E412 Compact H.264 Encoder

Technical Reference Manual

Version 1.1

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Introduction

The E412 is a compact H.264 encoder. It is a second generation encoder of the E12/E110/E112 encoders. The main differences are:

- fast boot up: only 2 seconds
- smaller and lower power consumption
- flexible: add your host system for stream formatting
  - a compact host system in E412 form factor is planned (it will install below E412)

Key features

- video input: standard size HDMI connector
- video resolution up to 1080p30 or 1080p60 (depending on the firmware loaded into the E412)
- video codec: H.264 (base, main and high profile)
- encoding chip: Geosemi Max64380 (http://www.geosemi.com/product/max64380/)
- only progressive video formats are supported (no interlaced video input)
- audio: PCM or compressed audio
- micro USB connector to connect to host system (with UVC driver)
- alternatively 2x2 2mm pin header to host system (on the bottom side)
- host system receives the compressed video stream and formats it with GStreamer or similar
- any protocol support through GStreamer (RTSP, RTMP, HLS, UDP or more)
- control of encoding parameters and firmware upgrade through MXCAM utility
- power consumption: 0.5 watt (with 1080p30 firmware) to 1 watt (with 1080p60 firmware)
- size: 22 x 64 mm

Host software

Auvidea provides the binary versions of the software below. Please find a list of host systems supported in the list below. If your host system is not on the list, please contact us for the source code of the software and its licensing details.

- optimised UVC driver for best performance
- MXCAM: control interface to the E412 module (including encoder firmware upgrade)
- QUERYDUMP: get detailed encoding parameters and statistics

Host systems

- x86 system with Ubuntu 14.04 LTS
- Raspberry Pi

Micro Controller Firmware

Release 1.0.2 (November 2016)

- firmware upgrade via UART2 interface not supported yet
- no I2C1 interface between Max64380 and micro controller (get status via UART2)

Encoder Firmware

Release 4.3.27 (December 2016)

- support for audio (audio=external)
- 8,16, 48 kHz audio sampling rate supported

Please let us know, if you do require other audio sample rates (such as 44.1kHz).

Firmware Images

The are 3 firmware images provided. fw-64380.img is the default image. The firmware may be changed and/or upgraded with the MXCAM app. Please choose the default firmware unless you need to support 1080p50 or 1080p60 encoding. Please note, that the other firmware sets a higher clock frequency and doubles the power dissipation. This may require active cooling of the module.

Please use the QUERYDUMP app to monitor the clock frequencies set.

firmware	MEM CLK	AVC CLK	max. resolution	typ. power
fw-64380	200MHz	150MHz	1080p30	0.5 watts
fw-64380-fast	333MHz	200MHz	1080p60	1 watt
fw-64380-400MHz	400MHz	225MHz	1080p60	1 watt

Below is a partial printout of QUERYDUMP with the default (200MHz) firmware image loaded.

```
$sudo querydump
. . .
Clock rates
             XIN      : 24000000
             PLL0     : 300000000
             PLL1     : 24000000
             PLL2     : 24576000
             PLL3     : 399500000
             PLL4     : 0
             VS       : 149812500
             VPU      : 0
             QMM      : 150000000
             AVC      : 150000000
             PME      : 0
             MPEG2    : 0
             JPEG     : 100000000
             AUD0     : 12288000
             AUD1     : 8192000
             V0PixClk : 24000000
             V1PixClk : 0
             V2PixClk : 24000000
             MemClk   : 199750000
. . .
```

Timing

The E412 supports various input timings (video resolutions):

active: the visible resolution of the video (horizontal, vertical)
total: the total resolution of the video (including front and back porch)
e.g. 1650 x 750 x 60 = 74,250,000 Hz = pixel frequency

input timing	resolution	vic	active	total
576p50	720x576 p (50 Hz)	17	[720,576]	[864,625]
720p50	1280x720 p (50 Hz)	19	[1280,720]	[1980,750]
720p60	1280x720 p (60 Hz)	4	[1280,720]	[1650,750]
1080p24	1920x1080 p (24 Hz)	32	[1920,1080]	[2750,1125]
1080p25	1920x1080 p (25 Hz)	33	[1920,1080]	[2640,1125]
1080p30	1920x1080 p (30 Hz)	34	[1920,1080]	[2200,1125]
1080p50	1920x1080 p (50 Hz)	31	[1920,1080]	[2640,1125]
1080p60	1920x1080 p (60 Hz)	16	[1920,1080]	[2200,1125]

UVC driver

Custom UVC driver

The E412 requires a custom UVC driver to be installed to get the best performance (frame rate).

Basic functionality is provided by the standard UVC driver, but the frame rate may be limited. Below are the DMESG messages which shows the activation of the standard UVC driver.

```
$dmesg
[    5.871950] uvcvideo: Found UVC 1.10 device MAX64380 (0b6a:4d52)
[    5.884253] input: MAX64380 as /devices/platform/soc/3f980000.usb/
usb1/1-1/1-1.4/1-1.4:1.0/input/input3
[    5.884849] uvcvideo: Found UVC 1.10 device MAX64380 (0b6a:4d52)
[    5.896172] uvcvideo: Unable to create debugfs 1-6 directory.
[    5.896998] input: MAX64380 as /devices/platform/soc/3f980000.usb/
usb1/1-1/1-1.4/1-1.4:1.2/input/input4
[    5.897476] usbcore: registered new interface driver uvcvideo
[    5.897489] USB Video Class driver (1.1.1)
```

MXCAM

Control and configuration of the encoder

MXCAM communicates with the Max64380 encoder firmware on the E412.

