

# DATA SHEET

## **TDA8784**

**18 Msps, 10-bit analog-to-digital  
interface for CCD cameras**

Product specification  
Supersedes data of 1998 Aug 05  
File under Integrated Circuits, IC02

1999 Sep 21

# 18 Msps, 10-bit analog-to-digital interface for CCD cameras

## TDA8784

### FEATURES

- Correlated Double Sampling (CDS), AGC, 10-bit ADC and reference regulator included, adjustable bandwidth (CDS and AGC)
- Fully programmable via a 3-wire serial interface
- Sampling frequency up to 18 MHz
- AGC gain from 4.5 to 34.5 dB (in 0.1 dB steps)
- CDS programmable bandwidth from 4 to 120 MHz
- AGC programmable bandwidth from 4 to 54 MHz
- Standby mode available for each block for power saving applications (20 mW typical)
- 6 dB fixed gain analog output for analog iris control
- 8-bit and 10-bit DAC included for analog settings
- Low power consumption of only 483 mW typical
- 5 V operation and 2.5 to 5.25 V operation for the digital outputs
- TTL compatible inputs, TTL and CMOS compatible outputs.

### APPLICATIONS

- CCD camera systems.

### GENERAL DESCRIPTION

The TDA8784 is a 10-bit analog-to-digital interface for CCD cameras. The device includes a correlated double sampling circuit, AGC and a low-power 10-bit Analog-to-Digital Converter (ADC) together with its reference voltage regulator.

The AGC and CDS have a bandwidth circuit controlled by on-chip DACs via a serial interface.

A 10-bit DAC controls the ADC input clamp level.

An additional 8-bit DAC is provided for additional system controls; its output voltage range is 1.4 V (p-p) which is available at pin OFDOUT.

### ORDERING INFORMATION

TYPE NUMBER	PACKAGE		
	NAME	DESCRIPTION	VERSION
TDA8784HL	LQFP48	plastic low profile quad flat package; 48 leads; body 7 × 7 × 1.4 mm	SOT313-2

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## QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$V_{CCA}$	analog supply voltage		4.75	5	5.25	V
$V_{CCD}$	digital supply voltage		4.75	5	5.25	V
$V_{CCO}$	digital outputs supply voltage		2.5	3	5.25	V
$I_{CCA}$	analog supply current		–	78	85	mA
$I_{CCD}$	digital supply current		–	18	20	mA
$I_{CCO}$	digital outputs supply current	$f_{CLK} = 18$ MHz; $C_L = 20$ pF; ramp input	–	1	–	mA
$ADC_{res}$	ADC resolution		–	10	–	bits
$V_{i(CDS)(p-p)}$	CDS input voltage (peak-to-peak value)		–	400	1200	mV
$G_{CDS}$	CDS output amplifier gain		–	6	–	dB
$f_{CLK(max)}$	maximum clock frequency	$f_{cut(CDS)} = 120$ MHz; $f_{cut(AGC)} = 54$ MHz	18	–	–	MHz
$AGC_{dyn}$	AGC dynamic range		–	30	–	dB
$N_{tot(rms)}$	total output noise from CDS input to ADC output (RMS value)	gain = 4.5 dB; $f_{cut(CDS)} = 120$ MHz; $f_{cut(AGC)} = 40$ MHz	–	0.125	–	LSB
$E_{in(rms)}$	equivalent input noise (RMS value)	gain = 34.5 dB	–	125	–	$\mu$ V
$P_{tot}$	total power consumption		–	483	550	mW

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### BLOCK DIAGRAM

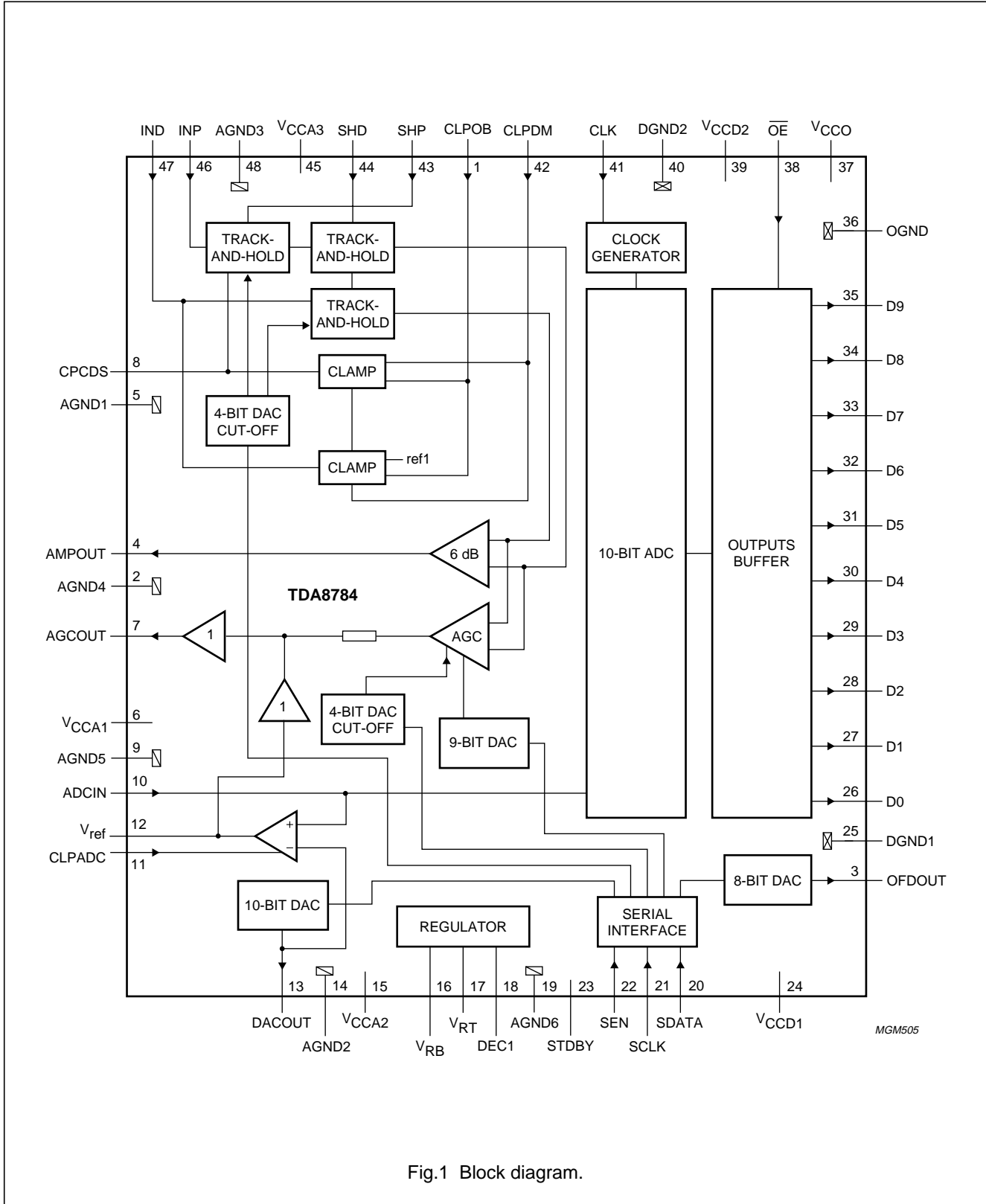


Fig.1 Block diagram.

