

CMOS digital camera co-processor

Features

- Real-time video - up to 30fps VGA
- USB 1.1 compliant
- Motion-JPEG compression
- Isochronous USB data transfer
- Direct Show driver support
- Programmable vendor ID
- RGB-preview, YCrCb or M-JPEG video output
- Automatic exposure, gain and white balance

Description

The STV0676 co-processor combined with ST CMOS image sensors offers highly integrated imaging products which deliver USB 1.1, RGB-preview, YCrCb or M-JPEG digital video data at up to 30 frames per second.

The STV0676 interfaces to CIF (352 x 288) or VGA (640 x 480) image sensor and performs:

- pixel defect correction,
- auto exposure, auto gain,
- auto white balance, anti-aliasing, anti-flicker,
- colour interpolation, colour balance,
- gamma correction,
- M-JPEG compression.

STV0676 chipsets are supported by a fully-featured USB driver. This provides a wide range of user definable settings for optimum camera setup and operation. Isochronous data transfer over USB guarantees video quality at all times, irrespective of the number of other peripherals.

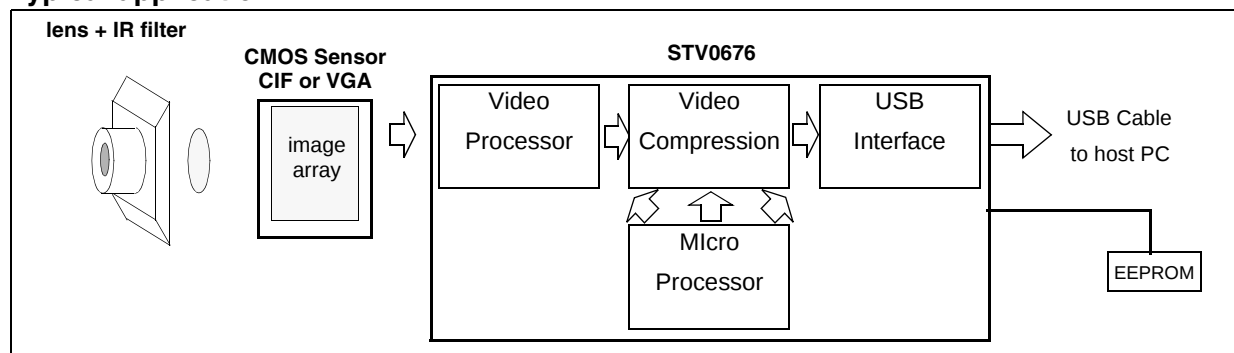
Low power consumption, highly integrated designs and simple support circuitry enable OEMs to design low cost, low power, camera products for high volume consumer market places.

STMicroelectronics offers camera manufacturers rapid-to-market camera products supported by comprehensive reference designs, software drivers and technical backup.

Applications

- USB camera
 - Biometric identification, toys and games
- Embedded applications support
 - PDA, notebook PC, mobile phone
 - Set top box, and security applications

Typical application



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1 Overview

1.1 STV0676 co-processor general description

The STV0676 is a digital video processor requiring no external RAM and a minimum of passive support components to provide a complete USB camera. STV0676 accepts raw digital video data from a ST VGA or CIF format CMOS sensor and is capable of transferring the resulting JPEG data to a host PC over USB at rates up to 30 frames per second VGA.

The internal STV0676 architecture consists of a number of separate functional blocks:

- Video processor (VP)
- Video compressor (VC)
- USB control block
- General purpose controller

The VP controls the sensor and processes the raw RGB pixel data into YCbCr images.

This YCbCr data is compressed by the VC.

The USB control block transfers the compressed data to the host PC.

