

DATA SHEET



SAA8116HL Digital PC-camera signal processor, microcontroller and USB interface

Objective specification
File under Integrated Circuits, IC22

2000 Apr 13

Digital PC-camera signal processor, microcontroller and USB interface

SAA8116HL

FEATURES

- High precision digital processing with 10-bit input
- Embedded microcontroller (80C51 core based) for control loops Auto Optical Black (AOB), Auto White Balance (AWB), Auto Exposure (AE) and USB interface control
- Compliant for VGA CCD and VGA CMOS sensors (RGB Bayer)
- USB 1.1 compliant core
- RGB processing
- Optical black processing
- Defect pixel concealment
- Programmable colour matrix
- RGB to YUV transform
- Programmable gamma correction (including knee)
- Programmable edge enhancement
- Video formatter with SIF/QSIF downscaler
- Compression engine
- Flexible Measurement Engine (ME) with up to eight measurements per frame
- Internal Pulse Pattern Generator (PPG) for wide range of VGA CCDs (Sony, Sharp and Panasonic) and frame rate selection
- Programmable H and V timings for the support of CMOS sensors
- Programmable output pulse for switched mode power supply of the sensor
- 3-wire interface to control the TDA8787A: Correlated Double Sampling (CDS) circuit, Automatic Gain Control (AGC) circuit and 10-bit ADC
- Analog microphone/audio input to USB: Low DropOut (LDO) supply filter, microphone supply, low noise amplifier, programmable amplifier, PLL and ADC
- Integrated analog USB driver (ATX)
- Integrated main oscillator including a clock PLL to increase the crystal frequency (from 12 to 48 MHz)
- USB 1.1 compliant bus-powered USB device with integrated power management and POR circuit.



APPLICATIONS

- USB PC-camera (video and audio).

GENERAL DESCRIPTION

The SAA8116HL is a highly integrated third generation of USB PC-camera ICs. It is the successor of the SAA8112HL and SAA8115HL. It processes the digitized sensor data and converts it to a high quality, compressed YUV signal. Together with the audio signal, this video signal is then properly formatted in USB packets.

In addition, an 80C51 microcontroller derivative with five I/O ports, I²C-bus, 512 bytes of RAM and 32 kbytes of program memory is embedded in the SAA8116HL. The microcontroller is used in combination with the programmable statistical measurement capabilities to provide advanced AE, AWB and AOB. The microcontroller is also used to control the USB interface.

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QUICK REFERENCE DATA

Measured over full voltage and temperature range: $V_{DD} = 3.3 \text{ V} \pm 10\%$ and $T_{amb} = 0 \text{ to } 70 \text{ }^\circ\text{C}$; unless otherwise stated.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V_{DD}	supply voltage		3.0	3.3	3.6	V
$I_{DD(\text{tot})}$	total supply current	$V_{DD} = 3.6 \text{ V}; T_{amb} = 70 \text{ }^\circ\text{C}$	–	–	tbf	mA
V_i	input voltage	$3.0 \text{ V} < V_{DD} < 3.6 \text{ V}$	low voltage TTL compatible			V
V_o	output voltage	$3.0 \text{ V} < V_{DD} < 3.6 \text{ V}$	low voltage TTL compatible			V
$f_{(i)\text{xtal}}$	crystal input frequency		–	12	–	MHz
δ	crystal frequency duty factor		–	50	–	%
P_{tot}	total power dissipation	$V_{DD} = 3.3 \text{ V}; T_{amb} = 25 \text{ }^\circ\text{C}$	–	–	300	mW
T_{stg}	storage temperature		–55	–	+150	$^\circ\text{C}$
T_{amb}	ambient temperature		0	25	70	$^\circ\text{C}$
T_j	junction temperature	$T_{amb} = 70 \text{ }^\circ\text{C}$	–	–	125	$^\circ\text{C}$

ORDERING INFORMATION

TYPE NUMBER	PACKAGE		
	NAME	DESCRIPTION	VERSION
SAA8116HL	LQFP100	plastic low profile quad flat package; 100 leads; body $14 \times 14 \times 1.4 \text{ mm}$	SOT407-1

