ENGINEERING
TOMORROW

Operation guide

Temperature transmitter CANopen
DST T92C

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1. General Information

1.1 Contact

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1.2 General

The temperature transmitter DST T92C measures the physical quantity temperature. The range is -40 – 150 °C for the medium. The measured value is transmitted on the CAN-Bus with the CANopen protocol. The transmitter takes 107 samples per second, does filtering and converts the raw value into the output format.

The CAN 2.0B interface is able to run up to a speed of 1 Mbit/sec.

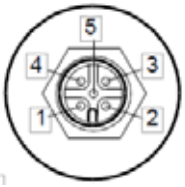
The CAN protocol complies with the CANopen specification DS301, the temperature transmitter function is presented by the CANopen device profile DS404. The possible configurations are set by the object dictionary. Heartbeat and emergency messages guarantee high reliability.

With the "Layer setting services" (LSS, DSP305 V2.0), the desired bit rate and node ID can be set easily.

1.3 CAN Interface

The device includes a Full CAN controller specified to CAN 2.0B. The physical layer of the 2-wire interface is specified according to ISO 11898. The wires are protected against short-circuit. By adjusting the rise and fall times of the CAN signals, the noise emission is minimized. The bus termination resistor is not included in the device.

2. Specifications

Electrical specifications		
Supply voltage		9 – 36 V DC protected against reverse polarity
Current consupmption at U_S = 24 V DC		I < 50 mA typical, I_{MAX} < 100 mA
CAN Interface		
Physical layer		2-wire interface, 5 V level according to ISO 11898 Protected against short-circuit
Max. Bit rate		1 Mbit/s
Signal rise time		Bit rate < 125 kbit/s 12 V/µs (without bus) Bit rate ≥ 125 kbit/s > 24 V/µs (without bus)
Bus termination		External
Protocol		CANopen DS301, Device Profile DS404
Environment		
EMC		EN 61326-1:2013
Operating temperature		-40 – 125 °C
Media temperature		-40 – 150 °C
M12 connector Pin Assignment (CiA DR303-1)		
	Pin 1 Pin 2 Pin 3 Pin 4 Pin 5	CAN shield, PE +U_B, +24 V DC GND, 0 V CAN_H, CAN+ CAN_L, CAN-

3. CANopen communication

3.1 Summary of the CANopen functions

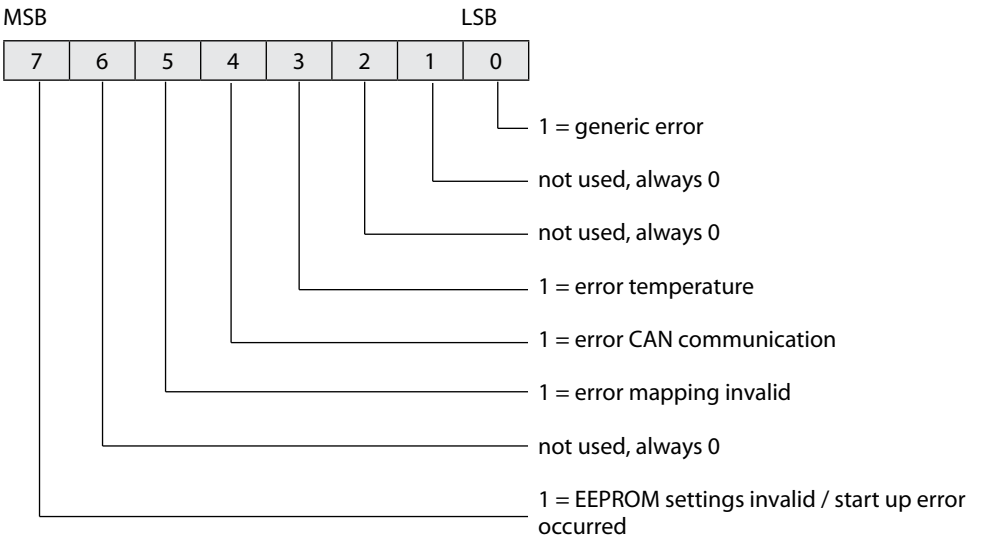
CANopen type	NMT slave
Network bootup	Minimum bootup
COB Id placing	Pre-defined connection set, SDO
Node Id	Object (specific entry)
Bitrate	Object (specific entry)
Number of PDOs	PDO1 synchronous, asynchronous PDO-mapping configurable
Emergency message	Supported
Heartbeat	Supported
Device profile	DS404
Layer setting services	Supported

Default settings:
Bitrate 125 kbit/s
Node ID 1

3.2 Object dictionary: Communication profile

Index (HEX)	Sub Index	Name	Type	Access	Default	Comment
1000	00	Device type	Unsigned32	ro	0x00020194	DSP404 analog input block
1001	00	Error register	Unsigned8	ro	0	

Error register (Index 1001H):



Index (HEX)	Sub Index	Name	Type	Access	Default	Comment
1003		Pre-defined error field				
	00	Number of errors	Unsigned8	rw	1	Write 0: clear errors
	01	Standard error field	Unsigned32	ro		

Standard error field (index 1003H, 01)			
MSB Bit31 – 24	Bit23 – 16	Bit15 – 0	LSB
not used, always 0	Error register (index 1001H)	Error code: 0x8100 communication error 0x6161 inernal software error (EEPROM setting invalid) 0x6363 PDO mapping error 0x6300 data error (startup error) 0xF011 pressure error	