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## PINNING

SYMBOL	PIN	DESCRIPTION
CLPOB	1	clamp pulse input at optical black
AGND4	2	analog ground 4
OFDOUT	3	analog output of the additional 8-bit control DAC (controlled via the serial interface)
AMPOUT	4	CDS amplifier output (fixed gain = 6 dB)
AGND1	5	analog ground 1
V <sub>CCA1</sub>	6	analog supply voltage 1
AGCOUT	7	AGC amplifier signal output
CPCDS	8	clamp storage capacitor pin
AGND5	9	analog ground 5
ADCIN	10	ADC analog signal input from AGCOUT via a short circuit
CLPADC	11	clamp control input for ADC analog input signal clamp (used with a capacitor from V <sub>ref</sub> to ground)
V <sub>ref</sub>	12	ADC input clamp reference voltage (normally connected to pin V <sub>RB</sub> or DACOUT, or shorted to ground via a capacitor)
DACOUT	13	DAC output for ADC clamp level
AGND2	14	analog ground 2
V <sub>CCA2</sub>	15	analog supply voltage 2
V <sub>RB</sub>	16	ADC reference voltage (BOTTOM) code 0
V <sub>RT</sub>	17	ADC reference voltage (TOP) code 1023
DEC1	18	decoupling 1 (decoupled to ground via a capacitor)
AGND6	19	analog ground 6
SDATA	20	serial data input for the 4 control DACs (9-bit DAC for AGC gain, 8-bit DAC for frequency cut-off; additional 8-bit DAC for OFD output voltage; 10-bit DAC for ADC clamp level and the standby mode per block and edge pulse control); see Table 1
SCLK	21	serial clock input for the control DACs and their serial interface; see Table 1
SEN	22	enable input for the serial interface shift register (active when SEN = logic 0); see Table 1
STDBY	23	standby control pin (active HIGH); all the output bits are logic 0 when standby is enabled
V <sub>CCD1</sub>	24	digital supply voltage 1
DGND1	25	digital ground 1
D0	26	ADC digital output 0 (LSB)
D1	27	ADC digital output 1
D2	28	ADC digital output 2
D3	29	ADC digital output 3
D4	30	ADC digital output 4
D5	31	ADC digital output 5
D6	32	ADC digital output 6
D7	33	ADC digital output 7
D8	34	ADC digital output 8
D9	35	ADC digital output 9 (MSB)
OGND	36	digital output ground
V <sub>CCO</sub>	37	digital output supply voltage

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SYMBOL	PIN	DESCRIPTION
$\overline{OE}$	38	output enable (active LOW: digital outputs active; active HIGH: digital outputs high impedance)
V <sub>CCD2</sub>	39	digital supply voltage 2
DGND2	40	digital ground 2
CLK	41	ADC clock input
CLPDM	42	clamp pulse input at dummy pixel
SHP	43	pre-set sample-and-hold pulse input
SHD	44	data sample-and-hold pulse input
V <sub>CCA3</sub>	45	analog supply voltage 3
INP	46	pre-set input signal from CCD
IND	47	data input signal from CCD
AGND3	48	analog ground 3

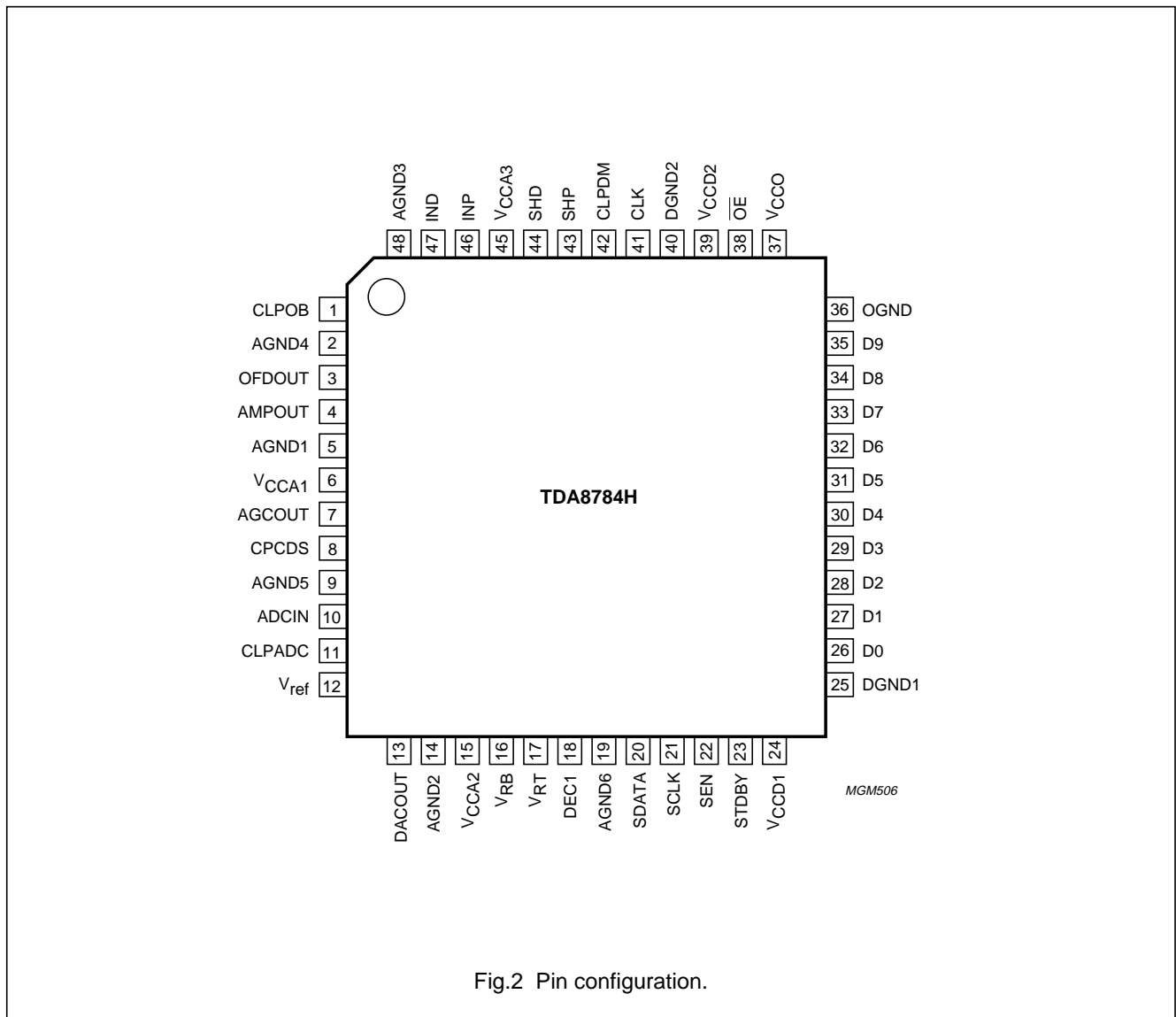


Fig.2 Pin configuration.

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## LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$V_{CCA}$	analog supply voltage	note 1	-0.3	+7.0	V
$V_{CCD}$	digital supply voltage	note 1	-0.3	+7.0	V
$V_{CCO}$	output stages supply voltage	note 1	-0.3	+7.0	V
$\Delta V_{CC}$	supply voltage difference between $V_{CCA}$ and $V_{CCD}$		-1.0	+1.0	V
	between $V_{CCA}$ and $V_{CCO}$		-1.0	+4.0	V
	between $V_{CCD}$ and $V_{CCO}$		-1.0	+4.0	V
$V_i$	input voltage	referenced to AGND	-0.3	+7.0	V
$V_{CLK(p-p)}$	AC input voltage for switching (peak-to-peak value)	referenced to DGND	-	$V_{CCD}$	V
$I_o$	output current		-	10	mA
$T_{stg}$	storage temperature		-55	+150	°C
$T_{amb}$	ambient temperature		-20	+75	°C
$T_j$	junction temperature		-	150	°C

### Note

- The supply voltages  $V_{CCA}$ ,  $V_{CCD}$  and  $V_{CCO}$  may have any value between -0.3 and +7.0 V provided that the supply voltage difference  $\Delta V_{CC}$  remains as indicated.

## HANDLING

Inputs and outputs are protected against electrostatic discharges in normal handling. However, to be totally safe, it is desirable to take normal precautions appropriate to handling integrated circuits.

## THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	VALUE	UNIT
$R_{th(j-a)}$	thermal resistance from junction to ambient	in free air	76	K/W

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 $V_{CCA} = V_{CCD} = 5\text{ V}$ ;  $V_{CCO} = 3\text{ V}$ ;  $f_{CLK} = 18\text{ MHz}$ ;  $T_{amb} = 25\text{ °C}$ ; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
<b>Supplies</b>						
$V_{CCA}$	analog supply voltage		4.75	5	5.25	V
$V_{CCD}$	digital supply voltage		4.75	5	5.25	V
$V_{CCO}$	digital outputs supply voltage		2.5	3	5.25	V
$I_{CCA}$	analog supply current		–	78	85	mA
$I_{CCD}$	digital supply current		–	18	20	mA
$I_{CCO}$	digital outputs supply current	$C_L = 20\text{ pF}$ on all data outputs; ramp input	–	1	–	mA
<b>Digital inputs</b>						
CLOCK INPUT: CLK (REFERENCED TO DGND)						
$V_{IL}$	LOW-level input voltage		0	–	0.8	V
$V_{IH}$	HIGH-level input voltage		2.0	–	$V_{CCD}$	V
$I_{IL}$	LOW-level input current	$V_{CLK} = 0.8\text{ V}$	–1	–	+1	$\mu\text{A}$
$I_{IH}$	HIGH-level input current	$V_{CLK} = 2.0\text{ V}$	–	–	20	$\mu\text{A}$
$Z_i$	input impedance	$f_{CLK} = 18\text{ MHz}$	–	46	–	$\text{k}\Omega$
$C_i$	input capacitance	$f_{CLK} = 18\text{ MHz}$	–	1	–	pF
INPUTS: SHP AND SHD						
$V_{IL}$	LOW-level input voltage		0	–	0.8	V
$V_{IH}$	HIGH-level input voltage		2.0	–	$V_{CCD}$	V
$I_{IL}$	LOW-level input current	$V_{IL} = 0.6\text{ V}$	–	–6	–	$\mu\text{A}$
$I_{IH}$	HIGH-level input current	$V_{IH} = 2.2\text{ V}$	–	0	–	$\mu\text{A}$
INPUTS: SEN, SCLK, SDATA, $\overline{OE}$ , STDBY, CLPDM, CLPOB AND CLPADC						
$V_{IL}$	LOW-level input voltage		0	–	0.8	V
$V_{IH}$	HIGH-level input voltage		2.0	–	$V_{CCD}$	V
$I_i$	input current		–2	–	+2	$\mu\text{A}$
<b>Correlated Double Sampling (CDS)</b>						
$V_{i(CDS)(p-p)}$	CDS input amplitude (peak-to-peak value)		–	400	1200	mV
$I_{CPCDS,INP,IND}$	input current pins 8, 46 and 47		–2	–	+2	$\mu\text{A}$
$t_{CDS(min)}$	CDS control pulses minimum active time	$f_{i(CDS1,2)} = f_{CLK(pix)}$ ; $V_{i(CDS)} = 1200\text{ mV (p-p)}$ black-to-white transition in 1 pixel ( $\pm 1\text{ LSB typ.}$ ); $f_{cut(CDS)} = 40\text{ MHz}$ ; $f_{cut(AGC)} = 40\text{ MHz}$	12	–	–	ns
$t_{hd1}$	hold time INP compared to control pulse SHP	see Fig.5	–	1	–	ns



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SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$t_{hd2}$	hold time of IND compared to control pulse SHD	see Fig.5	–	1	–	ns
$t_{set(CDS)}$	CDS settling time	see Fig.12; control DAC 4 bits input code; AGC gain = 0 dB; $f_{cut(AGC)} = 54$ MHz; $V_{i(CDS)} = 1200$ mV (p-p) black-to-white transition in 1 pixel (1 LSB typ.)				
		0000	–	12	–	ns
		0001	–	25	–	ns
		0010	–	45	–	ns
		0011	–	55	–	ns
		0100	–	105	–	ns
		0111	–	140	–	ns
		1000	–	270	–	ns
		1011	–	300	–	ns
		1111	–	365	–	ns
<b>Amplifier outputs</b>						
$G_{AMPOUT}$	output amplifier gain		–	6	–	dB
$Z_{AMPOUT}$	output amplifier impedance		–	300	–	$\Omega$
$V_{AMPOUT(p-p)}$	output amplifier dynamic voltage (peak-to-peak value)		–	2.4	–	V
$V_{AMPOUT(bl)}$	output amplifier black level voltage		–	1.5	–	V
$V_{AGCOUT(p-p)}$	AGC output amplifier dynamic voltage level (peak-to-peak value)		–	2000	–	mV
$V_{AGCOUT}$	AGC output amplifier black level voltage	$V_{ref}$ connected to DACOUT	–	$V_{ref}$	–	V
$Z_{AGCOUT}$	AGC output amplifier output impedance	at 10 kHz	–	5	–	$\Omega$
$I_{AGCOUT}$	AGC output static drive current	static	–	–	1	mA
$G_{AGC(min)}$	minimum gain of AGC circuit	AGC DAC input code = 00 (9-bit control)	–	4.5	–	dB
$G_{AGC(max)}$	maximum gain of AGC circuit	AGC DAC input code $\geq 319$ (9-bit control)	–	34.5	–	dB
$f_{cut(AGC)}$	cut-off frequency AGC	control DAC 4-bit input code = 00	–	54	–	MHz
		input code = 01	–	40	–	MHz
		input code = 15	–	4	–	MHz

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SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
<b>Clamps</b>						
$g_{m(ADC)}$	ADC clamp transconductance	at clamp level	–	7	–	mS
$g_{m(CDS)}$	CDS clamp transconductance	at clamp level	–	1.5	–	mS
<b>Analog-to-Digital Converter (ADC)</b>						
$f_{CLK(max)}$	maximum clock frequency		18	–	–	MHz
$t_{CPH}$	clock pulse width HIGH		15	–	–	ns
$t_{CPL}$	clock pulse width LOW		15	–	–	ns
$SR_{CLK}$	clock input slew rate (rising and falling edge)	10% to 90%	0.5	–	–	V/ns
$V_{i(ADC)(p-p)}$	ADC input voltage level (peak-to-peak value)		–	2	–	V
$V_{RB}$	ADC reference voltage output code 0		–	1.5	–	V
$V_{RT}$	ADC reference voltage output code 1023		–	3.5	–	V
$I_{ADCIN}$	input current pin 10		–2	–	+120	$\mu$ A
INL	integral non-linearity	ramp input	–	$\pm 0.6$	$\pm 1.5$	LSB
DNL	differential non-linearity	ramp input	–	$\pm 0.2$	$\pm 0.75$	LSB
$t_{d(s)}$	sampling delay time		–	–	5	ns
<b>Total chain characteristics (CDS + AGC + ADC)</b>						
$t_d$	time delay between SHD and CLK	see Fig.5; 50% at rising edges CLK and SHP: transition full scale code 0 to 1023; $f_{cut(CDS)} = 40$ MHz; $f_{cut(AGC)} = 40$ MHz; $V_{i(CDS)} = 1200$ mV	–	40	–	ns
$N_{tot(rms)}$	total output noise (RMS value)	$f_{cut(CDS)} = 120$ MHz; $f_{cut(AGC)} = 40$ MHz; note 1 $G_{AGC} = 4.5$ dB $G_{AGC} = 34.5$ dB	–	0.125	–	LSB
			–	1.6	–	LSB
$V_{offset(fl-d)}$	maximum offset between CCD floating level and CCD dark pixel level		–200	–	+200	mV
$V_{n(i)(eq)(rms)}$	equivalent input noise voltage (RMS value)	AGC gain = 34.5 dB	–	125	–	$\mu$ V
		AGC gain = 4.5 dB	–	150	–	$\mu$ V
<b>Digital-to-analog converter (OFDOUT)</b>						
$V_{OFDOUT(p-p)}$	additional 8-bit control DAC (OFD) output voltage (peak-to-peak value)		–	1.4	–	V
$V_{OFDOUT(0)}$	DC output voltage for code 0		–	2.3	–	V
$V_{OFDOUT(255)}$	DC output voltage for code 255		–	3.7	–	V