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BLOCK DIAGRAM

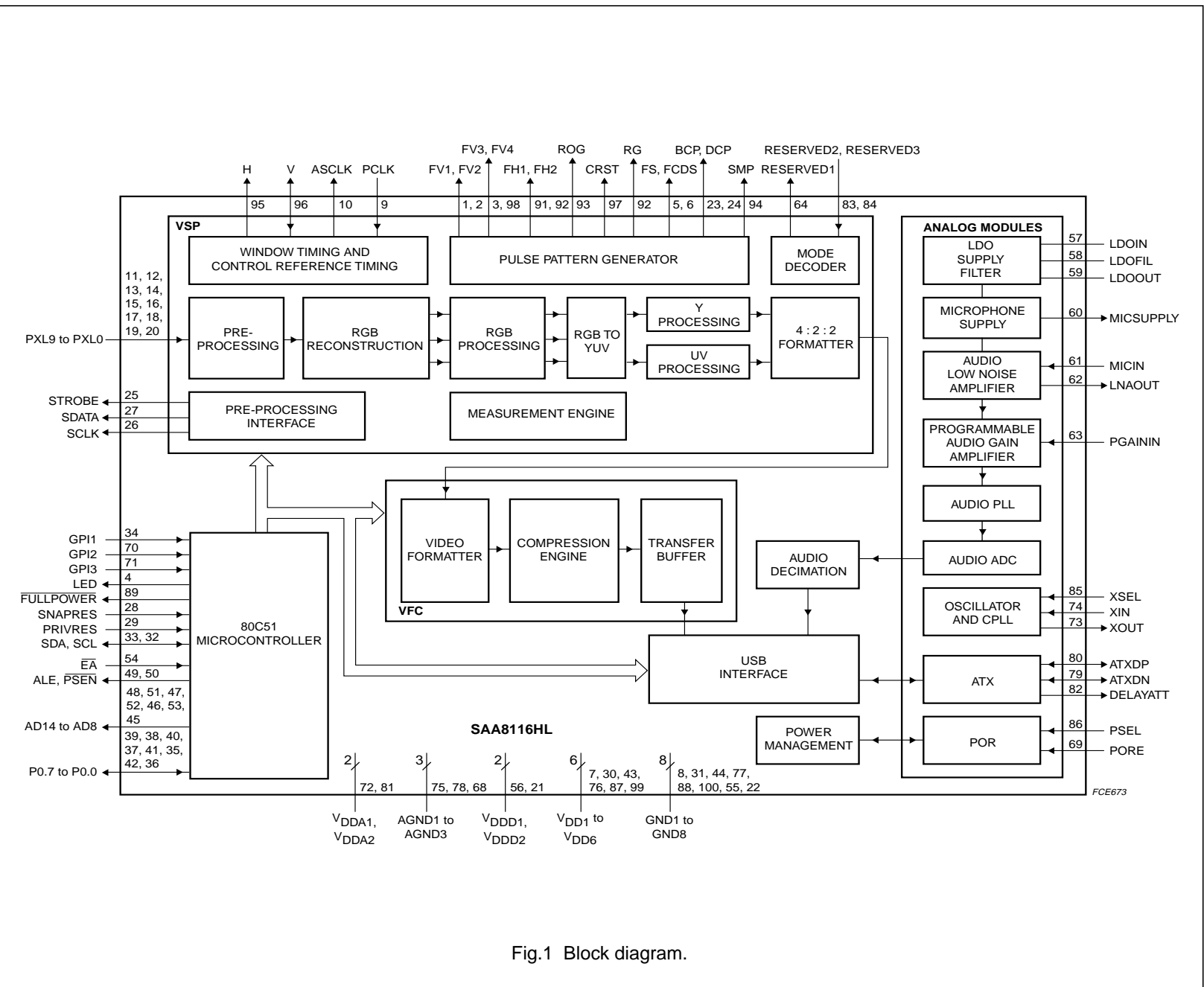


Fig.1 Block diagram.

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PINNING

PIN	SYMBOL	TYPE ⁽¹⁾	DESCRIPTION
1	FV1	O	vertical CCD transfer pulse output
2	FV2	O	vertical CCD transfer pulse output
3	FV3	O	vertical CCD transfer pulse output
4	LED	O	output to drive LED
5	FS	O	data sample-and-hold pulse output to TDA8787A (SHD)
6	FCDS	O	preset sample-and-hold pulse output to TDA8787A (SHP)
7	V _{DD1}	P	supply voltage 1 for output buffers
8	GND1	P	ground 1 for output buffers
9	PCLK	I	pixel input clock
10	ASCLK	O	clock1 (pixel clock) or clock2 (2 × pixel clock) output for ADC or CMOS sensor
11	PXL9	I	pixel data input; bit 9
12	PXL8	I	pixel data input; bit 8
13	PXL7	I	pixel data input; bit 7
14	PXL6	I	pixel data input; bit 6
15	PXL5	I	pixel data input; bit 5
16	PXL4	I	pixel data input; bit 4
17	PXL3	I	pixel data input; bit 3
18	PXL2	I	pixel data input; bit 2
19	PXL1	I	pixel data input; bit 1
20	PXL0	I	pixel data input; bit 0
21	V _{DD2}	P	supply voltage 2 for the digital core
22	GND8	P	ground 8 for input buffers and predrivers
23	BCP	O	optical black clamp pulse output to TDA8787A
24	DCP	O	dummy clamp pulse output to TDA8787A
25	STROBE	O	strobe signal output to TDA8787A or general purpose output of the microcontroller
26	SCLK	O	serial clock output to TDA8787A or general purpose output of the microcontroller
27	SDATA	O	serial data output to TDA8787A or general purpose output of the microcontroller
28	SNAPRES	I	snapshot input or remote wake-up trigger input (programmable)
29	PRIVRES	I	privacy shutter input or remote wake-up trigger input (programmable)
30	V _{DD2}	P	supply voltage 2 for input buffers and predrivers
31	GND2	P	ground 2 for input buffers and predrivers
32	SCL	I/O	I ² C-bus clock input/output (master/slave)
33	SDA	I/O	I ² C-bus data input/output (master/slave)
34	GPI1	I	general purpose input 1 (Port 4; bit 6)
35	P0.2	I/O	microcontroller Port 0 bidirectional (data - address); bit 2
36	P0.0	I/O	microcontroller Port 0 bidirectional (data - address); bit 0
37	P0.4	I/O	microcontroller Port 0 bidirectional (data - address); bit 4
38	P0.6	I/O	microcontroller Port 0 bidirectional (data - address); bit 6
39	P0.7	I/O	microcontroller Port 0 bidirectional (data - address); bit 7

