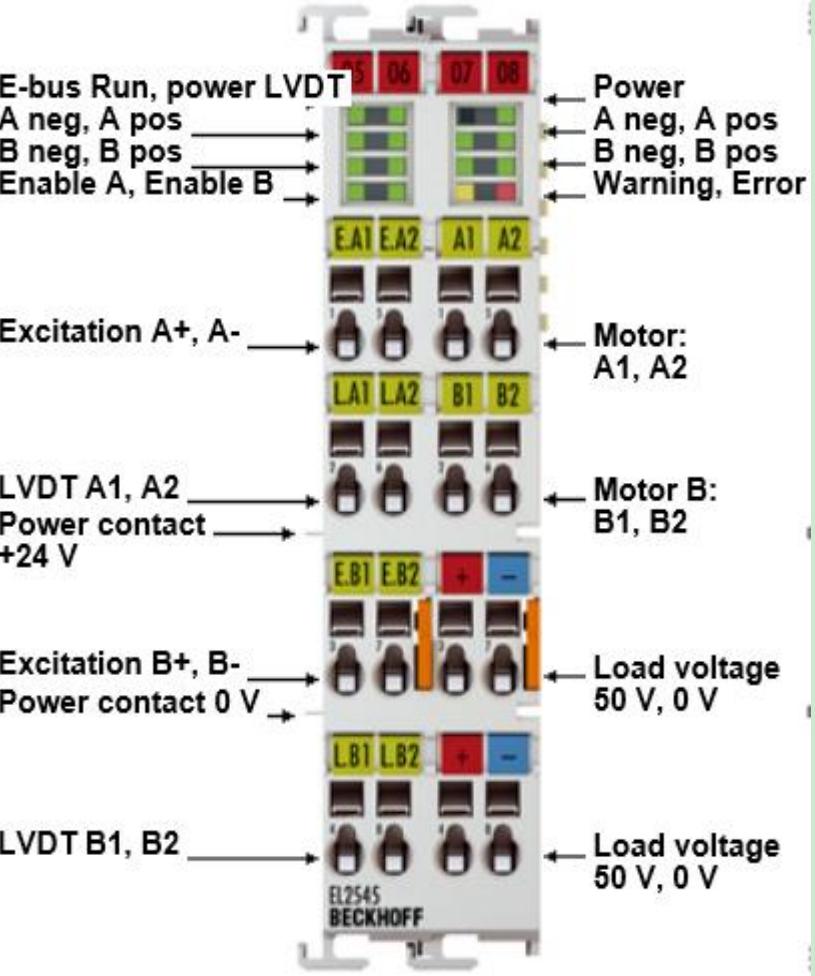
双通道脉冲宽度电流输出端子模块
50V DC， ±3.5 A



Technical data	EL2545 | ES2545
Connection technology	PWM output, push-pull outputs
Number of outputs	2
Rated load voltage	8…50 V DC
Load type	inductive > 1 mH
Auxiliary voltage	24 V DC via power contacts
Distributed clocks	yes
Max. output current	±3.5 A (short-circuit-proof, thermal overload-proof) per channel
Short circuit current	typ. < 5 A
PWM clock frequency	32 kHz default
Duty factor	0…100 % (current-controlled)
Resolution	12 bit
Reverse voltage protection	yes
Current consumption E-bus	typ. 180 mA
Current consumption auxiliary voltage	typ. 10 mA
Electrical isolation	500 V (E-bus/field potential)
Current consumption power contacts	typ. 50 mA + load
Bit width in the process image	48 inputs/outputs: 2 x 16 bit data, 2 x 8 bit control/status
Configuration	no address setting, configuration via the controller
Special features	with LVDT feedback

Beckhof 特色产品介绍 IO组 —— PWM 输出模块

3. 技术参数 EL2595

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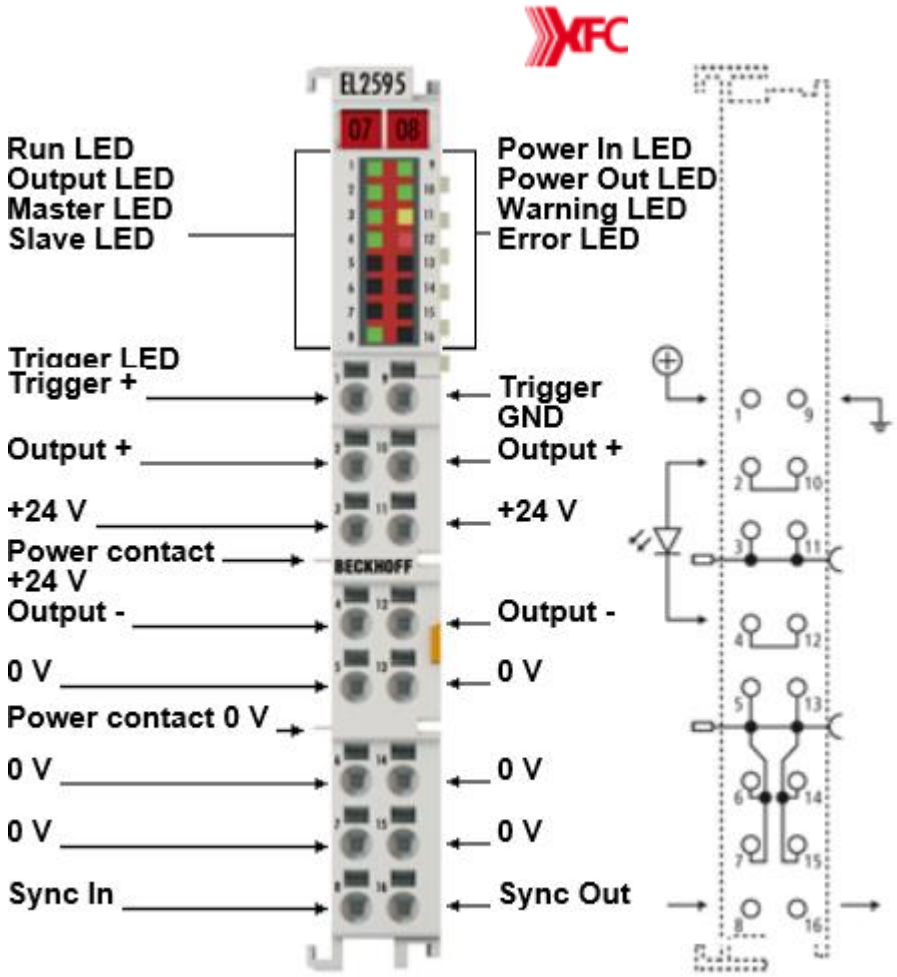
单通道 LED恒电流模块