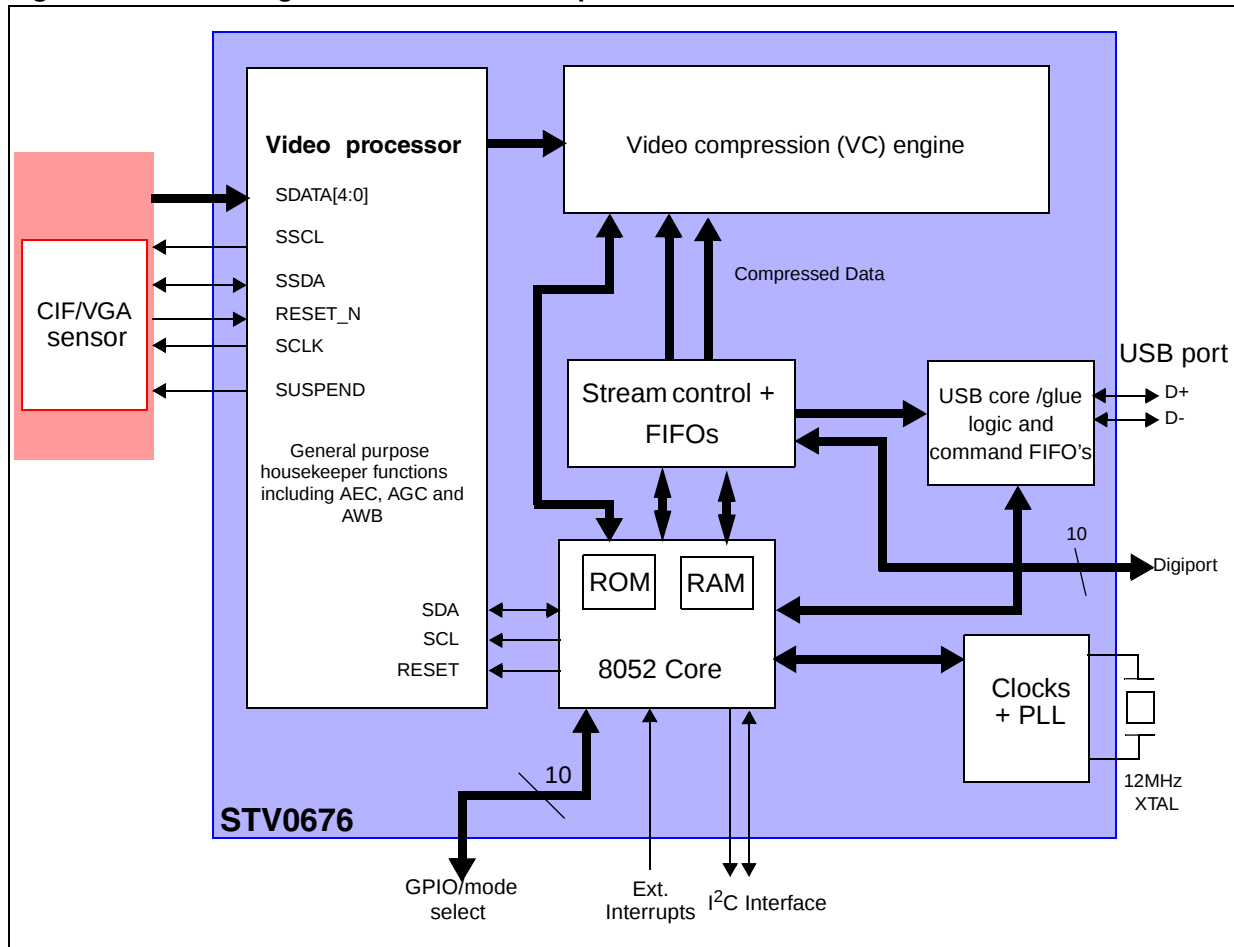
1.2 Video processor (VP)

1.2.1 Sensor interface

The VP interfaces directly to the image sensor. The sensor interface comprises:

- 5-wire data bus SDATA[4:0] for receiving both video data and embedded timing references,
- 2-wire serial control interface (SSDA, SSCL),
- sensor clock SCLK
- reset circuitry
- sensor suspend control

Figure 1. Block diagram of STV0676 video processor module



1.2.2 Video processor functions

STV0676 provides a master clock SCLK to the camera module. Each 10-bit pixel value generated by the sensor is transmitted across the 5 wire databus SDATA[4:0] as a pair of sequential 5-bit nibbles, most significant nibble first. Codes representing the start and end frames and the start and end of lines are embedded within the video data stream to allow the video processor to synchronise with the video data stream.

The video processing engine performs the following functions on incoming data:

- full colour restoration at each pixel site from Bayer-patterned input data,
- matrixing/gain on each colour channel for colour purity,
- peaking for image clarity,
- gamma correction,
- colour space conversion from raw RGB to YCbCr[4:2:2].

The 2-wire sensor serial interface (SSDA and SSCL) provides control of sensor configuration.

Note: The MSBit SDATA5 of the databus is unused in the current application but it will support future sensors where a 12bit ADC architecture may be used.

1.3 Auto exposure and gain control

The STV0676 automatically controls the sensor exposure, which is evaluated (and, where necessary modified) once per frame, where a frame consists of 2 video fields. The video fields are identical in length, that is, they do not contain any of the half line detail of the analogue video standards like CCIR or NTSC. Two fields per frame are required by the internal sensor video timing model. Integration time, sensor analogue gain and STV0676 digital gain are all used to control the overall exposure. The STV0676 exposure algorithm uses an asymptotic approach in calculating the change required in the present exposure value to approach the requested exposure target.

1.4 Defect correction

STV0676 automatically detects and corrects pixel defects without the need for any additional components or sensor calibration procedures. This greatly simplifies camera assembly and test when compared with previous EEPROM-based defect correction schemes. The pixel defect correction scheme ensures that the STV0676 + ST CMOS sensor appears as a 'defect free' chipset.

