Your Global Automation Partner

Absolute Single/ Multiturn Encoders

PROFIBUS®-DP

Singleturn Type RS-25 (shaft)/RS-33 (Blind hollow shaft)

Multiturn Type RM-29 (shaft)/RM-36 (Blind hollow shaft)

Manual

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Contents

1 General

PROFIBUS-DP basics
This description provides information concerning the implementation of the PROFIBUS-DP transmission protocol in the slave mode in our devices. It should be noted that the extent of the functions described might be limited according to the device or application. With protocol conversions in particular, as a rule fewer functions are used!

The profile required
The link between the decentralized process operation and the central control via the communication system takes place in the lowest hierarchy level on the filed or process bus. At this level, the main requirements are a simple protocol operation and short data transmission times for the communication. This ensures the fastest system reaction time to the dynamic states of the peripherals. In addition to the classic data exchange, the acyclic transmission of parameter, diagnostic and configuration data must be possible, without radically impeding the real-time capability of the bus. This is the only way to guarantee the achievement of good diagnostics and safe operation.

Characteristics
The main task of PROFIBUS-DP is the cyclic transmission of the process data from the control system to the peripheral equipment and vice versa. The access procedure uses the Master-Slave principle. Here in the polling operation a Master communicates with its assigned slave devices one after the other on the bus. A data exchange is initiated by a request telegram and ended by an acknowledgement telegram from the Slave concerned. So, each Slave only becomes active after a call from the Master. This avoids a simultaneous bus access. The hybrid access procedure of PROFIBUS allows a combined operation of several bus masters and even a mixed operation of PROFIBUS-DP and PROFIBUS-FMS within a bus section. However the pre-requisition for this is the correct configuration of the bus system and the unambiguous assignment of the Slave devices to the Masters. PROFIBUS-DP distinguishes two types of Master. The Class 1 Master carries out the cyclic transmission of the operating data and supplies the user data. The Class 1 Master can be addressed by a Class 2 Master using certain functions. Direct access to the Slaves is not permitted. The functions are limited to support services such as reading the diagnostic information of the slaves. A Class 2 Master is thus also understood as a programming or diagnostic device.

Protective functions
PROFIBUS-DP is equipped with many protective functions. These ensure safe fault-free communication not only in the harsh environment of the decentralised peripheral equipment, but also in the case of external interference or the failure of one or more stations. Wrong parameter settings are recognized directly, in that stations having the wrong parameters are not integrated in the operating data exchange.
The Master records the failure of any station and indicates this to the user by means of a general diagnostic message.
Any breakdown in the transmission path is detected by the Slave by means of time monitoring and leads to the outputs being switched off.
EMV disturbances are virtually filtered out by means of the difference signal, thanks to the particularly noise-immune RS485 transmission system.
Data transmission errors are recognized thanks to frame and check-sum controls and lead to the retransmission of the telegram.

2 Start-up

Before start up of a **PROFIBUS-DP system, unique bus addresses** must be assigned to all connected stations, including the master system. This is the only way to ensure unambiguous addressing on the bus. As an option, the station addresses can also be assigned via the bus.
The physical system settings are made using the parameter set of the Master. In addition to the bus address of the Master, this set includes, for example, the baud rate, the time-out delays and the number of repetitions of the transmission. Along with the Master parameter set, a Slave data set must be saved for each Slave to be activated. A data set contains the parameter assignment and configuration data of the Slave and the address indicator for the logical storage of the I/O data. If the parameter sets are present, the master system starts up the slaves one by one, either on the users request or automatically. The first diagnostic cycles identify the slaves on the bus. Only those slaves sending an error-free feedback will subsequently be parametrized with the corresponding data being stored in the master. If diagnostic and parameter cycles have been carried out correctly, configuration cycles follow next. During this process, required data stored in the master and actual configuration data stored I the slave are compared. Only error-free slaves are automatically integrated to the refresh by the master, ready to transfer operating data.

For diagnostic purposes, the Master provides a diagnostic buffer for each slave, which can be read by the user for other purposes. To simplify the diagnostics, a general diagnostic field is kept simultaneously, which shows bitwise whether a Slave has diagnostic data ready or not.

3 General wiring instructions

Installation instructions for RS-485
All devices are connected within a bus structure (line). Up to 32 stations (master or slaves) can be linked together in one segment. The bus is terminated at the beginning and at the end of each segment by an active bus termination (terminating resistors).
To ensure disturbance-free operation both bus terminations must always remain powered. The bus termination is provided ready-to-activate in the device of in the connector.
When there are more than 32 stations on the bus, repeaters must be inserted to connect the individual bus segments. The maximum line length depends on the transmission speed – refer to Table 1.
The line length indicated can be extended by means of using repeaters. It is recommended not to connect more than 3 repeaters in succession.

Baud rate (Kbit/s)	9.6	19.2	93.75	187.5	500	1500	12000
Range/Segment	1200 m	1200 m	1200 m	1000 m	400 m	200 m	100 m

Table 1: Range depending on the transmission speed for A-type cable

4 Cable shielding

EN 50 170 leaves it up to the user to decide, whether to use shielded or unshielded cable. Unshielded cable is allowed in interference-free environments. However, the following points argue for systematic use of shielded cable:

a) An area free from interference exists at best inside shielded cabinets. But as soon as this contains other electronic devices such as relays and contactors, then this is no longer guaranteed.
b) The use of unshielded cables requires additional protective measures against overvoltage at the bus signal inputs.

This is why we recommend on principle the use of shielded cables for the bus lines. This recommendation extends also to the possible use of power-supply cables coming from external power sources to the PROFIBUS devices, e.g. for repeaters. Double-shielded cables are particularly suitable for environments with strong EMC interference. In this case, in order to ensure optimal protection, the whole surface of the external shielding (braided shield) and the inner shielding (foil shield) must be connected at both cable ends to the protective earth by means of an earth clip.

Shielding rules
When using a shielded bus cable, it is recommended to connect the shield at both ends to the protective earth using low-induction connections. This ensures the highest possible electromagnetic compatibility (EMC). One exception concerns separated potentials (e.g. in refineries): generally, in these plants, earthing is permitted at one end only.
The connection between the cable shielding and the protective earth is best done using the metallic device housing and the screw terminal of the plug connector. Here it should be noted that discharge via the pin does not represent an optimal solution. To achieve the best EMC, it is better to expose the cable shielding at a suitable location and to connect it to the protective earth (e.g. the metallic cabinet frame) using a low-induction cable link that should be kept as short as possible. This can be done for example with a shielding clip before the bus plug.