Technical data	EL2595
Connection technology	2-wire
Number of outputs	1
Rated load voltage	2...48 V DC (controlled automatically)
Load type	ohmic
Distributed clocks	yes
Distributed clock precision	<< 1 µs
Max. output current	700 mA steady load (short-circuit-proof)
Switching times	typ. T_{ON}: < 1 µs, typ. T_{OFF}: < 1 µs
Current consumption E-bus	typ. 130 mA
Electrical isolation	500 V (E-bus/field potential)
Current consumption power contacts	typ. 20 mA + load
Special features	optional automatic operation in case of communication interruption, extensive real-time diagnostics, external trigger input
Weight	approx. 55 g
Operating/storage temperature	0...+55 °C/-25...+85 °C
Relative humidity	95 %, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27
EMC immunity/emission	conforms to EN 61000-6-2/EN 61000-6-4
Protect. class/installation pos.	IP 20/variable
Approvals	CE

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3. 技术参数 KL2502、KL2512

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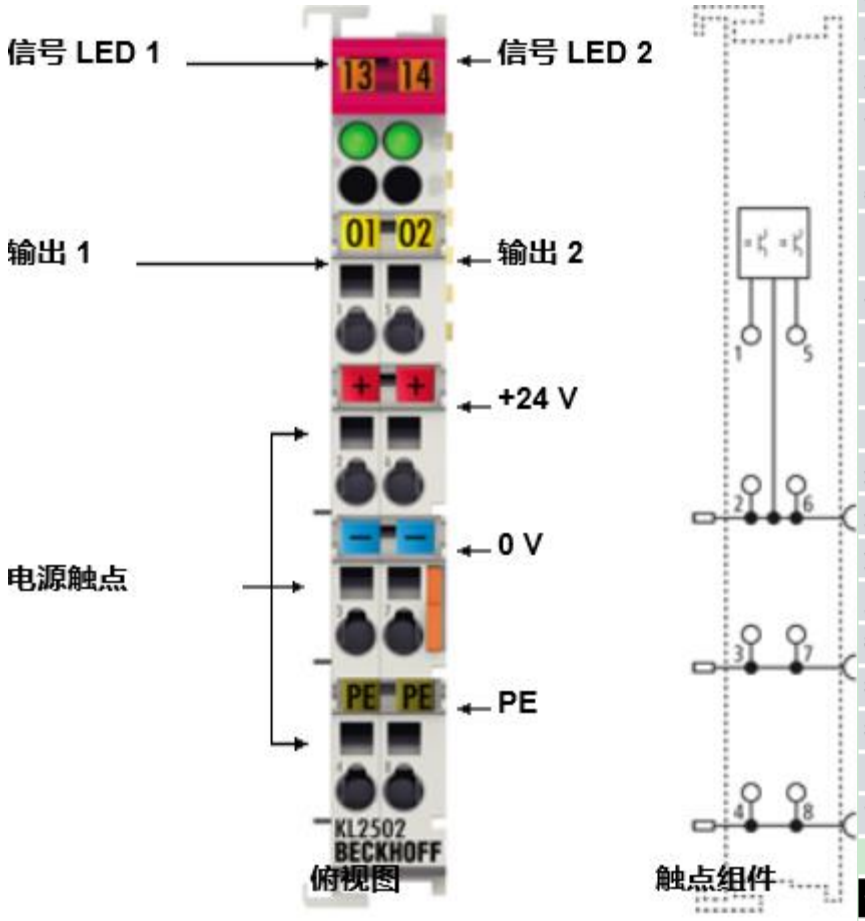

技术参数	KL2502 | KS2502	KL2512 | KS2512
输出点数	2	
额定负载电压	24 V DC (-15 %/+20 %)	
负载类型	电阻式负载, 电感式负载	电阻式负载
最大输出电流	每通道 0.1 A（短路保护，1 A 驱动组件）	每通道 1.5 A
基频	1…20 kHz, 默认为 250 Hz	
占空比	0…100 % (T_{ON} > 750 ns, T_{OFF} > 500 ns)	0…100 %
分辨率	最大 10 位	
电气隔离	500 V_{rms} (K-bus/现场电位)	
电源触点电流消耗	10 mA	
K-bus 电流消耗	18 mA	
过程映像中的位宽	48 点输入/输出：2 x 16 位数据，2 x 8 位控制/状态	
组态	无地址设置，通过总线耦合器或控制器组态	
重量	约 50 g	
工作/储藏温度	0…+55 °C/-25…+85 °C	
相对湿度	95%，无冷凝	
抗振/抗冲击性能能	符合 EN 60068-2-6/EN 60068-2-27/29 标准	
抗电磁干扰/抗电磁辐射性能	符合 EN 61000-6-2 /EN 61000-6-4 标准	
防护等级/安装位置	IP 20/可变	
可插拔接线	适用于所有 KSxxxx 总线端子模块	

专用端子模块	
KL2502-0010	30 kHz 步进电机端子模块
KL2502-0012	输出的延时设置
KL2502-3020	5 V 输出，30 kHz 极限限频