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PIN	SYMBOL	TYPE ⁽¹⁾	DESCRIPTION
40	P0.5	I/O	microcontroller Port 0 bidirectional (data - address); bit 5
41	P0.3	I/O	microcontroller Port 0 bidirectional (data - address); bit 3
42	P0.1	I/O	microcontroller Port 0 bidirectional (data - address); bit 1
43	V _{DD3}	P	supply voltage 3 for output buffers
44	GND3	P	ground 3 for output buffers
45	AD8	O	microcontroller Port 2 output (address); bit 0
46	AD10	O	microcontroller Port 2 output (address); bit 2
47	AD12	O	microcontroller Port 2 output (address); bit 4
48	AD14	O	microcontroller Port 2 output (address); bit 6
49	ALE	O	address latch enable output for external latch
50	$\overline{\text{PSEN}}$	O	program store enable output for external memory (active LOW)
51	AD13	O	microcontroller Port 2 output (address); bit 5
52	AD11	O	microcontroller Port 2 output (address); bit 3
53	AD9	O	microcontroller Port 2 output (address); bit 1
54	$\overline{\text{EA}}$	I	external access select input - internal or external program memory (active LOW)
55	GND7	P	ground 7 for input buffers and predrivers
56	V _{DD1}	P	supply voltage 1 for the digital core
57	LDOIN	P	analog supply voltage for LDO supply filter
58	LDOFIL	–	external capacitor connection (filter of LDO)
59	LDOOUT	–	external capacitor connection (internal analog supply voltage for PLL, amplifier and ADC)
60	MICSUPPLY	O	microphone supply output
61	MICIN	I	microphone input
62	LNAOUT	O	low noise amplifier output
63	PGAININ	I	programmable gain amplifier input
64	RESERVED1	O	test pin 1 (should not be used)
65	REF1	I	reference voltage 1 (used in the amplifier and the ADC)
66	REF2	I	reference voltage 2 (used in the ADC)
67	REF3	I	reference voltage 3 (used in the ADC)
68	AGND3	P	analog ground 3 for PLL, amplifier and ADC
69	PORE	I	external Power-on reset (backup)
70	GPI2	I	general purpose input 2 (Port 1; bit 4)
71	GPI3	I	general purpose input 3 (Port 3; bit 5)
72	V _{DDA1}	P	analog supply voltage 1 for crystal oscillator (12 MHz, fundamental)
73	XOUT	O	oscillator output
74	XIN	I	oscillator input
75	AGND1	P	analog ground 1 for crystal oscillator
76	V _{DD4}	P	supply voltage 4 for input buffers and predrivers
77	GND4	P	ground 4 for input buffers and predrivers
78	AGND2	P	analog ground 2 for ATX transceiver
79	ATXDN	I/O	negative driver of the differential data pair input/output (ATX)

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PIN	SYMBOL	TYPE ⁽¹⁾	DESCRIPTION
80	ATXDP	I/O	positive driver of the differential data pair input/output (ATX)
81	V _{DDA2}	P	analog supply voltage 2 for ATX transceiver
82	DELAYATT	O	delay attached control output; connected with pull-up resistor on ATXDP (USB)
83	RESERVED2	I	test pin 2 (should not be used)
84	RESERVED3	I	test pin 3 (should not be used)
85	XSEL	I	crystal selection input (backup)
86	PSEL	I	POR selection input (backup)
87	V _{DD5}	P	supply voltage 5 for output buffers
88	GND5	P	ground 5 for output buffers
89	FULLPOWER	O	full power signal output (active LOW)
90	FH2	O	horizontal CCD transfer pulse output
91	FH1	O	horizontal CCD transfer pulse output
92	RG	O	reset output for CCD output amplifier gate
93	ROG	O	vertical CCD load pulse output
94	SMP	O	switch mode pulse output for CCD supply
95	H	O	horizontal synchronization pulse output
96	V	I/O	vertical synchronization pulse input/output
97	CRST	O	CCD charge reset output for shutter control
98	FV4	O	vertical CCD transfer pulse output
99	V _{DD6}	P	supply voltage 6 for output buffers
100	GND6	P	ground 6 for output buffers

Note

1. I = input, O = output and P = power supply.

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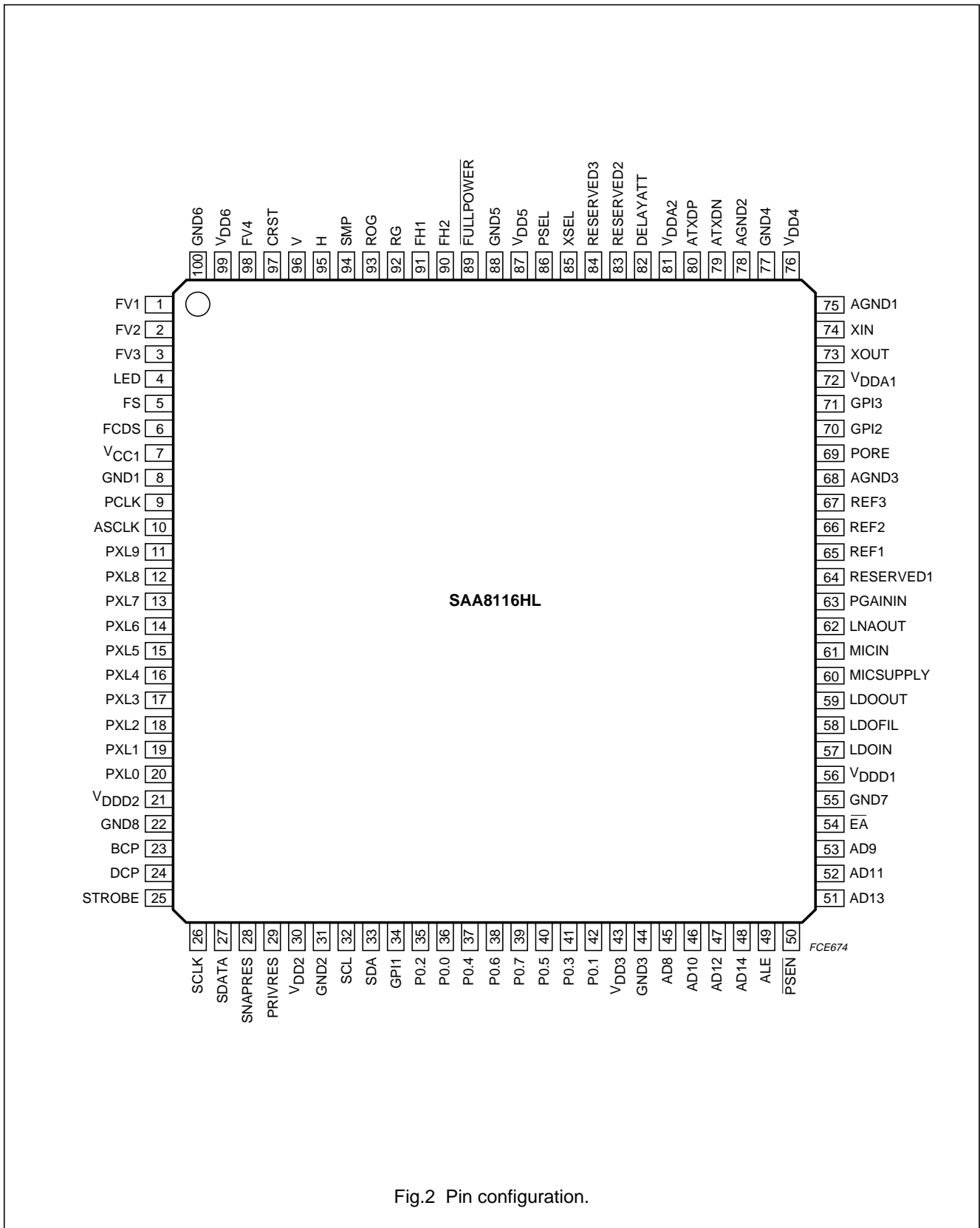


