BINSFELD ENGINEERING INC.

TorqueTrak TPM2 Stationary Interface

RS-422 Communications Specification

Scan for further Technical Product Information

866600-C_A

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1 General TPM2 Stationary Interface Communications

1.1 Data Byte Format

Each transmitted or received byte consists of: 1 start bit, 8 data bits, 1 parity bit (optional), 1 stop bit (minimum). The 8 data bits are transmitted least significant bit first.

2 TPM2 Stationary Interface Transmitted Data

2.1 Message Format

The TPM2 streams out samples at the selected sample rate. Each sample consists of 8 bytes as follows:

Table 1: TPM2 Stationary Interface sample transmit data

Byte	Description
0	Strain Gage Value (low byte)
1	Strain Gage Value (high byte)
2	Shaft Speed Value (low byte)
3	Shaft Speed Value (high byte)
4	Status Info (byte 0)
5	Status Info (byte 1)
6	Status Info (byte 2)
7	Checksum byte

2.1.1 Strain Gage Value

The combined low byte and high byte of the Strain Gage Value form a 16 bit signed integer that is used to calculate the torque strain using the equation:

$$\epsilon = (Val_{out} * 15729) / (G_{xmtr} * GF * 7864.32)$$

ϵ = strain (in units of µstrain)
Val_{out} = TPM2 output Strain Gage Value
G_{xmtr} = user selectable transmitter gain (see Table 3)
GF = gauge factor
(15729 / 7864.32) is a system derived constant

The Torque Strain value, along with the shaft parameters, allow the monitoring device to calculate the actual shaft torque in force times distance units (Newton-meters, ft-lbs, etc.) using the equation:

$$T = (\epsilon * \pi * E * (OD^4 - ID^4)) / (K_T * OD * (1 + v))$$

T = torque (N-m or ft-lbs)
ϵ = strain, (in units of µstrain)
E = modulus of elasticity of the shaft material (N/mm^2 or Mpsi)
OD = outside diameter (mm or inches)
ID = inside diameter (mm or inches)
v = Poisson's ratio of the shaft material
K_T = torque units dependent constant (for N-m, $K_T = 1.6 \times 10^{10}$: for ft-lbs, $K_T = 192$)

The sign of the Strain Gage Value indicates the relative torque force direction.

From the torque, the power can be calculated using the equation:

$P = (T * 2\pi * \omega) / K_p$

P = power
T= torque
2π is radians/revolution
ω = rotational speed (RPM)
Kp = torque units dependent power constant

Table 2: Power Constant values (K_p)

Power units	Torque units	K_p
watts	N-M	60
hp	ft-lbs	33000
hp	in-lbs	2750

2.1.2 Shaft Speed Value

The combined low byte and high byte of the Shaft Speed Value forms a 16 bit signed integer. This binary integer value is in either revolutions per minute (RPM) or hundredths of revolutions per minute (RPM x 100). The resolution of the Shaft Speed Value is indicated by the RPM_RES bit in status byte 0.

The sign of the Shaft Speed value indicates the relative direction of rotation. When looking at the front of the TPM2 Stator, a positive value indicates clockwise rotation and negative indicates counter-clockwise rotation. A zero Shaft Speed Value indicates that the shaft is turning slower than the minimum shaft speed value or has stopped.

The Shaft Speed Value is measured once per shaft revolution. This new value is transmitted with the next sample and the RPM_NEW status flag is set to indicate a new shaft speed measurement. This same value is transmitted on subsequent samples, until the shaft completes another rotation and a new speed is measured.

2.1.2.1 Shaft Power Calculation

The actual shaft power can be calculated using the measured Strain Gage Value, the shaft parameters and the measured Shaft Speed Value.

2.1.3 Status Information

The status information bytes are grouped bit flags that indicate the operating status of the TPM2. The flags are active high; bits set to ‘1’ indicate the condition exists and bits cleared to ‘0’ indicate the condition does not exist. Below is a description of each bit (flag).