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SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Z <sub>OFDOUT</sub>	additional 8-bit control DAC (OFD) output impedance		–	2000	–	Ω
I <sub>OFDOUT</sub>	OFD output current drive	static	–	–	50	μA
<b>ADC clamp control DAC (see Fig.8)</b>						
V <sub>DACOUT(p-p)</sub>	ADC clamp 10-bit control DAC output voltage (peak-to-peak value)		–	1	–	V
V <sub>DACOUT</sub>	DC output voltage	code 0	–	1.5	–	V
		code 1023	–	2.5	–	V
Z <sub>DACOUT</sub>	ADC clamp control DAC output impedance		–	–	250	Ω
I <sub>DACOUT</sub>	DAC output current drive	static	–	–	50	μA
OFE <sub>LOOP</sub>	maximum offset error of DAC + ADC clamp loop	code 0	–	±5	–	LSB
		code 1023	–	±5	–	LSB
<b>Digital outputs (f<sub>CLK</sub> = 18 MHz; C<sub>L</sub> = 20 pF)</b>						
V <sub>OH</sub>	HIGH-level output voltage	I <sub>OH</sub> = –1 mA	V <sub>CCO</sub> – 0.5	–	V <sub>CCO</sub>	V
V <sub>OL</sub>	LOW-level output voltage	I <sub>OL</sub> = 1 mA	0	–	0.5	V
I <sub>OZ</sub>	output current in 3-state mode	0 V < V <sub>o</sub> < V <sub>CCO</sub>	–20	–	+20	μA
t <sub>o(h)</sub>	output hold time	see Fig.5	8	–	–	ns
t <sub>o(d)</sub>	output delay time	C <sub>i</sub> = 20 pF; V <sub>CCO</sub> = 5 V	–	17	23	ns
		C <sub>i</sub> = 10 pF	–	15	21	ns
		C <sub>i</sub> = 20 pF; V <sub>CCO</sub> = 3 V	–	20	29	ns
		C <sub>i</sub> = 10 pF	–	17	25	ns
		C <sub>i</sub> = 20 pF; V <sub>CCO</sub> = 2.5 V	–	22	33	ns
		C <sub>i</sub> = 10 pF	–	18	28	ns
<b>Serial interface</b>						
f <sub>SCLK(max)</sub>	maximum frequency of serial interface		5	–	–	MHz

**Note**

- Noise measurement at ADC outputs: the coupling capacitor at the input is connected to ground, so that only the noise contribution of the front-end is evaluated. The front-end operates at 18 Mpix with a line of 1024 pixels. The first 40 are used to run CLPOB and the last 40 to run CLPDM. Data at the ADC outputs is measured during the other pixels. The differences between the types of codes statistic is then computed; the result is the noise. No quantization noise is taken into account as no signal is input.

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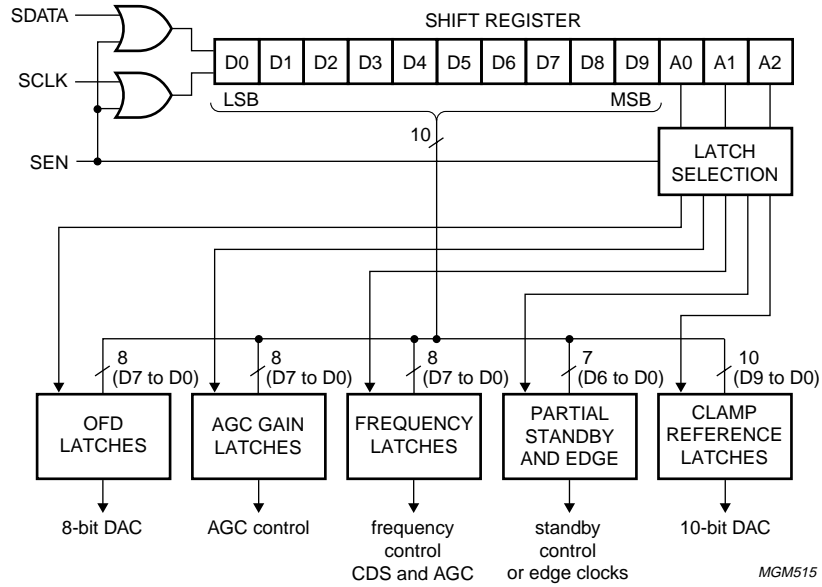
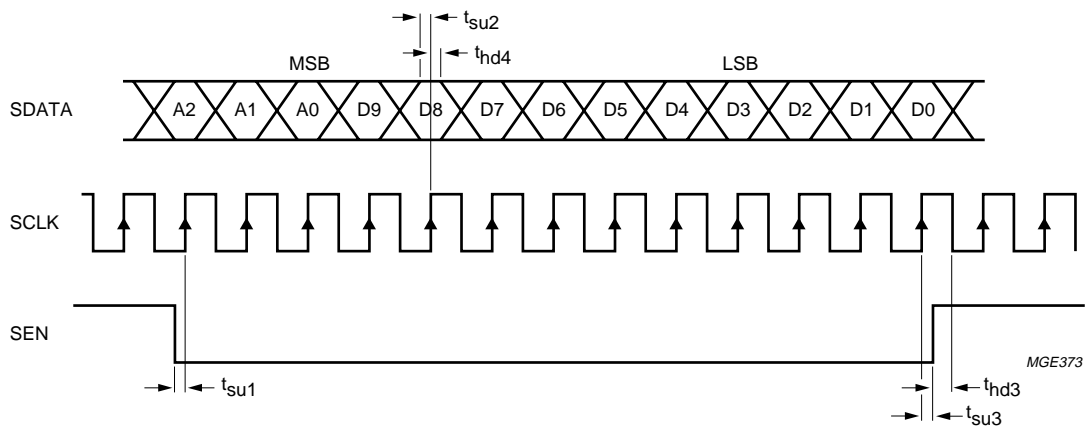


Fig.3 Serial interface block diagram.



$t_{su1} = t_{su2} = 4 \text{ ns (min.)}$ ;  $t_{hd3} = t_{hd4} = 4 \text{ ns (min.)}$ .

Fig.4 Loading sequence of control DACs input data via the serial interface.

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**Table 1** Serial interface programming

ADDRESS BITS			DATA BITS D9 to D0
A2	A1	A0	
0	0	0	OFD output control (D7 to D0).
0	0	1	Cut-off frequency of CDS and AGC. Only the 4 LSBs (D3 to D0) are used for CDS. D4 to D7 are used for AGC. D8 and D9 should be set to logic 0.
0	1	0	AGC gain control (D8 to D0).
0	1	1	Partial standby controls for power consumption optimization. Only the 4 LSBs (D3 to D0) are used. Edge control for pulses SHP, SHD, CLAMP and clock ADC: D0 = 1: CDS + AGC in standby; $I_{CCA} + I_{CCD} = 48 \text{ mA}$ D1 = 1: OFD DAC in standby; $I_{CCA} + I_{CCD} = 98 \text{ mA}$ D2 = 1: 6 dB amplifier (output on AMPOUT pin) in standby; $I_{CCA} + I_{CCD} = 98.5 \text{ mA}$ D3 = 1: SHP and SHD activated with falling edge (for positive pulse) D4 = 1: CLPDM, CLPOB and CLPADC activated on HIGH level; note 1 D5 = 0: CLKADC activated with falling edge D6 must be set to logic 0.
1	0	0	Clamp reference DAC (D9 to D0).

**Note**

1. When CLPADC is HIGH (D4 = 1: serial interface), the ADC input is clamped to voltage level  $V_{ref}$ .  $V_{ref}$  is connected to ground via a capacitance.

