


# TCON.H



## User Manual

### Firmware version 6.1

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	Ten Briele 3, 8200 Brugge, Belgium	26/01/2010
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# 1 Functional specification

## 1.1 General

The **TCON.H** (Transmission **C**ontroller for **ECM**) is a programmable electronic device part of a control system used to shift the Spicer Off Highway Products ECM power shift transmissions.

ECM means Electronic Controlled Modulation and refers to a transmission control technology that is available on a range of transmission models.

ECl means Electronic Controlled Inching. This refers to the capability of ECM transmissions with **TCON.H** to run at very low controlled speed at virtually any engine speed. This function is desirable in as for instance in forklift truck applications.

To date, within these models, six transmission types are supported: TE10, TE13, TE15, TE17, TE27 and TE32 transmissions with 3/3 or 4/4 gear sets.

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## 1.7 General functionality

The TCON.H takes care of the following functions

- direction change protection
- downshift protection
- overspeeding control
- automatic shifting
- automatic shifting in neutral
- electronic inching
- declutch
- engine control (certain configurations)
- service brakes (certain configurations)

## 1.8 Input functions

The following paragraphs describe the most commonly used external inputs. For a full listing of available input functions, refer to the configuration set description in chapter 2.

Please refer to the proper electrical wiring diagram for connections and logic of the inputs discussed below.

### 1.8.1 Shift lever

The main interface with the driver is the shift lever. It allows selecting the driving direction and the different ranges. The shift lever output signals serve as inputs for the TCON.H.

The TCON.H can be programmed to interact with a large number of shift levers. Models supported:

- Bump type shift lever: this type of shift lever generates pulse signals for up-and downshifting, while providing fixed signals for the direction (forward and reverse).
- Standard type shift lever: this type of shift lever generates a distinct pattern in each position. The TCON.H can be programmed to accommodate any such shift lever, provided it does not use more than 6 wires to determine its position.
- Remote control through CAN, see document chapter 3 paragraph 5.1.

The selection, of which type of shift lever is use, is defined in the configuration sets. By selecting the corresponding configuration, the defined shift lever is used - see chapter 2: configuration set description.

For automatic mode the shift lever position will limit the gear in which the controller is allowed to shift to.

Check the wiring diagram how the shift lever needs to be connected to the TCON.H.

### 1.8.2 Throttle pedal position

The throttle pedal is used by the TCON.H to determine which shift characteristics to use, and to control the engine if the option engine control is requested.

The throttle pedal position can be connected to the TCON.H by several possibilities:

- Use of a digital input – idle/not idle switch. A reflection of the throttle pedal position by a digital input can only be done if the TCON.H has NO engine control.

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N1		●				●	
N2			●				●
N3		●					
N4			●				
R1	●	●			●	●	
R2	●		●		●		●
R3	●	●			●		
R4	●		●		●		

Note that during a transition from one gear to the next, these wires carry current simultaneously. Example: when shifting from F1 to F2, “sel1/3” will be active during the transition and is switched off when 2<sup>nd</sup> gear is engaged.

Selector 2/4 is only used for transmission control on a 4 /4 transmission. On 3 speed transmissions it can be used to signal faults on the dashboard in case there’s no central display.

On 24V installations, depending on the type of transmission, the selector outputs may carry a 100Hz PWM signal. This is required to prevent damage to the 12V selector valves.

**Forward proportional valve – valve selector fwd**


These valves control the pressure in the forward clutch.

While inactive, Forward is disengaged. When about 900mA current flows through the proportional valve and the valve selector is engaged, the forward clutch is closed.

**Reverse proportional valve – valve selector rev**

These valves control the pressure in the reverse clutch.

While inactive, reverse is disengaged. When about 900mA current flows through the proportional valve and the valve selector is engaged,, the reverse clutch is closed.



When both forward and reverse clutches are commanded closed electrically, the first clutch that was engaged, will remain engaged, preventing the other clutch from closing. In the exceptional case that both clutches are commanded at the same time, no clutch can be engaged.

**1st / 3rd proportional valve – valve selector 1/3**

These valves control the pressure of either the 1st or the 3rd clutch.

Which clutch is selected depends on the state of the 1/3 selector. When the selector is on, 1st clutch is selected. Otherwise, 3rd clutch is selected

While inactive, the clutch is open. When about 900mA current flows, the clutch is closed.

**2nd / 4th proportional valve – valve selector 2/4**

These valves control the pressure of either the 2nd or the 4th clutch.