2.1.3.1 Status Info byte 0 (Stator Status and Error flags)

Bit Name/Description

0 RPM_NEW

1 = Shaft Speed value in this sample was just measured

0 = Shaft Speed value in this sample is old, a hold from the last sample measured

1 RPM_ERR

1 = An error was detected in the RPM measurement. Check rotor-stator alignment and spacing

0 = No RPM measurement errors detected.

2 RPM_RES

1 = The Shaft Speed value's resolution is 1/100 RPM, set when the shaft speed falls below approximately 53 RPM.

0 = The Shaft Speed value's resolution is 1 RPM, cleared when the shaft speed rises above approximately 105 RPM.

3 ECOM_ACK

1 = A command has been received OK. This is an acknowledgment that the TPM2 received one or more commands since the last sample was sent. It is set in the sample following reception of the command(s), after which it is cleared.

0 = No command received since last sample sent.

4 ECOM_ERR

1 = An error was detected in external communication link from the Connected Device. Possible errors: Transmit buffer overrun, received data parity error, received data framing error, incorrect received message checksum detected.

0 = No external communication errors detected

5 STAT_PWR_ERR

1 = The Stator main regulated power supply voltage is too high or low, or an over current error exists.

0 = No Stator main regulated power supply problems are detected.

6 II_AMP_TEMP_WRN

1 = The II power amplifier temperature is at or nearing thermal shutdown.

0 = The II power amplifier temperature is OK.

7 STAT_TEST_MODE

1 = Stator in test mode.

0 = Stator in normal mode.

2.1.3.2 Status Info byte 1 (Rotor Error Flags)

0 TRQ_HLD_ERR

1 = The Torque value in this sample is a hold from the last good sample received from the Transmitter

0 = The Torque value is new

1 TRQ_RNG_ERR

1 = The Torque value in this sample is out of range

0 = The Torque value is not out of range

2 GAGE_DIFF_ERR

1 = Gage differential mode input of the transmitter is out of range. This error will also give a TRQ_RNG_ERR

0 = Gage differential mode input of the transmitter is in range

3 GAGE_COM_ERR

1 = Gage common mode input of the transmitter is out of range. This error will also give a TRQ_RNG_ERR

0 = Gage common mode input of the transmitter is in range

4 ROT_PWR_LO_ERR

1 = The Rotor power supply voltage is too low.

0 = The Rotor power supply voltage is not low.

5 ROT_DATA_ERR

1 = An error has been detected receiving data from the Rotor (Transmitter)

0 = Rotor data is being received OK

6 ROT_DATA_GONE

1 = There is no Rotor (Transmitter) Data being received without error

0 = Rotor data is being received

7 RFU

Not currently used

2.1.3.3 Status Info byte 2 (Rotor Status)

0 GAIN0

1 GAIN1

2 GAIN2

Table 3: TPM2 Transmitter Gain settings

GAIN2	GAIN1	GAIN0	GAIN Factor	Strain Range Full Scale (με)	[1]Input Voltage Range Full Scale (mV/V)	Strain Gage Value Full Scale
0	0	0	1	±16000	±32.000	±16000
0	0	1	2	±8000	±16.000	±16000
0	1	0	4	±4000	±8.000	±16000
0	1	1	8	±2000	±4.000	±16000
1	0	0	16	±1000	±2.000	±16000
1	0	1	32	±500	±1.000	±16000
1	1	0	64	±250	±0.500	±16000
1	1	1	128	±125	±0.250	±16000

[1] Gage Factor = 2.0

3 Shunt 1 is ON

1 = Shunt 1 (200uV/V) is ON.

0 = Shunt 1 is OFF

4 Shunt 2 is ON

1 = Shunt 2 (1000uV/V) is ON.

0 = Shunt 2 is OFF

5 RFU

Not currently used

6 RFU

Not currently used

7 RFU

Not currently used

2.1.4 Checksum

The checksum byte is simply the low byte of the sum of the 7 other bytes in the sample.

3 TPM2 Stationary Interface Commands (Received Data)

Commands are sent to the TPM2 for set up and control of TPM2 operation.