**Table 2** Standby selection

STDBY	DATA BITS D9 to D0	$I_{CCA} + I_{CCD}$ (TYP.)
1	LOW	4 mA
0	active	99 mA

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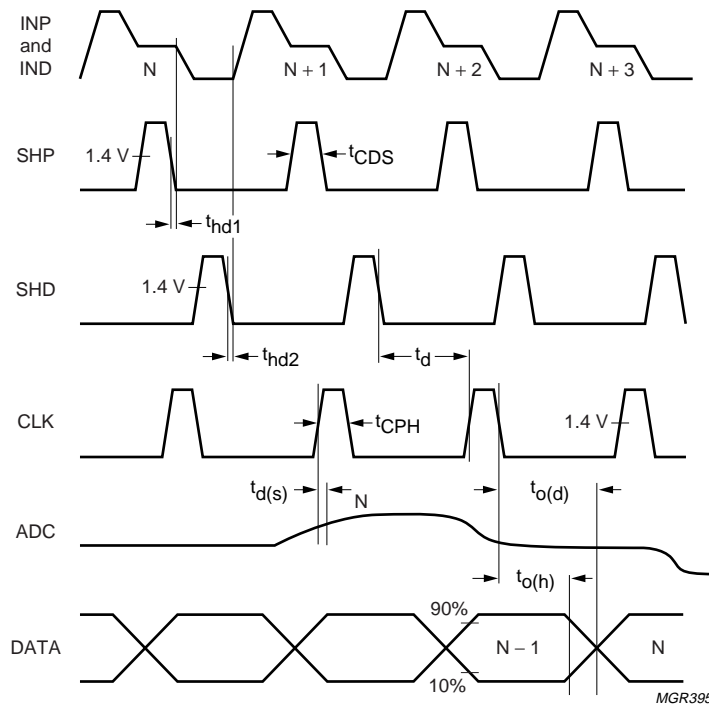
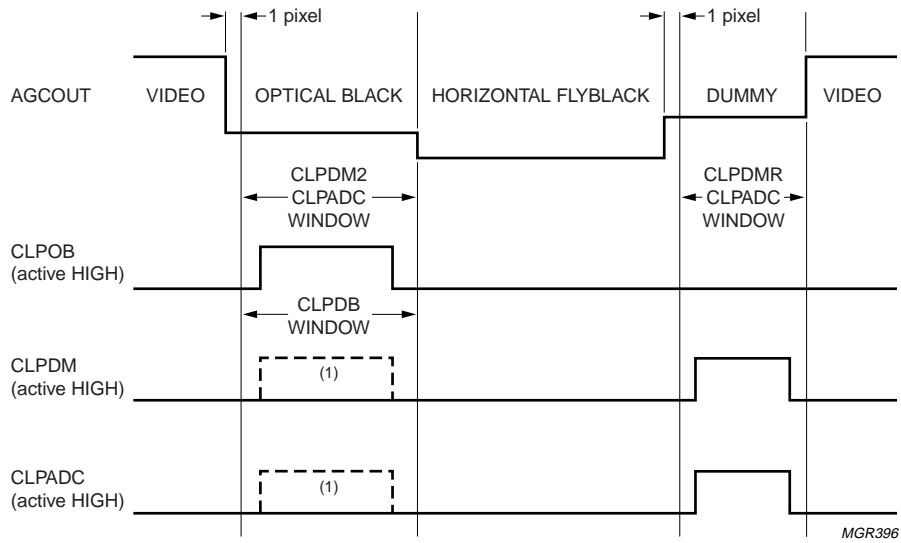


Fig.5 Pixel frequency timing diagram.

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(1) When dummy pixels are not available.

Fig.6 Line frequency timing diagram.

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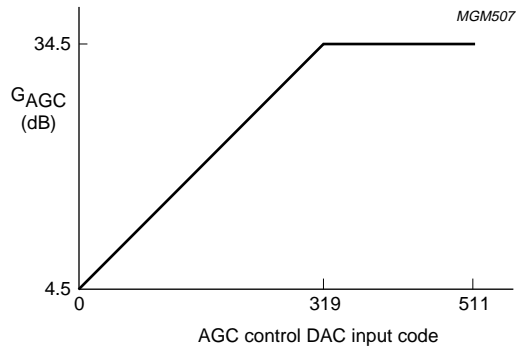


Fig.7 AGC gain as a function of DAC input code.

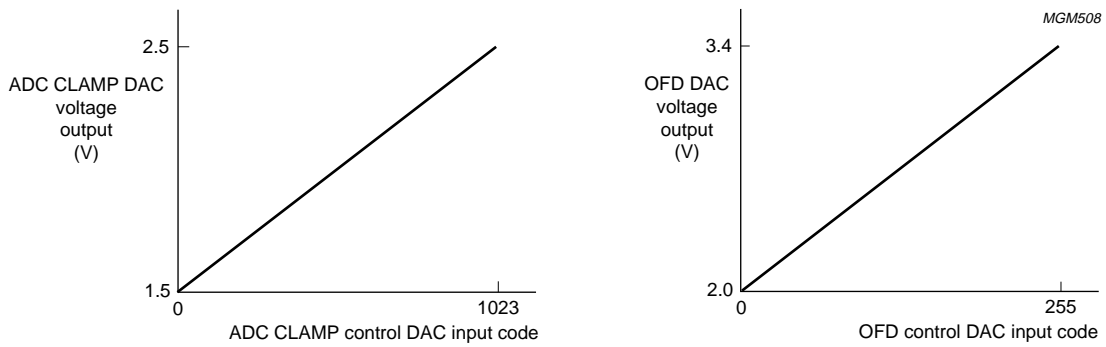


Fig.8 DAC voltage output as a function of DAC input code.



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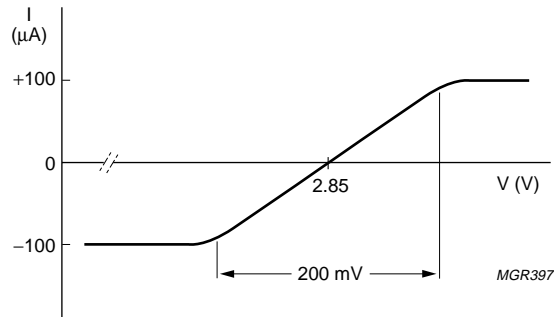


Fig.9 Typical clamp current for pin CPCDS.

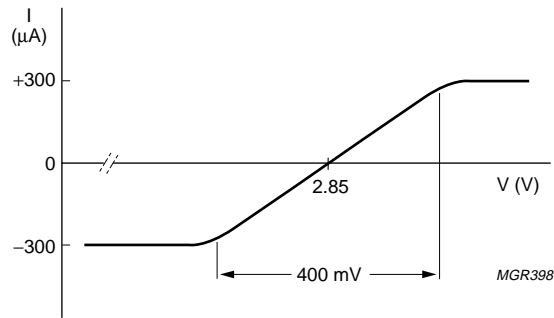


Fig.10 Typical clamp current for pins IND and INP.