Complete list of MXCAM subcommands

```
sudo ./mxcam
Usage: mxcam <subcommand> [options] [arguments]
Type 'mxcam help <subcommand>' for help on a specific subcommand

Available subcommands:
  list            : lists all compatible devices
  boot            : boot the camera with specified images
  flash           : flash the specified image(s) on camera
  bootmode        : display or change the existing bootmode
  getkey          : read the value stored on camera for the given key
  getccr          : read the ccr details from camera
  setkey          : write the key and value on camera
  removekey       : remove the key from config area
  erase           : erase the config area on camera
  info            : prints the information about the camera from usb boot/snor
  reset           : reset the camera
  gpiowr          : gpio write
  gpiord          : gpio read
  help            : describe the usage of mxcam or subcommands
  seteptype       : set the end point of camera to the specified type
  i2cwrite        : program i2c device on camera
  i2cread         : read i2c device from camera
  tcw             : read/write spi device's timing control word value of camera
  isp             : read/program ISP register
  version         : display the version of mxcam
  usbtest         : set USB test mode
  qcc             : read/write QCC registers
  whoami          : informations about maxim camera and supported commands
  memtest         : DDR memory test
  pwm             : read/configure pwm

Global options:
  --poll          : wait until ANY maxim device is connected
  --device        : select device with device-id
  --bus           : select device on bus X with addr Y (--addr required)
  --addr          : select device on bus X with addr Y (--bus required)
  --verbose       : display verbose messages
  --oldcam        : communicate with old generation Maxim cameras
```

CCR options

CCR	Key	Options	Description
1	BOOTMODE	usb, snor	boot mode of camera
2	BOARD	raptorbub raptorcam1 raptorcam2 raptorcam4	Board type
3	NVPP_SCALE	0, 1	Selects whether to use single LVPP + 2 NVPPs in datapath
4	NVPP_VID_ PASSTHROUGH	0, 1	Selects whether to set NVPP video to pass through mode
5	USB_AUDIO_SYNC	0, 1	ST/Link-2 programming interface of the micro controller (data)
6	BF	0, 1, 2	Type of beamformer: 0: Disable beamformer 1: Beamformer template 2: 4mic
7	beamformer	0 to 10 (3)	Thirdparty beamformer etc.
8	NRL	0	Value of Noise reduction level {-MAXINT to +MAXINT}
9	NPA	0 to 10 (0)	Type of Noise processing algorithm
10	BW	70	Value of Beam width {-MAXINT to +MAXINT}
11	MS	70	Value of Mic spacing {-MAXINT to +MAXINT}
12	CUS1	1	Custom 1 {-MAXINT to +MAXINT}
13	CUS2	7	Custom 2 {-MAXINT to +MAXINT}
14	CUS3	0	Custom 3 {-MAXINT to +MAXINT}
15	AGC	0, 1	Automatic gain control enable
16	PT	3	Peak threshold in dB {0, MAXINT}
17	AT	22	Average target power in dB {0, MAXINT}
18	AEC	0, 1	Acoustic echo cancellation enable
19	NR	0, 1	Enable noise reduction
20	NS	20	Noise reduction suppression level in dB {1 to 30}
21	MAXRES_INPUT	1080p60	Maximum support resolution for video input {qvga|wqvga|vga|wvga|720p30|720p60|1080p30|1200p|1296p|1536p}
22	MAXRES_MAIN	1080p60	Maximum supported resolution for main channel {qvga|wqvga|vga|wvga|720p30|720p60|1080p30}
23	MAXRES_PV	auto	Maximum supported resolution for preview channel {qvga|wqvga|vga|wvga|720p30|720p60|1080p30}
24	MAXRES_LVPP	1080p60	Maximum supported resolution for LVPP (live input module) {qvga|wqvga|vga|wvga|720p30|720p60|1080p30|1296p|1536p}
25	VRES_VPP	auto	Resolution for NVPP channels, in descending order {"[res0];[res1];...;[resN]"}{qvga|wqvga|vga|wvga|720p30|720p60|1080p30}
26	VRES_AVC	auto	Resolution for AVC encoders {"[res0];[res1];...;[resN]"}{none|qvga|wqvga|vga|wvga|720p30|720p60|1080p30}
27	VRES_MJPEG	auto	Resolution for MJPEG encoders {"[res0];[res1];...;[resN]"}{none|qvga|wqvga|vga|wvga|720p30|720p60|1080p30}

