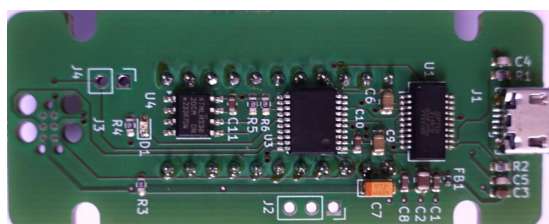
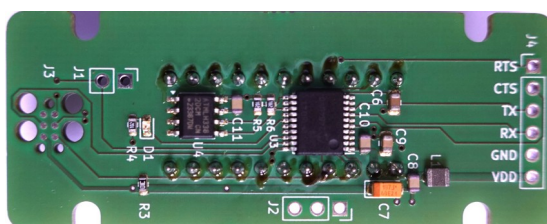


Parameter:	e9u-LSMD-TCD1304-EDU	e9u-LSMD-TCD1304-EDU
Interface:	USB 2.0	USB 2.0
Digitization depth	8 bit mode	12 bit mode
Width of values	8 bit	16 bit left aligned
Read noise (typ. rms)	300 e ⁻ (t.b.c.)	50 e ⁻ (t.b.c.)
Lineare Full Well Capacity	40 ke ⁻ (t.b.c.)	40 ke ⁻ (t.b.c.)
Full Scale Capacity	65 ke ⁻ (t.b.c.)	65 ke ⁻ (t.b.c.)
	@ 8 Bit: 330±100 e ⁻ /LSB	@ 16 Bit: 1.3±0.4 e ⁻ /LSB
Conversion Gain (typ @ 0.4 FS)	(t.b.c.)	(t.b.c.)
Maximum line rate	25 fps	25 fps
Free Run Mode with Fixed Line Rate	x	x
Minimum exposure time	20 µs	20 µs
Maximum exposure time	1.3 s	1.3 s
Step size exposure time	20 µs	20 µs
Read While Integrate	x	x
Trigger via USB	✓	✓
Integration Start/Stop via USB	x	x
Trigger or Start/Stop via USB latency typ.	10 ms	10 ms
Minimum / maximum baud rate	x	x
Trigger via UART	x	x
Trigger via UART Latenz	x	x
Trigger via UART Jitter	x	x
External Trigger Input	✓	✓
External Trigger Latency	20 µs	20 µs
External Trigger Jitter	±10 µs	±10 µs
External Trigger Latency, debounced	x	x
Isolatex external trigger input	x	x
External controll of exposure time	x	x
Lantecy of exposure time controll	x	x
Minimum external exposure time	x	x
Maximum external exposure time	x	x
Lantecy of exposure time controll, debounced	x	x
Minimum external exposure time, debounced	x	x
Trigger Output	✓	✓
High Resolution Timestamp: Trigger GPIO	x	x
Frane Buffer	✓	x
Optimized Frame Buffer	x	x
Size	61 x 25 x 12 mm	61 x 25 x 12 mm
Operation Voltage	5 V (USB)	5 V (USB)
Operation Current	< 250 mA	< 250 mA



Parameter:	e9u-LSMD-TCD1304-UART	e9u-LSMD-TCD1304-UART
Interface:	UART	UART
Digitization depth	8 bit mode	12 bit mode
Width of values	8 bit	16 bit left aligned
Read noise (typ. rms)	300 e ⁻ (t.b.c.)	50 e ⁻ (t.b.c.)
Lineare Full Well Capacity	40 ke ⁻ (t.b.c.)	40 ke ⁻ (t.b.c.)
Full Scale Capacity	65 ke ⁻ (t.b.c.)	65 ke ⁻ (t.b.c.)
	@ 8 Bit: 330±100 e ⁻ /LSB	@ 16 Bit: 1.3±0.4 e ⁻ /LSB
Conversion Gain (typ @ 0.4 FS)	(t.b.c.)	(t.b.c.)
Maximum line rate	(Baudrate / 40000), max. 25	25 fps
Free Run Mode with Fixed Line Rate	×	×
Minimum exposure time	20 µs	20 µs
Maximum exposure time	1.3 s	1.3 s
Step size exposure time	20 µs	20 µs
Read While Integrate	×	×
Trigger via USB	×	×
Integration Start/Stop via USB	×	×
Trigger or Start/Stop via USB latency	×	×
Minimum / maximum baud rate	1200 Baud bis 2 Mbaud	2 Mbaud only
Trigger via UART	✓	✓
Trigger via UART Latenz	20 µs + (10 / Baudrate)	25 µs
Trigger via UART Jitter	±10 µs + (5 / Baudrate)	±13 µs
External Trigger Input	✓	✓
External Trigger Latency	20 µs	20 µs
External Trigger Jitter	±10 µs	±10 µs
External Trigger Latency, debounced	×	×
Isolatex external trigger input	×	×
External controll of exposure time	×	×
Lantecy of exposure time controll	×	×
Minimum external exposure time	×	×
Maximum external exposure time	×	×
Lantecy of exposure time controll, debounced	×	×
Minimum external exposure time, debounced	×	×
Trigger Output	✓	✓
High Resolution Timestamp: Trigger GPIO	×	×
GPIO	×	×
Frane Buffer	✓	×
Optimized Frame Buffer	×	×
Size	61 x 25 x 12 mm	61 x 25 x 12 mm
Operation Voltage	3.3 V	3.3 V
Operation Current	< 250 mA	< 250 mA