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3. 技术参数 KL2535、KL2545

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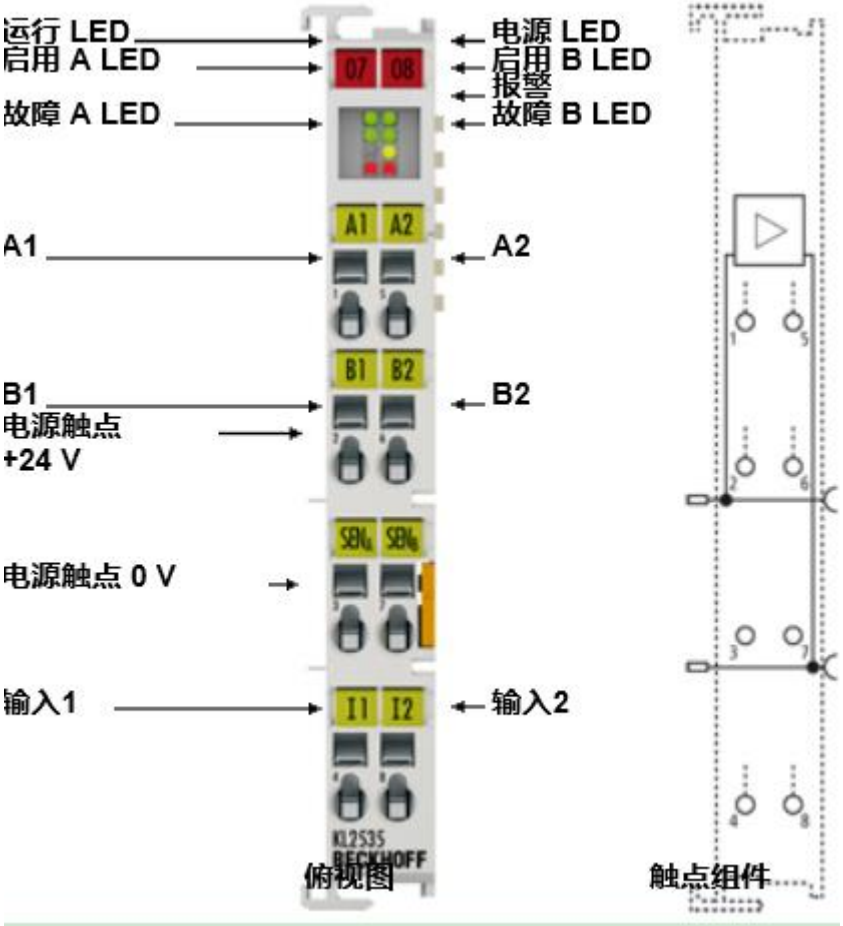