1.5 Video compression (VC) engine

The video compression engine performs 3 main functions:

- up scaling of input YCbCr 4:2:2 video stream from the VP (typically to scale from QVGA to CIF image formats),
- compression and encoding of YCbCr stream into Motion-JPEG (M-JPEG) format,
- USB bandwidth monitoring.

The data stream from the VP can be up to VGA size. The scaler in VC can downsize this image. Once scaled the video stream is then converted into M-JPEG format. M-JPEG simply treats video as a series of JPEG still images. The conversion is realised via a sequential DCT (discrete cosine transform) with Huffman encoding. After transfer over USB, the M-JPEG stream is decoded in the device driver running on the host.

The VC module is capable of compression ratios of up to 100:1 although this is scene-dependent. Image framerate produced by the STV0676 chipset is fixed and furthermore the available USB bandwidth is also fixed (within the software driver). The VC module varies the compression ratio to match the fluctuating input video data rates to the available USB bandwidth and required framerate.

The final stage of the VC block manages the data transfer from the local VC FIFO store to the USB core. STV0676 performs this management automatically by employing long-term (frame-level) and short-term (block-level) compression management.

1.6 Control processor

The embedded 8052 microprocessor core controls the data flow through the major sub blocks within STV0676 as well as the I²C communications to reconfigure the VP corresponding to requests from the device driver.

1.7 Power management

The chipset conforms to all power requirements specified by USB Version 1.1.

2 External interfaces

2.1 USB interface

The USB interface is designed to be compliant with version 1.1 of the USB specification. The STV0676 is a low power device and is therefore suitable for connection to any USB port on a PC, self-powered hub or when connected to a bus-powered hub.

The device complies with the device framework specified in Chapter 9 of the USB specification as follows:

- The device supports a single high power configuration (*Configuration 1*).
- Endpoint 0 is the default control endpoint and is always supported.
- Endpoint 0 supports all of the USB commands required by the device framework.
- Vendor specific commands on Endpoint 0 are used for all device control.
- Configuration 1 supports a single interface (interface 0).
- Interface 0 supports 8 alternate settings (alternates 0-7).
- The alternate settings support between 0 and 2 additional endpoints.
- Endpoint 1 is used for isochronous transfer of image data.
- Endpoint 3 is used for transferring status information, e.g. state of a hardware button.
- The endpoints are configured as follows (*Table 1*) in the alternate settings:

Table 1. Endpoint alternate settings

Alternate setting	Endpoint1 (isochronous)	Endpoint3 (interrupt)
0	Not present	Not present
1	Not present	8 bytes / packet; 1 packet / 8 frames
2	128 bytes / packet; 1 packet / frame	8 bytes / packet; 1 packet / 8 frames
3	384 bytes / packet; 1 packet / frame	8 bytes / packet; 1 packet / 8 frames
4	640 bytes / packet; 1 packet / frame	8 bytes / packet; 1 packet / 8 frames
5	768 bytes / packet; 1 packet / frame	8 bytes / packet; 1 packet / 8 frames
6	896 bytes / packet; 1 packet / frame	8 bytes / packet; 1 packet / 8 frames
7	1023 bytes / packet; 1 packet / frame	8 bytes / packet; 1 packet / 8 frames

The best and most consistent performance in terms of image quality is always obtained in the highest bandwidth setting (alternate 7). Under some circumstances it may not be possible for the host to allocate this amount of USB bandwidth to the device.

The isochronous settings reserve varying quantities of bandwidth - from 10% to 85% of USB bandwidth. The lower settings result in poor image quality due to heavy compression applied to maintain a high framerate streaming of image data, but at the same time leaving more bandwidth free for other USB devices. This is desirable if more than one camera is to be used, or if there are other isochronous peripherals connected. The device driver allows the user to specify the maximum bandwidth they wish to allocate to transfer data from the device. If the maximum specified by the user is not available, perhaps because another isochronous device has already reserved that bandwidth, then lower alternates are tried until one succeeds.

Benchmark testing of the STV0676 indicates that 30fps CIF video (compressed) can be accommodated in 50% of USB bandwidth.

2.2 Mode selection

All USB devices report a VID, PID and power consumption as part of a standard device descriptor. The VID and PID for STV0676 can be configured by the state of the digiport bits or by using an external EEPROM. The mode selection is made using the two MODESEL pins as described in [Table 2](#) below.

Table 2. Mode selection

MODESEL[1]	MODESEL[0]	Mode of operation
0	0	USB Mode. External EEPROM fitted, therefore PID, VID and power consumption read from this source. See Section 2.4
1	0	Slave I ² C mode.
0	1	USB mode. Default. No external EEPROM fitted, the PID VID and power consumption data determined by digiport[7:0]. See Section 2.3
1	1	Reserved

2.3 Selecting VID and PID via the digiport

Tables 4~7 demonstrate how the VID/PID information is defined via the digiport.

The current reference design for the STV0676-chipset has digiport[7:0] connected to VSS, thus the VID and PID are 16'h0553 and 16'h0140 respectively.

