BOUNDARY CONDITION

Chrysler CCD/SCI Scanner UART Protocol

V1.4X

Last update: 2020.09.09

1. Frame format

Start of frame	Frame length		Frame description		Data	End of frame
SYNC	**LENGTH HB**	**LENGTH LB**	**DATA CODE**	**SUB-DATA CODE**	**PAYLOAD**	**CHECKSUM**
3D	00	06	05	02	00 DA A9 0D	9D

Table 1. Frame format example (hex numbers implied).

SYNC byte: fixed value at the beginning of every frame (3D).

LENGTH bytes: number of bytes following (not including these two) until the CHECKSUM byte is reached. Maximum frame length is limited to 1024 bytes.
Size: 2 bytes.

DATA CODE byte: describes the source, target and command. Size: 1 byte.

SUB-DATA CODE byte: command extension if the command alone is not enough to describe the purpose of the frame. Size: 1 byte

PAYLOAD byte(s): optional. Arbitrary data can be stored here. Size: limited to a maximum of 1024-6=1018 bytes.

CHECKSUM byte: all bytes, except SYNC, summed up, lower byte of the result is placed here for error detection. Size: 1 byte.

Frame transmission and reception is realized via +5V logic serial communication with non-return-to-zero (NRZ) encoding at 250000 baudrate either trough the USB or FTDI connector.

2. Frame bytes in detail

2.1 DATA CODE byte description

DATA CODE byte							
Source		Target		Command			
bit 7	**bit 6**	**bit 5**	**bit 4**	**bit 3**	**bit 2**	**bit 1**	**bit 0**
0	0	1	0	0	1	1	0

Table 2. DATA CODE byte description.

Bit 7:6 - Source of the frame:
00b: USB
01b: CCD
10b: PCM
11b: TCM

Bit 5:4 - Target of the frame:
00b: USB
01b: CCD
10b: PCM
11b: TCM

USB: the scanner/laptop itself.
CCD: all modules on CCD-bus.
PCM: engine controller on SCI-bus.
TCM: transmission controller on a separate SCI-bus. This channel is currently unused. TCMs mainly communicate on the CCD-bus and can be reached there for diagnostics purposes.

Bit 3:0 - Command
0000b (00): Reset
0001b (01): Handshake
0010b (02): Status
0011b (03): Settings
0100b (04): Request
0101b (05): Response
0110b (06): Message TX
0111b (07): Message RX
1000b-1101b (08-0D): reserved
1110b (0E): Debug
1111b (0F): OK/Error

2.2 SUB-DATA CODE byte description

Individual bits have no special meaning. Different commands have different SUB-DATA CODE bytes associated with them. When not used it always reads 00, otherwise this value extends the meaning of the DATA CODE byte.

3. Frame examples

3.1 Reset (command: 00)

Applicable SUB-DATA CODE bytes (modes):
00: initiate scanner reset.
01: scanner reset done.
02-FF: reserved.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	~~PAYLOAD~~	CHECKSUM
3D	00	02	00	00		02

Table 3. Reset scanner request frame.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	03	00	00	00	03

Table 4. Scanner is being reset frame.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	03	00	01	00	04

Table 5. Scanner reset complete frame.

Note that the scanner never sends a communication packet without payload but accepts them without one. In a response made by the scanner at least a single 00 byte is included and it generally means success.

3.2 Handshake (command: 01)

Applicable SUB-DATA CODE bytes (modes):
00: request handshake only.
01: request handshake, hardware/firmware information and scanner status.
02-FF: reserved.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	~~PAYLOAD~~	CHECKSUM
3D	00	02	01	00		03

Table 6. Handshake request frame.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	~~PAYLOAD~~	CHECKSUM
3D	00	02	01	01		04

Table 7. Handshake request frame with additional information.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	17	01	00	43 48 52 59 53 4C 45 52 43 43 44 53 43 49 53 43 41 4E 4E 45 52	37

Table 8. Handshake response frame.

PAYLOAD contains an ASCII encoded text:
43 48 52 59 53 4C 45 52 43 43 44 53 43 49 53 43 41 4E 4E 45 52 =
CHRYSLERCCDSCISCANNER

A third party software should look for a response like this when searching for the scanner among many serial devices.