Cable specification: A-type cable for PROFIBUS – DP

Surge impedance:	135 to 165 Ohm, for a measurement frequency of 3 to 20 MHz.
Cable capacitance:	< 30 pF per metre
Conductor section:	> 0.34 mm², corresponds to AWG 22
Cable type:	twisted pair, 1 x 2 or 2 x 2 or 1 x 4 conductors
Loop resistance:	< 110 Ohm per km
Signal damping:	max. 9 dB over the whole length of the cable section
Shielding:	Copper braid shielding or braid shielding and foil shielding

5 Characteristics of the Multiturn Encoder on the Profibus

PNO-Ident-Number
The TURCK Absolute Singleturn/Multiturn Encoder has the PNO-Ident-Number FF40 (Hex). This number is registered at the PNO (Profibus User Organization) as an unique identification. The according GSD-Files are named as follows:

- Multiturn Series TRCKFF40.GSD
- Singleturn Series TRKSFF40.GSD

Start phase of the encoder on the PROFIBUS
When the encoder starts up it is in the 'Baud-Search' state. Once the baud rate has been recognized, it switches to the WAIT_PRM state and waits for the parameter data from the DP-Master. Parametrization is initialized automatically when the DP-Master starts up. The following parameters are transmitted to the encoder: count direction and the measuring length in steps (for more details, see the Encoder Profile from the PNO). When the correct parameter data have been successfully transferred, the encoder switches to the WAIT_CFG state. The PROFIBUS Master then sends a configuration byte to determine the number of inputs/outputs. If the configuration byte is correct, the encoder switches to the state **DATA_EXCHANGE**.

Configuration and Parameterization
The parameterization, i.e. the transfer of the parameters for count direction, encoder resolution etc., normally occurs within the configuration program for the PROFIBUS Master used. To do this, the type file or GSD (device file) should be copied to the respective directory for type or GSD files. With some programs such as COM PROFIBUS or STEP7 Manager, an update of the internal device list (hardware catalog) must be carried out within the software. For more information about integrating field devices, please refer to the documentation for the software you are using.
The two steps described below are normally necessary for integrating and parametrizing the encoder in a Master system.

Configuration
For configuration purposes, i.e. to input the length and type of the I/O on the PROFIBUS, the configuration programme normally provides an input mask (screen), in which – independently of the desired configuration – the identifier has normally already been set as a default, so that only the I/O addresses remain to be entered. Depending on the required configuration that is desired, the encoder allocates a varying number of input and output words on the PROFIBUS.
The following parameters described are also dependent on the required configuration. The GSD device file **(e.g. TRCKFF40.GSD)** contains five required configurations for PNO Class1 and 2, each with 16- and 32 Bit resolution.

6 Device Profile - Profile for Encoder V1.1

This profile describes a **manufacturer-independent** and mandatory determination of the interface for encoders. It is defined in the protocol, which Profibus functions are used as well as how they are to be used. This standard permits an open manufacturer-independent bus system.
The device profile is divided into two object classes:

Physical position

Class C1 Basic function

Absolute function

Class C2 Scaling function

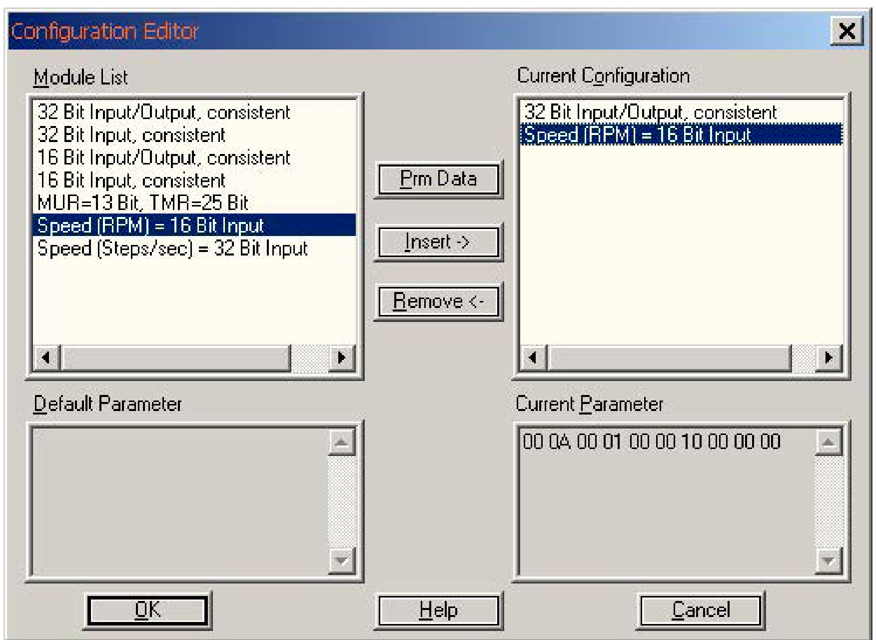
Class C2 Present function

Output position value

• **Class C1** describes all the basic functions, which the encoder should contain.

• **Class C2** contains a number of extended functions, which must either be supported by encoders of this class (Mandatory) or which are optional. Class C2 devices thus contain all the C1 and C2 mandatory functions, as well as additional manufacturer-dependent optional functions. An address area is also defined in the profile, which can be reserved for a manufacturer's own proprietary special functions.

Configuration
The configuration programme normally provides an input mask (screen) for parameterisation purposes, i.e. for entering the data for resolution, count direction etc. The individual modules are listed below:



7 configurations are available for the regular operation of the encoder:

- 32 Bit Input/Output, consistent
- 32 Bit Input, consistent
- 16 Bit Input/Output, consistent
- 16 Bit Input, consistent
- MUR=13 Bit and TMR=25 Bit (32 Bit Input/Output, consistent)
- all can combined with Speed (RPM) 16 Bit consistent or Speed (Units/s) 32 Bit consistent

TURCK

7 Profibus Encoder Profile 3062 (Version 1.1).

Class 2 32-Bit resolution, Input/Output consistent:
The encoder uses 2 input words and 2 output words, which are each consistently transmitted over the bus.

Class 2 32-Bit resolution, Input consistent:
The encoder uses 2 input words, which are each consistently transmitted over the bus.