UART Configuration:

USB-Version: Bits: 8
 Parity: none
 Stop Bits: 1
 Baud Rate: 3 Mbaud

UART-Version: Bits: 8
 Parity: none
 Stop Bits: 1
 Baud Rate: min. 1200 Baud to max. 2 Mbaud

Startup:

up on power up, wait for 100 ms and discard any traffic on the UART,
then send:

0x55 "U" like UART
to generate an alternating pattern on TX:
...1 0 10101010 1 1...
this is used to detect the frequency and set the baud rate

Response:
none

0x49 "I" like Identify

Response:
if the Baud rate was successfully detected, the camera answers with
21 Bytes: 0x65 39 75 5f 4c 53 4d 44 2d 54 43 44 31 33 30 34 2d 45 44 55 00
"e9u_LSDM-TCD1304-EDU"

If this does not work, transmit a BREAK and try again:

BREAK keep TX line low for long time, this resets the camera
then wait for 100 ms and discard any traffic on the UART

0x55 "U" like UART

Response:
none

0x49 "I" like Identify

Response:
21 Bytes: 0x65 39 75 5f 4c 53 4d 44 2d 54 43 44 31 33 30 34 2d 45 44 55 00
"e9u_LSDM-TCD1304-EDU"

Camera Configuration:

0x31 "1" like one byte per pixel (default)

enables the 8-bit mode:
8 bit ADC, 8-bit values

Response:
none

0x32 "2" like two bytes per pixel

enables the 16-bit mode:
12-bit ADC, 16-bit values left justified little endian

Response:
none

0x41 "A" like "Alive",

send keep alive 0xff bytes every 98.3 ms

Response:
none

0x61 "a" like not "alive" (default)

do not send keep alive bytes

Response:
none

0x54 "T" like "Trigger"

enable hardware trigger input at J2

Response:
none

0x74 "t" like no "trigger" (default)

disable hardware trigger input

Response:
none

0x50 "P" like write "Protection" (default)

protects offset from being changed

Response:
none

0x70 "p" like no write "protection",

needs to be sent just after startup and requires hardware jumper at J1
allows offset to be changed

Response:
none

Operation:

0x53 "S" like "Scan"
starts exposure of one scan,
if the exposure is longer than 100 ms,
keep alive packages are sent if enabled

Response:

After exposure the pixel values are transmitted:

SYNC 16 bit 0x0000 for synchronization
EXP 16 bit two bytes containing the exposure time little endian
FLAGS 8 bit one byte containing the configuration flags (see below)
PIXEL 3648 words
 1 byte mode: one byte per word
 2 byte mode: two byte per word, little endian, left aligned

0x45 "E" like "Exposure" time
direct followed by a 16 bit little endian value
representing the exposure time in 20 µs steps

Response:

none

0x4f "O" like "Offset" correction, if write protect is disabled
directly followed by an 8 bit value
representing the analog offset voltage

Response:

none

Special functions:

0x52 "R" like "Read" from EEPROM

Response:

16384 bytes

0x57 "W" like "Write" to EEPROM, if write protect is disabled
directly followed by 2 byte for address, **big endian**
directly followed by 64 bytes of data
make sure that the address is multiple of 64

Response:

none

0xff !Sync stay alive

Response:

none

0x55 "U" UART
go back to initialization, used to restart the camera

Response:

none

Flags:

Bit 0 (0x01)	TWOBYTE	= 16 Bit Mode
Bit 1 (0x02)	TRIGEREN	= external trigger is enabled
Bit 2 (0x04)	reserved	
Bit 3 (0x08)	reserved	
Bit 4 (0x10)	reserved	
Bit 5 (0x20)	WPDIS	= write protect is DISABLED
Bit 6 (0x40)	ALIVEEN	= keep alive packages are enabled
Bit 7 (0x80)	HIGHSPEED	= 3 Mbaud enabled

Notes:

- A. The interface protocol is kept very simple to reduce overhead and allow an easy control via small micro controllers and/or scripts.
The result is a compromise between complexity, flexibility and features.

- B. The camera has three operation sequences:

1. Idle: the camera waits for commands or trigger
2. Exposure: the camera was triggered and exposure is in progress
NOTE: during this time, no commands can be sent!
3. Readout: the sensor is read out and the pixel values are transferred
NOTE: during this time, no commands can be sent!

- C. To avoid time outs and/or race conditions at the host, the camera can be configured to send single 0xff byte as keep alive packages every 98.3 ms after the last traffic on the interface.
A 0xff byte received outside of the pixel values can be discarded.

- D. The camera resets, if communication is lost and the transmit buffer overflows.

If Keep-Alive packages are activated, the camera resets, if the packages are not received by the host just in time. Depending on the interface the buffer size varies:

1. USB: up to 512 packages
the camera resets, if the buffer is not read for 50.5 ms,
to avoid a camera reset regularly read within 20 s!
2. UART: only 2 packages
the camera resets, if the buffer is not read for 196 ms,
to avoid a camera reset regularly read within 100 ms!

- E. The pixel values are transmitted during read out:

1. 8-Bit mode:
the pixel values are buffered in a FIFO and could be read out slowly
2. 12-Bit mode:
the pixel values are not buffered and must be read at full speed with
200 Byte per second!