Another 2 separate frames are sent by the scanner when additional information is requested: 1 hardware/firmware version and 1 status frame.

3.3 Status (command: 02)

No sub-data code byte/mode is applicable here, reads always 00.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	~~PAYLOAD~~	CHECKSUM
3D	00	02	02	00		04

Table 9. Status request frame.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	2E	02	00	1E 98 01 01 31 31 00 1E AC AE 0B B2 00 00 00 51 00 00 00 00 00 00 00 00 91 00 00 00 0C 00 00 00 0C 01 27 14 04 14 01 02 13 88 00 32	9D

Table 10. Status response frame.

PAYLOAD offset:

```
00-02: AVR signature (1E 98 01 for ATmega2560).
03:    external EEPROM present (00: false, 01: true).
04:    external EEPROM checksum.
05:    external EEPROM calculated checksum.
06-09: current timestamp in milliseconds.
0A-0B: RAM usage out of 8192 bytes.
0C:    connected to vehicle (00: false, 01: true).
0D-0E: measured vehicle battery voltage (multiplied by 100).
0F:    CCD-bus status byte:
       Bit 7:6 - bus id bits, reads 01b for CCD-bus.
       Bit 5:  - change settings bit, reads always 0b (0b: keep, 1b: change).
       Bit 4:  - state bit (0b: disabled, 1b: enabled).
       Bit 3:  - logic bit, reads always 0b (0b: non-inverted, 1b: inverted).
       Bit 2:  - termination and bias (TB) bit (0b: disabled, 1b: enabled).
       Bit 1:0 - baudrate bits (00b: 976.5, 01b: 7812.5, 10b: 62500, 11b:
                 125000), reads always 01b as the only known communication
                 speed for CCD-bus.
10-13: number of CCD-bus messages received.
14-17: number of CCD-bus messages sent.
18:    SCI-bus (PCM) status byte:
       Bit 7:6 - bus id bits, reads 10b for the PCM.
       Bit 5:  - change settings bit (0b: keep settings, 1b: change settings).
       Bit 4:  - state bit (0b: disabled, 1b: enabled).
       Bit 3:  - logic bit (0b: non-inverted, 1b: inverted).
       Bit 2:  - OBD configuration bit (0b: A, 1b: B).
       Bit 1:0 - baudrate bits (00b: 976.5, 01b: 7812.5, 10b: 62500, 11b:
                 125000), 7812.5 and 62500 baud are most commonly used.
19-1C: number of SCI-bus (PCM) messages received.
1D-20: number of SCI-bus (PCM) messages sent.
21:    LCD state (00: disabled, 01: enabled).
22:    LCD I2C address.
23:    LCD width in characters.
24:    LCD height in characters.
25:    LCD refresh rate in Hz.
26:    LCD units (00: imperial, 01: metric).
27:    LCD data source (01: CCD-bus, 02: SCI-bus PCM, 03: SCI-bus TCM).
28-29: LED heartbeat interval in milliseconds.
2A-2B: LED blink duration in milliseconds.
```

3.4 Settings (command: 03)

Applicable SUB-DATA CODE bytes (modes):
01: heartbeat / LED behavior.
02: set CCD-bus.
03: set SCI-bus.
04: set repeat behavior.
05: set LCD.
00,06-FF: reserved.

3.4.1 Heartbeat / LED behavior mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	06	03	01	13 88 00 32	D7

Table 11. Change heartbeat / LED behavior setting frame.

PAYLOAD offset:
00-01: heartbeat interval in milliseconds, 5000 ms = 13 88.
02-03: blink duration for all LEDs in milliseconds, 50 ms = 00 32.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	07	03	01	00 13 88 00 32	D8

Table 12. Heartbeat / LED behavior setting response frame.

PAYLOAD offset:
00: setting state (00: ok, FF: error).
01-02: heartbeat interval in milliseconds.
03-04: LED blink duration in milliseconds.

3.4.2 Set CCD-bus mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	04	03	02	01 00	0A

Table 13. Change CCD-bus setting frame.