Class 1 16-Bit resolution, Input/Output consistent:
The encoder uses 1 input word and 1 output word, which are each consistently tr over the bus.

Class 1 16-Bit resolution, Input consistent:
The encoder uses 1 input word, which is consistently transmitted over the bus.

Combination with:
Class 2 32-Bit resolution, input consistent speed in (units/s) or
Class 2 16-Bit resolution, input consistent speed in (rpm)
The encoder uses max. 2 input words, which are each consistently transmitted over the bus.

Default setting Scaling on, 25 Bit total resolution
Class 2 32-Bit resolu on MUR=13Bit, TMR=25Bit:

Preset setting
In 'Class 2' mode the encoder can be adjusted over the PROFIBUS to any posi on value in the value range of 27 bit or 15 Bit. This is done by se ng the most significant bit (MSB) of the output data (2^31 for configuration Class 2 - 32 bit or 2^15 for configuration Class 2 – 16 bit).

The Preset Value that is transmitted in the data bytes 0 - 3 is accepted as the postion value with the rising edge of bit 32 (=bit 7 of data byte 3). The encoder then continues counting from this position Readjustment is then only possible a er the control bit has been reset. There is no acknowledgment of this action via the inputs.

Speed values
All modules can be combined with the configuration on of an additional Speed value. The input words are increased to a maximum length of 8 bytes (64 bit) depending on the configuration of the speed value. The speed value is signed and depends on the count direction.

Positive values in CW, negative in CCW direction.
Format is in "Big Endian":

Input word		Input word			
Byte 0	Byte 1	Byte 2	Byte 3	Format	Max.
		0	0	RPM	0
		17	70	RPM	6000
		E8	90	RPM	-6000
00	63	FF	9C	Units/s	6553500
FF	9C	00	64	Units/s	- 6553500

Speed limits:

Singleturn Encoder:	600 rpm	higher speed shows ffffh as value
Multiturn encoder:	12000 rpm	higher speed shows ffffh as value

8 Extended Diagnostics

1. Device profile for encoders

Class 1 Mandatory for all DP encoders

Function	Octet N°.	Data Type	Name
Data_Exchange	**1-4**	**Unsigned 32**	**Position Value (input)**
Data_Exchange	**1-4**	**Unsigned 32**	**Preset Value (output)**
Data_Exchange	**1-4**	**Unsigned 32**	**Speed Value (input) (units/s)**
Data_Exchange	**1-4**	**Unsigned 16**	**Speed Value (input) (rpm)**
RD_inp	1-4	Unsigned 32	Position Value
RD_inp	1-4	Unsigned 32	Speed Value
Slave_Diag	7	Octet String	External Diagnostic Header
Slave_Diag	8	Octet	String Alarms
Slave_Diag	9	Octet	String Operating Status
Slave_Diag	10	Octet	String Encoder Type
Slave_Diag	11-14	Unsigned 32	Singleturn Resolution
Slave_Diag	15,16	Unsigned 16	Number of Revolution
Set_prm	9	Octet String	Operating Parameters

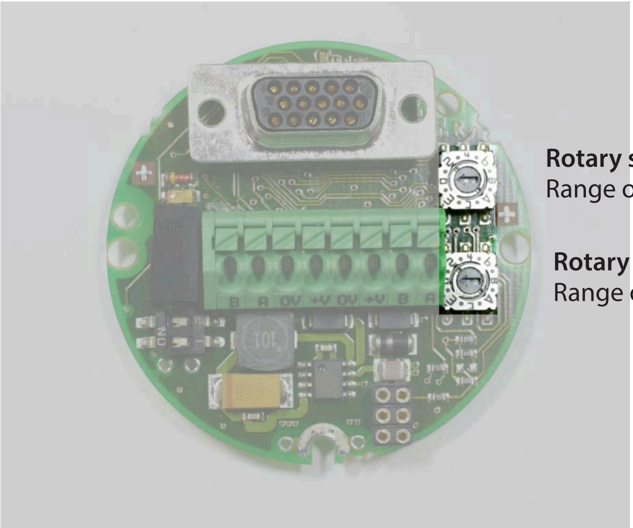
Class 2 Optional Functionality

Function	Octet N°.	Data Type	Name
Slave_Diag	17	Octet String	Additional Alarms
Slave_Diag	18,19	Octet String	Supported Alarms
Slave_Diag	20,21	Octet String	Warnings
Slave_Diag	22,23	Octet String	Supported Warnings
Slave_Diag	24,25	Octet String	Profile Version
Slave_Diag	26,27	Octet String	Software Version
Slave_Diag	28-31	Unsigned 32	Operating Time
Slave_Diag	32-35	Signed 32	Offset Value
Slave_Diag	36-39	Signed 32	Manufacturer Offset Value
Slave_Diag	40-43	Unsigned 32	Measuring Units per Revolution
Slave_Diag	44-47	Unsigned 32	Total measuring range in measuring units
Slave_Diag	48-57	ASCII String	Serial Number
Set_prm	10-13	Unsigned 32	Measuring Units per revolution
Set_prm	14-17	Unsigned 32	Total measuring range in measuring units

9 Initial Start-up - General Device Settings

Node number (Device address)
Setting the node number for the address, using both rotary switches and adjust the number to the according address. R1 for the low order addresses, R2 for the high order value.

View: into the opened bus cover



Rotary switch for **low order** R1
Range of values 1..F*

Rotary switch for **low order** R2
Range of values 1..7*

Example:
R1 set to F, R2 set to 3
3Fh corresponds to 63 decimal

10 Set Station address (SSA) *

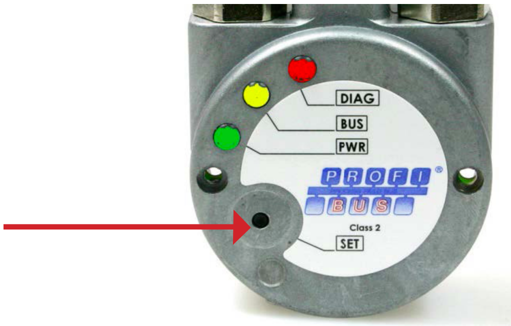
*** Adjust both rotary switches to position F for software "set station address" support with a Class2 Master.**
The software "set station address" support can only be carried out with a **Class2 Master**.
Default settings after a Power-on is **the address 125 (0x7D) for SSA_Support**.