CCR	Key	Options	Description
28	VRES_RAW	auto	Resolution for YUV/RAW encoder Only one allowed. {none|qvga|wqvga|vga|wvga|720p30|720p60|1080p30}
29	LENSSHADING	internal	Select where lens shading correction will be performed. {off|internal|sensor}
30	SENSOR	auto	Sensor type {auto|none}
31	SENSORVOLTAGE	2.8V	Indicates the AVDD of sensor input {2.8v|3.3v}
32	SENSOREXP	default	Initial sensor exposure setting
33	SENSORMAXAGAIN	auto	Set maximum sensor analog gain
34	SENSORFLIP	0, 1, 2 ,3	Set the sensor horizontal/vertical flip (bit 1: vflip, bit 0: hflip)
35	AWB	weighted	AWB algorithm select {gray|weighted|sensor|mesh}
36	LENS	default	Lens type for a corresponding sensor
37	RADSHADING	auto	Radial shading parameters. {"#,hiTemp,loTemp,data,..."}
38	HISTOEQ	0, 1	Histogram equalization enable
39	AWBPROBPEAK	auto	Specifies a point to create a probability peak {gr,gb}
40	SENSORPWR DWNMODE	0, 1	GPIO pin polarity to power down sensor
41	NIGHTGPIO	-1	GPIO pin and polarity to indicate night mode (BytePolarity|GPIOn)
42	ADAPTCCM	auto	Adaptive CCM. {"#,hiTemp,loTemp,data,..."}
43	POWERFREQ	50, 60	Power line freqency
44	ADC	auto	Specifies ADC module. {WM8750|WM8737|MAX9860|MAX9867}
45	AUDCLK	external	I2S audio mode must be set to external for E412 (I2S slave mode)
46	ADC_MASTER	auto	Choose which ADC port to be master. {0|1|none}
47	ADCMAXVOL	auto	Specifies the max volume setting in ADC (in dB)
48	AIN0_INPUT	0, 1	the audio input port to which Max64380 audio input 0 has to connect
49	AIN1_INPUT	0, 1	the audio input port to which Max64380 audio input 1 has to connect
50	AEC_DELAY	4	specifies the window length within which the echo cancellation is done. Should be power of 2. window length for echo cancellation is = (AEC_DELAY) x (no:of samples per frame)
51	MAPPEN	0, 1	Control mobiapp support
52	RAWDUMP_RES	auto	Set raw dump resolution {width,height}
53	WATCHDOG	0, 1	HW Watchdog Enable
54	CAMERA_MODE	SKYPE_BULK	camera mode {IPCAM|SECS|UVC_STUB|AEC|SKYPE_ISOC|SKYPE_BULK|DEVEL}
55	3D_MODE	0, 1	3D mode
56	AUDIO_INTERVAL	1, 2, 3, 4	Polling interval for audio endpoint

```
$sudo ./mxcam getccr
-------------------------------
 MAXIM AREA CCR LIST
 key, default, description
-------------------------------
……
key count   : 55
```

List the keys configured

```
$sudo ./mxcam getkey
BOOTMODE=snor
BF=1
CUS1=1
CUS2=7
MS=70
BW=70
BOARD=raptorcam2
CAMERA_MODE=SKYPE_BULK
VIDEO_INPUT=YUV1_16
MAXRES_INPUT=1080p60
MAXRES_LVPP=1080p60
MAXRES_MAIN=1080p60
HSTART=190
VSTART=36
HSEL=1
LSEL=0
VIDEOCONTROL=80380828
NVPP_VID_PASSTHROUGH=1
AUDCLK=external

key count   : 19
config size : 262/1024 bytes
```