Which clutch is selected depends on the state of the 2/4 selector. When the selector is on, 2nd clutch is selected. Otherwise, 4th clutch is selected

While inactive, the clutch is open. When about 900mA current flows, the clutch is closed.

**1.9.2 Low/high range**

To be able to change from a low to a high range gear there is an output provided. This output is set by an operator demand and is only accepted when the machine was put in Neutral and

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It's possible to change direction while inching at full throttle. In other words, if you're too close to an obstacle, it's okay to just reverse the direction with the foot on the brake (**and on the 'inching-enable' switch**) and the engine at full throttle. Make sure to cycle the shift lever quickly to the other direction as otherwise the inching system gets disabled.

When standing still and you want to start while inching, you'd typically press the brake into the de-clutch range (with the 'inching-enable' switch pressed!) and slowly release it, holding it halfway until the vehicle starts rolling. Once it's rolling, further release the brake pedal in order to pick up more speed.

### 1.13.12 Uphill inching

Driving uphill generally takes a lot of power, quite often more than the inching system is allowed to provide.

Nevertheless, there are conditions where inching can be used quite successfully on a slope - for instance on slopes typically used to load trucks and trailers – provided the vehicle is not heavily loaded.

If you have a good 'run-in' on the slope, you best start inching before the start of the slope. If you start inching on the slope, depending how you treat the brake pedal, you run the risk of coming to a stop and eventually start rolling backwards. Once you roll backwards the inching system gets confused and won't help you slow down again.



Note that on most transmissions with speed controlled inching, the APC 200 is not capable to sense the actual driving direction, causing it to mistake the rolling backwards for the forward movement.

The thing to do in that case is to stop on the hill (and de-clutch) and gently release the brake pedal until you get forward movement again. Careful brake pedal usage usually gets you where you want.

The TCON.H has a built-in feature that protects the inching clutches. If you use the inching system in a condition where the required inching torque exceeds a pre-programmed limit, the inching system is disabled. The customer can choose the option to engage into converter drive.

When this happens (and it will on certain slopes and with certain loads), you will have to reduce the engine speed to control the vehicle speed. This behavior is what you'd want anyway, because the inching system would not be able to provide the power required to get you moving in this condition.

### 1.13.13 Downhill inching

While driving downhill the TCON.H has no means to control the vehicle speed. **This means you're on your own as far as speed controlled inching is concerned.** Following remarks may help you make the best of speed controlled inching.

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## 4 Control system: Analog Input Signals Calibration

The TCON.H firmware contains several calibration procedures for all supported analog input signals. These are needed so that the TCON.H reads the correct values from these signals.

These analog input signal calibrations have to be performed:

- when the vehicle is built at the OEM.
- when the sensor of an analogue input signals is replaced
- when the TCON.H is replaced.



The optional DANA tool "Dashboard" includes a user friendly interface to perform the calibration of analog input signals using a PC. For more detailed information, please refer to the "Dashboard" help or contact a DANA sales representative.



Calibration should only be performed by competent and qualified personnel. Incorrect calibration can lead to restricted or uncomfortable machine behaviour.

### 4.1 Activating the calibration mode

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If one of the conditions is not fulfilled, the corresponding display will be shown. Please see paragraph 5.3.1 for a listing of those displays.

The automatic transmission calibration procedure starts. This is indicated on the TCON.H-display:

c1.001; c1.002; c2.001; etc.

'c1' stands for 'clutch 1' being forward, while 'M1' stands for 'mode 1' of the calibration. When all clutches have been calibrated, the TCON.H displays:

done

At this point, the automatic calibration has completed successfully. A complete automatic transmission calibration can take 10 to 15 minutes.

To exit the automatic calibration mode, you need to switch off the ignition key the vehicle. Make sure that the TCON.H has powered down – wait for 2 seconds. Now restart the vehicle and the new tuning results will be activated automatically.