Only **valid addresses** will be stored in a non-volatile memory and are active by now.
The **Node number 0** is reserved and must not be used by any node.
The resulting node numbers lie in the range **1...7Dh** hexadecimal (1...125 decimal).

11 External Position Reset

The device can be set to a reset position by means of the built-in SET key. The resulting position is 0. The resulting offset between the physical zero position of the disc and the electronic zero position can be interrogated via the extended diagnostics header.

Note:
The device can be set to a reset position by means of the built-in SET key. The resulting position is 0. The resulting offset between the physical zero position of the disc and the electronic zero position can be interrogated via the extended diagnostics header.



Postion: 0

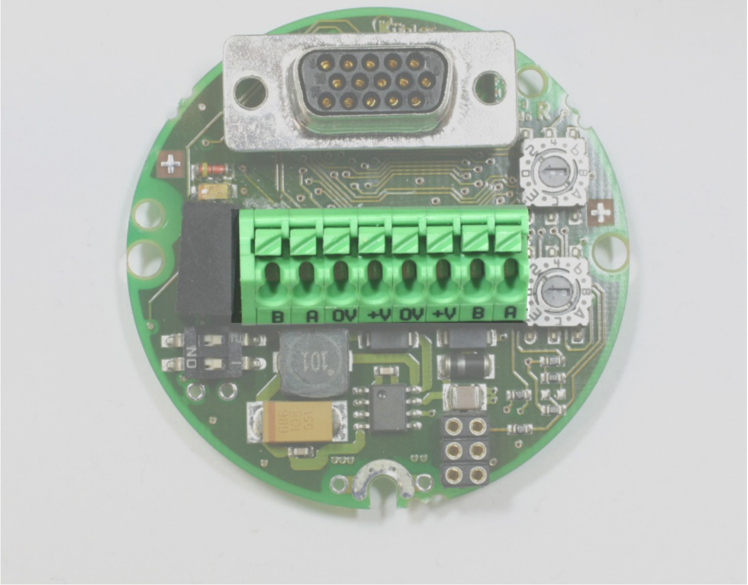
12 Profibus connection PG

Bus connection with separate power supply and PG cable gland connection
Undo both screws on the bus cover and remove the bus cover from the encoder.

Feed the incoming bus cable through the left cable gland and connect it to the left terminal (B) and terminal (A). Place the cable shield onto the cable gland. If **further devices** follow in the bus segment:
Run continuing cable through the right cable gland and connect to **terminal (B) and terminal (A)**.

Supply voltage
Run the supply voltage for the encoder through the central cable gland and connect it to the **terminals** on the left **(+V) and (0V)**. Place the cable shield onto the cable gland.
(see wiring diagram)

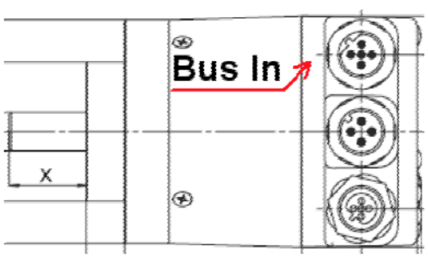
View: into opened bus cover



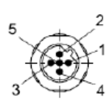
Description from left to right

Abbreviation	Description	Direction
B	Profibus	Out
A	Profibus	Out
0V	0Volt Supply	Out
+V	+UB Supply	Out
0V	0Volt Supply	In
+V	+UB Supply	In
B	Profibus	In
A	Profibus	IN

13 Profibus connection M12

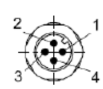


Terminal assignment M12 connector version:



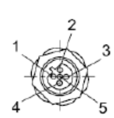
Bus in:

Signal :	–	BUS-A	–	BUS-B	Shield
Pin:	1	2	3	4	5



Supply voltage:

Signal :	U_B	–	0 V	–
Pin:	1	2	3	4



Bus out:

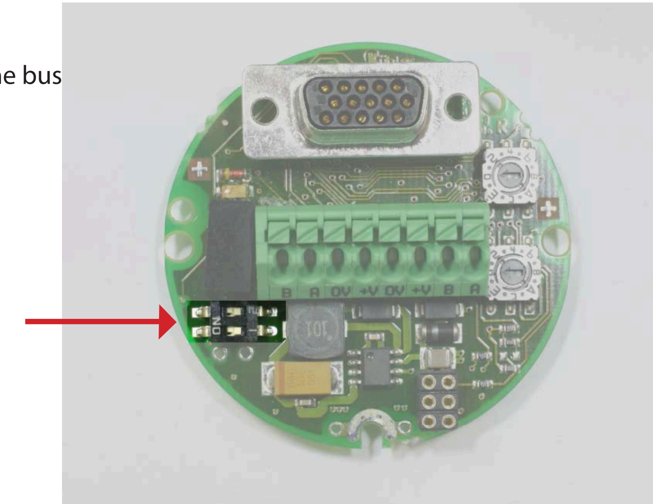
Signal :	BUS_VDC[1)]	BUS-A	BUS_GND[1)]	BUS-B	Shield
Pin:	1	2	3	4	5

[1)] for powering an external Profibus-DP terminating resistor

Bus termination
The bus termination is set via hardware using **both DIP switches** on the bus cover on the rear of the encoder.

When the switch is set to 'ON -> the termination is active

If the device represents the final station on the bus, then the looped-through Profibus must be actively terminated at both ends with a bus termination resistor between **A and B**.



Note:
For units without removable bus covers it is necessary to order with the internal termination adjusted for the application, otherwise it will require an external resistor to adapt it accordingly.