The digiport also controls the device current consumption that is reported to the host at device enumeration.

Table 3. Basic digiport configuration

Digiport bit slice	Function
[3:0]	configures the LS nibble of the PID
[5:4]	master VID/PID select
[7:6]	power setting

Table 4. Digiport LS nibble configuration

digiport[3:0]	PID LS nibble
4'b0000	4'b0000
4'b0001	4'b0001
4'b0010	4'b0010
4'b0011	4'b0011
4'b0100	4'b0100

Table 4. Digiport LS nibble configuration (continued)

digiport[3:0]	PID LS nibble
4'b0101	4'b0101
4'b0110	4'b0110
4'b0111	4'b0111
4'b1000	4'b1000
4'b1001	4'b1001
4'b1010	4'b1010
4'b1011	4'b1011
4'b1100	4'b1100
4'b1101	4'b1101
4'b1110	4'b1110
4'b1111	4'b1111

Table 5. Master VID/PID selection

digiport[5:4]	VID/PID reported
2'b00	16'h0553/16'h014x ⁽¹⁾
2'b01	16'h0553/16'h015x ⁽¹⁾
2'b10	16'h0553/16'h026x ⁽¹⁾
2'b11	16'h0553/16'h017x ⁽¹⁾

1. The 'x' ls nibble of the PID is defined by the value from [Table 4](#) above

Table 6. Device power consumption indicator

digiport[7:6]	current consumption reported
2'b00	98mA
2'b01	250mA
2'b10	350mA
2'b11	500mA

2.4 Serial EEPROM

STV0676 is designed to be used with a 128 or 256 byte serial I²C EEPROM. The EEPROM can be programmed with data to allow a user to fully customise the USB identity of STV0676. The configuration of this data is as follows.

2.5 EEPROM format and contents

Table 7. EEPROM format and contents

Location	Contents
0	fixed number, must be 0xED
1	fixed number, must be 0x15
2	reserved, must be 0x00
3	max device power (=mA/2, e.g. 400mA enter 0xC8)
4	VidLo, low byte of the vendor ID
5	VidHi, highbyte of the vendor ID
6	PidLo, low byte of the product ID
7	PidHi, highbyte of the product ID
8	manufacturer string offset, example below
9	product string offset, see below
10	interface 0 String offset
11	reserved, must be 0x00
12	reserved, must be 0x00
13	checksum

The remaining space is available for the string blocks indexed at locations 8, 9 and 10.

2.6 Strings

The strings referred to above (locations 8-10), are the USB string descriptors referenced from the device, configuration and interface descriptors. The value should be set to '0' if the string is not implemented or to the offset in bytes of the start of the string block in the EEPROM.

The first byte of each string block is the number of the characters in the string. Subsequent bytes are the actual string, which need not include a terminating null ([Table 8](#)).

Table 8. EEPROM device string example

Location	Contents
8	Manufacturer string offset = 16
16	String length = 5
17	String text = 'H' (in ascii)
18	String text = 'e' (in ascii)
19	String text = 'l' (in ascii)
20	String text = 'l' (in ascii)
21	String text = 'o' (in ascii)

2.7 CheckSum

The checksum is calculated by adding the byte value of EEPROM locations 0 to 12 inclusive, the low order byte of the result is stored in location 13.

2.8 I²C slave mode

STV0676 can be configured to behave as an I²C slave. This allows the device to be configured by host devices other than PCs. Details of the I²C messages supported and description of the I²C register bank are available from STMicroelectronics.

2.9 Digiport

The Digiport is a 10-bit bi-directional data port which can be used to transfer video data in or out of the device. This port can also be used to configure USB descriptor information at power up see ([Section 2.3](#)). Full details on the digiport operation and control are available from STMicroelectronics.

2.10 General purpose input and output

STV0676 provides up to 8 pins which can be used as general purpose I/O. These pins can be used to interface to led's, buzzers, switches etc.

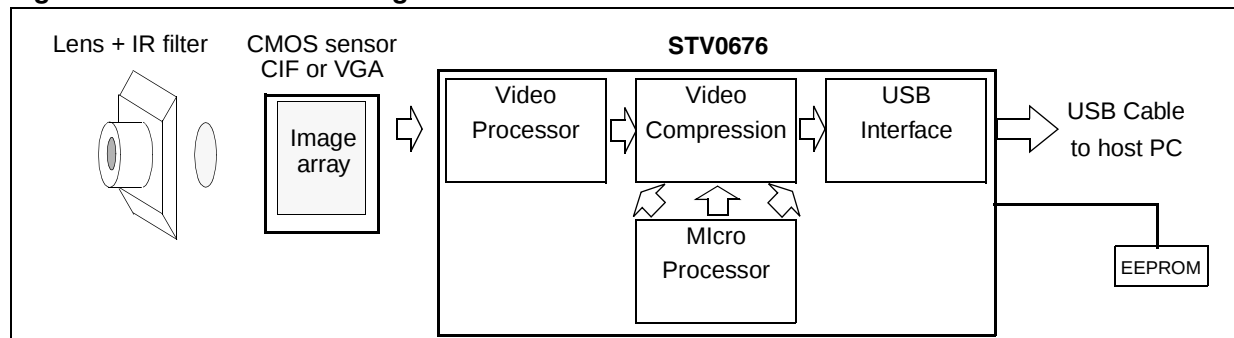
3 STV0676 application example

3.1 USB webcam

Figure 2 shows a block diagram of a basic webcam using the minimum of external components. The camera is controlled entirely through PC drivers over USB.