*This power down is very important because at this point the results obtained in the calibration are saved to the permanent memory of the TCON.H.*

**REMARK 1:**



*If you get any different information on the TCON.H display as described above, there can be two possible reasons:*

- *the calibration conditions are not fulfilled (temperature is too low, parking brake switched off, the vehicle is moving, engine rpm is too high or too low)*
- *a calibration error has occurred during the calibration (message starting with an 'E'). See paragraph 5.3 for further details.*

**REMARK 2:**

*By selecting REVERSE on the shift lever, while the automatic calibration is performing, the procedure will abort the automatic calibration immediately and restart the TCON.H. You can use this as an emergency procedure when something goes wrong during the calibration procedure.*

*Note: by aborting the automatic calibration, the calibration is not finalized and needs to be done from the beginning.*

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# **CHAPTER 2:**

# **TCON.H**

# **Configuration Sets**

# **Description**

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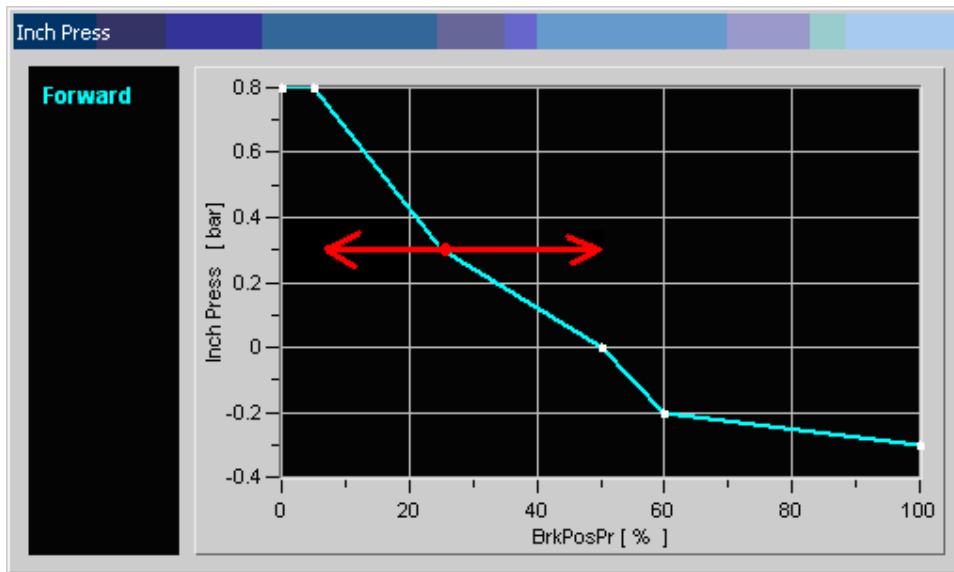
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## 2.2.38 ConfigSet ID

**Vehicle ID**

ColWidth Edit Download Commit to Flash Table

Value CfgSetNr

0 0 ---

GDE Info	GDE Info
Tool ID	GDE32V4.00
Tool Ser No	BBEA567026
File ID	
Update DTG	200401211815
APC Box P/N	004502947000
APC Box S/N	NO SERIALN
SW Version	3.0 R6
SW Label	ECM
Approval No	
Build Date	NO DATE INFO
Produced By	PROD
Transm S/N	
Vehicle ID	
ConfigSet ID	0 ---

0 ---  
1 ---  
2 ---  
3 ---  
4 ---

Edit Mode : FULL

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### 5.3.3 TC\_to\_CVC\_2.Byte 2

Here the index value of the new requested configuration set index is shown. There are different values possible:

- **echo of CVC\_to\_TC\_3.byte2** (=requested index):

The request to select a new configuration set was accepted

- **FF(hex)** = there is no valid configuration set currently active
- Same value as **CVC\_to\_TC\_3.byte3** (=currently active index)

The request to select a new configuration was not accepted or there was no request to write a new index. In these cases the index of the currently active configuration set is shown.

### 5.3.4 TC\_to\_CVC\_2.Byte 3

This byte simply shows the index of the configuration set that is currently active. If this shows FF(hex) this means that there is no valid configuration set active.

**IMPORTANT REMARK:** When there is no write request to select a new configuration request, TC\_to\_CVC.byte2 and TC\_to\_CVC.byte3 will show the same value.

When a new configuration set has been selected successfully however, TC\_to\_CVC.byte2 and TC\_to\_CVC.byte3 will show a different index value. Only after a normal power down of the TCON.H (key contact) and a restart, the new configuration set will be activated!

This can be checked by reading the active configuration set index after power up and verifying that it corresponds to the selected one.