3.1 Command Format

Commands consist of 4 byte blocks.

Table 4: Stationary Interface command message format

Byte	Description
0	Command code
1	Command data byte1
2	Command data byte2
3	Checksum byte

3.1.1 Command bytes

Command code, Command data byte1, Command data byte2

The first byte is the command byte. It is a single byte value The first three bytes identify the command and command data.

3.1.2 Checksum

The checksum (chksum) byte is simply the low byte of the sum of the three command bytes.

Table 5: Stationary Interface commands

Command Description	byte0 cmd code	byte1	byte2	byte3 chksum
Establish communications (auto baud detect) Send the entire message at the desired baud rate repeatedly. If possible, insert a byte of dead time between messages to allow the TPM2 to properly frame the message. If it is not possible to create this transmission timing, send the message repeatedly with zero or no more than a few bits of dead time between messages for a minimum of 10msec (at least two messages at low baud rates, whichever is longer). Then stop transmitting for at least 8 byte times. Keep repeating the sequence until an auto baud response data (55 01 02 03 FE E8 C4 05) is received back from the TPM2 indicating success. Dead time greater than 120msec terminates auto baud detection whether it is successful or not. If auto baud detection is unsuccessful, the TPM2 will revert to its last known good settings. When auto baud detection is successful, the TPM2 will	0x55	0x08	0xef	chksum

Command Description	byte0 cmd code	byte1	byte2	byte3 chksum
continue to transmit the auto baud response data once every 90msec until it detects receive dead time of more than 120msec. After detecting sufficient receive dead time, normal data transmission is resumed.				
Configure communications byte1 bits b7, b6 – parity 00 = none (default) 01 = even 10 = odd b5 – stop bits 0 = 1 stop bit (default) 1 = 2 stop bits b4 downto b0 - baud rate code value 0 = 460.8K 1 = 230.4K 2 = 115.2K (default) 3 = 57.6K 4 = 28.8K 5 = 14.4K 6 = 9600 7 = 4800 8 = 2400 9 = 1200 byte2, TX sample rate value: 0 = 4800 samples/sec 1 = 2400 2 = 1200 (default) 3 = 600 4 = 300 5 = 150 6 = 75 7 = 37.5 8 = 18.75 9 = 9.375 **Note: the baud rate code value in byte1must be <= the sample rate value in byte2 because the baud rate limits the possible sample rates.**	0x8a			chksum
System control: byte1 - RFU byte2 1 = Reset TPM2 Transmitter 2 = Reset TPM2 System 0x80 = Disable Auto Baud detection. Auto Baud detection is active by default at power-up or system reset.	0x90	0x00		chksum

Command Description	byte0 cmd code	byte1	byte2	byte3 chksum
Transmitter control byte1 bits, shunt control b7 downto b2, RFU b1 – shunt 2, 0 = OFF, 1 = ON b0 – shunt 1, 0 = OFF, 1 = ON byte2, transmitter gain value 0 = gain of 1 (default) 1 = gain of 2 2 = gain of 4 3 = gain of 8 4 = gain of 16 5 = gain of 32 6 = gain of 64 7 = gain of 128	0xa0			chksum
Speed input configuration byte1 – zero speed RPM threshold value (0 to 250). Value of 0 sets the threshold to its minimum which is approximately = 0.4RPM / PPR. Default value is 60RPM. byte2 – pulses per revolution (PPR) value (1 to 254). Value of 0 means speed input not used. Default value is 1.	0x60			chksum

Notes:

The ECOM_ACK bit in sample data status byte 0 serves as an acknowledgement to messages sent to the TPM2.

The baud rate, parity, stop bits, sample rate and transmitter gain parameters are saved in non-volatile memory and retained through power loss.

The effects of Transmitter Control Commands are delayed due to internal communications between the Transmitter and the TPM2. Transmitter control commands that modify either the gain or shunts require approximately 2.5 seconds to take effect. A command that modifies both gain and shunts at the same time requires 4 seconds.