Note: If required a custom USB PID/VID can be configured by the use of an EEPROM, as detailed in [Section 2.3](#)

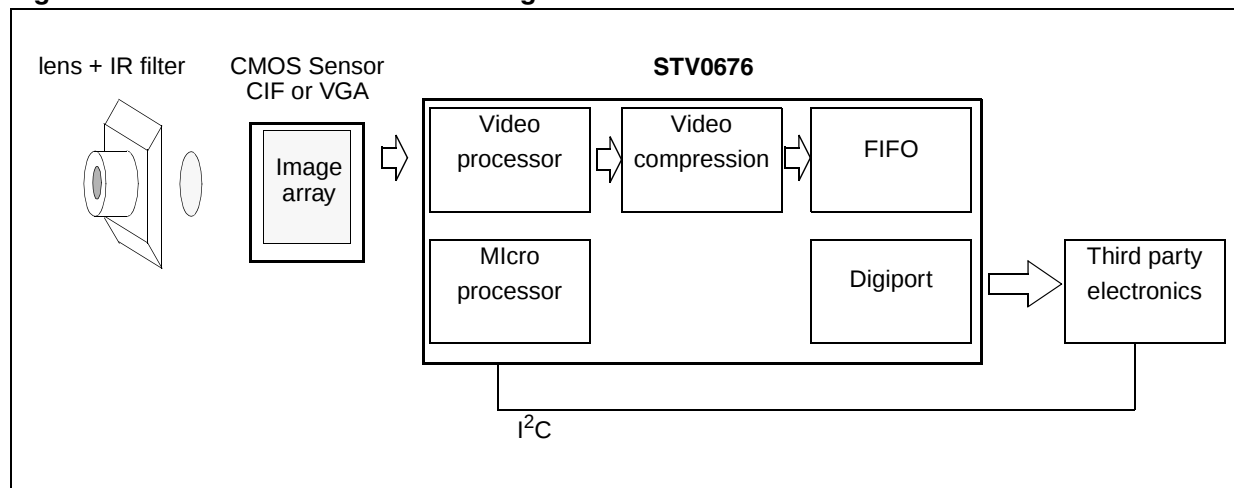
Figure 2. Webcam block diagram



3.2 Embedded camera

Figure 3 shows a block diagram of a camera intended for embedded applications, outputting JPEG, YCrCb or RGB preview over an 8bit bus, the third party electronics would control the STV0676 using I²C.