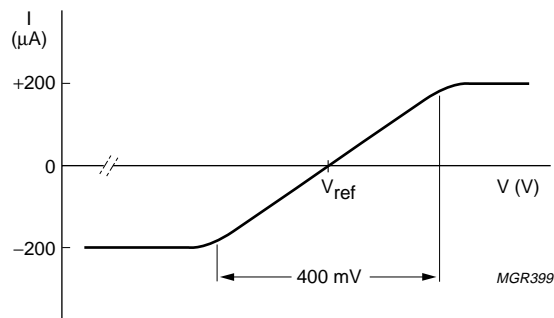
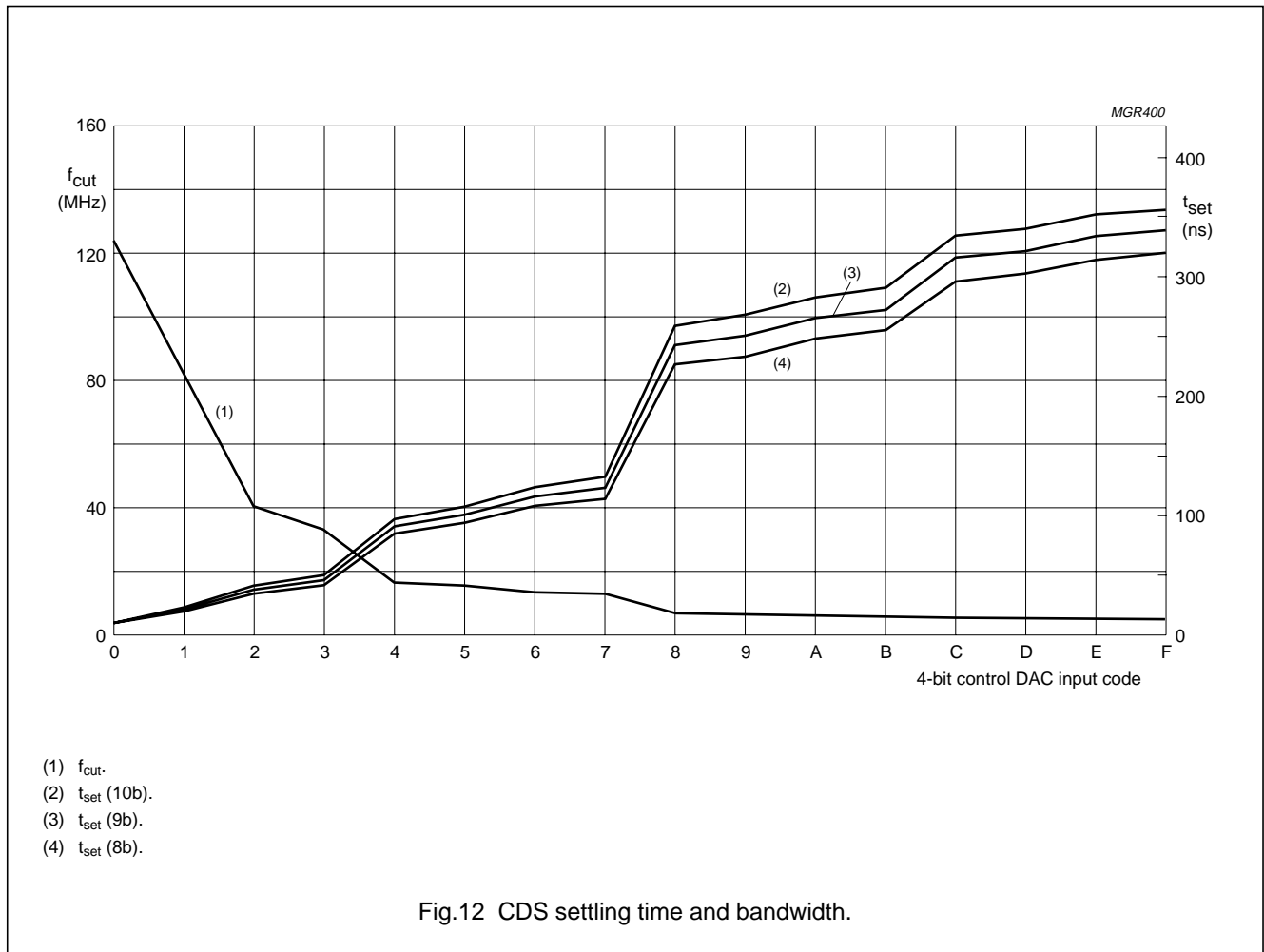


Fig.11 Typical clamp current for pin  $V_{\text{ref}}$ .