PAYLOAD offset:
00: CCD-bus state (00: disabled, 01: enabled).
01: internal CCD-bus termination and bias state (00: disabled,
    01: enabled). This feature is available for V1.44+ hardware versions only.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	05	03	02	00 01 00	0B

Table 14. CCD-bus setting response frame.

PAYLOAD offset:
00: setting state (00: ok, FF: error).
01: CCD-bus state.
02: internal CCD-bus termination and bias state.

3.4.3 Set SCI-bus mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	03	03	03	B1	BA

Table 15. Change SCI-bus setting frame.

```
PAYLOAD offset:
00: SCI-bus status:
    Bit 7:6 - bus id bits, reads 10b for the PCM (11b for TCM).
    Bit 5:  - change settings bit (0b: keep settings, 1b: change settings).
    Bit 4:  - state bit (0b: disabled, 1b: enabled).
    Bit 3:  - logic bit (0b: non-inverted, 1b: inverted).
    Bit 2:  - OBD configuration bit (0b: A, 1b: B).
    Bit 1:0 - baudrate bits (00b: 976.5, 01b: 7812.5, 10b: 62500, 11b: 125000)

Example: B1 = 10110001b
              10b: PCM
                1b: change settings
                 1b: enabled state
                  0b: non-inverted logic
                   0b: A-configuration
                    01b: 7812.5 baudrate
```

The 5th change settings bit must always be set, otherwise the scanner ignores the request.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	04	03	03	00 91	9B

Table 16. SCI-bus setting response frame.

```
PAYLOAD offset:
00: setting state (00: ok, FF: error).
01: SCI-bus state.

Example: 91 = 10010001b
              10b: PCM
                0b: keep settings
                 1b: enabled state
                  0b: non-inverted logic
                   0b: A-configuration
                    01b: 7812.5 baudrate
```

The 5th change settings bit is necessarily cleared if it comes as a response.

3.4.4 Set repeat behavior mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	07	03	04	01 00 64 00 02	75

Table 17. Change repeat behavior setting frame.

PAYLOAD offset:
00: target bus (01: CCD-bus, 02: SCI-bus PCM, 03: SCI-bus TCM).
01-02: message repeat interval in milliseconds, 100 ms = 00 64.
03-04: message increment for every repeat, 2 = 00 02.

When message repeating is enabled the scanner uses the interval set here for message timing. Message incrementing is applicable to a specific B2-request message only.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	08	03	04	00 01 00 64 00 02	76

Table 18. Repeat behavior setting response frame.

PAYLOAD offset:
00: setting state (00: ok, FF: error).
01: target bus.
02-03: message repeat interval in milliseconds.
04-05: message increment for every repeat.

3.4.5 Set LCD mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	09	03	05	01 27 14 04 14 01 02	68

Table 19. Change LCD setting frame.

PAYLOAD offset:
00: state (00: disabled, 01: enabled).
01: I2C address, 27 (hex).
02: character width, 14: 20 characters.
03: character height, 04: 4 characters.
04: refresh rate in Hz, 14: 20 Hz.
05: units (00: imperial, 01: metric).
06: data source (01: CCD-bus, 02: SCI-bus PCM, 03: SCI-bus TCM).

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	0A	03	05	00 01 27 14 04 14 01 02	69

Table 20. LCD setting response frame.

PAYLOAD offset:
00: setting state (00: ok, FF: error).
01-07: current LCD settings, refer to Table 19’s PAYLOAD offset.

LCD settings are saved to the external EEPROM.

3.5 Request/Response (command: 04/05)

Applicable SUB-DATA CODE bytes (modes):
01: hardware/firmware information.
02: timestamp.
03: battery voltage.
04: external EEPROM checksum.
05: CCD-bus voltages.
00,06-FF: reserved.

3.5.1 Hardware/Firmware information request mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	~~PAYLOAD~~	CHECKSUM
3D	00	02	04	01		07

Table 21. Hardware/Firmware information request frame.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	1C	05	01	00 8C 00 00 00 00 5B 7B EA 33 00 00 00 00 5C 02 56 AF 00 01 00 00 5F 19 B9 2A	60

Table 22. Hardware/Firmware information response frame.