Figure 3. Embedded camera block diagram



4 Pinout and pin descriptions

4.1 STV0676 pin details

Figure 4. STV0676 pinout

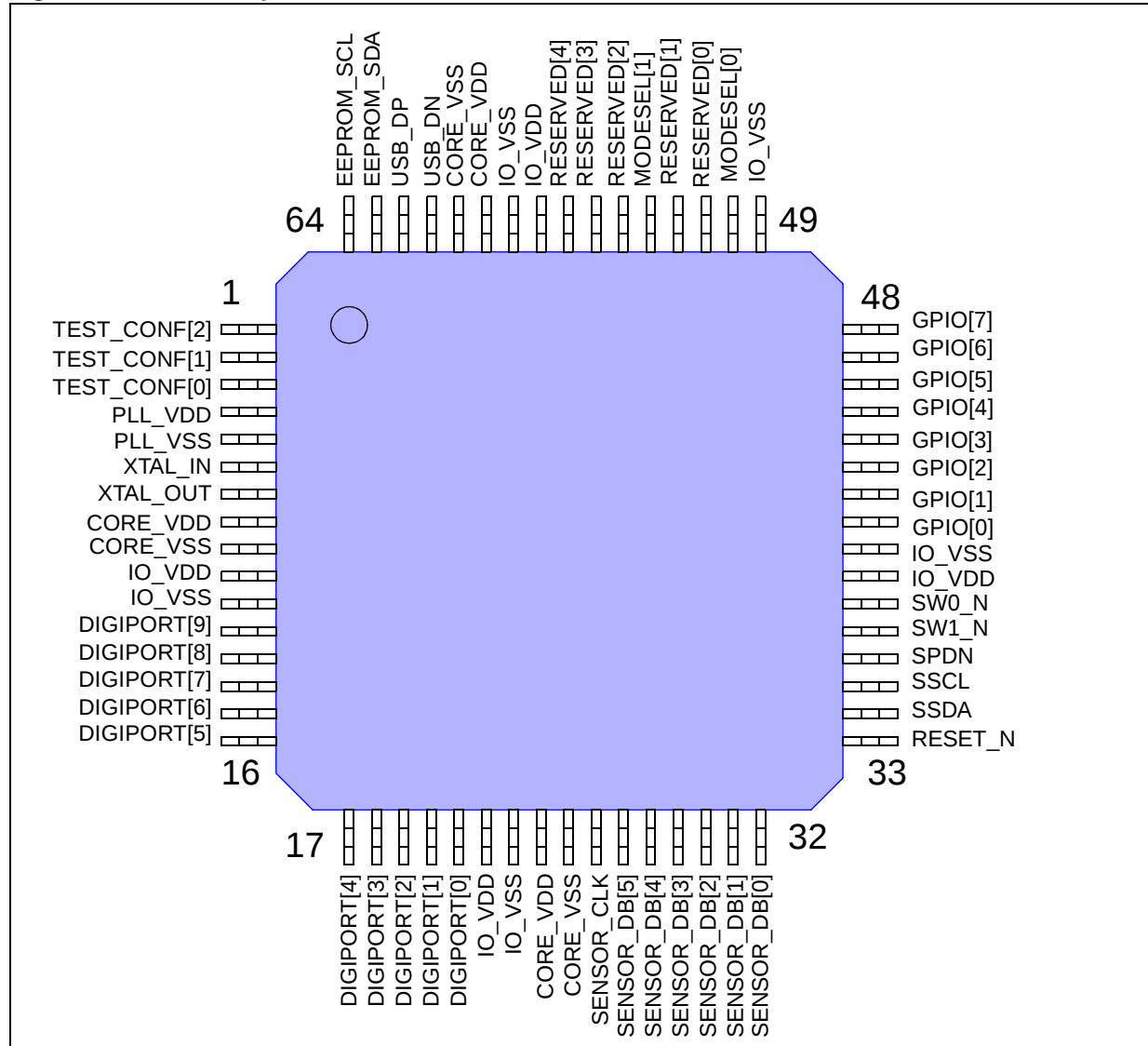


Table 9. STV0676 pin description

Pin	Signal	Type	Description
Power supplies			
4	PLL_VDD	INPUT	VDD for internal phase locked loop
5	PLL_VSS	INPUT	GND for internal phase locked loop
8	CORE_VDD	INPUT	VDD for core logic
9	CORE_VSS	INPUT	Ground for core logic
10	IO_VDD	INPUT	VDD for pad ring
11	IO_VSS	INPUT	Ground for pad ring
22	IO_VDD	INPUT	VDD for pad ring
23	IO_VSS	INPUT	Ground for pad ring
24	CORE_VDD	INPUT	VDD for core logic
25	CORE_VSS	INPUT	Ground for core logic
39	IO_VDD	INPUT	VDD for pad ring
40	IO_VSS	INPUT	Ground for pad ring
49	IO_VSS	INPUT	Ground for pad ring
57	IO_VDD	INPUT	VDD for pad ring
58	IO_VSS	INPUT	Ground for pad ring
59	CORE_VDD	INPUT	VDD for core logic
60	CORE_VSS	INPUT	Ground for core logic
Device master clock and reset			
6	XTAL_IN	ANA	System clock pad
7	XTAL_OUT	OSC	System clock pad
33	RESET_N	SCHMITT	System, power-on-reset supplied by companion sensor
Digiport/usb configuration interface			
12	DIGIPOINT[9]	BIDIR	Digiport operation
13	DIGIPOINT[8]	BIDIR	Digiport operation
14	DIGIPOINT[7]	BIDIR	Digiport operation /programmable USB current consumption reported
15	DIGIPOINT[6]	BIDIR	Digiport operation /programmable USB current consumption reported
16	DIGIPOINT[5]	BIDIR	Digiport operation /programmable USB VID/PID
17	DIGIPOINT[4]	BIDIR	Digiport operation /programmable USB VID/PID
18	DIGIPOINT[3]	BIDIR	Digiport operation /programmable USB PID
19	DIGIPOINT[2]	BIDIR	Digiport operation /programmable USB PID
20	DIGIPOINT[1]	BIDIR	Digiport operation /programmable USB PID
21	DIGIPOINT[0]	BIDIR	Digiport operation /programmable USB PID

Table 9. STV0676 pin description (continued)