14 Installation notes when using housings with cable glands:

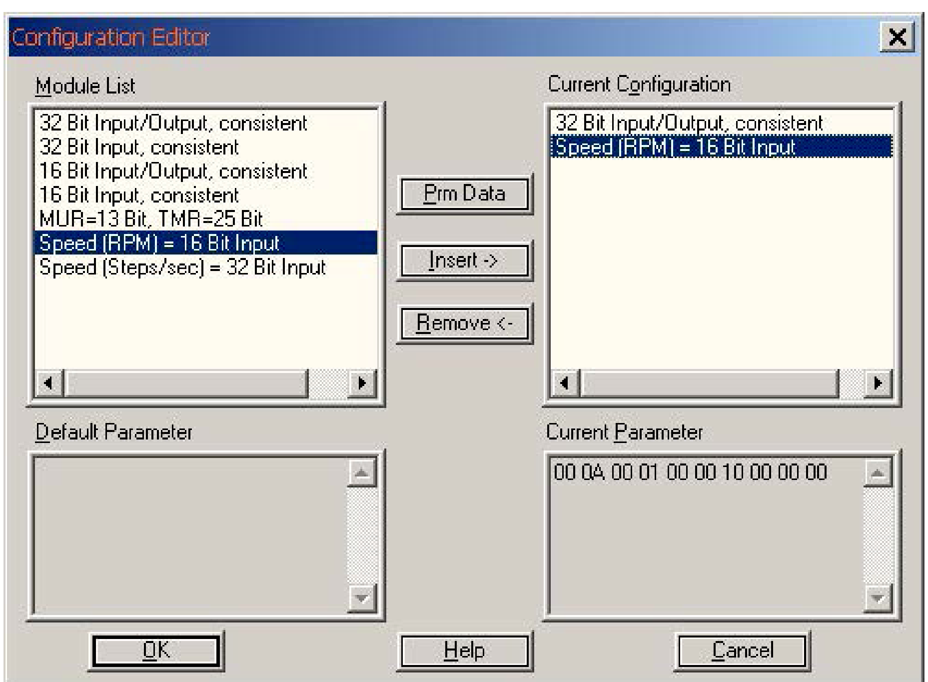
Only use approved Profibus cables with suitable shielding as bus or connection cable.

Place the cable shield on the cable gland

15 Parameterisation

In order to carry out a general parameterisation of the device, it is necessary first to select a module from the GSD file **(TRCKFF40.GSD)**.

Example:



With the parameter telegram (except for the 25-Bit configuration) the following can be defined:

- Code Sequence (Octet 9, Bit 0)
- 0 = clockwise
- 1 = counter clockwise

- Class 2 functionality (Octet 9, Bit 1)
- 0 = no
- 1 = yes

- Scaling enabled (Octet 9, Bit 3)
- 0 = no
- 1 = yes

- Scaling type (Octet 9, Bit 7)
- 0 = Standard (MUR + TMR)
- 1 = Alternative (NDR + TMR)

- Scaling parameter MUR or NDR (Octets 10-13)
- MUR = Measuring Units per Revolution
- NDR = Number of Distinguished Revolutions

- Scaling parameter TMR (Octets 14-17)
- TMR = Total Measuring Range

16 Scaling

Standard Scaling:
- With MUR and TMR
- One revolution is equivalent exactly to MUR = TMR values

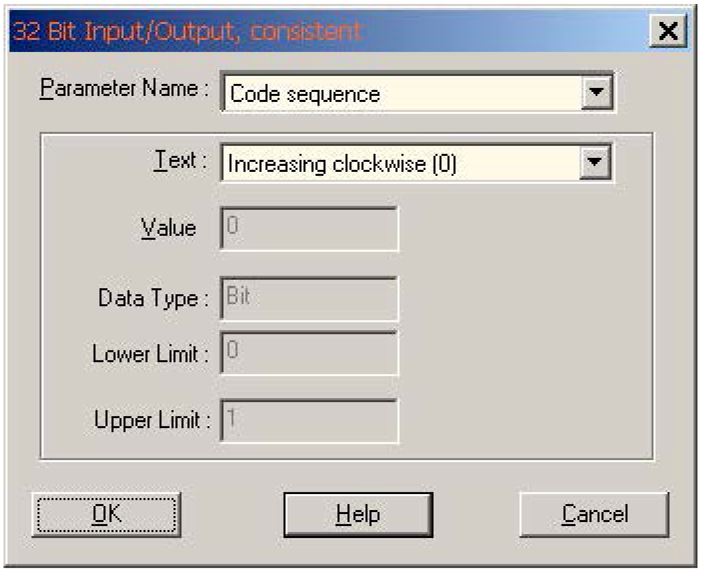
$\text{Position}_{\text{scaled}} = ((\text{Position}_{\text{unscaled}} / \text{Singleturn-resolution}) * \text{MUR}) \% \text{TMR}$

Alternative Scaling:
- With NDR and TMR
- NDR revolutions are equivalent exactly to the TMR values

$\text{Position}_{\text{scaled}} = ((\text{Position}_{\text{unscaled}} / (\text{NDR} * \text{Singleturn-resolution})) * \text{TMR}) \% \text{TMR}$

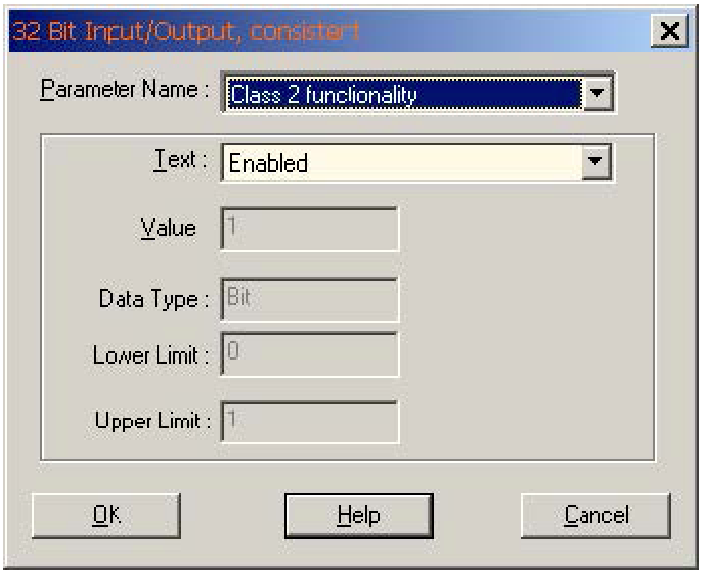
1. Code sequence CW

Possible settings:
Increasing clockwise (0) (CW)
Increasing counter-clockwise (1) (CCW)