Fig.2 Pin configuration.

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LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 60134); note 1.

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
V_{DD}	supply voltage	-0.5	+4.0	V
V_n	voltage on pins GND and AGND all other pins	-0.5 -0.5	+4.0 $V_{DD} + 0.5$	V V
T_{stg}	storage temperature	-55	+150	°C
T_{amb}	ambient temperature	0	70	°C
T_j	junction temperature	-40	+125	°C

Note

1. Stress beyond these levels may cause permanent damage to the device.

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	VALUE	UNIT
$R_{th(j-a)}$	thermal resistance from junction to ambient	in free air	53	K/W

CHARACTERISTICS

$V_{DD} = V_{DDD} = V_{DDA} = 3.3 \text{ V} \pm 10\%$; $T_{amb} = 0$ to 70 °C ; unless otherwise stated.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Supplies						
V_{DD}	supply voltage		3.0	3.3	3.6	V
V_{DDD}	supply voltage for digital core		3.0	3.3	3.6	V
V_{DDA}	analog supply voltage		3.0	3.3	3.6	V
$I_{DDD(tot)}$	total digital supply current	$V_{DD} = V_{DDD} = 3.3 \text{ V}$; $T_{amb} = 25 \text{ °C}$	–	–	75	mA
$I_{DDA(tot)}$	total analog supply current	$V_{DDA} = 3.3 \text{ V}$; $T_{amb} = 25 \text{ °C}$	–	–	16	mA
Digital data and control inputs						
V_{IL}	LOW-level input voltage		–	–	0.8	V
V_{IH}	HIGH-level input voltage		2	–	–	V
Digital data and control outputs						
V_{OL}	LOW-level output voltage		0	–	$0.1V_{DD}$	V
V_{OH}	HIGH-level output voltage		$0.9V_{DD}$	–	V_{DD}	V
LDO supply filter						
V_{ref}	reference voltage	at $0.5V_{DDA}$	–	1.50	–	V
V_O	output voltage on pin LDOOUT	$V_{DDA} = 3.0 \text{ V}$	–	3.0	–	V
I_O	output current on pin LDOOUT		–	5	10	mA

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SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Microphone supply						
I_{DDA}	supply current		–	0.85	1.2	mA
V_{ref}	reference voltage	at $0.5V_{DDA}$	–	1.50	–	V
V_O	output voltage on pin MICSUPPLY	$V_{DDA} = 3.0\text{ V}$	–	2.7	–	V
I_O	output current on pin MICSUPPLY		–	–	2.0	mA
Audio low noise amplifier						
TRANSFER FUNCTION						
R_i	input resistance		3.5	5.0	–	k Ω
I_{DDA}	supply current		–	0.85	1.2	mA
A	amplification		28	30	32	dB
THD	total harmonic distortion	note 1	–	–70	–60	dB
$V_{o(rms)}$	output voltage (RMS value)		–	–	800	mV
V_{OO}	output offset voltage		–	0.0	1.0	mV
BIASING						
I_{ref}	reference current		–	10	–	μ A
Programmable audio gain amplifier						
TRANSFER FUNCTION						
R_i	input resistance		7.0	10.5	25	k Ω
I_{DDA}	supply current		–	0.45	0.6	mA
V_{OO}	output offset voltage	A = 0 dB	–	1.0	2.0	mV
		A = 30 dB	–	14	30	mV
A	amplification		0.0	–	30	dB
THD	total harmonic distortion	A = 0 dB; note 1	–	–83	–78	dB
		A = 30 dB; note 1	–	–59	–54	dB
BIASING						
I_{ref}	reference current		–	10	–	μ A
Audio phase-locked loop						
$f_{i(clk)}$	clock input frequency		–	48	–	MHz
$f_{o(clk)}$	clock output frequency	note 2	–	8.19200	–	MHz
			–	11.2996	–	MHz
			–	12.2880	–	MHz
B	bandwidth		–	2.3	–	kHz
ζ	damping		–	0.98	–	
Audio ADC ($\Sigma\Delta$ converter)						
INPUTS						
f_i	input signal frequency		1	–	20	kHz
$V_{i(rms)}$	input voltage (RMS value)		–	800	–	mV