Index (HEX)	Sub Index	Name	Type	Access	Default	Comment
1005	00	COB-ID SYNC	Unsigned32	rw	0x80	
1008	00	Manufacturer Device Name	String	ro	DST T92C CANopen	
1009	00	Manufacturer Hardware Version	String	ro	"x.xxrx"	
100A	00	Manufacturer Software Version	String	ro	"x.xxrx"	
1010		Store parameters				
	00	Number of entries	Unsigned8	ro	1	
	01	Save all parameters	Unsigned32	rw	1	Data will be saved with the command 0x65766173 (ASCII: "save")
1011		Restore default parameters				
	00	Number of entries	Unsigned8	ro	1	
	01	Restore default parameters	Unsigned32	rw	0c01	Default values will be restored with the command 0x64616F6C (ASCII: "load"). Reset of device required
1014	00	COB ID Emergency message	Unsigned32	ro	0x81	0x00000080 + Node-ID
1016		Consumer heartbeat time				
	00	Number of entries	Unsigned8	ro	1	
	01	Consumer heartbeat time	Unsigned32	rw	0	
1017	00	Producer heartbeat time	Unsigned16	rw	0	
1018		Identify object				
	00	Number of entries	Unsigned8	ro	4	
	01	Vendor Id	Unsigned32	ro	0x23D	Danfoss vendor-Id
	02	Product code	Unsigned32	ro		Danfoss code number
	03	Revision number	Unsigned32	ro		Firmware version
	04	Serial number	Unsigned32	ro		Danfoss internal serial number

Index (HEX)	Sub Index	Name	Type	Access	Default	Comment
1800		Transmit PD01 parameter				
	00	Number of entries	Unsigned8	ro	5	
	01	COB ID used by PDO	Unsigned32	rw	0x181	(0x00000180 + Node-ID)
	02	Transmission type	Unsigned8	rw	0x01	Only 0x01 (sync) or 0xFF (async) with delta and/or event timer
	03	Inhibit time	Unsigned16	rw	0	
	04	Reversed	Unsigned8	rw	0	
	05	Event timer	Unsigned16	rw	1000	1000:default value of DS404
1A00		Transmit PDO1 mapping				
	00	Number of entries	Unsigned8	rw	2	
	01	PDO mapping for the 1. application object to be mapped	Unsigned32	rw	0x91300120	Temperature as int32: 0x91300120 Temperature as float32: 0x61300120 Status temperature as uint8: 0x61500108 Meaning of status bits (if set): Bit 0: temperature value invalid Bit 1: positive overload Bit 2: negative overload
	02	PDO mapping for the 2. application object to be mapped	Unsigned32	rw	0x61500108	
	03	PDO mapping for the 3. application object to be mapped	Unsigned32	rw	0	
	04	PDO mapping for the 4. application object to be mapped	Unsigned32	rw	0	
1F80	00	NMT start up	Unsigned32	rw	4	0x00000004: the NMT master has to start the NMT slave. 0x00000008: NMT slave shall enter the NMT state ***Operational*** after the NMT state ***Initialisation*** autonomously (self starting)

3.3 Object dictionary: Manufacturer specific profile

Index (HEX)	Sub Index	Name	Type	Access	Default	Comment
3000	00	Temperature overflow counter	Unsigned16	rw	0	Counter for overtemperature
3001	00	Temperature underflow counter	Unsigned16	rw	0	Counter for undertemperature
4E00		Manufacturer serial number				
	00	Number of entries	Unsigned8	ro	4	
	01	Serial number - Part 1	Unsigned8	ro		
	02	Serial number - Part 2	Unsigned32	ro		
	03	Serial number - Part 3	Unsigned16	ro		
	04	Serial number - complete	Visible_ string	ro		00.000000.0000
4F00	00	Bit rate	Unsigned8	rw	4	[1] see following table. Changes take effect after reset node or power on
4F01	00	Node ID	Unsigned8	rw	1	1 – 127; Changes take effect after reset node or power on

[1] Bit rates indices:

Index	Bit rate [kbit/s]
0	1000
1	800
2	500
3	250
4	125
5	
6	50
7	20

3.4 Object dictionary: Device profile

Index (HEX)	Sub Index	Name	Type	Access	Default	Comment
6110		Ai_Sensor_Type				
	00	Number of entries	Unsigned8	ro	1	
	01	Ai_Sensor_Type_1	Unsigned16	ro	100	100 = temperature sensor
6124		Ai_Input_Offset				
	00	Number of entries	Unsigned8	ro	1	
	01	Ai_Input_Offset_1	Float32	rw	0	Temperature offset; will be added to the current temperature value; Min./max. value=min./max. temperature of DST T92C
6125		Ai_Input_Autozero				
	00	Number of entries	Unsigned8	ro	1	
	01	Ai_Input_Autozero_1	Unsigned32	wo		Autozero for temperature 0x6F72657A (ASCII: "zero")
6130		Ai_Input_PV				
	00	Number of entries	Unsigned8	ro	1	
	01	Ai_Input_PV_1	Float32	ro		actual temperature value
6131		Ai_Physical_Unit_PV				
	00	Number of entries	Unsigned8	ro	1	
	01	Ai_Physical_Unit_ PV_1	Unsigned32	rw	0x002D0000	Temperature unit: 0x002D0000: °C 0x00AC0000: °F 0x00050000: °K
6132		Ai_Decimal_Digits_ PV				
	00	Number of entries	Unsigned8	ro	1	
	01	Ai_Decimal_Digits_ PV_1	Unsigned8	rw	0	[0 – 5]
6133		Ai_Interrupt delta input PV				
	00	Number of entries	Unsigned8	ro	1	
	01	PV_1	Float32	rw	0	0: disabled
6134		AI interrupt lower limit input PV				
	00	Number of entries	Unsigned8	ro	1	
	01	PV_1	Float32	rw	-2.000.000.000	(2.000.000.000:disabled)