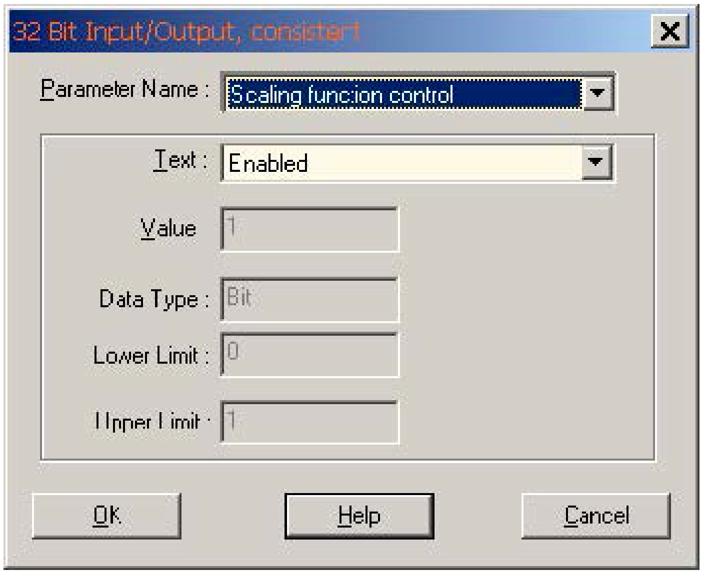
2. Class 2 functionality on

Class 2 must be turned on when scaling is active.



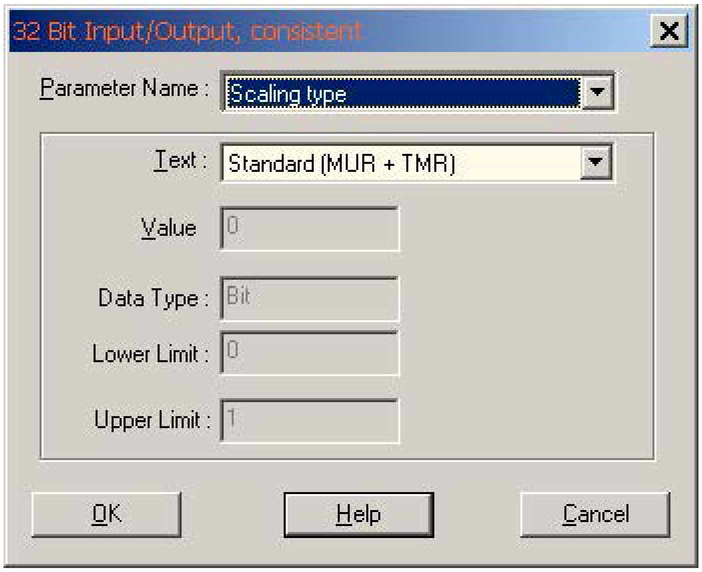
3. Scaling function control on

When scaling is turned on – Position depends on the values MUR and TMR.



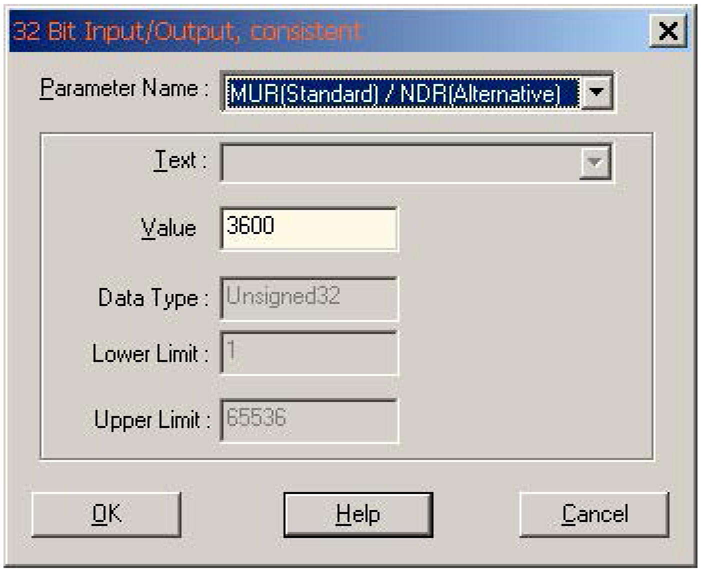
4. Scaling type MUR+TMR

Scaling type (MUR + TMR)



5. Value for Resolution per Revolution MUR

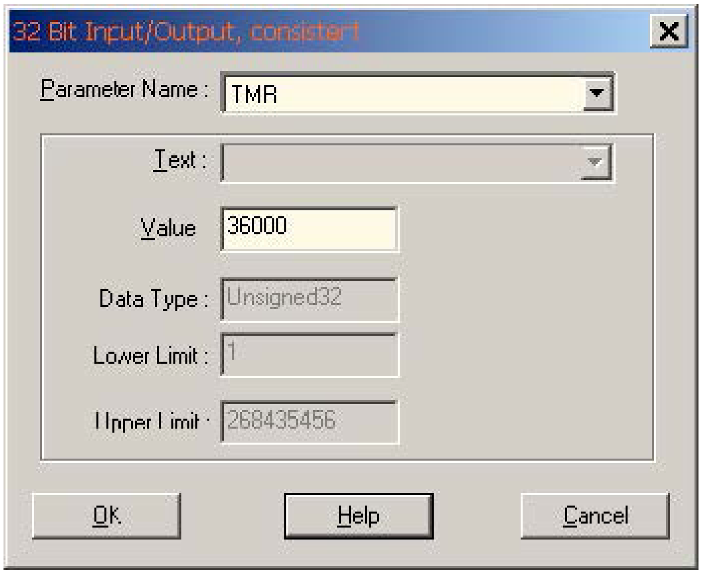
Example: 3600 Steps per revolution



6. Value for Total Resolution

Example: Value for total resolution 36000

Position range: 0…36000
Revolutions 10



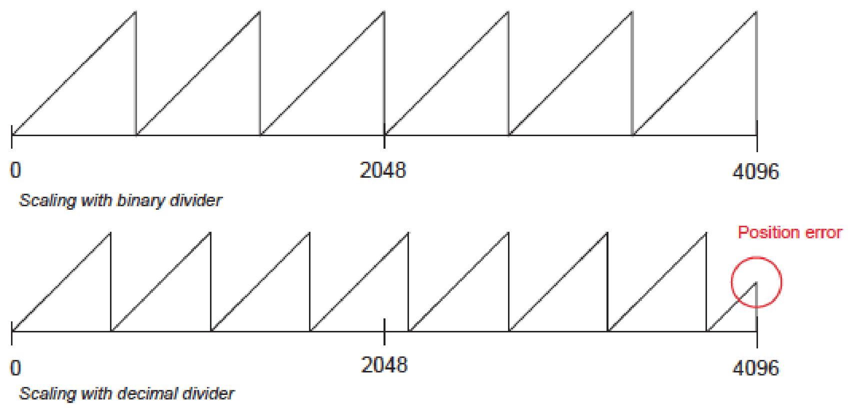
Range end problems with encoder with limited multiturn value

An error appears at the end of the physical resolu on of an encoder, when scaling is enabled, if the division of the **physical boundaries (GP_U)** by the programmable **total resolution (TMR)** is not a n integer.

k = GP_U / TMR   k <> integer

At the end of the multiturn range during clockwise rota on, the encoder outputs position zero again. The same error appears immediately, if the encoder is set back to zero with a preset and the maximum mul turn value is approached after.