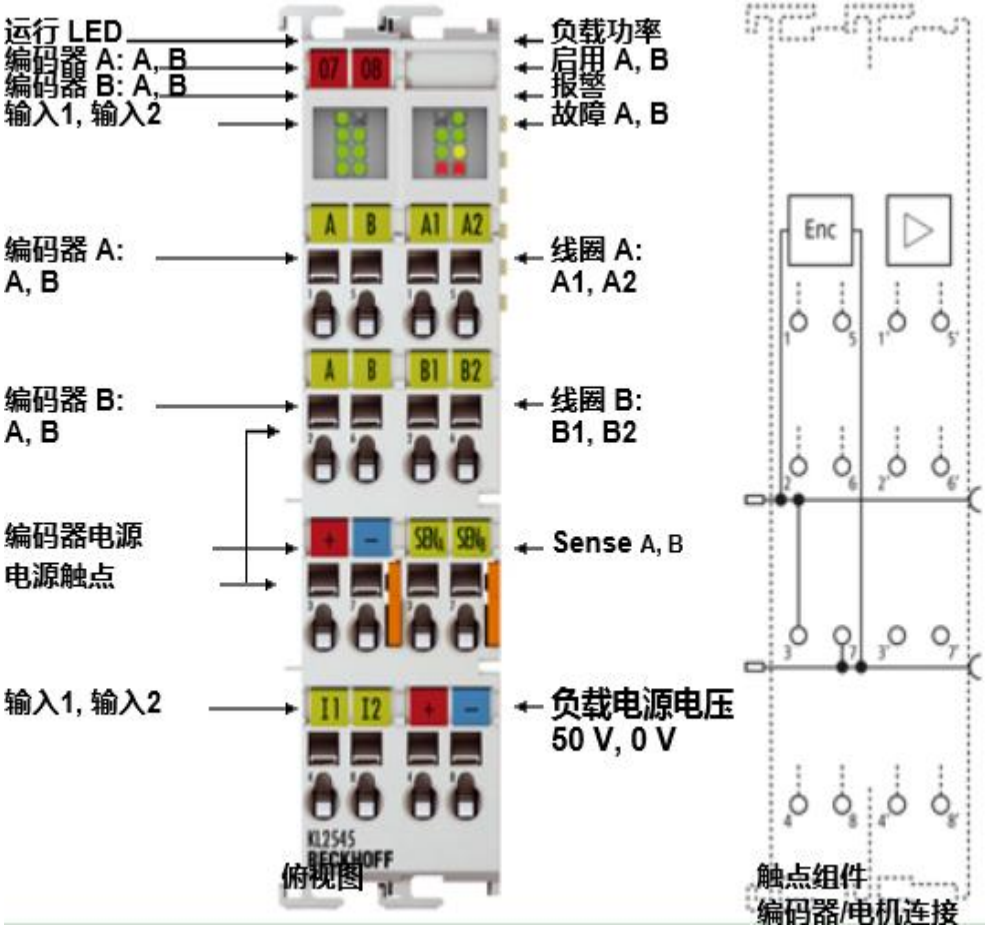

Beckhof 特色产品介绍 IO组 —— PWM 输出模块

4. 案例（１）：EL2502用于激光器控制

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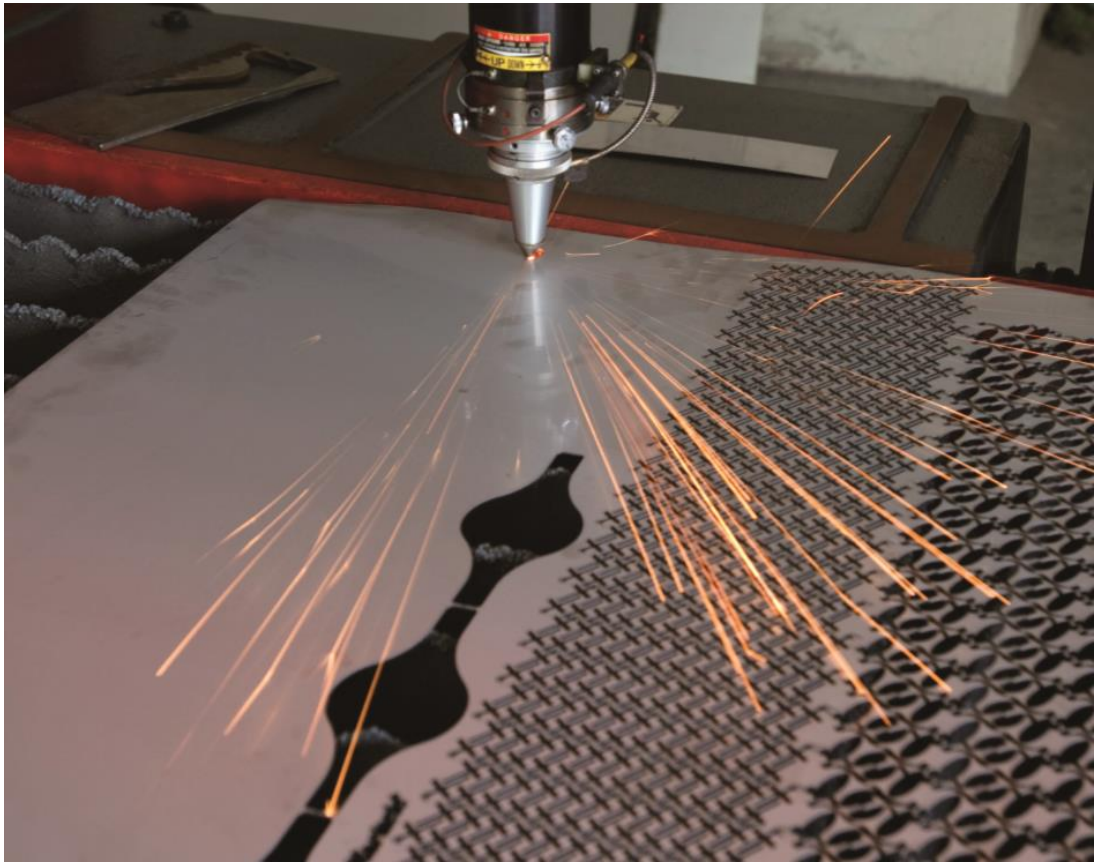
工艺简介：介绍工艺过程，这个模块在其中的作用
设备外观：设备图，或者与模块相关的原理图，
方案优点：与其它方案对比，体现该特色模块的优势
效果展示：文字或者数据说明



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4. 案例（ 2 ）： EL2535用于控制液压系统的比例阀

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工艺简介：介绍工艺过程，这个模块在其中的作用
设备外观：设备图，或者与模块相关的原理图，
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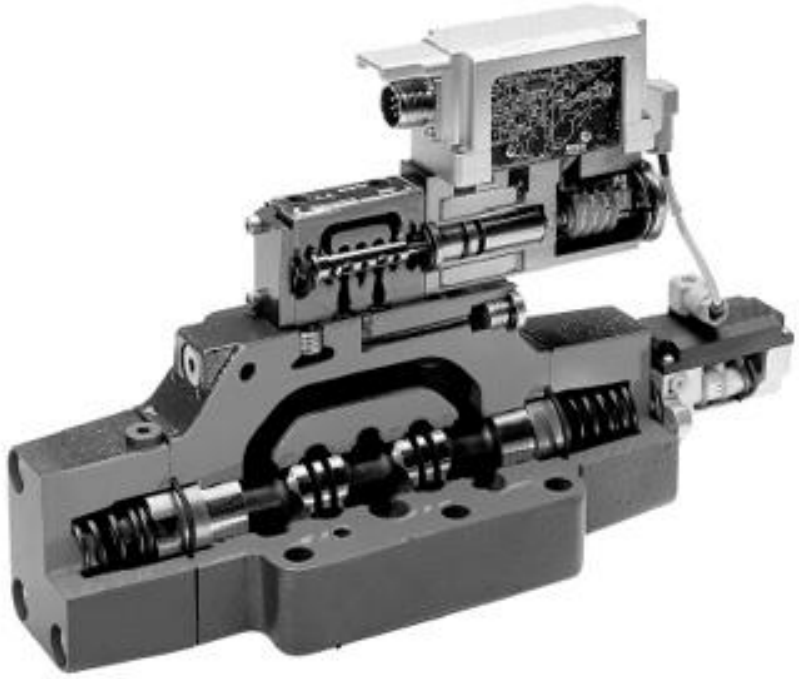
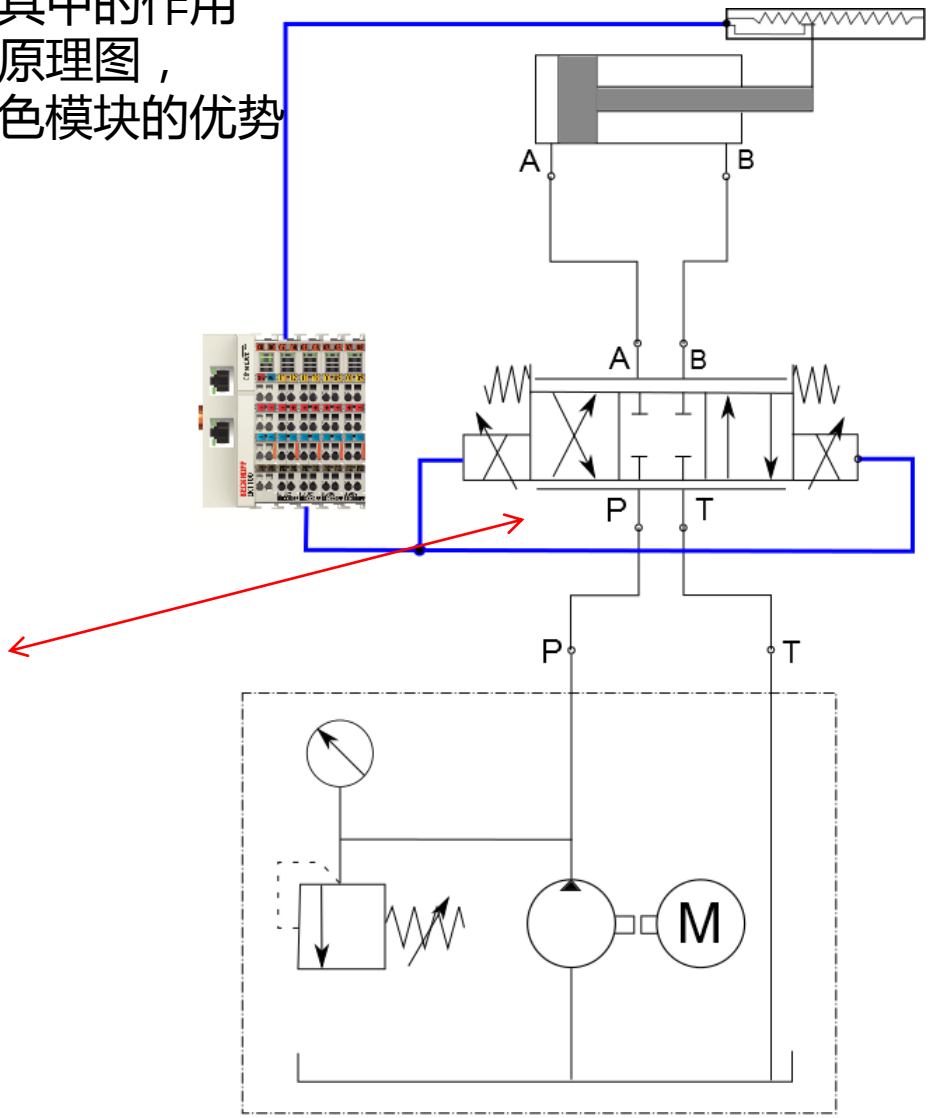
效果展示：文字或者数据说明