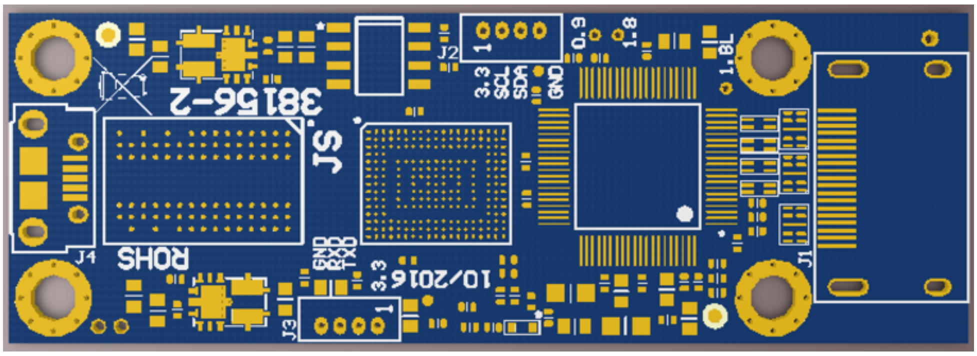
QUERYDUMP

Get statistics of the encoder

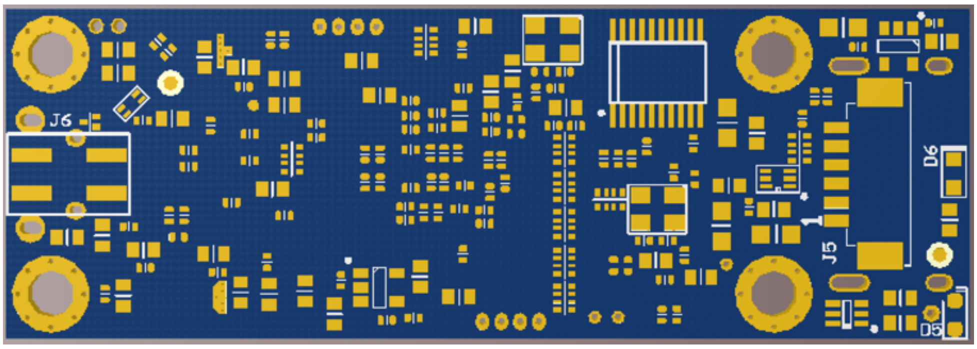
```
$sudo ./querydump
Error opening the file for Query Dump....
 Outputting to the Console
Core: Retrieved 0x405c0bcc as GPB

vinh is attached type  = 2
lvpp0 is attached type  = 3
lvpp1 is attached type  = 3
avcenc0 is attached type  = 5
avcenc1 is attached type  = 5
jpegenc1 is attached type  = 13
audfil0 is attached type  = 16
audfil1 is attached type  = 16
audfil2 is attached type  = 16
audenc1 is attached type  = 11

System Control : ID 0
       Heartbeat : 319724
       Dropped Events: 0
       Event Handler State:
       Event Queue Pointers: Read 4 / Write 5
       Event Pending: 0
       Event Handler Load Average : 0% ints/s 0 events/s 0
       Codec load: Enc HW 42% (MB 42%) Enc SW 5% Dec HW 0% Dec SW 0%
       Audio load: Enc 0% Dec 0%
       Mux load: 0%
       USB load: 0%
       Allocated pool memory : 108584960/127918080
       Heap 0 Utilization : 932480/2097152
       Heap 1 Utilization : 563840/2097152
       VIN0:
              INT: now:0us max:0us n:18736
              ISR: min:307us avg:567us max:1334us hwload:72.61% swload:3.32% dbg:0
              Interleave: twsync:0x0000 syncerrors:0 nullframes:0
              Input status: 0x1 (top vlines=1 hwidth=0 )
       VIN1:
              INT: now:39991us max:23021312us n:13350
              ISR: min:865us avg:996us max:1561us hwload:0.00% swload:0.00% dbg:0
              Interleave: twsync:0x0000 syncerrors:0 nullframes:0
              Input status: 0x0 (top vlines=0 hwidth=0 )
       AIN0:
              INT: now:10034us max:10069us n:2411
              ISR: min:80us avg:302us max:886us dbg:4
              framesCaptured:2410 captureFailures:2 captureOverflow:0
              SamplesPerFrame:480 RampTime:10us

       AIN1:
              INT: now:0us max:0us n:0
              ISR: min:0us avg:0us max:0us dbg:0
              framesCaptured:0 captureFailures:0 captureOverflow:0
              SamplesPerFrame:0 RampTime:0us

       Memory bandwidth (bytes/sec) over the last 5040ms:
       ------------------------------------------------------------------------------------------------
       | sys qmm read: 2696238 | sys qmm write: 2732745 | vid qmm read: 3437740 | vid qmm write:  299570 |
       | ahb per read:       0 | ahb per write:       0 | vpp0 read: 1041898    | vpp0 write   : 4351502 |
       | vpp1 read   : 4325070 | vpp1 write   : 4359095 | fbr0: 4359095         | fbr1         :       0 |
       | fbw         :       0 | avc readd 0  : 4922596 | avc read 1: 2772273   | avc db       : 2668856 |
       | aii 0       :  776677 | aii 1        :       0 | jpeg read:      0     | jpeg write   :       0 |
       | sbc read    :       0 | sbc write    :       0 | spi read:      0      | spi write    :       0 |
       | bsr read    :       0 | bsr write    :       0 | avc bits:  165062     | avc stat     : 5070463 |
       -------------------------------------------------------------------------------------------------
       Total: 43978880 bytes/sec

       Clock rates
              XIN      : 24000000
              PLL0     : 300000000
              PLL1     : 24000000
              PLL2     : 24576000
              PLL3     : 399500000
              PLL4     : 0
              VS       : 149812500
              VPU      : 0
              QMM      : 150000000
              AVC      : 150000000
              PME      : 0
```

```
             MPEG2    : 0
             JPEG     : 100000000
             AUD0     : 12288000
             AUD1     : 8192000
             V0PixClk : 24000000
             V1PixClk : 0
             V2PixClk : 24000000
             MemClk   : 199750000
       UVC statistics
             Audio frames - queued                         : 2000
             Audio frames - transferred                    : 37
             Audio frames - transfer error                 : 0
             Audio frames - dropped                        : 1946
             Audio frames - max time between queueing (us) : 11731
             Audio frames - min time between queueing (us) : 8273
             Audio frames - max time between transfer (us) : 12916
             Audio frames - min time between transfer (us) : 7988
LVPP : ID 1 "vinh"
       Frames Captured : 13350
       Capture Failures : 0
       Capture Overflow : 0
       A/V Synch Drops : 0
       A/V Synch Repeats : 0
       Input Drops : 0
       Output PTS : 0x0013188cc
       Dest Size : 1920x1088
       Tamper frame number : 0
       Tamper Defocus Comp:Thd : 0 : 0
       Tamper FieldofView Comp:Thd : 0 : 0
       Tamper Block Comp:Thd : 0 : 0
       Temporal Filter Strength : 0
       Horizontal Filter Level : 0
NVPP : ID 2 "lvpp0"
       Frame transit time min:14302 avg:14350 max:15043
       Frames Captured : 5387
       Capture Failures : 0
       Capture Overflow : 0
       A/V Synch Drops : 0
       A/V Synch Repeats : 0
       Input Drops : 0
       Output PTS : 0x0038c5d24
       Dest Size : 1280x720
NVPP : ID 3 "lvpp1"
       Frame transit time min:14423 avg:29681 max:30577
       Frames Captured : 13350
       Capture Failures : 0
       Capture Overflow : 0
       A/V Synch Drops : 0
       A/V Synch Repeats : 0
       Input Drops : 0
       Output PTS : 0x0038c62df
       Dest Size : 1280x720
AVC Encoder : ID 4 "avcenc0"
       Frames Encoded    : 5363
       Performance (IPB) : 18575/20431/0
       PerformanceJitter (IPB) : 1/5362/0
       Latency           : 662130644 us
       Buffer Fullness   : 1931 / 6500000 (max 1080156)
       Base QP           : 12
       State             :
       Frames Input          : 5387
       Input frame drops     : 0
       Rate control drops    : 23
       Last RC drop cause    : 4
       Last RC drop pic type : 0
       Last RC drop pic size : 73945
       Last RC drop pic QP   : 14
       Last RC drop pic Edge : 23432
       Telecine field drops  : 0
       Nalus exceed limit    : 0
       Complexity RC override: 0
       Last block ready addr : 0x0
       Last block ready size : 0x0
       Last block done addr  : 0x0
       Last block done size  : 0x0
       Current PTS:          : 0x0038c5d24
       Y SNR:                : 45.12
       Ref Pool Used         : 2
       Recon Preview Drops   : 0
       Frame output delta E  : 16152/161202 us (Min/Max)
       Frame output delta S  : -1/0 us (Min/Max)
       Frame signature       : 62856826
       Current bitrate       : 378.570862 kb/s
       Frame Rate            :  25.00
AVC Encoder : ID 5 "avcenc1"
       Frames Encoded        : 0
       Performance (IPB)     : 0/0/0
       PerformanceJitter (IPB) : 0/0/0
       Latency               : 0 us
       Buffer Fullness       : 0 / 0 (max 0)
       Base QP               : 0
       State                 : Idle
       Frames Input          : 0
       Input frame drops     : 0
       Rate control drops    : 0
       Last RC drop cause    : 0
       Last RC drop pic type : 0
       Last RC drop pic size : 0
       Last RC drop pic QP   : 0
       Last RC drop pic Edge : 0
       Telecine field drops  : 0
       Nalus exceed limit    : 0
       Complexity RC override: 0
       Last block ready addr : 0x0
       Last block ready size : 0x0
       Last block done addr  : 0x0
       Last block done size  : 0x0
       Current PTS:          : 0x000000000
       Y SNR:                : 50.00
       Ref Pool Used         : 0
       Recon Preview Drops   : 0
       Frame output delta E  : 0/0 us (Min/Max)
       Frame output delta S  : 0/0 us (Min/Max)
       Frame signature       : 0
       Current bitrate       : 0.000000 kb/s
       Frame Rate            : 0.00
JPEGENC : ID 6 "jpegenc1"
       Encoder index : 0
       Encoder state : Idle(0)
       In DATA tokens dequeued : 0
       Frames encoded : 0
       In DATA tokens dropped : 0
       Last quality factor : 0
       Min quality factor allowed : 0
       Max quality factor allowed : 0
       Last frame size (bytes) : 0 [min: 0 max: 0]
       Total encoded frames size (bytes) : 0
       Frames encoded since last reset: 0
       Encoded frames size since last reset: 0
       Current bitrate (bits/s): 0
       Current PTS : 0x0000000000000000
       Token standby time (us) : 0
       Software setup time (us) : 0
       Hardware encode time (us) : 0
       Input data que occupancy : 0/0
       Input data que overflows : 0
       Output buffer fullness (bytes) : 0/0
       Downstream overflows (current)/(total) : 0/0
       Encoder status: Notified.
       Mastser ISR status: Notified.
AUDFLTR : ID 7 "audfil0"
       Filter stream ID : 0
       Filter state : Idle (0)
       Last received command/interrupt : 18
       Input ports : 0
       Output ports : 1
       Input frames received in current round : 0
       Rounds of input frames received from src channels : 0
       Output frames sent in current round : 0
       Rounds of output frames sent to output ports : 0
       Output buffer overflow count (current) : 0
       Output buffer overflow count (total)   : 0
       Input buffer occupancy: (0/0)
       Output buffer occupancy: (0/0)
       Audio Sync: Delta 0 Resample Ratio 0x0 (0 ppm)
       Computation latency: 0 us
AUDFLTR : ID 8 "audfil1"
       Filter stream ID : 1
       Filter state : Waiting for input frames (1)
       Last received command/interrupt : 3
       Input ports : 1
       Output ports : 1
       Input frames received in current round : 0
       Rounds of input frames received from src channels : 30649
       Output frames sent in current round : 1
       Rounds of output frames sent to output ports : 30649
       Output buffer overflow count (current) : 0
       Output buffer overflow count (total)   : 0
       Input buffer occupancy: (0/128)
       Output buffer occupancy: (0/32)
       Audio Sync: Delta 0 Resample Ratio 0x0 (0 ppm)
       Computation latency: 1620 us
AUDFLTR : ID 9 "audfil2"
       Filter stream ID : 2
       Filter state : Idle (0)
       Last received command/interrupt : 18
       Input ports : 0
       Output ports : 1
       Input frames received in current round : 0
       Rounds of input frames received from src channels : 0
       Output frames sent in current round : 0
       Rounds of output frames sent to output ports : 0
       Output buffer overflow count (current) : 0
       Output buffer overflow count (total)   : 0
       Input buffer occupancy: (0/0)
       Output buffer occupancy: (0/0)
       Audio Sync: Delta 0 Resample Ratio 0x0 (0 ppm)
       Computation latency: 0 us
Audio Encoder : ID 10 "audenc1"
       Frames Encoded    : 0
       State             : Idle
       Latency           : 0 us
       Buffer Fullness   : 0 / 0
       Frames Input      : 0
       Input frame drops : 0
       Current PTS:      : 0x000000000
       Frame output delta E  : 0/0 us (Min/Max)
       Frame output delta S  : 0/0 us (Min/Max)
       Current bitrate   : 0.000000 kb/s
usb mem interface World End
```