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SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
TRANSFER FUNCTION						
N	order of the $\Sigma\Delta$		–	3	–	
N _{bit}	number of output bits		–	1	–	
N _{bit(eq)}	equivalent output resolution (bit)		–	16	–	
DR _i	dynamic range at input	note 3	–	96.6	–	dB
f _{clk}	clock frequency		–	–	5.6448	MHz
δ	clock frequency duty factor		–	50	–	%
THD	total harmonic distortion		–	–70	–55	dB
ATX transceiver full speed mode: pins ATXDP and ATXDN						
DRIVER CHARACTERISTICS						
t _{t(rise)}	rise transition time	C _L = 50 pF	4	–	20	ns
t _{t(fall)}	fall transition time	C _L = 50 pF	4	–	20	ns
t _{t(match)}	transition time matching	note 4	90	–	110	%
V _{cr}	output signal crossover voltage		1.3	–	2.0	V
Z _o	driver output impedance	steady state drive	30	–	42	Ω
RECEIVER CHARACTERISTICS						
f _{i(D)}	data input frequency rate		–	12.00	–	Mbits/s
t _{frame}	frame interval		–	1.000	–	ms

Notes

1. The distortion is measured at HIGH level, 1 kHz and V_o = 800 mV (RMS).
2. Frequencies depend on PLL settings.
3. Defined here as: $20 \times \log \frac{\text{input voltage}}{\text{equivalent input noise voltage}}$
4. Transition time matching: $t_{t(\text{match})} = \frac{t_{t(\text{rise})}}{t_{t(\text{fall})}} \times 100\%$

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APPLICATION INFORMATION

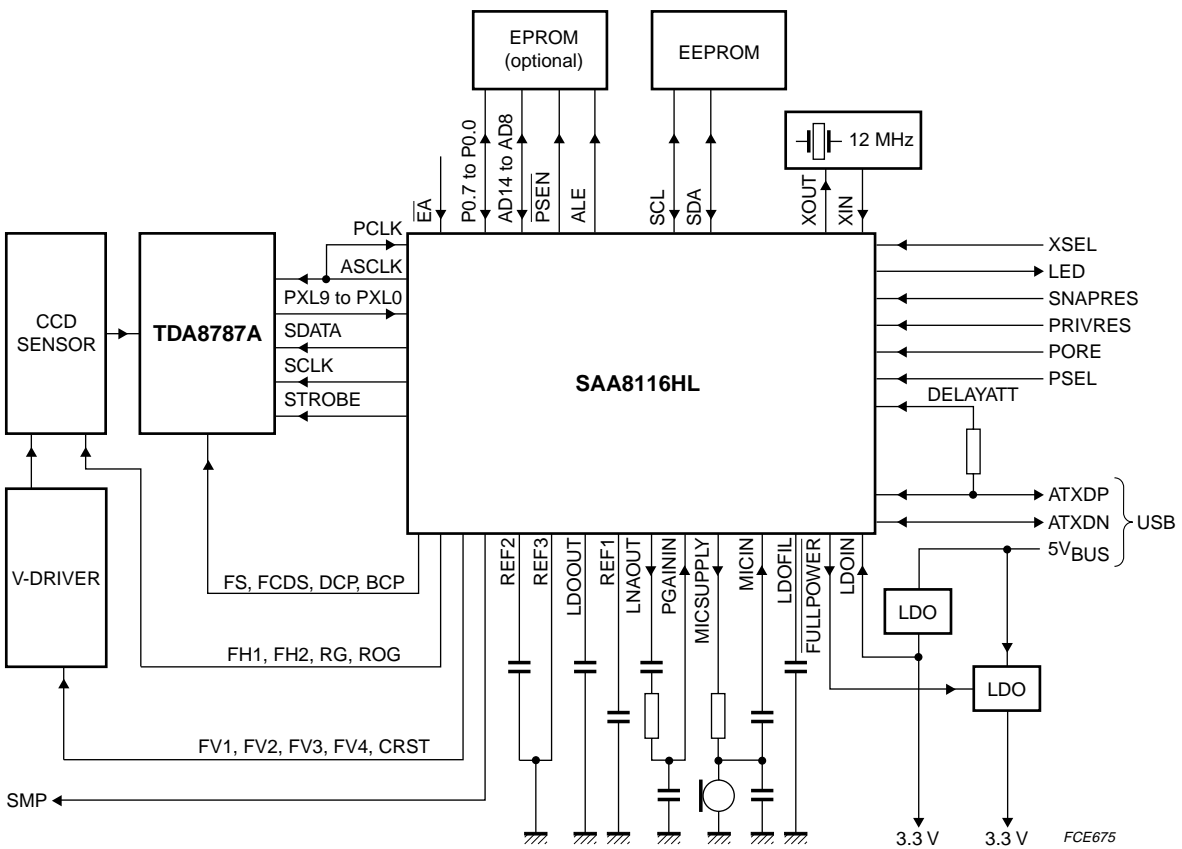


Fig.3 CCD sensor application.