Index (HEX)	Sub Index	Name	Type	Access	Default	Comment
6135		Ai interrupt upper limit input PV				
	00	Number of entries	Unsigned8	ro	2	
	01	PV_1	Float32	rw	-2.000.000.000	(2.000.000.000: disabled)
6148		Ai_span_start				
	00	Number of entries	Unsigned8	ro	1	
	01	Ai_span_start_1	Float32	ro		Min. temperature of measurement
6149		Ai_span_end				
	00	Number of entries	Unsigned8	ro	1	
	01	Ai_span_end_1	Float32	ro		Max. temperature of measurement
6150		Ai status				
	00	Number of entries	Unsigned8	ro	1	
	01	PV_1	Unsigned8	ro	0	(bit set => error) Bit 0 = 1: invalid Bit 1 = 1: pos. overload Bit 2 = 1: neg. overload
61A0		Ai_filter_type				
	00	Number of entries	Unsigned8	ro	1	
	01	Ai_filter_type_1	Unsigned8	rw	0	0: no filter 1: moving average 2: repeating average
61A1		Ai_filter_constant				
	00	Number of entries	Unsigned8	ro	1	
	01	Ai_filter_constant_1	Unsigned8	rw	0	
9100		Ai_input_FV				
	00	Number of entries	Unsigned8	ro	1	
	01	Ai_input_FV_1	Integer32	ro		Current temperature ADC value
9124		Ai_input_offset				
	00	Number of entries	Unsigned8	ro	1	
	01	Ai_input_offset_1	Integer32	rw	0	Temperature offset; will be added to the current temperature value; min/ max value= min/max temperature of DST T92C
9130		Ai_input_PV				
	00	Number of entries	Unsigned8	ro	1	
	01	Ai_input_PV_1	Integer32	ro		Current temperature value

Index (HEX)	Sub Index	Name	Type	Access	Default	Comment
9133		Ai_interrupt delta input PV				
	00	Number of entries	Unsigned8	ro	1	
	01	PV_1	Integer32	rw	0	0: disabled
9134		Ai_interrupt lower limit input PV				
	00	Number of entries	Unsigned8	ro	1	
	01	PV_1	Integer32	rw	-2.000.000.000	-2.000.000.000: disabled
9135		Ai interrupt upper limit input PV				
	00	Number of entries	Unsigned8	ro	1	
	01	PV_1	Integer32	rw	2.000.000.000	2.000.000.000: disabled
9148		Ai_span_start				
	00	Number of entries	Unsigned8	ro	1	
	01	Ai_span_start_1	Integer32	ro		Min. temperature of measurement
9149		Ai_span_end				
	00	Number of entries	Unsigned8	ro	1	
	01	Ai_span_end_1	Integer32	ro		Max. temperature of measurement

3.5 Configuration of the transmit PDO

This chapter describes the configuration of the transmit PDO.

Dynamic mapping:
The PDO configuration is done by the OD entry TPDO1 mapping (index 0x1A00) and its sub indices. The sub index 1 defines the first value (lower position) transmitted by the PDO. The sub index 2 defines the second value, the sub index 3 the third and the sub index 4 the fourth value transmitted by the PDO.

If not all values are used, the upper sub indices must be set to 0.

To change the mapping, the following procedure must be observed:
1. Set the "Nr. of mapped objects" (0x1A00/0x00) to 0. => The PDO is deactivated.
2. Set the desired mapping values (0x1A00/0x01…0x04).
3. Set the "Nr. of mapped objects" (0x1A00/0x00) to the desired number of mapping objects.

Default mapping
The default values of these sub indices are 0x91300120 (sub index 1), 0x61500108 (sub index 2) and 0 (sub index 3 and 4):

Name	Index	Subindex	Value
TPDO1 Mapping - Nr Of Mapped Obj	0x1a00	0x00	0x2
TPDO1 Mapping - value 1	0x1a00	0x01	0x91300120
TPDO1 Mapping - value 2	0x1a00	0x02	0x61500108
TPDO1 Mapping - value 3	0x1a00	0x03	0x0
TPDO1 Mapping - value 4	0x1a00	0x04	0x0

That means:
The first value which will be sent by the transmit PDO is the value of the
OD index 0x9130 with the sub index 0x01 and the length 0x20 bits (=> 0x91300120). It is the temperature value (signed integer 32 bit).
The second value of the transmit PDO is the OD index 0x6150 with the sub index 0x01 and the length 0x08 bits (=> 0x61500108). It is the temperature status (unsigned integer 8 bit).