Pin	Signal	Type	Description
Sensor interface			
26	SENSOR_CLK	BIDIR	Sensor clock
27	SENSOR_DB[5]	INPUT	Sensor data bus [bit5]
28	SENSOR_DB[4]	INPUT	Sensor data bus [bit4]
29	SENSOR_DB[3]	INPUT	Sensor data bus [bit3]
30	SENSOR_DB[2]	INPUT	Sensor data bus [bit2]
31	SENSOR_DB[1]	INPUT	Sensor data bus [bit1]
32	SENSOR_DB[0]	INPUT	Sensor data bus [bit0]
34	SSDA	3 state	Sensor serial interface data
35	SSCL	3 state	Sensor serial interface clock
36	SPDN	BIDIR	Control line to sensor to select ultra low power SUSPEND mode
Misc. control			
37	SW1_N	INPUT	Spare switch input
38	SW0_N	INPUT	Remote wakeup
GPIO interface/ other			
41	GPIO[0]	BIDIR	General purpose input/output (GPIO)
42	GPIO[1]	BIDIR	General purpose input/output (GPIO)
43	GPIO[2]	BIDIR	General purpose input/output (GPIO)
44	GPIO[3]	BIDIR	General purpose input/output (GPIO)
45	GPIO[4]	BIDIR	General purpose input/output (GPIO)
46	GPIO[5]	BIDIR	General purpose input/output (GPIO)
47	GPIO[6]	BIDIR	General purpose input/output (GPIO)
48	GPIO[7]	BIDIR	General purpose input/output (GPIO)
50	MODESEL[0]	BIDIR	Along with ModeSel[1] used to configure I ² C interface and PID/VID selection. Please see Table 2 for further details
51	RESERVED[0]	BIDIR	Not connect in reference design
52	RESERVED[1]	BIDIR	Connect to VDD in reference design
53	MODESEL[1]	BIDIR	Along with ModeSel[0] used to configure I ² C interface and PID/VID selection. Please see Table 2 for further details
54	RESERVED[2]	BIDIR	Connect to VDD in reference design
55	RESERVED[3]	BIDIR	Not connect in reference design
56	RESERVED[4]	BIDIR	Not connect in reference design

Table 9. STV0676 pin description (continued)

Pin	Signal	Type	Description
USB interface			
61	USB_DN	BIDIR	USB data line
62	USB_DP	BIDIR	USB data line
Test mode selection			
1	TEST_CONF[0]	INPUT	Test configuration bit - connect to VDD for normal operation
2	TEST_CONF[1]	INPUT	Test configuration bit - connect to VDD for normal operation
3	TEST_CONF[2]	INPUT	Test configuration bit - connect to VDD for normal operation
EEPROM interface⁽¹⁾			
63	EEPROM_SDA	BIDIR	Serial data to/from the EEPROM or slave I ² C clock
64	EEPROM_SCL	BIDIR	Serial clock to the EEPROM or slave I ² C clock

1. The I²C pins EEPROM_SCL and EEPROM_SDA can be reconfigured to act as a low speed I²C slave device that allows the user to directly control the internal register space of the VP and VC modules.

5 Detailed specifications

5.1 STV0676 absolute maximum ratings

Table 10. Absolute maximum ratings

Description	Range	Unit
Operating temperature	0 to 70	°C
Storage temperature	-50 to 150	°C

5.2 STV0676 AC/DC characteristics

Table 11. AC/DC characteristics

Parameter	Description	Min	Typ	Max	Units
VDD_CORE	Primary STV0676 power supply	1.55	1.8	1.95	V
VDD_IO	3.3V power supply for on-chip USB transceiver and IO	3.0	3.3	3.6	V
VDD_PLL	Analog supply to the PLL	1.60	1.8	2.0	V
I_core _{suspend}	Current consumption in suspend mode		3		μA
I_core _{standby}	Current consumption in standby mode		9.6		mA
I_core _{active}	Current consumption while active, VGA 30fps		52		mA
I_IO _{suspend}	Current consumption in suspend mode		40		μA
I_IO _{standby}	Current consumption in standby mode		540		μA
I_IO _{active}	Current consumption while active, VGA 30fps		6.6		mA
I_PLL _{suspend}	Current consumption in suspend mode		0.4		μA
I_PLL _{standby}	Current consumption in standby mode		476		μA
I_PLL _{active}	Current consumption while active, VGA 30fps		476		μA
V _{IL}	CMOS input low voltage (XTAL_IN)			0.687	V
V _{IH}	CMOS input high voltage (XTAL_IN)	1.19			V
V _{HYS}	Hysteresis (XTAL_IN)		0.51		V
V _{IL}	CMOS input low voltage			0.35V _D	V
V _{IH}	CMOS input high voltage	0.65V _D			V
V _{T+}	CMOS schmitt input low to high threshold voltage		2.15		V
V _{T-}	CMOS schmitt input high to low threshold voltage		1.05		V
V _T	Threshold point		1.65		V
V _{OH}	Output high voltage	2.4			V
V _{OL}	Output low voltage			0.4	V