Connectors



top view of the E412 rev 2



bottom view of the E412 rev 2

HDMI input (J1)

Please connect an non HDCP video source with progressive timing. Interlaced video is not supported. At startup the onboard micro controller inits the HDMI input chip and programs the EDID. Once this has completed the HDP pin (19) is raised high, to flag to the HDMI source connected, that the receiver is ready to receive a signal and that the EDID may now be read.

Micro USB 2.0 (J4)

This USB port puts out the H.264 encoded video stream and allows control and setup of the encoder and the HDMI input chip via tunnelled I2C. As the USB port does not transfer any raw uncompressed data but only compressed H.264 video data, the bandwidth of USB 2.0 (480Mbit/s max.) is more than sufficient. J6 is an optional connector to bridge USB 2.0 from board to board.

Pin	Function	Description
1	5V	5V power input of the E412 module (100mA typical)
2	USB-D-	USB 2.0 data
3	USB-D+	USB 2.0 data
4	USB_ID	not connected
5	GND	Ground

UART2 (J5)

This UART2 port is the console interface to the on-board micro controllers. The commands are described in a section below. Commands allow to setup the system and to retrieve the status like the video properties of the HDMI video source connected. The baud rate settings of UART2 are 115200 8/N/1. Please use a USB to TTL UART converter. Swap RxD and TxD when connecting this interface.