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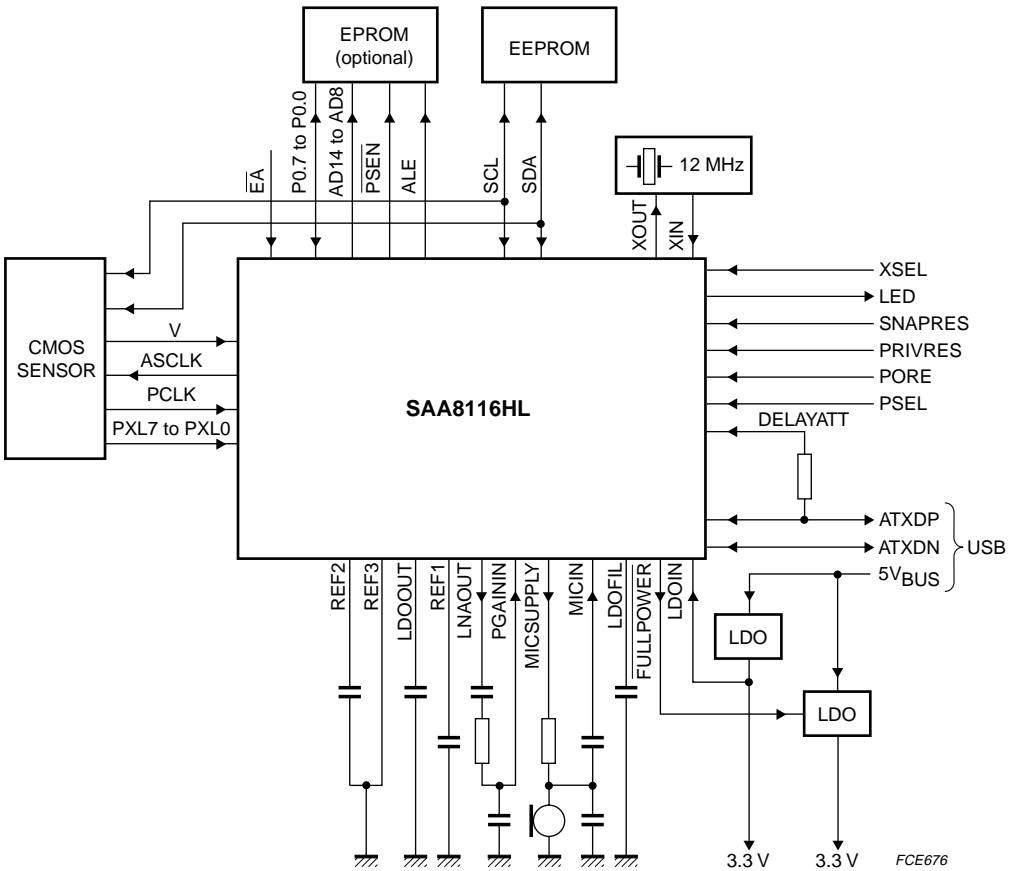


Fig.4 CMOS sensor application.

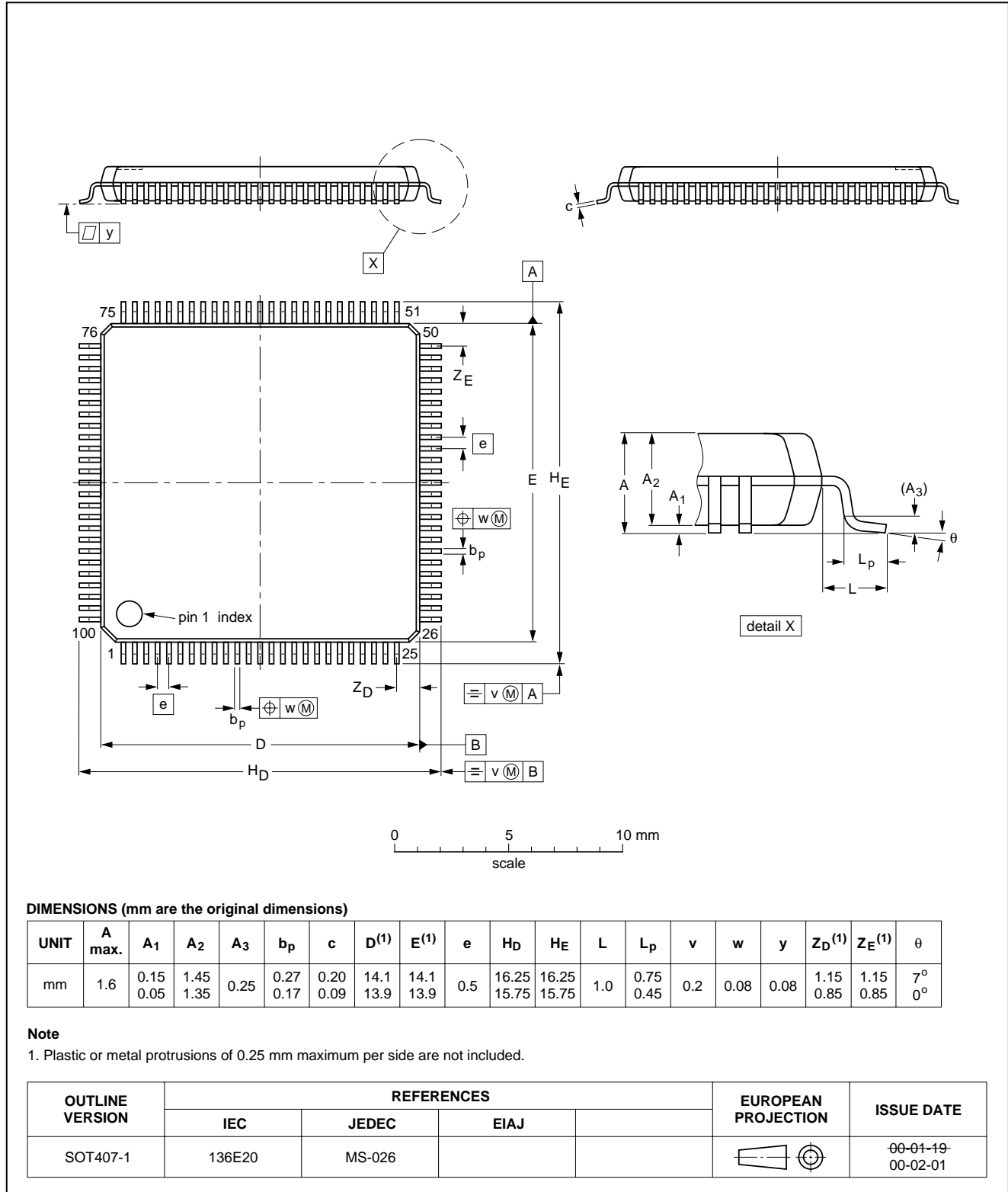
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PACKAGE OUTLINE

LQFP100: plastic low profile quad flat package; 100 leads; body 14 x 14 x 1.4 mm

SOT407-1



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SOLDERING

Introduction to soldering surface mount packages

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our *"Data Handbook IC26; Integrated Circuit Packages"* (document order number 9398 652 90011).