So the transmit PDO may look like the following message:

Transmit PDO (example)

	ID	DLC	Byte 0			Data		Byte 7
TPDO	0x180 + Node ID	5	0xA0 (temp. LSB)	0x86	0x01	0x00 (temp. MSB)	0x00 (temp. status)	not available

This example shows a temperature value of 100000 (= 0x186A0) and the status 0 (valid).

Units:
The units of the sent values are defined by the settings of the following object dictionary entries:
- AI Physical unit PV (index 0x6131): these specify the physical units of the values of indices 0x6130 and 0x9130.
- AI Decimal digits PV (index 0x6132): these specify the decimal digits of the integer values of the index 0x9130. 1 means that the value is multiplied by 10, and 2 means multiplied by 100, …

The possible settings can be seen in chapter 3.4 .

Hint:
Only the following object dictionary indices are mappable:
- index 0x6130, sub index 0x01 (temperature, float32)
- index 0x6150, sub index 0x01 (temperature status, unsigned8)
- index 0x9130, sub index 0x01 (temperature, integer32)

Example mapping:
To get the temperature value with float 32 bit and the temperature value with signed integer 32 bit, the sub index 1 has to be set to 0x61300120 (0x6130, 0x01, 0x20) and the sub index 1 to 0x91300120 (0x9130, 0x01, 0x20).

3.6 Emergency message

Emergency messages show an internal device error. If the error situation for the device has changed, it will send an emergency message with the current error code.

An error code 0x0000 shows that all errors are removed.

The current error situation could be read out with the object profile entry "Pre-defined Error Field" index 0x1003, sub index 1.

The COB-ID of an emergency message is shown in the communication profile of the object dictionary, index 0x1014 (= 0x80 + Node ID).

Construction of the emergency message

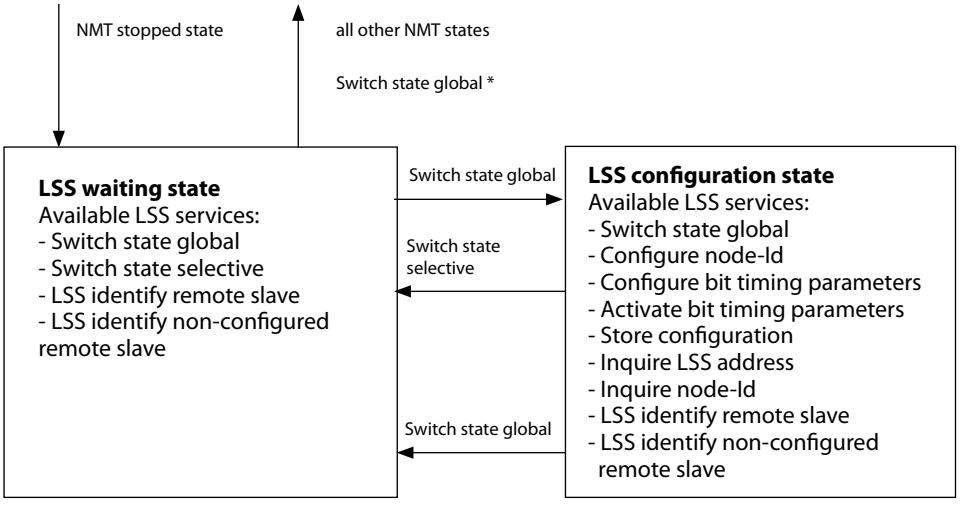
Data			
Byte 0			**Byte 7**
Error code LSB	Error code MSB	Error register (Index 0x1001)	Not used

Error codes

Error codes	Explanation
0x8100	Error CAN-communication
0x6161	Internal software-error (EEPROM settings invalid)
0x6363	PDO-mapping error
0x6300	Data-error (start up error)
0xF011	Error temperature, limits exceeded

4. Layer setting services

The DST T92C with CANopen supports the Layer setting services.
These services and protocols are used to inquire the settings of the LSS address (object 0x1018), the bit rate and the node ID. Also the bit rate and the node ID could be changed by the LSS.



Some requirements/hints must be observed when using the LSS:

- The producer heartbeat time must be 0 (=default; object 0x1017)
- The DST T92C must be in NMT stopped state
- In LSS configuration state, no NMT-command will be executed
- Only a stored bit rate and node ID will appear in the object dictionary (0x4F00 and 0x4F01)
- The LSS address consists of four values:
  - Vendor-Id: Object dictionary index 0x1018, sub-index 1: always 0x23D
  - Product-code: Object dictionary index 0x1018, sub-index 2: order number of this DST T92C (BCD)
  - Revision-number: Object dictionary index 0x1018, sub-index 3: software version of this DST T92C (BCD)
  - Serial-number: Object dictionary index 0x1018, sub-index 4: a unique serial number

4.1 Supported services

All services of DSP305 V2.0 can be used. The supported parameters of the services can be found in this section. The CAN identifiers are reserved for LSS:

- 0x7E5 for commands from LSS master
- 0x7E4 for answers from LSS slave

Switch state global:

	Data							
	Byte 0							**Byte 7**
Command	Command specifier request	mode	reserved	reserved	reserved	reserved	reserved	reserved

Command specifier request: 0x04
Mode: 0x00 switches to waiting state
0x01 switches to configuration state

Hints:

- After storing a new node ID, the "Switch state global" service with the parameter "switches to waiting state" will activate the last stored node ID and it will be used immediately. So after that, the DST T92C will transmit the bootup-message and stays in NMT preoperational state.
- Once the LSS configuration state has been left, all not stored data is no longer available.