Pin	Function	Description
1	3.3V	3.3V reference voltage (do not apply power from an external source to this pin)
2	UART2_TxD	TTL UART transmit data of the micro controller (3.3V)
3	UART2_RxD	TTL UART receive data of the micro controller (3.3V)
4	SWCLK	ST/Link-2 programming interface of the micro controller (clock)
5	SWDIO	ST/Link-2 programming interface of the micro controller (data)
6	GND	Ground

Encoder Debug UART (J3)

This optional UART port shows the debug and boot up messages of the Max64380 encoder chip. Baud rate: 115200 8/N/1.

Pin	Function	Description
1	3.3V	3.3V reference voltage (do not apply power from an external source to this pin)
2	DBG_TxD	TTL UART transmit data of the Max64380 (3.3V)
3	DGB_RxD	TTL UART receive data of the Max64380 (3.3V)
4	GND	Ground

I2C port (J2)

This optional I2C port interconnects the Max64380, the on-board micro controller and the HDMI in receiver chip. Normally the micro controller controls this bus as master. Please use the console interface on UART2, to manually read and write registers of the HDMI receiver chip for debug purposes. It is not recommended to use the MXCAM I2C tunnel to let the Max64380 take control of this I2C bus, as this access could collide with the micro controller driving this bus.

Pin	Function	Description
1	3.3V	3.3V reference voltage (do not apply power from an external source to this pin)
2	I2C0_CLK	I2C bus 0 clock (3.3V)
3	I2C0_DAT	I2C bus 0 data (3.3V)
4	GND	Ground

Console control

UART2

Please connect a terminal emulation program with a USB to TTL UART converter, to connect to the console interface of the on-board micro controller. This provides a command line interface to setup and control the E412 module.

h

Print out a list of commands supported.

```
>h
v: print version number
t: print timing information
r: read i2c register
w: write i2c register
l: list i2c devices
avi: print avi infoframe
col: set color mode
edid: print edid
bootloader: prepare for firmware upgrade
```

v

Print out the version of the firmware.

```
>v
38156_v1.0.2
```

t

Print the timing details for the HDMI video source connected. The example below shows the 1080p25 timing with an actual resolution of 1920x1080 an a total size of 2640x1125. 0 is progressive. “528,148,44” is the horizontal timing (front porch, back porch, pulse width). “4,36,5” is the vertical timing (front porch, back porch, pulse width).
horizontal: 1920 + 528 + 148 + 44 = 2640
vertical: 1080 + 4 + 36 + 5 = 1125
“01” is the status.

```
>t
1920,1080,2640,1125,0,528,148,44,4,36,5,01
```

r <i2c device> <register>

Read I2C register. “0x3C” reads the HDMI receiver chip.

```
>r 0x3C 0x1
reg: 0x01 data: 0x00
```

w <i2c device> <register> <data>

Writes I2C register. “0x3C” reads the HDMI receiver chip.

```
>w 0x3c 0x40 0x2f
```

l

List all I2C devices. On the E412 this is just a single I2C device at address “0x3C”.

```
>l
     0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F
00:          -- -- -- -- -- -- -- -- -- -- -- -- --
10: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
20: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
30: -- -- -- -- -- -- -- -- -- -- -- -- 3C -- -- --
40: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
50: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
60: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
70: -- -- -- -- -- -- -- --
```

avi

Print out the avinfoframe received by the HDMI receiver chip.

```
>avi
2,150,16,168,0,33,0,0,0,0,0,0,0,0,0,0
```

col

Read and write the color mode of the HDMI receiver chip. “auto” means that the micro controller reads and avinfoframe and determines the color model by the HDMI input. This is then programmed into the HDMI receiver chip, so that the color model is correct.

```
>col
auto
```

edid

Print out the 256 byte EDID of the HDMI receiver chip. This EDID may be also read by the HDMI source connected via the DDC interface on the HDMI cable.

```
>edid
0x00 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0x00 0x41 0xA5 0x01 0x00 0x00 0x00 0x00 0x00
0x1A 0x17 0x01 0x03 0x80 0x10 0x09 0x78 0x0A 0xEE 0x91 0xA3 0x54 0x4C 0x99 0x26
0x0F 0x50 0x54 0x01 0x00 0x00 0x45 0xC0 0x81 0xC0 0x01 0x01 0x01 0x01 0x01 0x01
0x01 0x01 0x01 0x01 0x01 0x01 0x00 0x00 0x00 0xFE 0x00 0x56 0x34 0x5F 0x31 0x00
0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x01 0x1D 0x00 0xBC 0x52 0xD0 0x1E 0x20
0xB8 0x28 0x55 0x40 0xA0 0x5A 0x00 0x00 0x00 0x1E 0x00 0x00 0x00 0xFD 0x00 0x18
0x3C 0x1A 0x51 0x11 0x00 0x0A 0x20 0x20 0x20 0x20 0x20 0x20 0x00 0x00 0x00 0xFC
0x00 0x45 0x34 0x31 0x32 0x0A 0x20 0x20 0x20 0x20 0x20 0x20 0x20 0x20 0x01 0xEF
0x02 0x03 0x20 0xF3 0x48 0x13 0x04 0x3C 0x3D 0x3E 0xA0 0xA1 0xA2 0x23 0x09 0x04
0x01 0x83 0x01 0x00 0x00 0x67 0x03 0x0C 0x00 0x10 0x00 0x80 0x10 0xE2 0x00 0x2A
0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00
0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00
0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00
0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00
0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00
0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x18
```