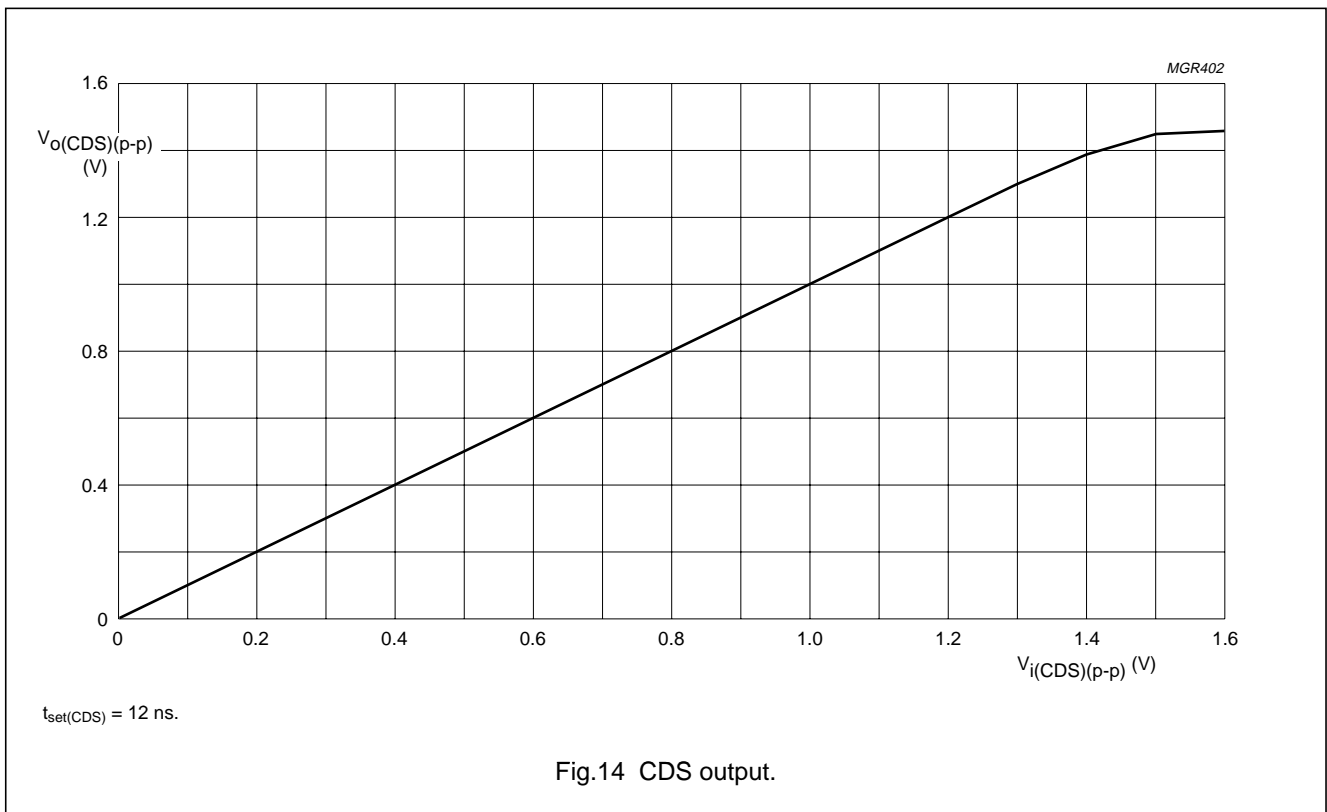
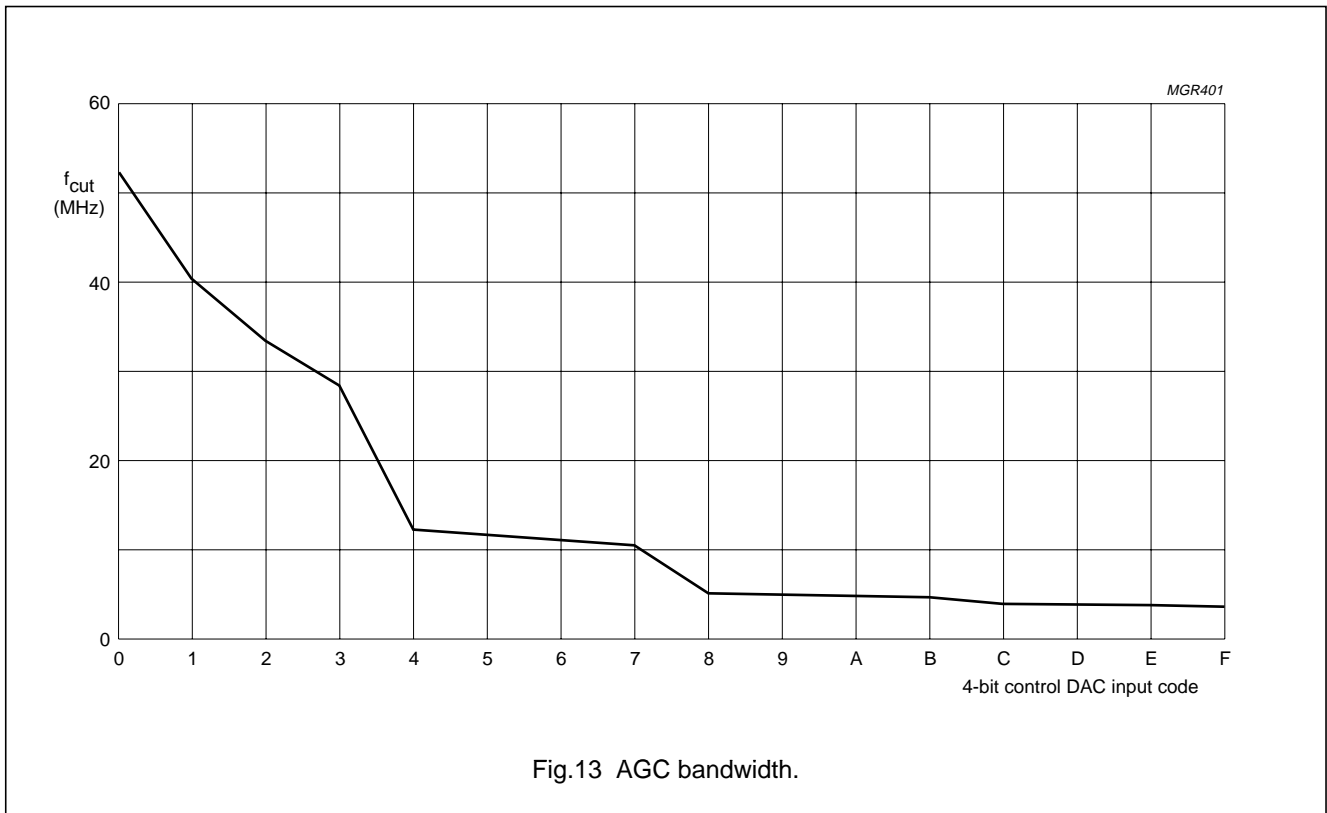
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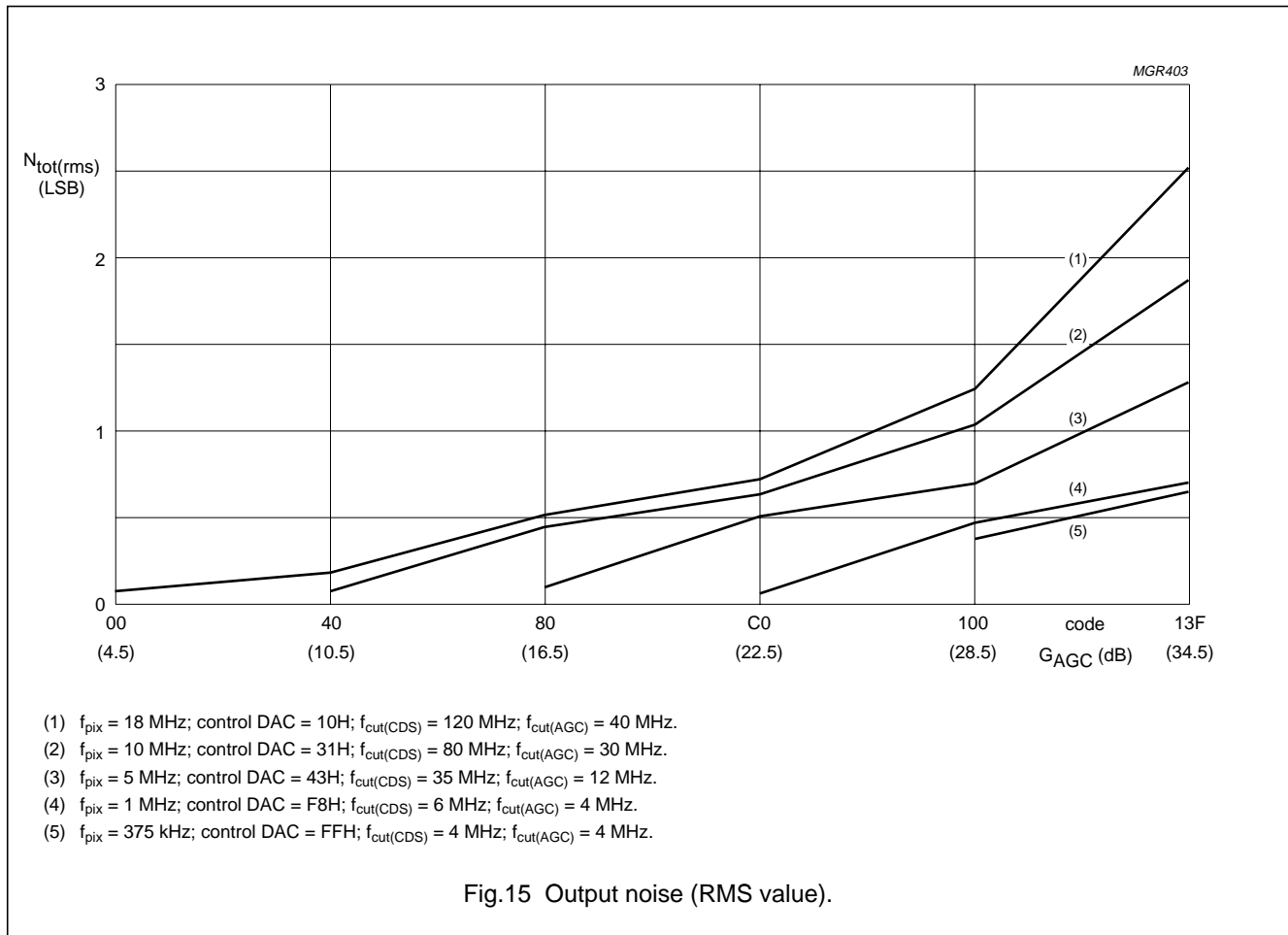
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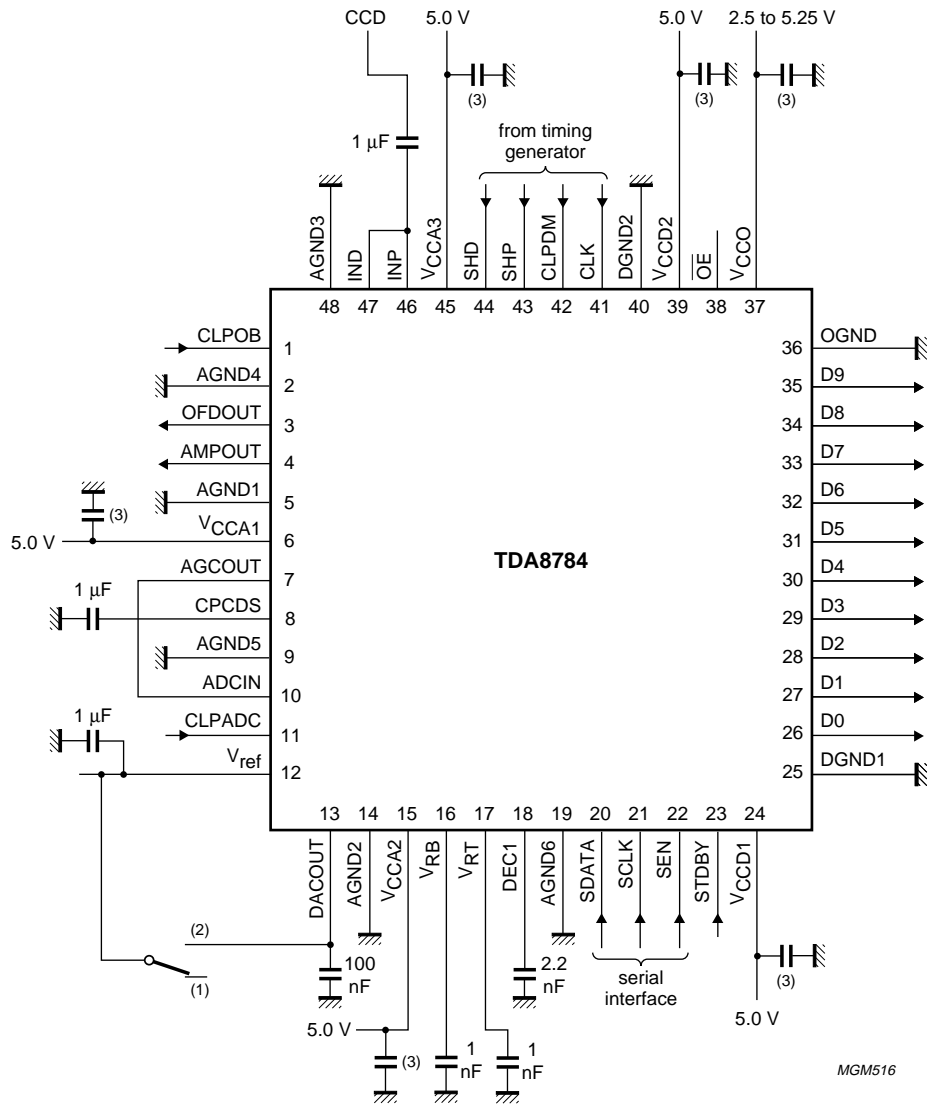
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## APPLICATION INFORMATION