There is no soldering method that is ideal for all surface mount IC packages. Wave soldering is not always suitable for surface mount ICs, or for printed-circuit boards with high population densities. In these situations reflow soldering is often used.

Reflow soldering

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement.

Several methods exist for reflowing; for example, infrared/convection heating in a conveyor type oven. Throughput times (preheating, soldering and cooling) vary between 100 and 200 seconds depending on heating method.

Typical reflow peak temperatures range from 215 to 250 °C. The top-surface temperature of the packages should preferably be kept below 230 °C.

Wave soldering

Conventional single wave soldering is not recommended for surface mount devices (SMDs) or printed-circuit boards with a high component density, as solder bridging and non-wetting can present major problems.

To overcome these problems the double-wave soldering method was specifically developed.

If wave soldering is used the following conditions must be observed for optimal results:

- Use a double-wave soldering method comprising a turbulent wave with high upward pressure followed by a smooth laminar wave.
- For packages with leads on two sides and a pitch (e):
 - larger than or equal to 1.27 mm, the footprint longitudinal axis is **preferred** to be parallel to the transport direction of the printed-circuit board;
 - smaller than 1.27 mm, the footprint longitudinal axis **must** be parallel to the transport direction of the printed-circuit board.

The footprint must incorporate solder thieves at the downstream end.

- For packages with leads on four sides, the footprint must be placed at a 45° angle to the transport direction of the printed-circuit board. The footprint must incorporate solder thieves downstream and at the side corners.

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Typical dwell time is 4 seconds at 250 °C.

A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

Manual soldering

Fix the component by first soldering two diagonally-opposite end leads. Use a low voltage (24 V or less) soldering iron applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C.

When using a dedicated tool, all other leads can be soldered in one operation within 2 to 5 seconds between 270 and 320 °C.

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SAA8116HL**Suitability of surface mount IC packages for wave and reflow soldering methods**

PACKAGE	SOLDERING METHOD	
	WAVE	REFLOW ⁽¹⁾
BGA, SQFP	not suitable	suitable
HLQFP, HSQFP, HSOP, HTSSOP, SMS	not suitable ⁽²⁾	suitable
PLCC ⁽³⁾ , SO, SOJ	suitable	suitable
LQFP, QFP, TQFP	not recommended ⁽³⁾⁽⁴⁾	suitable
SSOP, TSSOP, VSO	not recommended ⁽⁵⁾	suitable

Notes

1. All surface mount (SMD) packages are moisture sensitive. Depending upon the moisture content, the maximum temperature (with respect to time) and body size of the package, there is a risk that internal or external package cracks may occur due to vaporization of the moisture in them (the so called popcorn effect). For details, refer to the Drypack information in the *"Data Handbook IC26; Integrated Circuit Packages; Section: Packing Methods"*.
2. These packages are not suitable for wave soldering as a solder joint between the printed-circuit board and heatsink (at bottom version) can not be achieved, and as solder may stick to the heatsink (on top version).
3. If wave soldering is considered, then the package must be placed at a 45° angle to the solder wave direction. The package footprint must incorporate solder thieves downstream and at the side corners.
4. Wave soldering is only suitable for LQFP, TQFP and QFP packages with a pitch (e) equal to or larger than 0.8 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.65 mm.
5. Wave soldering is only suitable for SSOP and TSSOP packages with a pitch (e) equal to or larger than 0.65 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.5 mm.

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DEFINITIONS

Data sheet status	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
Limiting values	
Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 60134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.	
Application information	
Where application information is given, it is advisory and does not form part of the specification.	

LIFE SUPPORT APPLICATIONS

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Philips customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Philips for any damages resulting from such improper use or sale.

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Purchase of Philips I²C components conveys a license under the Philips' I²C patent to use the components in the I²C system provided the system conforms to the I²C specification defined by Philips. This specification can be ordered using the code 9398 393 40011.

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NOTES

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NOTES

Philips Semiconductors – a worldwide company

Argentina: see South America

Australia: 3 Figtree Drive, HOMEBUSH, NSW 2140,
Tel. +61 2 9704 8141, Fax. +61 2 9704 8139

Austria: Computerstr. 6, A-1101 WIEN, P.O. Box 213,
Tel. +43 1 60 101 1248, Fax. +43 1 60 101 1210

Belarus: Hotel Minsk Business Center, Bld. 3, r. 1211, Volodarski Str. 6,
220050 MINSK, Tel. +375 172 20 0733, Fax. +375 172 20 0773

Belgium: see The Netherlands

Brazil: see South America

Bulgaria: Philips Bulgaria Ltd., Energoproject, 15th floor,
51 James Bourchier Blvd., 1407 SOFIA,
Tel. +359 2 68 9211, Fax. +359 2 68 9102

Canada: PHILIPS SEMICONDUCTORS/COMPONENTS,
Tel. +1 800 234 7381, Fax. +1 800 943 0087

China/Hong Kong: 501 Hong Kong Industrial Technology Centre,
72 Tat Chee Avenue, Kowloon Tong, HONG KONG,
Tel. +852 2319 7888, Fax. +852 2319 7700

Colombia: see South America

Czech Republic: see Austria

Denmark: Sydhavnsgade 23, 1780 COPENHAGEN V,
Tel. +45 33 29 3333, Fax. +45 33 29 3905

Finland: Sinikalliontie 3, FIN-02630 ESPOO,
Tel. +358 9 615 800, Fax. +358 9 6158 0920