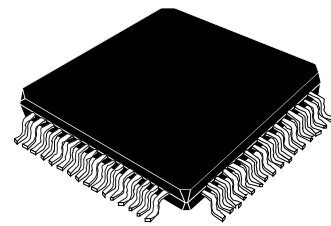
6 Package mechanical data

Dim.	mm			inch		
	Min	Typ	Max	Min	Typ	Max
A			1.60			0.063
A1	0.05		0.15	0.002		0.006
A2	1.35	1.40	1.45	0.053	0.055	0.057
B	0.18	0.23	0.28	0.007	0.009	0.011
C	0.12	0.16	0.20	0.0047	0.0063	0.0079
D		12.00			0.472	
D1		10.00			0.394	
D3		7.50			0.295	
e		0.50			0.0197	
E		12.00			0.472	
E3		7.50			0.295	
L	0.40	0.60	0.75	0.0157	0.0236	0.0295
L1		1.00			0.0393	
K	0°C (min.), 7°C (max.)					



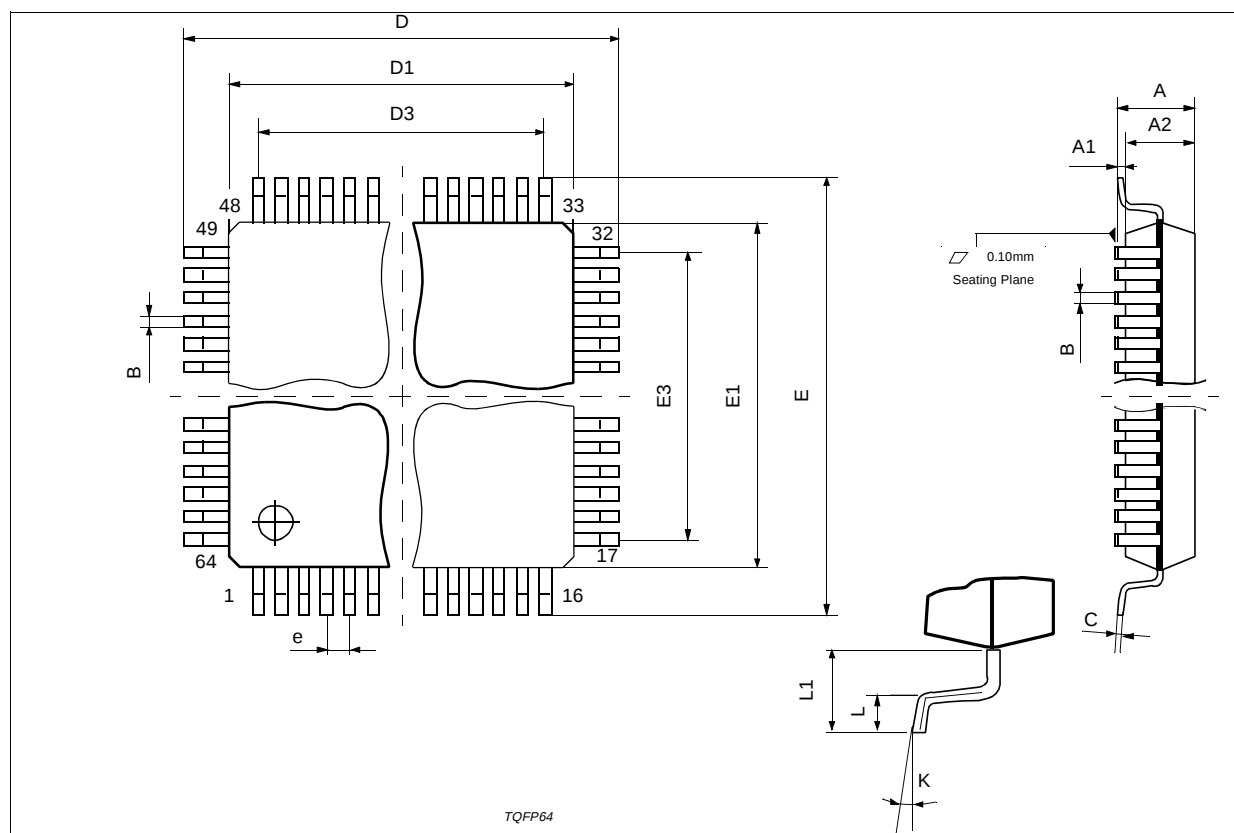
OUTLINE AND MECHANICAL DATA

Weight: 0.30 gr



Body: 10x10x1.40mm

TQFP64



7 **Reference design and evaluation kits**

STMicroelectronics supply a full range of supporting reference design kits for their range of sensors and coprocessors.

Please refer to the STMicroelectronics website for the up-to-date list of available reference designs and evaluation kits.

8 **Design issues**

There are no restrictions on the positioning of the STV0676 coprocessor with respect to the sensor.

An EEPROM is required for full USB 1.1 compliance, see reference design manual for details.

9 Revision history

Table 12. Document revision history

Date	Revision	Changes
13-Aug-2002	1	Initial release.
10-Apr-2006	2	Format update

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