PAYLOAD offset:
00-01: hardware version, 00 8C = 140 -> v1.40.
02-09: hardware date, 00 00 00 00 5B 7B EA 33:
64-bit UNIX time (2018.08.21 12:32:19).
0A-11: assembly date, 00 00 00 00 5C 02 56 AF:
64-bit UNIX time (2018.12.01 10:38:55).
12-09: firmware version/date:
00 01 00 00: major minor patch (build) -> v0.1.0(.0),
5F 19 B9 2A: 32-bit UNIX time (2020.07.23 18:22:02).

3.5.2 Timestamp request mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	~~PAYLOAD~~	CHECKSUM
3D	00	02	04	02		08

Table 23. Timestamp request frame.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	06	05	02	01 F2 03 23	26

Table 24. Timestamp response frame.

PAYLOAD offset:
00-03: milliseconds elapsed since last reset:
01 F2 03 23 = 32637731 ms = 09:03:57.731 (HH:mm:ss.fff).

3.5.3 Battery voltage request mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	~~PAYLOAD~~	CHECKSUM
3D	00	02	04	03		09

Table 25. Battery voltage request frame.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	06	05	03	04 E0	F2

Table 26. Battery voltage response frame.

PAYLOAD offset:
00-01: battery voltage multiplied by 100, 04 E0 = 1248 = 12.48 V.

3.5.4 External EEPROM checksum request mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	~~PAYLOAD~~	CHECKSUM
3D	00	02	04	04		0A

Table 27. External EEPROM checksum request frame.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	05	05	04	01 AE AE	6B

Table 28. External EEPROM checksum response frame.

PAYLOAD offset:
00: checksum state (00: error, 01: ok).
01: stored checksum, AE.
02: calculated checksum, AE.

3.5.5 CCD-bus voltages request mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	~~PAYLOAD~~	CHECKSUM
3D	00	02	04	05		0B

Table 29. CCD-bus voltages request frame.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	06	05	05	00 F8 00 FC	04

Table 30. CCD-bus voltages response frame.

PAYLOAD offset:
00-01: CCD+ wire voltage multiplied by 100, 00 F8 = 248 = 2.48 V.
02-03: CCD- wire voltage multiplied by 100, 00 FC = 252 = 2.52 V.

CCD-bus wire voltage measuring is available for V1.44+ hardware versions only.

3.6 Message TX/RX (command: 06/07)

Applicable SUB-DATA CODE bytes (modes):
01: stop message transmission.
02: send a single message once.
03: send a list of messages once.
04: send a single message repeatedly.
05: send a list of messages repeatedly.
00,06-FF: reserved.

3.6.1 Stop message transmission mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	~~PAYLOAD~~	CHECKSUM
3D	00	02	16	01		19

Table 31. Stop message transmission request frame.

DATA CODE byte:
16 = 00010110b
00b: source - USB
01b: target - CCD-bus
0110b: command - message Tx

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	04	06	01	00 01	0C

Table 32. Stop message transmission response frame.

PAYLOAD offset:
00: response state (00: ok, FF: error).
01: target bus (01: CCD-bus, 02: SCI-bus PCM, 03: SCI-bus TCM).

3.6.2 Send a single message once mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	06	16	02	E4 00 00 E4	E6

Table 33. Send a single message once frame.

DATA CODE byte:
16 = 00010110b
00b: source - USB
01b: target - CCD-bus
0110b: command - message Tx

PAYLOAD bytes(s):
E4 00 00 E4: message to be transmitted on the target bus.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	04	06	02	00 01	0D

Table 34. Send a single message once acknowledgment frame.

PAYLOAD offset:
00: acknowledgment state (00: ok, FF: error).
01: target bus (01: CCD-bus, 02: SCI-bus PCM, 03: SCI-bus TCM).

This response frame acknowledges that the message transmission request has been processed and the message is waiting in the transmit buffer.
  Normally transmission occurs almost immediately and a second frame is received containing a timestamp and the received message.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	0A	47	02	00 53 88 06 E4 00 00 E4	FC

Table 35. Message received frame.