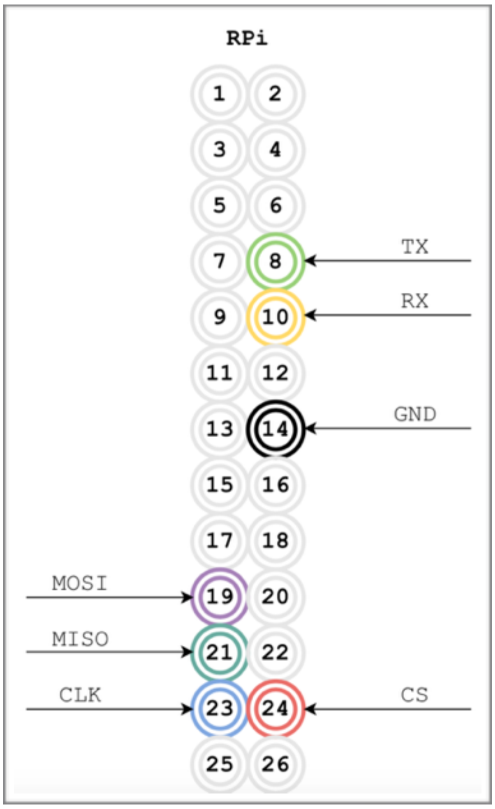
bootloader

Prepare the micro controller for firmware upgrade via the UART2 interface. This feature is not supported by the firmware yet. Please use the SWD interface and a ST/LINK-2 programmer to perform a firmware upgrade of the E412.

```
>bootloader
ready for firmware upgrade
please terminate your terminal emulation program now
and start the STM Flash Loader Demonstrator
```

Raspberry to E412

Raspberry to E412 UART2 connection



You may connect the UART of the Raspberry Pi to the UART2 on the E412 with 3 wires (J5 of the E412). The UART pins on the GPIO header of the Raspberry Pi have the right voltage (3.3V).

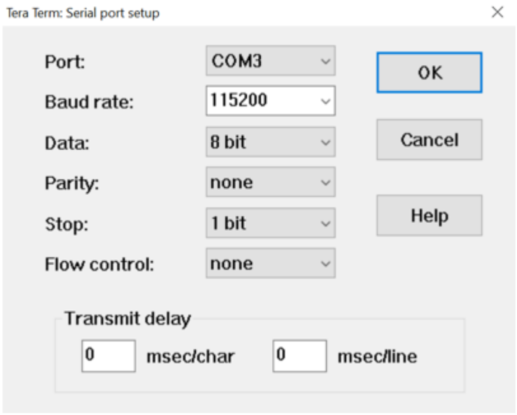
- GND: pin 14 of the RPi to pin 6 of J5 (E412)
- RxD: pin 10 of the RPi to pin 2 (TxD) of J5 (E412)
- TxD: pin 8 of the RPi to pin 3 (RxD) of J5 (E412)

Terminal emulation

Tera Term (PC)

We have tested this terminal application (Tera Term 4.92) on Windows 7 and 10. Please use an USB to UART TTL with pin header. Then connect three wires: GND, RxD and TxD of UART2 to this pin header. Please make sure to swap RxD and TxD.

1. please install the FTDI 232RL driver. Windows 10 can do this automatically. Please check the device manager that this hardware was installed successfully.
2. The FTDI 232RL driver creates a virtual COM port. The COM number may vary from system to system. Please go to setup - serial port and configure COM port number and baud rate (115200).
3. now you should be able to communicate with the E412. Test the „v“ command.



Tera Term: Serial port setup

Port: COM3

Baud rate: 115200

Data: 8 bit

Parity: none

Stop: 1 bit

Flow control: none

Transmit delay

0 msec/char 0 msec/line

```
v                                   – print the version
```

minicom (Raspberry Pi)

We have tested this terminal application (minicom) on the Raspberry Pi. Please configure it for 115200 baud and 8/N/1.

Raspberry Pi video out

For testing purposes the Raspberry Pi may be used as a programmable video output generator. It supports 59 video modes (CEA) and 86 computer modes (DMT). Therefore the output resolution may be very flexibly adjusted. Up to date information may be retrieved from:

https://www.raspberrypi.org/documentation/configuration/config-txt.md

1. log into the Raspberry Pi with mouse, keyboard and monitor or with ssh remote access.

```
ssh pi@<ip address>                 - connect via ssh
password: raspberry
```

2. edit config.txt to modify the HDMI output settings

```
sudo nano /boot/config.txt          - edit config file
```

3. you may want to disable the EDID, to force the Pi into a specific output mode and therefore ignoring any EDID it may get from the E412 or another system it is connected to. Search for the line and edit it.

```
hdmi_ignore_edid=0xa5000080         - ignore EDID
```

4. next select the hdmi_group 1, to specify CEA output modes

```
hdmi_group=1
```

5. on the web site you find the complete list of CEA codes. Also they are listed in the timing table on page 6 of this document. Examples:

```
hdmi_mode=16                        - 1080p60
hdmi_mode=31                        - 1080p50
hdmi_mode=32                        - 1080p24
hdmi_mode=33                        - 1080p25
hdmi_mode=34                        - 1080p30
```

6. now save and close the config.txt file

```
<ctrl> o                            - save the file
<ctrl> x                            - close the file and editor
<ctrl> c                            - close without saving
```