Example multiturn value 4096



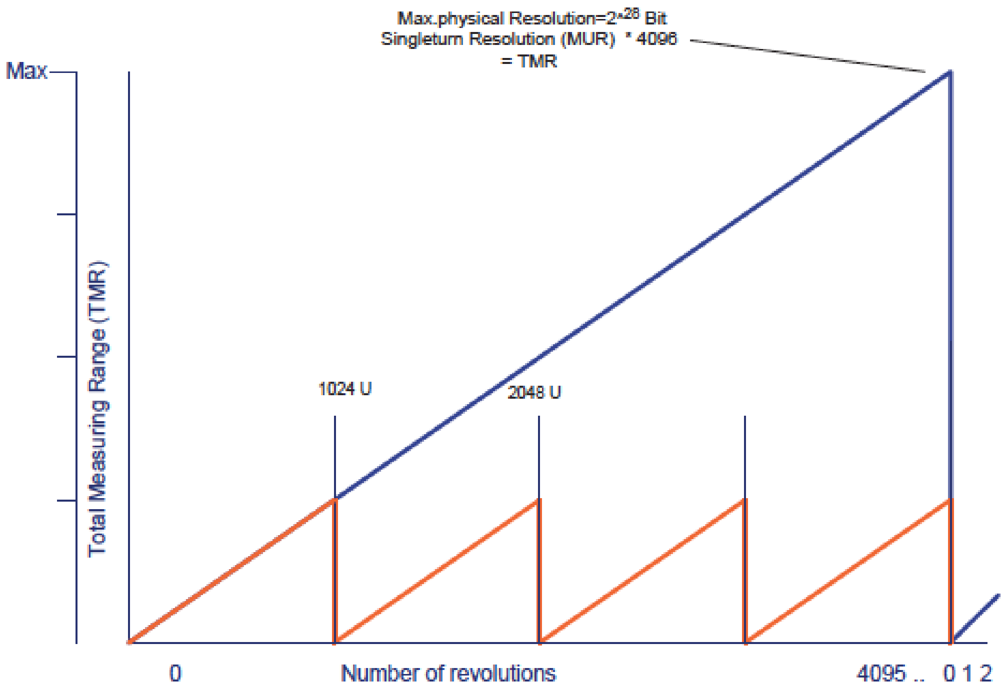
Example with binary divider: MUR = 16384

Total position $_{Scaled}$ = (# of rotations * MUR)

Total position $_{Scaled}$ = (# of rotations* 16384)
Total position $_{Scaled}$ = (4096 * 16384)
TMR = 67,108,864

k = GP_U/ TMR   k= integer
k = 2^{28} /67,108,864 = 4   -> no position error with multiturn carry-over

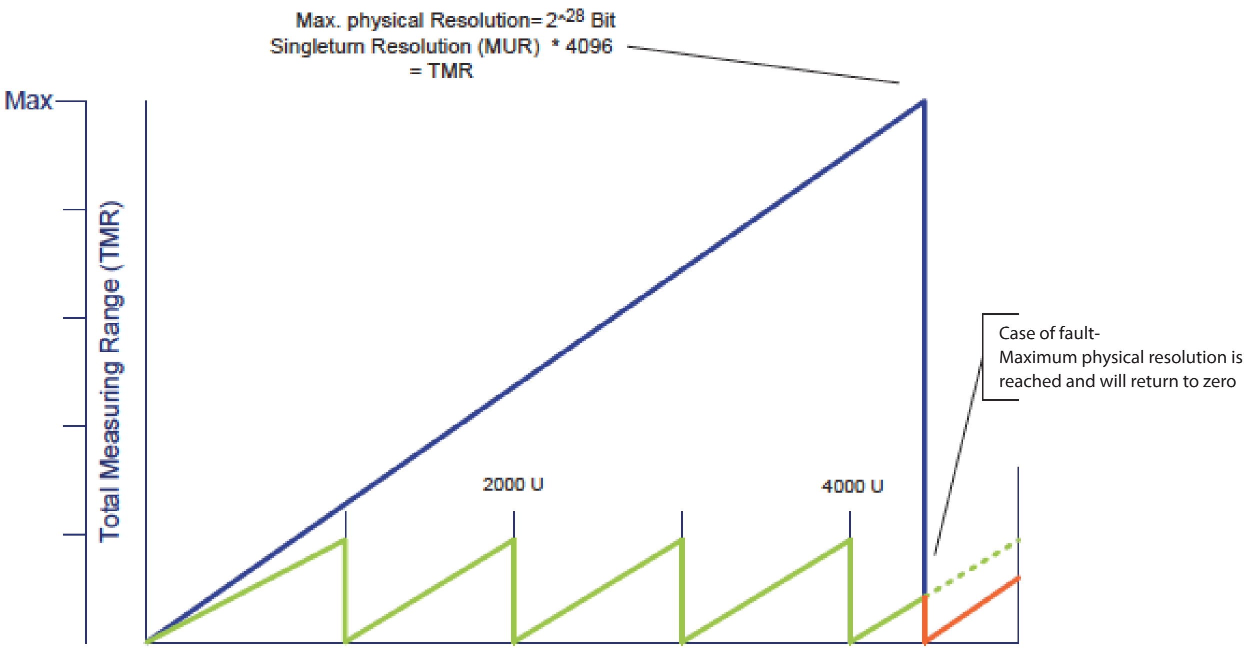
Example with binary divider:



Example with decimal divider:

MUR= 65000
TMR= 65,000,000

Calculated number of MT rotations = 1000
k = GP_U/ TMR k= integer
Error k = 2^{28} /65,000,000 = 4.1297



17 Default settings on delivery

Factory set parameters on delivery.