DATA CODE byte:
47 = 01010110b
     01b: source - CCD-bus
       00b: target - USB
         0111b: command - message Rx

PAYLOAD offset:
00-03: timestamp in milliseconds, 00 53 88 06 = 5474310 ms = 01:31:14.310.
04-07: received message from source bus, E4 00 00 E4.

This type of frame is received for every kind of transmission modes regardless of list transmission and message repeating.

3.6.3 Send a list of messages once mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	0E	16	03	00 02 04 24 00 00 24 04 E4 00 00 E4	41

Table 36. Send a list of messages once frame.

DATA CODE byte:
16 = 00010110b
     00b: source - USB
       01b: target - CCD-bus
         0110b: command - message Tx

PAYLOAD offset:
00: message iteration state (00: disabled, 01: enabled), for this mode it reads always 00.
01: number of messages in the list, 02: 2 messages.

02: first message length, 04: 4 bytes.
03-06: first message to be transmitted on the target bus, 24 00 00 24.
07: second message length.
08-0B: second message to be transmitted on the target bus, E4 00 00 E4.

The list goes on similarly: every message is preceded with its length.

The delay value between messages is taken from the repeat behavior settings, which is 100 ms by default.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	04	06	03	00 01	0E

Table 37. Send a list of messages once acknowledgment frame.

PAYLOAD offset:
00: acknowledgment state (00: ok, FF: error).
01: target bus (01: CCD-bus, 02: SCI-bus PCM, 03: SCI-bus TCM).

The following frames are marked as single messages described in Table 35.

3.6.4 Send a single message repeatedly mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	09	16	04	00 01 04 24 00 00 24	70

Table 38. Send a single message repeatedly frame.

DATA CODE byte:
16 = 00010110b
00b: source - USB
01b: target - CCD-bus
0110b: command - message Tx

PAYLOAD offset:
00: message iteration state (00: disabled, 01: enabled).
01: number of messages in the list, 01: 1 message.
02: message length, 04: 4 bytes.
03-06: message to be transmitted on the target bus, 24 00 00 24.

The delay between messages is taken from the repeat behavior settings, which is 100 ms by default.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	04	06	04	00 01	0F

Table 39. Send a single message repeatedly acknowledgment frame.

PAYLOAD offset:
00: acknowledgment state (00: ok, FF: error).
01: target bus (01: CCD-bus, 02: SCI-bus PCM, 03: SCI-bus TCM).

3.6.4.1 Send iterated messages mode

This is a special mode in which start/end messages are provided and the start message is incremented for every repeat until the ending message is reached.

For CCD-bus the B2-request message can be incremented only. SCI-bus is more flexible but still limited to a maximum of 4-bytes message length. This special mode is useful for automatic ROM readings or when a range of values need to be read once.

The delay between messages and the increment value is taken from the repeat behavior setting. Defaults: delay = 100 ms, increment = 2 for CCD-bus, 1 for SCI-bus. CCD-bus message increment is 2 because for one ROM value request actually two bytes are returned and it is enough to read every second address.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	11	16	04	01 01 06 B2 20 22 00 00 F4 B2 20 22 FF FE F1	FD

Table 40. Send iterated messages to the CCD-bus frame.

```
DATA CODE byte:
16 = 00010110b
     00b: source - USB
       01b: target - CCD-bus
         0110b: command - message Tx

PAYLOAD offset:
00:    message iteration state (00: disabled, 01: enabled).
01:    number of messages in the list, 01: 1 message.
02:    message length, 06: 6 bytes.
03-08: starting message to be transmitted on the target bus, B2 20 22 00 00 F4.
09-0E: ending message to be transmitted on the target bus, B2 20 22 FF FE F1.
```

Note that the message length only appears once. Also in this special case only the 4th and 5th bytes (known as request/response parameters) are considered for incrementing.

This particular example requests ROM values from the Body Control Module (BCM). Its ROM has a 16-bit address space so requested addresses range between 00 00 and FF FE. Since the response message (F2) has also two parameters therefore 2 bytes are returned: 1 byte at the requested ROM location and the next byte.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	04	06	04	00 01	0F

Table 41. Send iterated messages to the CCD-bus acknowledgment frame.