Depending on the application, the following connections must be made:

- (1) The clamp level of the signal input at ADCIN can be tuned from code 00 to code 511 in 0.5 LSB steps of ADC via the serial interface (clamp ADC activated).
- (2) Clamp ADC not activated, direct connection from DACOUT to V<sub>ref</sub>.
- (3) All supply pins must be decoupled with 100 nF capacitors as close as possible to the device.

Fig.16 Application diagram.

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### Power and grounding recommendations

When designing a printed-circuit board for applications such as PC cameras, surveillance cameras, camcorders and digital still cameras, care should be taken to minimize the noise.

For the front-end integrated circuit, the basic rules of printed-circuit board design and implementation of analogue components (such as classical operational amplifiers) must be respected, particularly with respect to power and ground connections.

The following additional recommendation is given for the CDS input pin(s) which is/are internally connected to the programmable gain amplifier:

- The connections between CCD interface and CDS input should be as short as possible and a ground ring protection around these connections can be beneficial. Separate analogue and digital supplies provide the best solution. If it is not possible to do this on the board then the analogue supply pins must be decoupled effectively from the digital supply pins. If the same power supply and ground are used for all the pins then the decoupling capacitors must be placed as close as possible to the IC package.
- In a two-ground system, in order to minimize the noise through package and die parasitics, the following recommendations must be implemented:
  - All the analogue and digital supply pins must be decoupled to the analogue ground plane. Only the ground pin associated with the digital outputs must be connected to the digital ground plane. All the other ground pins should be connected to the analogue ground plane. The analogue and digital ground planes must be connected together at one point as close as possible to the ground pin associated with the digital outputs.
  - The digital output pins and their associated lines should be shielded by the digital ground plane which can be used then as return path for digital signals.

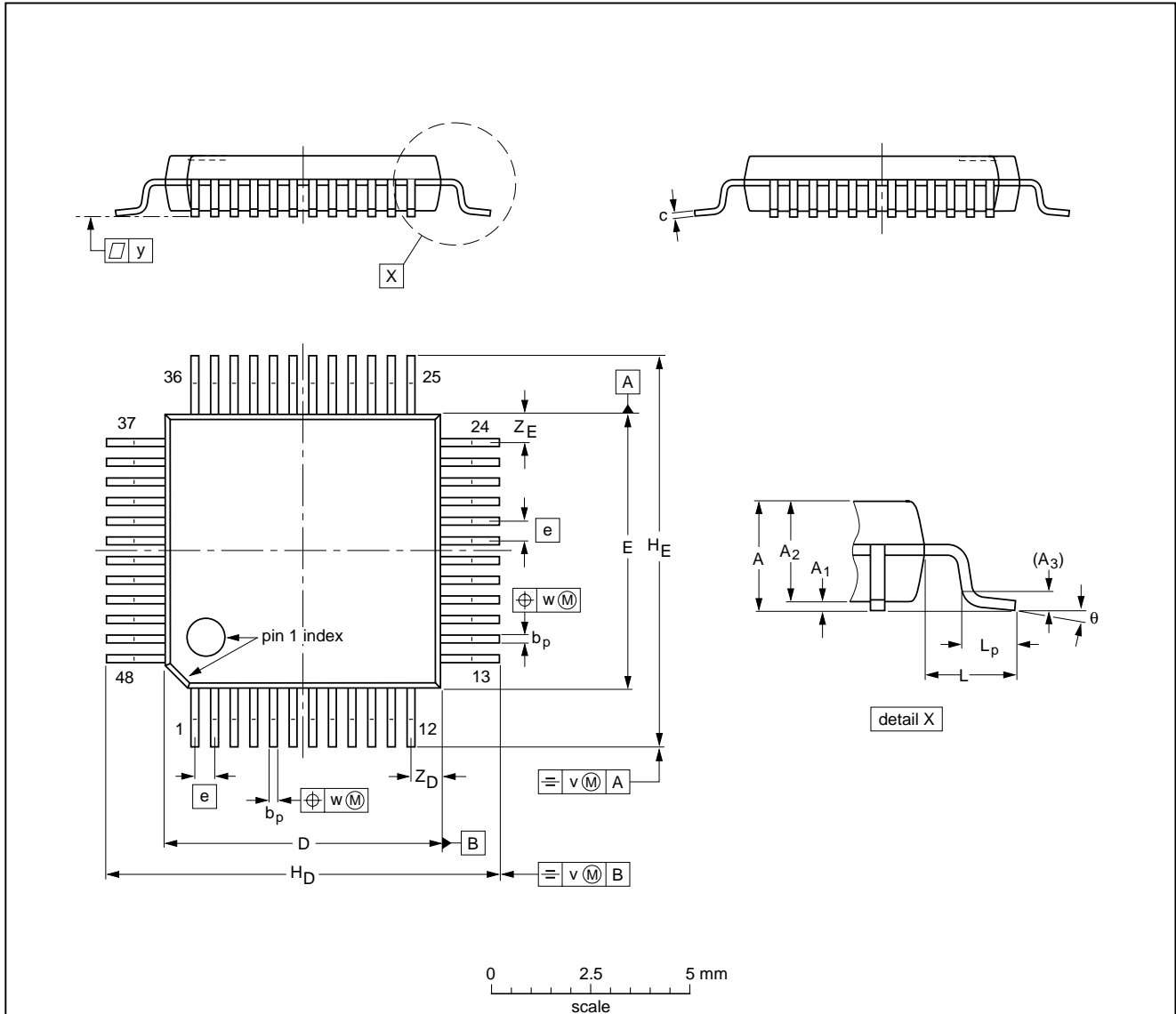
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PACKAGE OUTLINE

LQFP48: plastic low profile quad flat package; 48 leads; body 7 x 7 x 1.4 mm

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DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	b <sub>p</sub>	c	D <sup>(1)</sup>	E <sup>(1)</sup>	e	H <sub>D</sub>	H <sub>E</sub>	L	L <sub>p</sub>	v	w	y	Z <sub>D</sub> <sup>(1)</sup>	Z <sub>E</sub> <sup>(1)</sup>	θ
mm	1.60	0.20 0.05	1.45 1.35	0.25	0.27 0.17	0.18 0.12	7.1 6.9	7.1 6.9	0.5	9.15 8.85	9.15 8.85	1.0	0.75 0.45	0.2	0.12	0.1	0.95 0.55	0.95 0.55	7° 0°

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT313-2						94-12-19 97-08-01

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

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

### Notes

- 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".
- 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).
- 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.
- 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.
- 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.

### 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 134). 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.	

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