Description	Setting	Switch
Baud rate	automatic	Not available
Node address	63	Switch setting 3Fh (63)* *At closed housings the switch is set to the preorded node address or to 0xFF for "set station address" with software
Termination	OFF	Switch setting off

Index (hex)	Name	Standard value
	Encoder Profile	
Set_prm 9	Operating Parameter	Bit 3 Scaling on
		Class 2 on /CW
Set_prm 10-13	Measuring Units per Revolution	8192 (13 Bit)
Set_prm 14-17	Total Measuring Range	33554432 (25 Bit)

The original Standard Values (Default values on delivery) can be reloaded by pressing the button on the rear when switching on (Restore parameters).

Warning:
If errors have occurred during programming of the objects and if these parameters have been saved in the EEPROM, it will not be possible to address the encoder next time it is switched on; this error can be cleared only by means of a general **Reset** of the encoder.

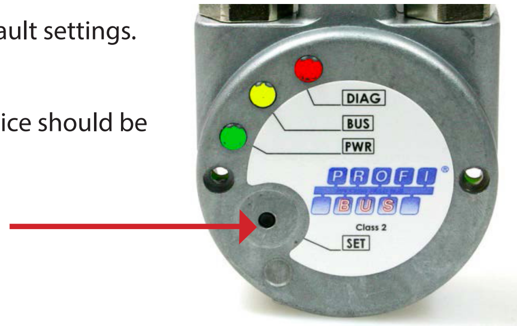
18 General Reset of the device

Please note that all programmed parameters will be lost.

- Switch the encoder off.
- Turn the encoder back on, keeping the **SET-Key*** pressed for approx. 3 sec. until the DIAG LED flashes
- Switch the device off again

When the encoder is **rebooted** all values will be reset to their default settings. (SSA-address is 125)

*only for devices with an external **SET-Key**; in other cases the device should be returned to the factory.



19 LED Monitoring during operation

red LED = DIAGnostics

yellow LED = BUS

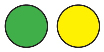
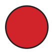
green LED = PWR Bus voltage

Annunciator	LED	Description	Cause of error	Addendum
PWR OFF		No bus voltage present	No power to device Power supply unit defective	Check power supply [3]
PWR ON		Bus voltage present. Device ready for operation	Device is in configuration mode	
BUS OFF		Device is waiting for configuration or parameterisation	GSD module must be loaded and sent to the encoder	Observe combination with DIAG LED
BUS ON		Connection to Master established DATA_Exchange Mode		Exchange of process data

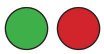
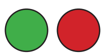
The individual LED annunciators can of course also occur in combinations.

[2] Master can be either a PLC or a second communication partner
[3] Operting voltage

LED combinations during operation

Annunciator	LED	Description	Cause of error	Addendum
PWR+BUS ON		Data_Exchange Mode		Device will exchange position data
Diag flashing		Red LED flashing	Over-temperature Sensor monitoring Single bit function error Sensor current monitoring	Connection to Master interrupted + additional causes of error (Diagnostic header is requested)

Warning: Error Display after switching on

Display	LED	Description	Cause of error	Addendum
PWR +Diag flashing		Red LED flashing 1 x short Break 1.6 sec.	Data connection fault to sensor Sensor fault	Return device to manufac-turer for checking
PWR +Diag flashing		Red LED flashing 2 x short Break 1.6 sec.	Incorrect node address Profibus short-circuit Termination fault	Check Profibus

Note: General RESET - Switching the device on with the SET Key pressed

Display	LED	Description	Cause of error	Addendum
Err flashing		Short flashing of red LED	Diagnostic mode	Device is ready for diagnostics

- Switch the encoder off.
- Turn the encoder back on, keeping the SET key* pressed for approx. 3 sec.
- The red LED flashes
- Switch the device off again

When the encoder is rebooted all values will be reset to their default settings.

20 Decimal-Hexadecimal Conversion Table

With numerical data, the decimal values are given as numerals with no affix (e.g. 1408), binary values are identified by the letter b (e.g. 1101b) and hexadecimal values with an h (e.g., 680h) after the numerals. The values shown in bold are to be entered on the rotary switches.

Example:

Left figure high order rotary switch

Right figure low order rotary switch

Dez	Hex	Dez	Hex	Dez	Hex	Dez	Hex
0	**00**	32	**20**	64	**40**	96	**60**
1	**01**	33	**21**	65	**41**	97	**61**
2	**02**	34	**22**	66	**42**	98	**62**
3	**03**	35	**23**	67	**43**	99	**63**
4	**04**	36	**24**	68	**44**	100	**64**
5	**05**	37	**25**	69	**45**	101	**65**
6	**06**	38	**26**	70	**46**	102	**66**
7	**07**	39	**27**	71	**47**	103	**67**
8	**08**	40	**28**	72	**48**	104	**68**
9	**09**	41	**29**	73	**49**	105	**69**
10	**0A**	42	**2A**	74	**4A**	106	**6A**
11	**0B**	43	**2B**	75	**4B**	107	**6B**
12	**0C**	44	**2C**	76	**4C**	108	**6C**
13	**0D**	45	**2D**	77	**4D**	109	**6D**
14	**0E**	46	**2E**	78	**4E**	110	**6E**
15	**0F**	47	**2F**	79	**4F**	111	**6F**
16	**10**	48	**30**	80	**50**	112	**70**
17	**11**	49	**31**	81	**51**	113	**71**
18	**12**	50	**32**	82	**52**	114	**72**
19	**13**	51	**33**	83	**53**	115	**73**
20	**14**	52	**34**	84	**54**	116	**74**
21	**15**	53	**35**	85	**55**	117	**75**
22	**16**	54	**36**	86	**56**	118	**76**
23	**17**	55	**37**	87	**57**	119	**77**
24	**18**	56	**38**	88	**58**	120	**78**
25	**19**	57	**39**	89	**59**	121	**79**
26	**1A**	58	**3A**	90	**5A**	122	**7A**
27	**1B**	59	**3B**	91	**5B**	123	**7B**
28	**1C**	60	**3C**	92	**5C**	124	**7C**
29	**1D**	61	**3D**	93	**5D**	125	**7D**
30	**1E**	62	**3E**	94	**5E**	126	**7E**
31	**1F**	63	**3F**	95	**5F**	127	**7F**

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MA1025 A 7/2016

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