PAYLOAD offset:
00: acknowledgment state (00: ok, FF: error).
01: target bus (01: CCD-bus, 02: SCI-bus PCM, 03: SCI-bus TCM).

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	0D	26	04	01 01 04 26 00 00 00 26 01 FF FF	88

Table 42. Send iterated messages to the SCI-bus frame.

DATA CODE byte:
26 = 00100110b
00b: source - USB
10b: target - SCI-bus (PCM)
0110b: command - message Tx

PAYLOAD offset:
00: message iteration state (00: disabled, 01: enabled).
01: number of messages in the list, 01: 1 message.
02: message length, 04: 4 bytes.
03-08: starting message to be transmitted on the target bus, 26 00 00 00.
09-0E: ending message to be transmitted on the target bus, 26 01 FF FF.

Note that the message length only appears once. Possible message lengths are 1-4 bytes.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	04	06	04	00 02	10

Table 43. Send iterated messages acknowledgment frame.

PAYLOAD offset:
00: acknowledgment state (00: ok, FF: error).
01: target bus (01: CCD-bus, 02: SCI-bus PCM, 03: SCI-bus TCM).

3.6.5 Send a list of messages repeatedly mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	0E	16	05	00 02 04 24 00 00 24 04 E4 00 00 E4	43

Table 44. Send a list of messages repeatedly frame.

DATA CODE byte:
16 = 00010110b
00b: source - USB
01b: target - CCD-bus
0110b: command - message Tx

PAYLOAD offset:
00: message iteration state (00: disabled, 01: enabled).
01: number of messages in the list, 02: 2 messages.
02: first message length, 04: 4 bytes.
03-06: first message to be transmitted on the target bus, 24 00 00 24.
07: second message length.
08-0B: second message to be transmitted on the target bus, E4 00 00 E4.

The list goes on similarly: every message is preceded with its length.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	04	06	04	00 01	0F

Table 45. Send a list messages repeatedly acknowledgment frame.

PAYLOAD offset:
00: acknowledgment state (00: ok, FF: error).
01: target bus (01: CCD-bus, 02: SCI-bus PCM, 03: SCI-bus TCM).

3.7 Debug (command: 0E)

Applicable SUB-DATA CODE bytes (modes):
01: generate random CCD-bus messages.
02: read internal EEPROM byte.
03: read internal EEPROM block.
04: read external EEPROM byte.
05: read external EEPROM block.
06: write internal EEPROM byte.
07: write internal EEPROM block.
08: write external EEPROM byte.
09: write external EEPROM block.
00,0A-FF: reserved.

3.7.1 Generate random CCD-bus messages mode

This feature is useful for bench-testing the scanner's internal CCD-bus circuits. However, the random generated messages may confuse modules on a live CCD-bus network. Use this debug mode carefully.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	07	0E	01	01 00 64 01 F4	70

Table 46. Send random CCD-bus messages frame.

PAYLOAD offset:
00: state (00: disabled, 01: enabled).
00-01: minimum interval in milliseconds between two random messages,
00 64 = 100 ms.
02-03: maximum interval in milliseconds between two random messages,
01 F4 = 500 ms.

Minimum interval should be no less than 20 ms because CCD-bus load is near 100% at this value. Message lengths are fixed between 3 and 6 bytes to make the messages look more authentic.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	04	0E	01	00 01	14

Table 47. Send random CCD-bus messages acknowledgment frame.

PAYLOAD offset:
00: acknowledgment state (00: ok, FF: error).
01: target bus (01: CCD-bus, 02: SCI-bus PCM, 03: SCI-bus TCM).

3.7.2 Read internal EEPROM byte mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	04	0E	02	00 00	14

Table 48. Read internal EEPROM byte frame.

PAYLOAD offset:
00-01: internal EEPROM offset, 00 00.

Possible offset for the ATmega2560 MCU range between 00 00 and 0F FF (4 kB).

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	06	0E	02	00 00 00 00	16

Table 49. Read internal EEPROM byte response frame.

PAYLOAD offset:
00: response state (00: ok, FF: error).
01-02: internal EEPROM offset.
03: value at the given offset, 00.