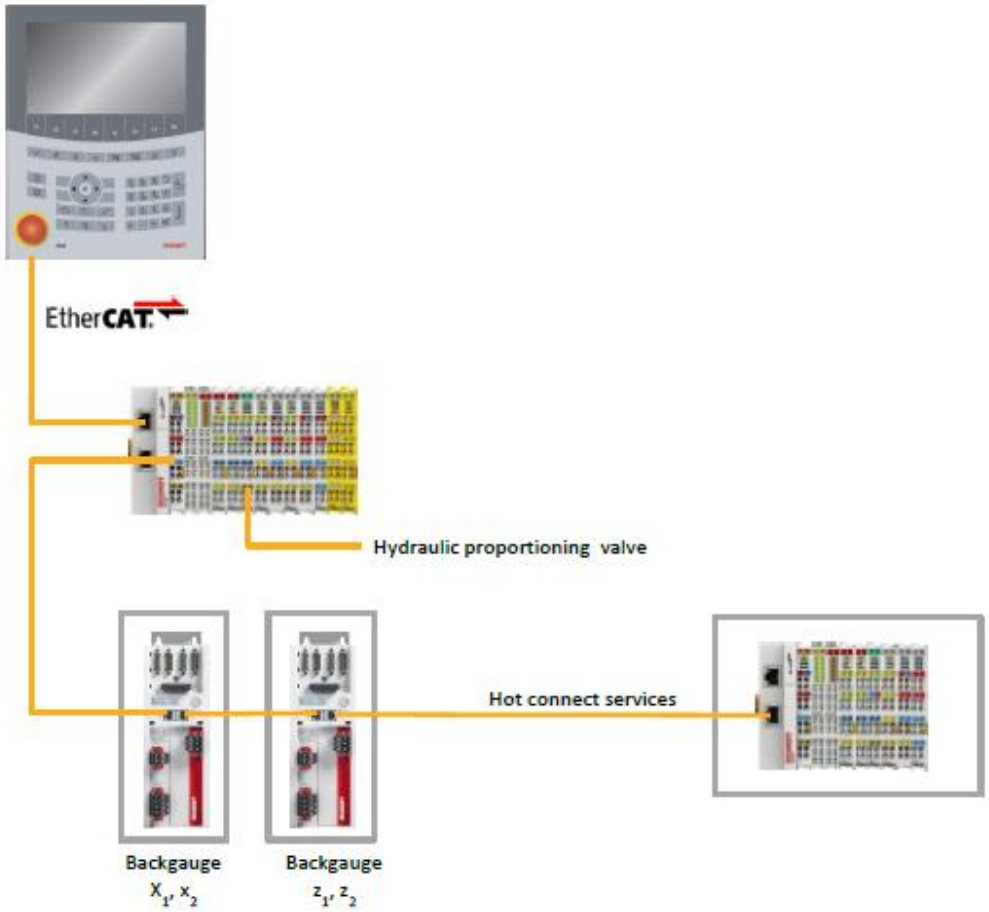




Beckhof 特色产品介绍 IO组 —— PWM 输出模块

4. 案例（ 2 ）： EL2535用于控制液压系统的比例阀

BECKHOFF



- EL2535 控制比例阀输出，EL3062-0015 阀芯位置反馈，实现Y1/Y2轴的精确定位
- EL2535控制系统压力
- EL2535控制挠度补偿
- 优势：可以省掉比例阀的模拟量转电流的驱动模块，达到节省成本的目的。

