Image transition over SPI and USB virtual COM port

Use a Serial Peripheral Interface (SPI) to carry the data. The SCK (Serial Clock), /CS (Chip Select, active low), MISO (Master In/Slave Out) and MOSI (Master Out/Slave In) signals are present. Data exchange takes place between a single master and a single slave.

The EPD-Driver operates as a slave only. The host controller must operate as an SPI master to generate the SCK (Serial Clock) signal. The SCK frequency is max. 45MHz in a full capability mode.

The EPD-Driver uses SPI Mode (CPOL=0, CPHA=1). SCK is high on idle. Data is set up by the driver on the falling edge of SCK and should be sampled by the host controller on the rising edge of SCK.

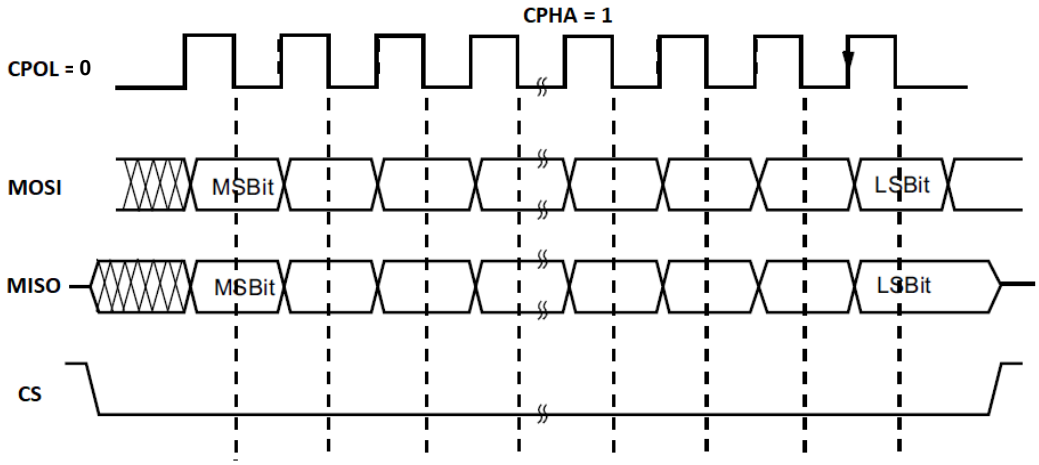

Figure 1: Data clock timing diagram.

Data is transferred most-significant byte first and in big-endian order. For example, the value 0x8C08 will appear on the MISO line as shown below:

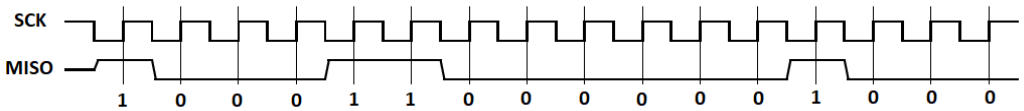

Figure 2: SPI Bit Order.

The EPD-Driver implementation of SPI consists of image packets and command packets.

The communication between PC and EPD-Driver can be realized via USB virtual COM port as well. The configuration to use virtual port is: baud rate of 115,200 bps, 8 data bits, no parity, 1 stop bit (8N1) and hardware flow control.

Beck GmbH & Co. Elektronik
Bauelemente KG
Eltersdorfer Str. 7
90425 Nürnberg
Germany

Tel.: +49 – (0)911 – 9 34 08 – 0
Fax: +49 – (0)911 – 9 34 08 – 28
E-Mail: info@beck-elektronik.de
Internet: www.beck-elektronik.de

The basic frame structure for both interfaces is as follows (see Table 1):

1. Start Byte.
2. Two-byte length of the frame
3. One-byte Message ID, which specifies the type of message being transmitted
4. Data Counter – is a sequence number of the transmitted data (max: 0x0FFF)
5. Message Data, which can be variable lengths
6. Message Frame Check Sequence (FCS). The FCS is a 16-bit CRC with the least significant byte first.