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# **CHAPTER 3:**

# **TCON.H CAN EDI**

# **Protocol**

# **Description**

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### 5.3.5 CVC\_to\_TC\_3: Error Info

		Value	Detail
Byte 0	Bit 0	Request code	<p><b><u>Request code</u></b></p> <p>The following codes can be used to read the error info from the TCON.H and clear the error buffer of inactive errors. For the description of the reply format, see paragraph 6.2.3.</p> <p><b>Supported values :</b></p> <p>10<sub>(Hex)</sub> = 1<sup>st</sup> active error info                      11<sub>(Hex)</sub> = next active error info                      12<sub>(Hex)</sub> = 1<sup>st</sup> inactive error info                      13<sub>(Hex)</sub> = next inactive error info                      14<sub>(Hex)</sub> = clear inactive errors buffer</p>
	...		
	Bit 7		
Byte 1	Bit 8	FF <sub>(Hex)</sub>	<p>(all bits should be 1)</p> <p>These bytes have no relevance with the request types described above To avoid any confusion and following the principle of the SAE J1939 standard, it is recommended to set all bits to 1 (= all bytes to FF<sub>(Hex)</sub>).</p>
Byte 2		FF <sub>(Hex)</sub>	
Byte 3		FF <sub>(Hex)</sub>	
Byte 4		FF <sub>(Hex)</sub>	
Byte 5		FF <sub>(Hex)</sub>	
Byte 6		FF <sub>(Hex)</sub>	
Byte 7		Bit 63	



#### Usage of CVC\_to\_TC\_3 to read TCON.H error info

*In the TCON.H, several errors can be active at the same time. These active errors can be read from a buffer where the errors are presented in order of priority.  
To read the error with the highest priority, simply send the request code 10<sub>(Hex)</sub> in CVC\_to\_TC\_3.  
For reading the rest of the active errors, repeat sending the request code 11<sub>(Hex)</sub> in CVC\_to\_TC\_3.  
As long as there are active errors present, the TCON.H will reply the error info. When there are no more errors present, the TCON.H will reply a code indicating this (see paragraph 6.2.3)  
To repeat reading all the active errors, simply send the request code 10<sub>(Hex)</sub> in CVC\_to\_TC\_3 again, followed by repeating request code 11<sub>(Hex)</sub> in CVC\_to\_TC\_3 until no more error info is present.*

*The same principle is used for keeping track of inactive errors. These are errors that have been active before, but are no longer present.  
Similar to reading the active errors, send the request code 12<sub>(Hex)</sub> in CVC\_to\_TC\_3 to read the inactive error with the highest priority, followed by request code 13<sub>(Hex)</sub> in CVC\_to\_TC\_3 until no more error info is present to read the other inactive errors.  
One more extra request type, 14<sub>(Hex)</sub>, is provided to clear all error info from the inactive error buffer. So once this error info has been read and/or processed, it can be cleared.*

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### 5.3.13 CVC\_to\_TC\_3: DANA reserved codes


 Some of the request codes in the available range of byte0 in CVC\_to\_TC\_3 are exclusively reserved for use by DANA applications!  
 These codes are not to be used by any device for other purposes, so be sure not to use these codes when integrating the TCON.H in a CAN bus network!

		Value	Detail
Byte 0	Bit 0	DANA Reserved Request code	<p><b><u>DANA Reserved Request code</u></b></p> <p>The following codes are exclusively reserved for DANA applications and are not to be used by any other device!</p> <p><b>1A</b> (Hex)  <b>1B</b> (Hex)  <b>1C</b> (Hex)  <b>1D</b> (Hex)    <b>3A</b> (Hex)  <b>3B</b> (Hex)  <b>3C</b> (Hex)  <b>3D</b> (Hex)    <b>50</b> (Hex)    <b>7F</b> (Hex)    <b>82</b> (Hex)  <b>83</b> (Hex)    <b>90</b> (Hex)    <b>A0</b> (Hex)  <b>AA</b> (Hex)  <b>AB</b> (Hex)</p>
	...		
	Bit 7		
Byte 1	DANA Reserved	DANA Reserved	<p><b><u>DANA Reserved</u></b></p>
Byte 2			
Byte 3			
Byte 4			
Byte 5			
Byte 6			
Byte 7			