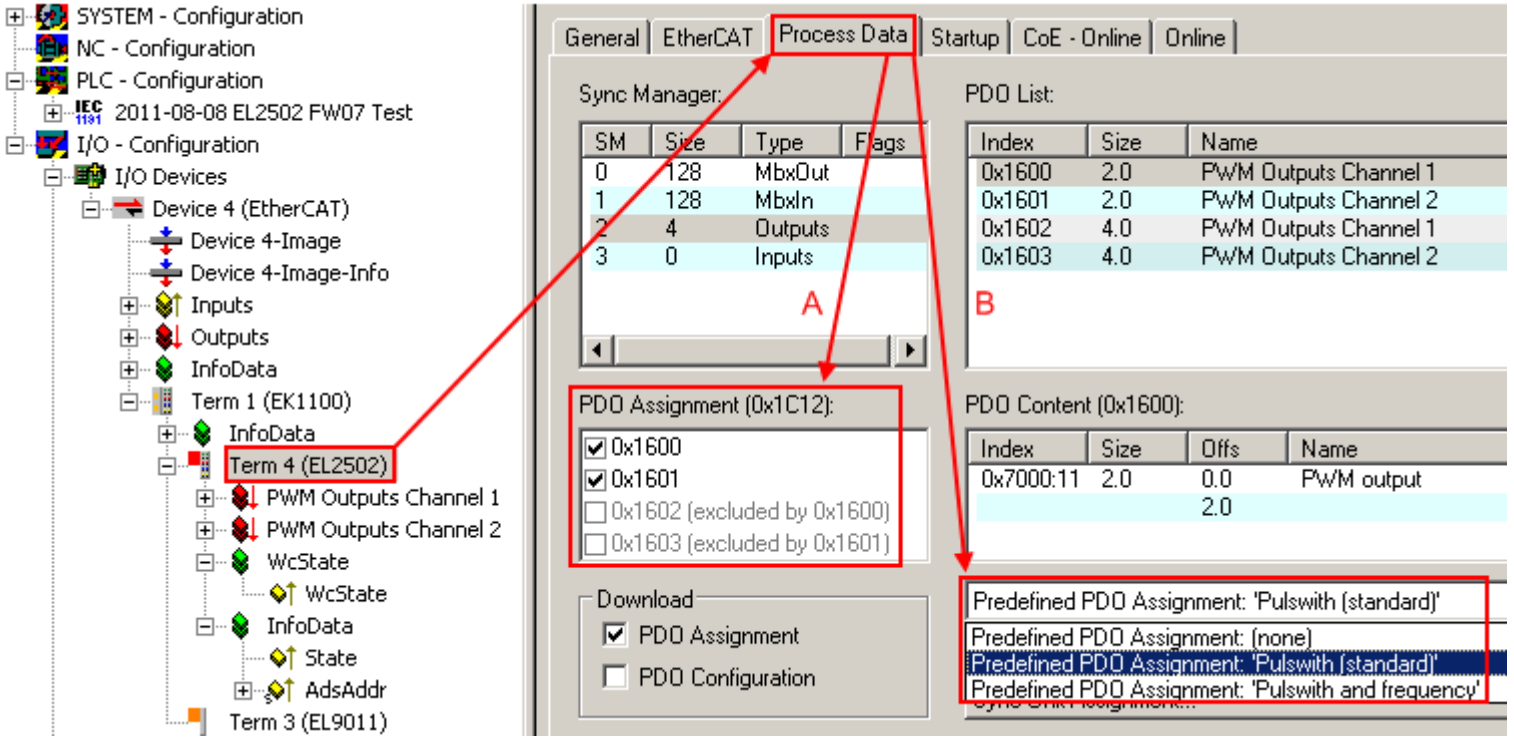
Beckhof 特色产品介绍 IO组 —— PWM 输出模块

5. 模块使用（ 1 ） EL2502

BECKHOFF

- 该模块输出脉宽可调的24V方波，每个通道的最大负载能力是0.5A，占空比（[0..100%]）和频率（[1Hz..20kHz]）都可调。

- 三种工作模式可选



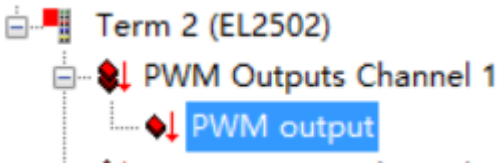
Beckhof 特色产品介绍 IO组 —— PWM 输出模块

5. 模块使用（ 1 ） EL2502

BECKHOFF

- Pulse width (standard) 脉宽（标准模式）：

  -占空比通过过程数据实时修改



  -频率通过CoE修改

  -每个通道的频率操作模式可以通过CoE 80n0:07 (channel 1: n=0, channel 2: n=1) 进行修改

Operation mode	Note	CoE x80n0:07	Period value from	Period unit	Permissible value range	Frequency range
PWM 20 Hz. .. 20 kHz		0	CoE x80n0:15	[1000 ns = 1 µs]	80..32657 (signed) 80..65535 (unsigned)	20 Hz. .. 20 kHz
PWM 100ns frequ. resolution		2	CoE x80n0:15	[100 ns]		153 Hz .. 125 kHz
PWM 1 Hz. .. 20 kHz	From firmware 07, rev. EL2502-0000-0019	3	CoE x80n0:16	[1000 ns = 1 µs]		1 Hz .. 20 kHz

具体的频率设置需要根据上面的相应模式，在CoE 80n0:15或80n0:16修改周期时间来获得

这种模式适用于占空比需要实时修改，但频率不需要实时修改的场合

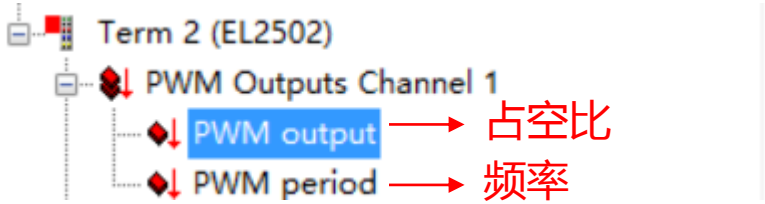
Beckhof 特色产品介绍 IO组 —— PWM 输出模块

5. 模块使用（ 1 ） EL2502

BECKHOFF

- Pulse width and frequency (16 bit), extended
  (from firmware 02, revision EL2502-0000-0017)

脉宽和频率（16位）模式：
-占空比通过过程数据实时修改
-频率[20 Hz .. 20 kHz]也通过过程数据（16 bit unsigned ）实时修改
1 digit = 1 µs period



Operation mode	Note	CoE x80n0:07	Period value from	Period unit	Permissible value range	Frequency range
PWM 20 Hz. .. 20 kHz		not relevant	process data	[1000 ns = 1 µs]	0..65535 (only unsigned)	20 Hz .. 20 kHz (typ. 17 .. 21 kHz)

这种模式适用于占空比和频率都需要实时修改的场合

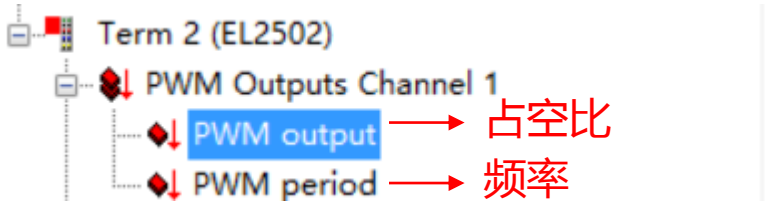
Beckhof 特色产品介绍 IO组 —— PWM 输出模块

5. 模块使用（ 1 ） EL2502

BECKHOFF

- Pulse width and frequency (32 bit), extended
  (from firmware 08, revision EL2502-0000-0021)

  脉宽和频率（32位）模式：
  -占空比通过过程数据实时修改
  -频率[1 Hz .. 20 kHz]也通过过程数据（32 bit unsigned ）实时修改
  1 digit = 1 µs period



Operation mode	Note	CoE x80n0:07	Period value from	Period unit	Permissible value range	Frequency range
PWM 20 Hz. .. 20 kHz		not relevant	process data	[1000 ns = 1 µs]	0..65535 (only unsigned)	20 Hz .. 20 kHz (typ. 17 .. 21 kHz)

这种模式适用于占空比和频率都需要实时修改的场合，并且频率可以低至 **1 Hz**

Beckhof 特色产品介绍 IO组 —— PWM 输出模块

5. 模块使用（ 2 ） EL2535

BECKHOFF

- 该模块通过对电源（供电）电压脉宽的控制实现对输出电流的控制。该模块的负载必须是感性负载，电感要>1mH。否则就可能会出现如下图2中所示情况。

Pulse width modulation (PWM)

The EL2535 feature an integrated compact PWM output stage.