Switch state selective:

	Data							
	Byte 0							**Byte 7**
Command	Command specifier request	data LSB	data	data	data MSB	reserved	reserved	reserved
Answer	Command specifier answer	reserved	reserved	reserved	reserved	reserved	reserved	reserved

Command specifier request: 0x40 Vendor-Id
0x41 Product-code
0x42 Revision-number
0x43 Serial-number
Command specifier answer: 0x44

Hint:
The revision-number can be ignored by using 0.

Configure node ID:

	Data							
	Byte 0							**Byte 7**
Command	Command specifier request	Node-Id	reserved	reserved	reserved	reserved	reserved	reserved
Answer	Command specifier answer	Error code	spec. code	reserved	reserved	reserved	reserved	reserved

Command specifier request: 0x11
Node ID: 1 – 127
Command specifier answer: 0x11
Error code: 0 Protocol successfully completed
1 Node ID out of range
Spec. error always 0

Configure bit timing parameters:

	Data							
	Byte 0							**Byte 7**
Command	Command specifier request	table selector	table index	reserved	reserved	reserved	reserved	reserved
Answer	Command specifier answer	error code	spec. error	reserved	reserved	reserved	reserved	reserved

Command specifier request: 0x13
Table selector: 0 Standard CiA bit timing table

Table index:

Standard CiA bit timing table:
0 1 Mbit/s
1 800 kbit/s
2 500 kbit/s
3 250 kbit/s
4 125 kbit/s
5 reserved
6 50 kbit/s
7 20 kbit/s

Command specifier answer: 0x13
Error code:
0 Protocol successfully completed
1 Bit timing not supported
always 0

Activate bit timing parameters:

	Data							
	Byte 0							**Byte 7**
Command	Command specifier	switch_ delay	reserved	reserved	reserved	reserved	reserved	reserved

Command specifier: 0x15
Switch_delay: The duration of the two periods of time to wait. See DSP305 for more details. Unit: milliseconds.

Hints:
- Only the last saved bit timing will be activated by this service.
- After setting the new bit timing valid, the DST T92C will transmit the bootup-message, but also it will stay in NMT stopped state.

Store configuration:

	Data							
	Byte 0							**Byte 7**
Command	Command specifier request	reserved	reserved	reserved	reserved	reserved	reserved	reserved
Answer	Command specifier answer	error code	spec. error	reserved	reserved	reserved	reserved	reserved

Command specifier request: 0x17
Command specifier answer: 0x17
Error code:
0 Protocol successfully completed
1 Node ID out of range
255 See spec. error
Spec. error:
only with error code 255:
1 Nothing to store

Inquire LSS address:

	Data							
	Byte 0							**Byte 7**
Command	Command specifier request	reserved	reserved	reserved	reserved	reserved	reserved	reserved
Answer	Command specifier answer	data LSB	data	data	data MSB	reserved	reserved	reserved

Command specifier request:
0x5A Vendor-Id
0x5B Product-code
0x5C Revision-number
0x5D Serial-number
Command specifier answer: like request
Data: requested value

Inquire node ID:

	Data							
	Byte 0							**Byte 7**
Command	Command specifier request	reserved	reserved	reserved	reserved	reserved	reserved	reserved
Answer	Command specifier answer	node ID	reserved	reserved	reserved	reserved	reserved	reserved

Command specifier request: 0x5E
Command specifier answer: 0x5E
Node ID: node ID

Hint:
- The return value of the node ID will be the valid and stored value from EEPROM.

LSS identify remote slave:

	Data							
	Byte 0							**Byte 7**
Command	Command specifier request	data LSB	data	data	data MSB	reserved	reserved	reserved
Answer	Command specifier answer	reserved	reserved	reserved	reserved	reserved	reserved	reserved

Command specifier request: 0x46 Vendor-Id
0x47 Product-code
0x48 Revision-number-low
0x49 Revision-number-high
0x4A Serial-number-low
0x4B Serial-number-high
Command specifier answer: 0x4F

Hints:
- The revision-number-low and revision-number-high can be ignored by using 0.
- To identify the slave, the shown order of the requests must be observed.

LSS identify non-configured remote slave:

	Data							
	Byte 0							**Byte 7**
Command	Command specifier request	reserved	reserved	reserved	reserved	reserved	reserved	reserved
Answer	Command specifier answer	reserved	reserved	reserved	reserved	reserved	reserved	reserved

Command specifier request: 0x4C
Command specifier answer: 0x50

4.2 LSS example

This example of the usage of the Layer setting services shows the changing of the node ID from 1 to 5 and the changing of the bit rate to 250 kbit/s. Only one slave has to be connected to the CAN bus if using this example.