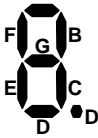
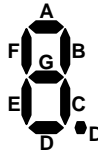
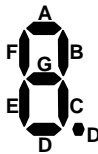
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			<p>0 = 0 mA ( 0 %) 253 &gt;= 1012 mA ( 99 %)</p> <p>254 = fault related to the analogue output 255 = measurement not supported</p> <p>Byte 2 = AnaOut 1 current Conversion see above ( replace byte 1 by byte 2 )</p> <p>Byte 3 = AnaOut 2 current Conversion see above ( replace byte 1 by byte 3 )</p> <p>Byte 4 = AnaOut 3 current Conversion see above ( replace byte 1 by byte 4 )</p> <p>Byte 5 = AnaOut 4 PWM duty cycle Conversion : analogue output PWM duty cycle = byte 5 * 100 / 256</p> <p>0 = 0 % 253 &gt;= 99 %</p> <p>254 = fault related to the analogue output 255 = measurement not supported</p> <p>Byte 6 = AnaOut 5 PWM duty cycle Conversion see above ( replace byte 5 by byte 6 )</p> <p>Byte 7 = AnaOut 7 PWM duty cycle Conversion see above ( replace byte 5 by byte 7 )</p> <p><b>34<sub>(Hex)</sub> = speed sensor state rpm</b></p> <p>Similar to the reply format of reply code <b>31<sub>(Hex)</sub></b>, but this time the speeds are already converted from Hz to rpm and ordered by function instead of electrical connection</p> <p>Byte 1 – 6: speed values in rpm</p> <p>The speed values are coded with 12 bit precision and 8 rpm resolution.</p> <p>Conversion :</p> <p>Engine speed = ( byte 1 + (( byte 2 &amp; 0F<sub>(hex)</sub> ) * 256 )) * 8 [rpm] Turbine speed = ((( byte 2 &amp; F0<sub>(hex)</sub> ) / 16 )) + ( byte 3 * 16 )) * 8 [rpm] Drum speed = ( byte 4 + (( byte 5 &amp; 0F<sub>(hex)</sub> ) * 256 )) * 8 [rpm] Output speed = ((( byte 5 &amp; F0<sub>(hex)</sub> ) / 16 )) + ( byte 6 * 16 )) * 8 [rpm]</p> <p><b>Note :</b> the ‘&amp;’ operator used above, is the <b>bitwise AND</b> operator (as ‘&amp;’ in the C language).</p> <p>0 = 0 rpm 1021 = 8168 rpm</p> <p>1022 = fault related to the speed sensing 1023 = measurement not supported</p> <p>Byte 7 : reserved</p> <p><i>Continued on next page</i></p>
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## 6.2.9 TC\_to\_CVC\_2: TCON.H user interface

		Value	Detail
Byte 0	Bit 0 ... Bit 7	Reply code	<p><b>Reply code</b></p> <p>Echo of the request code in byte 0 of the CVC_to_TC_2 to which this TC_to_CVC_2 is the reply. Use this code as an identification to check if it is the answer to the request that was sent.</p> <p><b>Supported values :</b></p> <p>70<sub>(Hex)</sub> = TCON.H user interface</p>
Byte 1	Bit 8 ... Bit 15	FF <sub>(Hex)</sub>	Reserved = FF <sub>(Hex)</sub>
Byte 2	Bit 16 ... Bit 23	7 segment LED digit 1	<p><b>7 segment LED digit 1 (= most left)</b></p>  <p>bit 16 = segment A : 0 = not lit / 1 = lit bit 17 = segment B : 0 = not lit / 1 = lit bit 18 = segment C : 0 = not lit / 1 = lit bit 19 = segment D : 0 = not lit / 1 = lit bit 20 = segment E : 0 = not lit / 1 = lit bit 21 = segment F : 0 = not lit / 1 = lit bit 22 = segment G : 0 = not lit / 1 = lit bit 23 = segment DP : 0 = not lit / 1 = lit</p>
Byte 3	Bit 24 ... Bit 31	7 segment LED digit 2	<p><b>7 segment LED digit 2 (= 3<sup>rd</sup> of right)</b></p>  <p>bit 24 = segment A : 0 = not lit / 1 = lit bit 25 = segment B : 0 = not lit / 1 = lit bit 26 = segment C : 0 = not lit / 1 = lit bit 27 = segment D : 0 = not lit / 1 = lit bit 28 = segment E : 0 = not lit / 1 = lit bit 29 = segment F : 0 = not lit / 1 = lit bit 30 = segment G : 0 = not lit / 1 = lit bit 31 = segment DP : 0 = not lit / 1 = lit</p>
Byte 4	Bit 32 ... Bit 39	7 segment LED digit 3	<p><b>7 segment LED digit 3 (= 2<sup>nd</sup> of right)</b></p>  <p>bit 32 = segment A : 0 = not lit / 1 = lit bit 33 = segment B : 0 = not lit / 1 = lit bit 34 = segment C : 0 = not lit / 1 = lit bit 35 = segment D : 0 = not lit / 1 = lit bit 36 = segment E : 0 = not lit / 1 = lit bit 37 = segment F : 0 = not lit / 1 = lit bit 38 = segment G : 0 = not lit / 1 = lit bit 39 = segment DP : 0 = not lit / 1 = lit</p>