7. reboot the Raspberry Pi so that the changes can take effect

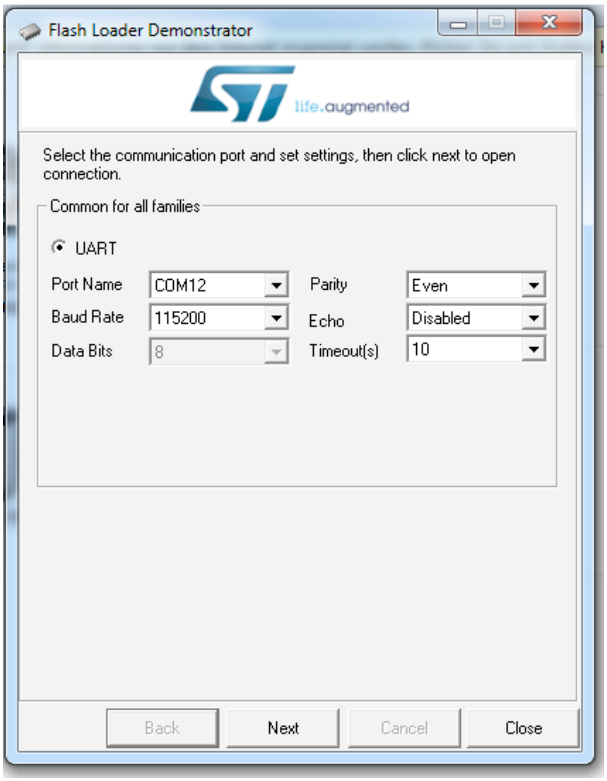
8. the Raspberry may also be used to read the EDID of the E412, if the HDMI out of the Raspberry Pi is connected to the HDMI input of the E412. Please make sure that the EDID is enabled in the config.txt file.

```
#hdmi_ignore_edid=0xa5000080        - edit the config.txt file, to read EDID
```

```
tvservice -d test.edid              - save the EDID of the E412 to a file
hexdump test.edid                   - dump the EDID hex fil
```

Firmware upgrade

The firmware of the E412 may be upgraded via the UART connection. A UART connection to a Windows PC is required as the STM flash software only supports Windows at this time.



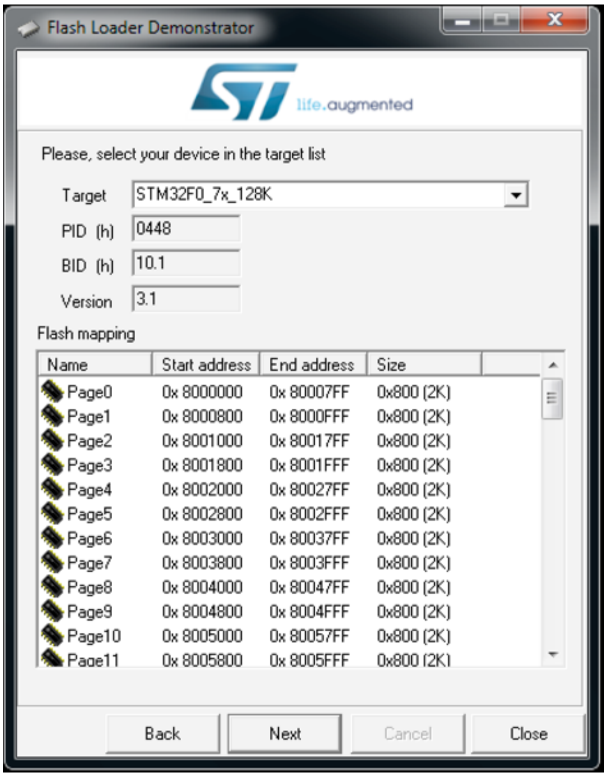
Select the communication port and set settings, then click next to open connection.

Common for all families

● UART

Port Name	COM12	Parity	Even
Baud Rate	115200	Echo	Disabled
Data Bits	8	Timeout(s)	10

1. download and install the STM32 Flash loader demonstrator (Windows only) from http://www.st.com/content/st_com/en/products/development-tools/software-development-tools/stm32-software-development-tools/stm32-programmers/flasher-stm32.html
2. connect E412 via USB-to-UART cable to your Windows PC
3. start terminal emulation software and connect with your E412 (FT232R USB UART) (USB Serial COM Port)
4. check firmware version with the API command „v“
   example: 38156_v1.0.2
5. start bootloader with the API command „bootloader"



Please, select your device in the target list

Target STM32F0_7x_128K
PID (h) 0448
BID (h) 10.1
Version 3.1

Flash mapping

Name	Start address	End address	Size
Page0	0x 8000000	0x 80007FF	0x800 (2K)
Page1	0x 8000800	0x 8000FFF	0x800 (2K)
Page2	0x 8001000	0x 80017FF	0x800 (2K)
Page3	0x 8001800	0x 8001FFF	0x800 (2K)
Page4	0x 8002000	0x 80027FF	0x800 (2K)
Page5	0x 8002800	0x 8002FFF	0x800 (2K)
Page6	0x 8003000	0x 80037FF	0x800 (2K)
Page7	0x 8003800	0x 8003FFF	0x800 (2K)
Page8	0x 8004000	0x 80047FF	0x800 (2K)
Page9	0x 8004800	0x 8004FFF	0x800 (2K)
Page10	0x 8005000	0x 80057FF	0x800 (2K)
Page11	0x 8005800	0x 8005FFF	0x800 (2K)

6. terminate terminal emulation program. We have tested this with TeraTerm. Some other terminal emulation programs may not terminate correctly (e.g. Putty).
7. start STM Flash Loader Demonstrator and program the micro controller. First select the port name (COM12 in our example). If “next” flags an error, then the terminal emulation program did not release the com port.
   - select the target device: STM32F0_4x_32k (STM32F042)
   - select the firmware xxx.elf.hex file
   - flash the device (do not interrupt or power down until the flashing has finished)
8. restart E412
9. verify that new firmware has been programmed with the API command „v“

Note: if the flashing has failed and the E412 does not boot anymore, it can be rescued by connecting an ST-LINK programmer SWD interface on connector J5.

FAQ

1.

Disclaimer

Thank you for reading this manual. If you have found any typos or errors in this document or any bugs or issues in the software or API, please let us know.

The Auvidea Team