France: 51 Rue Carnot, BP317, 92156 SURESNES Cedex,
Tel. +33 1 4099 6161, Fax. +33 1 4099 6427

Germany: Hammerbrookstraße 69, D-20097 HAMBURG,
Tel. +49 40 2353 60, Fax. +49 40 2353 6300

Hungary: see Austria

India: Philips INDIA Ltd, Band Box Building, 2nd floor,
254-D, Dr. Annie Besant Road, Worli, MUMBAI 400 025,
Tel. +91 22 493 8541, Fax. +91 22 493 0966

Indonesia: PT Philips Development Corporation, Semiconductors Division,
Gedung Philips, Jl. Buncit Raya Kav.99-100, JAKARTA 12510,
Tel. +62 21 794 0040 ext. 2501, Fax. +62 21 794 0080

Ireland: Newstead, Clonskeagh, DUBLIN 14,
Tel. +353 1 7640 000, Fax. +353 1 7640 200

Israel: RAPAC Electronics, 7 Kehilat Saloniki St, PO Box 18053,
TEL AVIV 61180, Tel. +972 3 645 0444, Fax. +972 3 649 1007

Italy: PHILIPS SEMICONDUCTORS, Via Casati, 23 - 20052 MONZA (MI),
Tel. +39 039 203 6838, Fax +39 039 203 6800

Japan: Philips Bldg 13-37, Kohnan 2-chome, Minato-ku,
TOKYO 108-8507, Tel. +81 3 3740 5130, Fax. +81 3 3740 5057

Korea: Philips House, 260-199 Itaewon-dong, Yongsan-ku, SEOUL,
Tel. +82 2 709 1412, Fax. +82 2 709 1415

Malaysia: No. 76 Jalan Universiti, 46200 PETALING JAYA, SELANGOR,
Tel. +60 3 750 5214, Fax. +60 3 757 4880

Mexico: 5900 Gateway East, Suite 200, EL PASO, TEXAS 79905,
Tel. +9-5 800 234 7381, Fax +9-5 800 943 0087

Middle East: see Italy

Netherlands: Postbus 90050, 5600 PB EINDHOVEN, Bldg. VB,
Tel. +31 40 27 82785, Fax. +31 40 27 88399

New Zealand: 2 Wagener Place, C.P.O. Box 1041, AUCKLAND,
Tel. +64 9 849 4160, Fax. +64 9 849 7811

Norway: Box 1, Manglerud 0612, OSLO,
Tel. +47 22 74 8000, Fax. +47 22 74 8341

Pakistan: see Singapore

Philippines: Philips Semiconductors Philippines Inc.,
106 Valero St. Salcedo Village, P.O. Box 2108 MCC, MAKATI,
Metro MANILA, Tel. +63 2 816 6380, Fax. +63 2 817 3474

Poland: Al.Jerozolimskie 195 B, 02-222 WARSAW,
Tel. +48 22 5710 000, Fax. +48 22 5710 001

Portugal: see Spain

Romania: see Italy

Russia: Philips Russia, Ul. Usatcheva 35A, 119048 MOSCOW,
Tel. +7 095 755 6918, Fax. +7 095 755 6919

Singapore: Lorong 1, Toa Payoh, SINGAPORE 319762,
Tel. +65 350 2538, Fax. +65 251 6500

Slovakia: see Austria

Slovenia: see Italy

South Africa: S.A. PHILIPS Pty Ltd., 195-215 Main Road Martindale,
2092 JOHANNESBURG, P.O. Box 58088 Newville 2114,
Tel. +27 11 471 5401, Fax. +27 11 471 5398

South America: Al. Vicente Pinzon, 173, 6th floor,
04547-130 SÃO PAULO, SP, Brazil,
Tel. +55 11 821 2333, Fax. +55 11 821 2382

Spain: Balmes 22, 08007 BARCELONA,
Tel. +34 93 301 6312, Fax. +34 93 301 4107

Sweden: Kottbygatan 7, Akalla, S-16485 STOCKHOLM,
Tel. +46 8 5985 2000, Fax. +46 8 5985 2745

Switzerland: Allmendstrasse 140, CH-8027 ZÜRICH,
Tel. +41 1 488 2741 Fax. +41 1 488 3263

Taiwan: Philips Semiconductors, 6F, No. 96, Chien Kuo N. Rd., Sec. 1,
TAIPEI, Taiwan Tel. +886 2 2134 2886, Fax. +886 2 2134 2874

Thailand: PHILIPS ELECTRONICS (THAILAND) Ltd.,
209/2 Sanpavuth-Bangna Road Prakanong, BANGKOK 10260,
Tel. +66 2 745 4090, Fax. +66 2 398 0793

Turkey: Yukari Dudullu, Org. San. Blg., 2.Cad. Nr. 28 81260 Umraniye,
ISTANBUL, Tel. +90 216 522 1500, Fax. +90 216 522 1813

Ukraine: PHILIPS UKRAINE, 4 Patrice Lumumba str., Building B, Floor 7,
252042 KIEV, Tel. +380 44 264 2776, Fax. +380 44 268 0461

United Kingdom: Philips Semiconductors Ltd., 276 Bath Road, Hayes,
MIDDLESEX UB3 5BX, Tel. +44 208 730 5000, Fax. +44 208 754 8421

United States: 811 East Arques Avenue, SUNNYVALE, CA 94088-3409,
Tel. +1 800 234 7381, Fax. +1 800 943 0087

Uruguay: see South America

Vietnam: see Singapore

Yugoslavia: PHILIPS, Trg N. Pasica 5/v, 11000 BEOGRAD,
Tel. +381 11 3341 299, Fax.+381 11 3342 553

For all other countries apply to: Philips Semiconductors,
International Marketing & Sales Communications, Building BE-p, P.O. Box 218,
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Internet: <http://www.semiconductors.philips.com>

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