PWM output stages control the output current through pulse width modulation (PWM) of the supply voltage. This means that the full supply voltage is activated or deactivated at the output. The duty cycle (pulse width) is modified, but not the voltage level. The current is built up based on the load connected to the inductance.

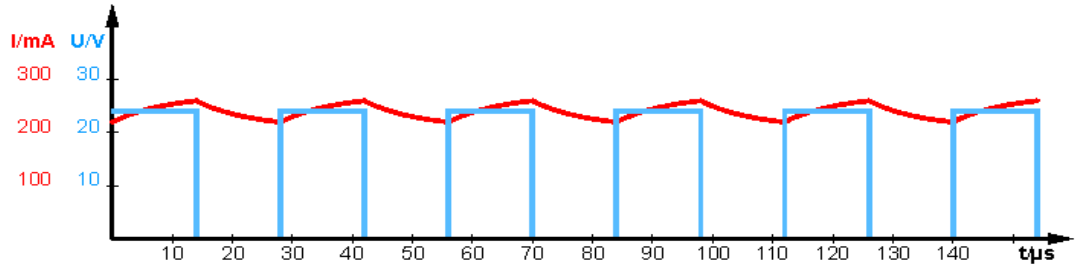


Fig. 1: Operation at load with adequate inductance

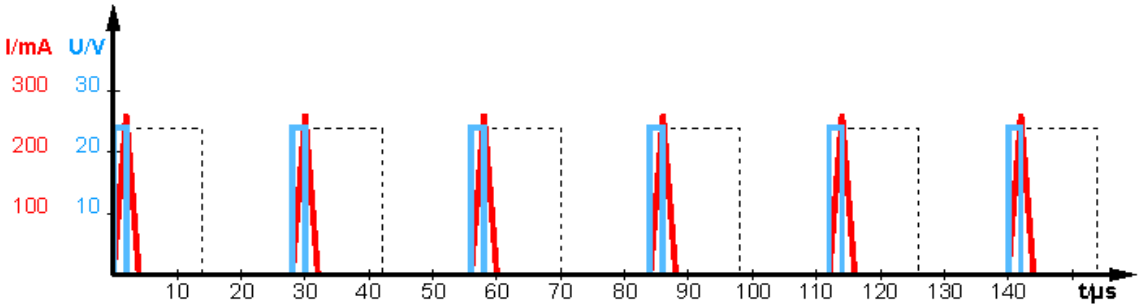


Fig. 2: Operation at load inadequate inductance (near ohmic)

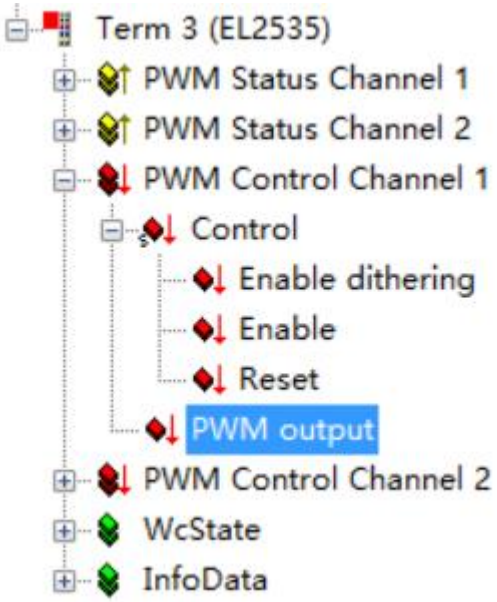
Fig. 2 illustrates operation with inadequate inductance. Continuous current flow is not reached. The current has "gaps". This mode of operation is not permitted.

Beckhof 特色产品介绍 IO组 —— PWM 输出模块

5. 模块使用（ 2 ） EL2535

BECKHOFF

- 通过过程数据直接控制输出电流的大小。

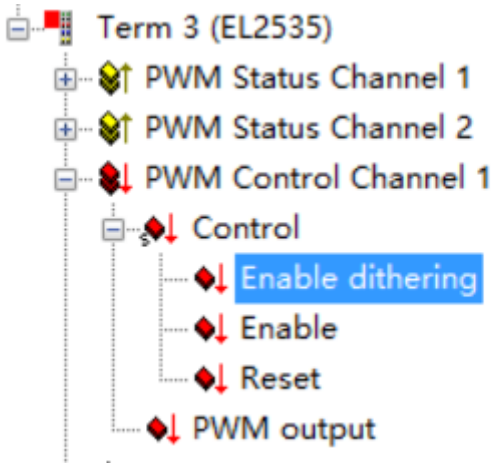


Beckhof 特色产品介绍 IO组 —— PWM 输出模块

5. 模块使用（ 2 ） EL2535

BECKHOFF

- 震颤功能



8pp0:1E	Dithering frequency [Hz]	Dither frequency in Hertz	UINT16	RW	0x0064 (100_{dec})
8pp0:1F	Dithering amplitude [%]	Dithering amplitude in percent of the maximum permitted current (rated terminal current * 8pp0:10)	UINT8	RW	0x0A (10_{dec})

使用该模块控制液压系统中的比例阀的时候，该功能需要打开，以消除阀芯迟滞的现象。

Beckhof 特色产品介绍 IO组 —— PWM 输出模块

5. 模块使用（ 2 ） EL2535

BECKHOFF

➢ 过程数据流程图

Process data flow

In the flow chart below the process data flow of the EL2535 is illustrated.