No.	Servi ce	CAN-Id	DLC	Data								Dir	Comment
				D0	D1	D2	D3	D4	D5	D6	D7		
	NMT boot-up	0x701	1	0x00								Rx	boot-up message from slave
1	NMT stopped	0x000	2	0x02	0x00							Tx	set slave to NMT stopped state
2	Switch state global: LSS configuration state	0x7E5	8	0x04	0x01	0x00	0x00	0x00	0x00	0x00	0x00	Tx	set slave to LSS configuration state
3	Configure node ID	0x7E5	8	0x11	0x05	0x00	0x00	0x00	0x00	0x00	0x00	Tx	set new node ID: 5
		0x7E4	8	0x11	0x00	0x00	0x00	0x00	0x00	0x00	0x00	Rx	answer: OK
4	Configure bit timing parameters	0x7E5	8	0x13	0x00	0x03	0x00	0x00	0x00	0x00	0x00	Tx	set new bit rate: 250 kbit/s
		0x7E4	8	0x13	0x00	0x00	0x00	0x00	0x00	0x00	0x00	Rx	answer: OK
5	Store figuaration	0x7E5	8	0x17	0x00	0x00	0x00	0x00	0x00	0x00	0x00	Tx	store the new settings to EEPROM
		0x7E4	8	0x17	0x00	0x00	0x00	0x00	0x00	0x00	0x00	Rx	answer: OK
6	Activate bit timing parameters	0x7E5	8	0x15	0x64	0x00	0x00	0x00	0x00	0x00	0x00	Tx	activate the new bit rate after 100ms
		0x701	1	0x00								Rx	boot-up message from slave with new bit rate (but with old node ID)
7	Switch state global: LSS waiting state	0x7E5	8	0x04	0x00	0x00	0x00	0x00	0x00	0x00	0x00	Tx	set all slaves to LSS waiting state
		0x705	1	0x00								Rx	boot-up message from slave (with new code ID)

Direction: Tx: message from (NMT/LSS) master
Rx: message from slave

Hint:
- Services no. 6 and 7 can be replaced by a power supply cycle.

5. CAN communication without CANopen functionality

5.1 Basic configuratione

The CAN temperature transmitter can be used without any problems in CAN networks without CANopen functionality. Before using the DST T92C, the following basic configurations should be set:

1. Bit rate, default is 125 kbit/s, object 0x4F00
2. Node ID, default is 1, object 0x4F01. The CAN identifier will be created from the node ID (see table 5.5). All CAN identifiers are 11 bit identifiers (default setting).
3. Additional settings (phys. unit, etc.) can be found in the object dictionary (3.4 Object Dictionary: Device Profile) and in 5.4 Change Node Configuration Manually.
4. The new settings are saved with object 0x1010/01. The 0x65766173 (ASCII: „save“) must be entered here. The settings will be saved to non-volatile memory.

5.2 Network operation without CANopen master

After connecting the transmitter to the supply voltage, the transmitter will send a boot-up message with the CAN identifier 0x700 + Node ID (default 0x701) with one data byte (content = 0) if no error is detected.

If an error is detected the error code (see 3.6 emergency message) will be sent together with the CAN identifier.

The temperature transmitter is now in the “Pre_Operational_State”. With the CANopen command “Start_Remote_Node” the temperature transmitter will be activated.

“Start_Remote_Node”:

	ID	DLC	Date							
			Byte 0							Byte 7
Command “start_ Remote_Node”	0x000	2	0x01	Node ID or 0x00 (all CAN-open members)						

The “Start_Remote_Node” will be answered with a data message (PDO) with the CAN identifier 0x180 + Node ID (default 0x181). Now the CAN transmitter sends cyclically (default setting) PDOs with the temperature value and the status.

Construction of the message for temperature measurement (PDO):

	ID	DLC	Date						
			Byte 0						Byte 7
PDO mes- sage	0x180 + Node ID	5	0x01	Temp. Signed32 LSB	Temp. Signed32	Temp. Signed32	Temp. Signed32 MSB	Temp. status	

The values of the temperature measurement can be also read as 32 bit integer or 32 bit float. The choice is done by the PDO mapping and is described in 3.5 Configuration of the transmit PDO.
The values of the temperature measurement can be also read from the object dictionary (SDO access) as 32 bit integer or 32 bit float. The floating point format is explained in the appendix (chapter 7.1 Definition of IEEE 32bit floating point numbers). This access is independent of the current operational state of the temperature transmitter.
The status provides the following information:
Bit 0: temperature value invalid
Bit 1: positive overload
Bit 2: negative overload

Temperature measurement

Request value of temperature measurement (float32, SDO access):

	ID	**DLC**	**Data**							
			Byte 0							**Byte 7**
Command	0x600 + Node ID	8	SDO Re- quest 0x40	Index LSB 0x30	Index MSB 0x61	Sub Index 0x01	Not used			
Answer	0x580 + Node ID	8	SDO Ack. 0x43	Index LSB 0x30	Index MSB 0x61	Sub Index 0x01	Data LSB	Data	Data	Data MSB

Request value of temperature measurement (integer32, SDO access):

	ID	DLC	Data							
			Byte 0							Byte 7
Command	0x600 + Node ID	8	SDO Request 0x40	Index LSB 0x30	Index MSB 0x91	Sub Index 0x01	Not used			
Answer	0x580 + Node ID	8	SDO Ack. 0x43	Index LSB 0x30	Index MSB 0x91	Sub Index 0x01	Data LSB	Data	Data	Data MSB

Temperature measurement

Request value of temperature measurement (float32, SDO access):

	ID	DLC	Data							
			Byte 0							Byte 7
Command	0x600 + Node ID	8	SDO Request 0x40	Index LSB 0x30	Index MSB 0x61	Sub Index 0x01	Not used			
Answer	0x580 + Node ID	8	SDO Ack. 0x43	Index LSB 0x30	Index MSB 0x61	Sub Index 0x01	Data LSB	Data	Data	Data MSB

5.2.1 SDO abort codes

If the SDO access fails, the DST T92C will answer with a SDO abort code.