3.7.3 Read internal EEPROM block mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	06	0E	03	00 00 00 02	19

Table 50. Read internal EEPROM block frame.

PAYLOAD offset:
00-01: internal EEPROM offset, 00 00.
02-03: number of bytes to read, 00 02 = 2 bytes.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	07	0E	03	00 00 00 00 00	18

Table 51. Read internal EEPROM block response frame.

PAYLOAD offset:
00: response state (00: ok, FF: error).
01-02: internal EEPROM offset.
03: value at the given offset, 00.
04: value at next address, 00.
XX: value at a further consecutive address.

3.7.4 Read external EEPROM byte mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	04	0E	04	00 00	16

Table 52. Read external EEPROM byte frame.

PAYLOAD offset:
00-01: external EEPROM offset, 00 00.

Possible offsets for the 24LC32A chip range between 00 00 and 0F FF (4 kB).

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	06	0E	04	00 00 00 00	18

Table 53. Read external EEPROM byte response frame.

PAYLOAD offset:
00: response state (00: ok, FF: error).
01-02: external EEPROM offset.
03: value at the given offset, 00.

3.7.5 Read external EEPROM block mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	06	0E	05	00 00 00 02	1B

Table 54. Read external EEPROM block frame.

PAYLOAD offset:
00-01: external EEPROM offset, 00 00.
02-03: number of bytes to read, 00 02 = 2 bytes.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	07	0E	05	00 00 00 00 8C	A6

Table 55. Read external EEPROM block response frame.

PAYLOAD offset:
00: response state (00: ok, FF: error).
01-02: external EEPROM offset.
03: value at the given offset, 00.
04: value at next address, 8C.
XX: value at a further consecutive address.

3.7.6 Write internal EEPROM byte mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	05	0E	06	00 00 00	19

Table 56. Write internal EEPROM byte frame.

PAYLOAD offset:
00-01: internal EEPROM offset, 00 00.
02: value to write, 00.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	06	0E	06	00 00 00 00	16

Table 57. Write internal EEPROM byte response frame.

PAYLOAD offset:
00: response state (00: ok, FF: error).
01-02: internal EEPROM offset.
03: value confirmation at the given offset, 00.

3.7.7 Write internal EEPROM block mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	06	0E	07	00 00 00 00	1B

Table 58. Write internal EEPROM block frame.

PAYLOAD offset:
00-01: internal EEPROM offset, 00 00.
02: value to write at offset, 00.
03: value to write at next address, 00.
XX: further value to write at next consecutive address.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	07	0E	07	00 00 00 00 00	1C

Table 59. Write internal EEPROM block response frame.

PAYLOAD offset:
00: response state (00: ok, FF: error).
01-02: internal EEPROM offset.
03: EEPROM value confirmation at the given offset, 00.
04: EEPROM value confirmation at the next address, 00.
XX: value confirmation at next consecutive address.

3.7.8 Write external EEPROM byte mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	05	0E	08	00 00 00	1B

Table 60. Write external EEPROM byte frame.

PAYLOAD offset:
00-01: external EEPROM offset, 00 00.
02: value to write, 00.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	06	0E	08	00 00 00 00	1C

Table 61. Write external EEPROM byte response frame.

PAYLOAD offset:
00: response state (00: ok, FF: error).
01-02: external EEPROM offset.
03: EEPROM value confirmation at the given offset, 00.

3.7.9 Write external EEPROM block mode

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	06	0E	09	00 00 00 8C	A9

Table 62. Write external EEPROM block frame.

PAYLOAD offset:
00-01: external EEPROM offset, 00 00.
02: value to write at offset, 00.
03: value to write at next address, 8C.
XX: further value to write at next consecutive address.

SYNC	LENGTH HB	LENGTH LB	DATA CODE	SUB-DATA CODE	PAYLOAD	CHECKSUM
3D	00	07	0E	09	00 00 00 00 8C	AA

Table 63. Write external EEPROM block response frame.

PAYLOAD offset:
00: response state (00: ok, FF: error).
01-02: external EEPROM offset.
03: value confirmation at the given offset, 00.
04: value confirmation at next address, 00.
XX: value confirmation at next consecutive address.