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## 7.2 EEC2: Electronic engine controller # 2

Message identifier : CF00300<sub>(Hex)</sub> (CAN 2.0 B ⇒ 29 bit identifier)

Priority code + R <sub>bit (= 0)</sub> + DP <sub>bit (= 0)</sub>	Message ID	Address sender
C <sub>(Hex)</sub> = 01100 <sub>(Bin)</sub> : Priority ⇒ 3 <sub>(Dec)</sub>	F003 <sub>(Hex)</sub> = 61443 <sub>(Dec)</sub>	00 <sub>(Hex)</sub> = 0 <sub>(Dec)</sub>

Originator: engine controller

Repetition rate: 50 ms

DLC: 8

		Value	Detail
Byte 0	Bit 0	Accelerator pedal low idle switch	<b>Status bits (*)</b> Bit 0 – 1: accelerator pedal low idle switch 00 <sub>(Bin)</sub> : accelerator pedal not in low idle condition 01 <sub>(Bin)</sub> : accelerator pedal in low idle condition Bit 2 – 3 : accelerator pedal kickdown switch 00 <sub>(Bin)</sub> : kickdown passive 01 <sub>(Bin)</sub> : kickdown active Bit 4 – 7 : not defined 0000 <sub>(Bin)</sub>
	Bit 1		
	Bit 2	Accelerator pedal kickdown switch	
	Bit 3		
	Bit 4	0	
	Bit 5	0	
	Bit 6	0	
Bit 7	0		
Byte 1	Bit 8	Accelerator pedal position	<b>Accelerator pedal position</b> Conversion: pedal position = byte 1 * 0.4 [%]
	Bit 9		
	Bit 10		
	Bit 11		
	Bit 12		
	Bit 13		
	Bit 14		
Bit 15			
Byte 2	Bit 16	Load at current speed	<b>Load at current speed (*)</b> Conversion : load = byte 2 - 125 [%]
	Bit 17		
	Bit 18		
	Bit 19		
	Bit 20		
	Bit 21		
	Bit 22		
Bit 23			
Byte 3	Bit 32	FF <sub>(Hex)</sub>	(all bits should be 1)  These bytes are not defined. To avoid any confusion and following the principle of the SAE J1939 standard, it is recommended to set all bits to 1 (= all bytes to FF <sub>(Hex)</sub> ).
Byte 4		FF <sub>(Hex)</sub>	
Byte 5	...	FF <sub>(Hex)</sub>	
Byte 6		FF <sub>(Hex)</sub>	
Byte 7	Bit 63	FF <sub>(Hex)</sub>	

(\*) APC does not interpret these signals.

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## 6 Behaviour in case of faults

### 6.1 General

It is considered critical to be able to select Neutral in all circumstances.

Selection of Neutral also is considered the safe state in case of many faults.

The TCON.H has been designed to guarantee automatic selection of Neutral in some conditions. This is accomplished through use of an external watchdog timer and a redundant shutdown path for outputs.



*Following paragraphs describe the detection principles of the different considered faults and the behavior of the control system in case of faults.*

*For a complete overview of the corresponding error codes that are reported, the explanation, the severity and the actions taken for each error code, please refer to the list of error codes, as referenced in **paragraph 10** of this chapter!*

### 6.2 Reset Condition

When power is applied, the TCON.H first selects Neutral without range clutch engaged and starts initialising itself (about 1 second). This includes a series of self-tests to assure system integrity.

This position is believed to be the safest possible condition in case of an intermittent power failure.

After power up, the TCON.H is in the so-called Neutral Lock State. This means that the transmission remains in Neutral until the shift lever is cycled physically through Neutral.

### 6.3 Power supply faults

#### 6.3.1 Excess supply voltage

The TCON.H is very tolerant to large transients on its power lines. Please refer to operating limits and environmental conditions as described in the hardware technical leaflet for your hardware version.

When the supply voltage exceeds 40V, the controller shuts off its outputs to prevent damage.

A voltage out of the normal operating range will result in an error code. Please refer to **paragraph 10** for location of error list & descriptions.

#### 6.3.2 Low supply voltage

Please refer to operating limits and environmental conditions as described in the hardware technical leaflet for your hardware version.

A voltage out of the normal operating range will result in an error code. Please refer to **paragraph 10** for location of error list & descriptions.

Insufficient voltage supply may result in a power down and even power loss for the TCON.H.

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