Table 1: Message Structure

Start Byte A8 (1-byte)	Frame length (2-bytes)	Message ID (1-byte)	DATA Counter (2-bytes)	DATA (Byte 0)	…	DATA (Byte N)	FCS CRC-16 (2-bytes)

Each transferred frame must be confirmed by following acknowledge bytes over MISO line:

- 0x00 - OK
- 0x01 - FAIL
- 0x02 – BUSY

All transferred data of the interface are hexadecimal "0xXX". The characters in the frame should have an unsigned value.

Table 2: Packet description

Offset	Size	Field	Value hex	Description
0	1	Start Byte	0xA8	Specifies the beginning of the package
1	2	Frame Length	0xXXXX	Specifies number of bytes in the frame
3	1	Message ID	0xXX	Content
4	2	DATA Counter	0x0XXX	Contains the sequence number of the transmitted date (max: 0x0FFF)
6	x	DATA	…	Contains the actual data
6+x	2	FCS CRC-16	0xXXXX	CRC16 Data byte; reserved for checksum of the whole frame

There are several different types of messages in the data interface. It is recommended to put a delay after each message to give some time for the function implementation before the next message will be sent. Table 3 presents a syntax of the messages according to its ID number.

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Bauelemente KG
Eltersdorfer Str. 7
90425 Nürnberg
Germany

Tel.: +49 – (0)911 – 9 34 08 – 0
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Table 3: Message syntax

Message ID	Data	Description	Recommended delay
0x01	0x0XXX 0x0XXX	Display Resolution Length and Width – number of pixels on the horizontal (x) and (y) axis	2-5 ms
0x02	0x0XXX 0x0XXX	Image Width – number of pixels on the vertical (x) and (y) axis	2-5 ms
0x03	0xXXXX	VCOM in Millivolt *(unsigned integer)*	2-5 ms
0x04	0x02,0x04, 0x08 or 0x10	Number of the grades of gray level *(2, 4, 8 or 16 bit)*	2-5 ms
0x05	0x08 or 0x10	Display data bus *(8 or 16 bit)*	2-5 ms
0x06	0xXX	Display contrast ratio 1 -100 in % (1% - 0xXX, 100% - 0xXX)	2-5 ms
0x07	0xXX	Data transfer into RAM (two pixels in one byte)	2-5 ms
0x08	0x01	Show the picture from RAM	10 sec
0x09	0x00	Clear screen	4 sec
0x0A	0x00	Fill screen white	2 sec
0x0B	0x00	Fill screen black	2 sec

Image transfer

The transfer of the picture takes place in series. For example, the image content can be transferred by string. The transfer must begin with the first pixel and the first line of the image. Each pixel contains 4 bits of information. Therefore, one byte of data should contain 2 pixels. The data counter contains the number of the transmitted strings, so the counter must be increased by one, each time a new line is transmitted.

For example, the content of the image with a size of 640x480 pixels can be transmitted as follows:

Start Byte	Frame length	Message ID	Data Counter	DATA xxxx xxxx (bits)			FCS
0xA8	0x0148	0x07	0x0000	Pix(1,1)	…	Pix(640,1)	0xXXXX
0xA8	0x0148	0x07	0x0001	Pix(1,2)	…	Pix(640,2)	0xXXXX
0xA8	0x0148	0x07	0x0002	Pix(1,3)	…	Pix(640,3)	0xXXXX
0xA8	0x0148	0x07	…	…	…	…	0xXXXX
0xA8	0x0148	0x07	0x01DE	Pix(1,479)	…	Pix(640,479)	0xXXXX
0xA8	0x0148	0x07	0x01DF	Pix(1,480)	…	Pix(640,480)	0xXXXX

The next command transfers the image from the RAM memory to the display:

Start Byte	Frame length	Message ID	Data Counter	DATA (bits)	FCS
0xA8	0x0009	0x08	0x0000	0x01	0xXXXX