3.8 Error (command: 0F)

Applicable SUB-DATA CODE bytes (modes):
01: invalid frame length value.
02: invalid DATA CODE byte command.
03: invalid SUB-DATA CODE byte value.
04: invalid PAYLOAD values.
05: invalid frame checksum value.
06: frame timeout occurred.
07: buffer overflow.
08-F6: reserved.
F7: not enough MCU RAM.
F8: no response from SCI-bus high-speed memory table.
F9: invalid SCI-bus high-speed memory table.
FA: no response from SCI-bus high-speed mode.
FB: external EEPROM not found.
FC: external EEPROM read error.
FD: external EEPROM write error.
FE: internal error.
FF: fatal error.

3.8.1 Invalid frame length value mode

Due to the ATmega2560 microcontroller's limited RAM size the maximum receivable frame length is limited to 1024 bytes. Also the minimum meaningful frame length is 6 bytes. Whenever these conditions are violated (frame length less then 6 bytes or more than 1024 bytes) the scanner sends this error frame back to the host computer.

3.8.2 Invalid DATA CODE byte command mode

When unused/reserved commands (08-0D) are being called this error frame is sent as a response.

3.8.3 Invalid SUB-DATA CODE byte value mode

Depending on the particular command when unused/reserved modes are being called this error frame is sent as a response.

3.8.4 Invalid PAYLOAD values mode

If a frame sent to the scanner does not contain the required number of payload bytes then this error frame is sent as a response. More payload bytes are not a problem, because the scanner discards extra bytes and processes the necessary bytes only.

3.8.5 Invalid frame checksum value mode

The scanner verifies every received frame by calculating what the checksum byte at the end of the frame should be. If this value does not equal to the received checksum byte then this error frame is sent as a response.

3.8.6 Frame timeout occurred mode

When the scanner received the frame length bytes it calculates how much more bytes it should receive until the frame ends. If the remaining frame bytes do not arrive within 100 milliseconds then this error frame is sent back to the host computer.

3.8.7 Buffer overflow mode

Whenever an applicable buffer in the scanner firmware tries to store more data than its size then this error frame is sent as a response.

3.8.8 Not enough MCU RAM mode

Due to the ATmega2560 microcontroller's limited RAM size there is a certain upper limit of the length of outgoing frames. This length is calculated every time before a frame is assembled to avoid freezing and RAM issues. Whenever such event occurs the MCU returns this error frame before anything bad could happen. Easiest way to trigger this error if several kilobytes of EEPROM data are requested at once.

3.8.9 No response from SCI-bus high-speed memory table mode

Not all memory tables are accessible through the high-speed mode of the SCI-bus. When no echo is heard from a memory table this error frame is sent as a response.

3.8.10 Invalid SCI-bus high-speed memory table mode

Valid high-speed mode memory tables range between F0 and FF, except FE which makes the engine controller return to low-speed mode. If values other than that are received by the scanner as first message byte then this error frame is sent as a response.
It is worth noting that the engine controller itself does not mind if a RAM value request message does not start with a memory table identifier. This condition is enforced to make every request/response message as clear as possible.

3.8.11 No response from SCI-bus high-speed mode

In high-speed mode if a RAM value cannot be read within a certain timeout limit (5-20 milliseconds) then this error frame is sent as a response.

3.8.12 External EEPROM not found mode

The diagnostic scanner uses an external EEPROM chip for settings storage and it is initialized every time the scanner resets. If the chip cannot be initialized at startup then this error frame is sent.

3.8.13 External EEPROM read error mode

If the external EEPROM cannot be read for some reason then this error frame is sent as a response.

3.8.14 External EEPROM write error mode

If the external EEPROM cannot be written for some reason then this error frame is sent as a response.

3.8.15 Internal error mode

When the scanner experiences an unhandled timeout this error frame is sent back to the host computer.

3.8.16 Fatal error mode

When something goes horribly wrong in the firmware of the diagnostic scanner, then this error frame is sent back to the host computer.

4. Revision history

2020.09.01: original.

2020.09.09:
- add: LCD I2C address to status response (Table 10),
- add: LCD I2C address to LCD settings (Table 19 and 20).