SDO abort code	Meaning
0x06010001	Attempt to read a write only object
0x06010002	Attempt to write a read only object
0x06020000	Object does not exist in the object dictionary
0x06040041	Object cannot be mapped to the PDO
0x06040042	The number and length of the objects to be mapped would exceed PDO length
0x06040043	General parameter incompatibility reason
0x06060000	Access failed due to an hardware error
0x06070012	Data type does not match, length of service parameter too high
0x06070013	Data type does not match, length of service parameter too low
0x06090011	Sub-index does not exist.
0x06090030	Value range of parameter exceeded (only for write access)
0x06090031	Value of parameter written too high
0x06090032	Value of parameter written too low

5.3 Cyclically sending

The temperature transmitter DST T92C is able to send the values of measurements (PDO) cyclic with a programmable time interval.

The event timer is activated by writing 0xFF to the object 0x1800 subindex 2 (transmission type).

The timer interval is written to the object 0x1800 subindex 5 (event timer). The value (unsigned16) is set in units of 1 ms. The value range is from 0 ms to 65535 ms. 0 stops the event timer.

Default settings:
- Transmission type: 0xFF (event timer active)
- Event timer: 1000 ms

Activate event timer (SDO access):

	ID	DLC	Data					
			Byte 0					Byte 7
Command	0x600 + Node ID	8	SDO write 0x2F	Index LSB 0x00	Index MSB 0x18	Sub Index 0x02	Trans-mission Type 0xFF	Not used
Answer	0x580 + Node ID	8	SDO Ack. 0x60	Index LSB 0x00	Index MSB 0x18	Sub Index 0x02	Not used	

Set event timer (SDO access):

	ID	DLC	Data						
			Byte 0						Byte 7
Command	0x600 + Node ID	8	SDO write 0x2B	Index LSB 0x00	Index MSB 0x18	Sub Index 0x05	Timer LSB	Timer MSB	Not used
Answer	0x580 + Node ID	8	SDO Ack. 0x60	Index LSB 0x00	Index MSB 0x18	Sub Index 0x05	Not used		

Get event timer (SDO access):

	ID	DLC	Data						
			Byte 0						Byte 7
Command	0x600 + Node ID	8	SDO Re-quest 0x40	Index LSB 0x00	Index MSB 0x18	Sub Index 0x05	Not used		
Answer	0x580 + Node ID	8	SDO Ack. 0x4B	Index LSB 0x00	Index MSB 0x18	Sub Index 0x05	Timer LSB	Timer MSB	Not used

Note:
If the device is not configured as self-starting device (OD 0x1F80), the message "start_remote_node" must be sent after reset or power up.

The temperature transmitter can sample up to 107 values of measurement per second. The maximum data rate on the CAN bus depends on the bitrate and the maximum workload.

5.4 Change node configuration manually

The basic configuration of the temperature transmitter can be manually set through the object dictionary with the addresses 0x4F01 (node ID) and 0x4F00 (CAN bitrate). The new settings are active after a reset.

Node ID

Set Node ID:

	ID	DLC	Data					
			Byte 0					Byte 7
Command	0x600 + Node ID	8	SDO write 0x2F	Index LSB 0x01	Index MSB 0x4F	Sub Index 0x00	Node ID Byte	Not used
Answer	0x580 + Node ID	8	SDO Ack. 0x60	Index LSB 0x01	Index MSB 0x4F	Sub Index 0x00	Not used	

Get Node ID:

	ID	DLC	Data					
			Byte 0 7					Byte
Command	0x600 + Node ID	8	SDO Re-quest 0x40	Index LSB 0x01	Index MSB 0x4F	Sub Index 0x00	Not used	
Answer	0x580 + Node ID	8	SDO Ack. 0x4F	Index LSB 0x01	Index MSB 0x4F	Sub Index 0x00	Node ID Byte	Not used

CAN-Bitrate

Set CAN Bitrate index:

	ID	DLC	Data					
			Byte 0					Byte 7
Command	0x600 + Node ID	8	SDO write 0x2F	Index LSB 0x00	Index MSB 0x4F	Sub Index 0x00	Bitrate-index Byte	Not used
Answer	0x580 + Node ID	8	SDO Ack. 0x60	Index LSB 0x00	Index MSB 0x4F	Sub Index 0x00	Not used	

Get CAN Bitrate index:

	ID	DLC	Data					
			Byte 0					Byte 7
Command	0x600 + Node ID	8	SDO Re-quest 0x40	Index LSB 0x00	Index MSB 0x4F	Sub Index 0x00	Not used	
Answer	0x580 + Node ID	8	SDO Ack. 0x4F	Index LSB 0x00	Index MSB 0x4F	Sub Index 0x00	Bitrate-index Byte	Not used

NMT start-up

Activate automatic transition to the "Operational_State":