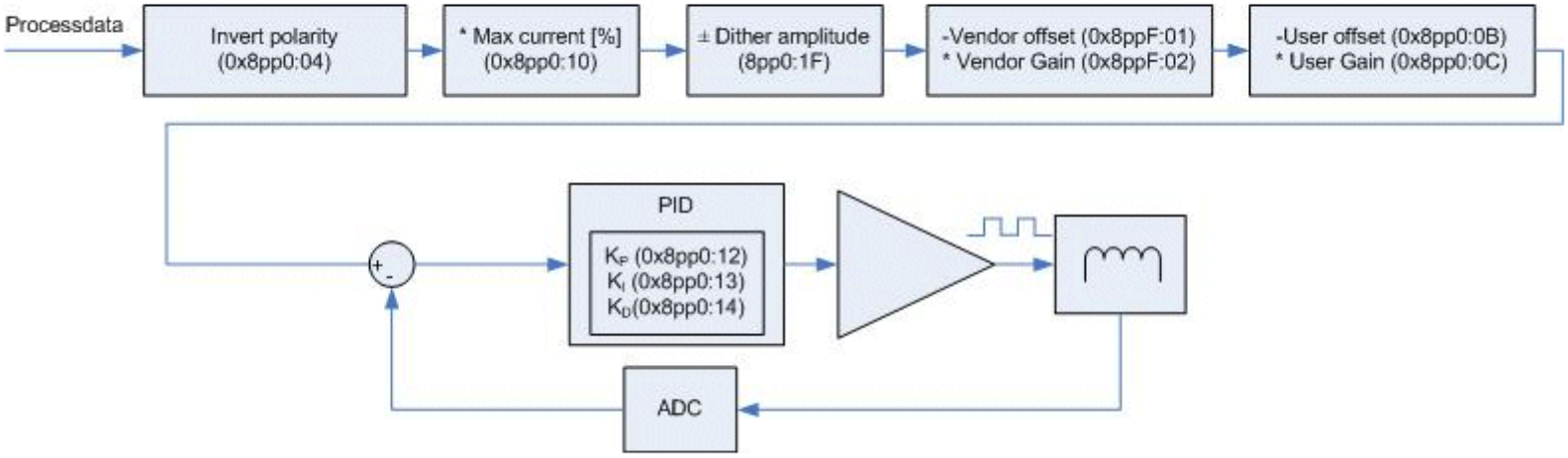


Fig. 1: Process data flow of the EL2535

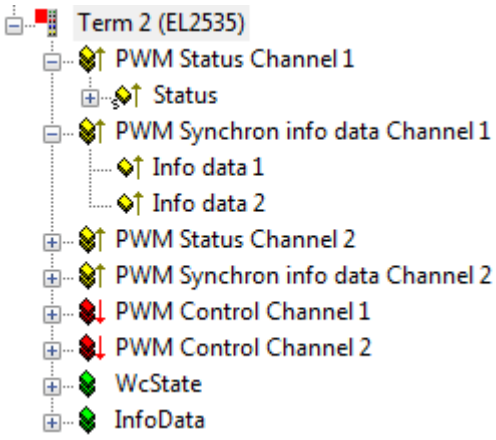
8pp0:12	Kp factor	P-component of the current controller	UINT16	RW	0x015E (350_{dec})
8pp0:13	Ki factor	I-component of the current controller	UINT16	RW	0x0006 (6_{dec})
8pp0:14	Kd factor	D-component of the current controller	UINT16	RW	0x0032 (50_{dec})

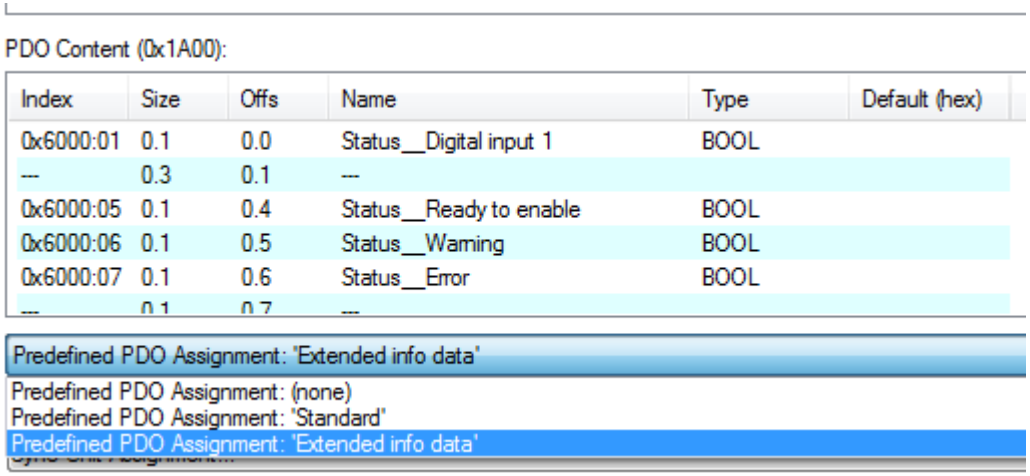
Beckhof 特色产品介绍 IO组 —— PWM 输出模块

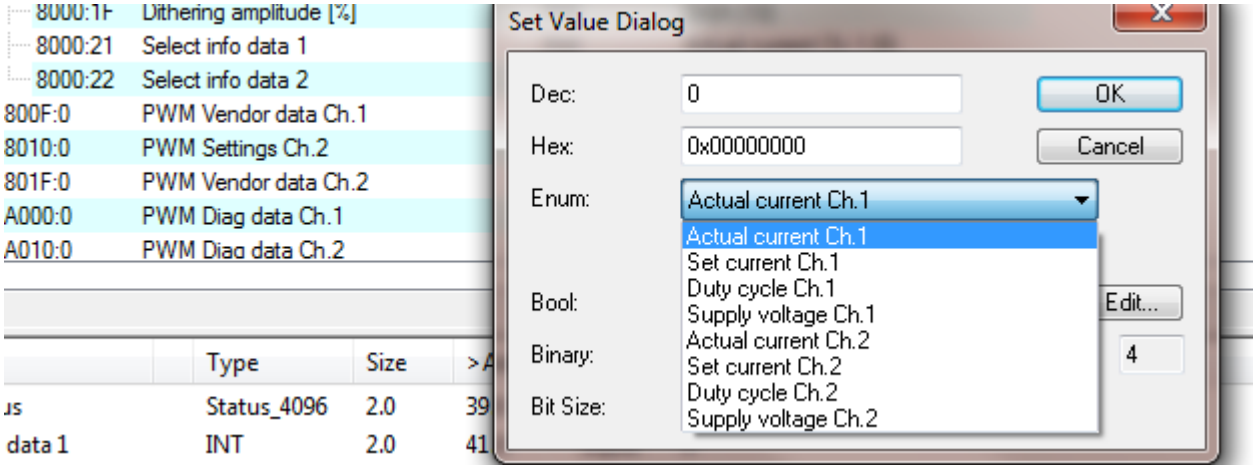
5. 模块使用（ 2 ） EL2535

BECKHOFF

- 通过过程数据采集模块重要参数







6. FAQ