	ID	DLC	Data							
			Byte 0							Byte 7
Command	0x600 + Node ID	8	SDO write 0x23	Index LSB 0x80	Index MSB 0x1F	Sub Index 0x00	Data LSB 0x08	Data 0x00	Data 0x00	Data MSB 0x00
Answer	0x580 + Node ID	8	SDO Ack. 0x60	Index LSB 0x80	Index MSB 0x1F	Sub Index 0x00	Not used			

Deactivate automatic transition to the "Operational_State":

	ID	DLC	Data							
			Byte 0							Byte 7
Command	0x600 + Node ID	8	SDO write 0x23	Index LSB 0x80	Index MSB 0x1F	Sub Index 0x00	Data LSB 0x04	Data 0x00	Data 0x00	Data MSB 0x00
Answer	0x580 + Node ID	8	SDO Ack. 0x60	Index LSB 0x80	Index MSB 0x1F	Sub Index 0x00	Not used			

"Save"-command to store all parameters to non-volatile memory

	ID	DLC	Data							
			Byte 0							Byte 7
Command	0x600 + Node ID	8	SDO Re-quest 0x23	Index Lo 0x10	Index Hi 0x10	Sub Index 0x01	ASCII ‚s' 0x73	ASCII ‚a' 0x61	ASCII ‚v' 0x76	ASCII ‚e' 0x65
Answer	0x580 + Node ID	8	SDO Ack. 0x60	Index Lo 0x10	Index Hi 0x10	Sub Index 0x01	Not used			

"Load"-command to restore all default parameters

	ID	DLC	Data							
			Byte 0							Byte 7
Command	0x600 + Node ID	8	SDO Re-quest 0x23	Index Lo 0x11	Index Hi 0x10	Sub Index 0x01	ASCII ‚i' 0x6C	ASCII ‚o' 0x6F	ASCII ‚a' 0x61	ASCII ‚d' 0x64
Answer	0x580 + Node ID	8	SDO Ack. 0x60	Index Lo 0x11	Index Hi 0x10	Sub Index 0x01	Not used			

5.5 Reserved CAN identifiers

The following CAN identifiers are reserved by the CAN protocol:

CAN-identifier (11 Bit), Hex	Description
0x000	NMT, network management
0x080	SYNC, synchronisation message, not used in asynchronous mode (see 3.2)
0x080 - Node ID max. range 0x081 – 0x0FF	Emergency message
0x180 - Node ID max. range 0x181 – 0x1FF	PDO1 TX, message with the value of temperature measurement
0x580 - Node ID max. range 0x581 – 0x5FF	SDO Tx, CANopen configuration message
0x600 - Node ID max. range 0x601 – 0x67F	SDO Rx, CANopen configuration message
0x700 - Node ID max. range 0x701 – 0x77F	CANopen node guarding

6. Extensions

- Device profile DS404
- Heartbeat function
- Different units for the temperature values available
- Programmable monitoring of the measurement range
- Autozero function
- Offset shift

7. Appendix

7.1 Definition of IEEE 32Bit (single precision floating point numbers (IEEE-754 standard)

Single precision floating point numbers cover a value range of - $3.4 \cdot 10^{38}$ – $3.4 \cdot 10^{38}$.

32 bit floating point numbers need 4 byte (32 bit) storage memory. The following table shows the IEEE 32 bit implementation of floating point numbers:

Bit position:	31	30 – 23	22 – 0
Function	S	exponent	mantissa

S = sign bit

The value can be calculated with this formula:
$(-1)^S 2^{(exponent-127)} (1 + mantissa)$
The mantissa starts behind the comma (position 2^{-1}). The first number in front of the comma (position 2^0) is always 1 and will not be stored in the mantissa.

Example:
Hex: 400C CCEA$_{HEX}$
Binary: 0100 0000 0000 1100 1100 1100 1110 1010$_{BIN}$

Sign bit: = 0
Exponent = 10000000$_{BIN}$ = 128$_{DEC}$

Mantissa = 00011001100110011101010$_{BIN}$
= $0 \cdot 2^{-1} + 0 \cdot 2^{-2} + 0 \cdot 2^{-3} + 1 \cdot 2^{-4} + 1 \cdot 2^{-5} + - + 1 \cdot 2^{-22}$
= 0.100003481$_{DEC}$

$400CCCEA_{HEX} = (-1)^0 2^{(128-127)} (1+0.100003481) = 2.200007_{DEC}$

More examples and IEEE-754 definitions:

Hex	Decimal
00000000$_{HEX}$	0.0
3F800000$_{HEX}$	1.0
BF800000$_{HEX}$	-1.0
FFFFFFFF$_{HEX}$	Not a number (NaN)

7.2 CoEdit

The CoEdit is a program for reading and writing the objects of the DST T92C. The objects are defined in the EDS file for the temperature transmitter.

7.3 References

DS301 Application Layer and Communication Profile
DS302-2 Additional Application Layer Functions Part 2: Network Management
DR303-1 Cabling and Connector Pin Assignment
DS404 Device Profile Measuring Devices and Closed-Loop Controllers

7.4 Definitions

COB Communication Object
Data must be sent inside a COB across a CAN network. There exist 2048 different COBs in a CAN network. A COB contains maximal 8 data bytes.
LSS Layer setting services
PDO Process Data Object
SDO Service Data Object

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