TDA8768B
12-bit, 80 Msps Analog-to-Digital Converter (ADC)

Rev. 02 — 20 January 2004   **Product data**

1. Description

The TDA8768B is a biCMOS 12-bit Analog-to-Digital Converter (ADC) optimized for EDGE and W-CDMA cellular infrastructures, professional telecommunications and other applications such as advanced FM radio and professional imaging. Its main innovation is the RF sampling, based on high-speed clock (up to 80 Msps) combined with a high input frequency (up to 176 MHz). It converts the analog input signal into 12-bit binary coded digital words at a maximum sampling rate of 80 MHz. All static digital inputs (SH, $\overline{CE}$ and OTC) are TTL and CMOS compatible and all outputs are CMOS compatible. A sine wave clock input signal can also be used.

2. Features

- 12-bit resolution
- Sampling rate up to 80 MHz:
  - ◆ 52 Msps at f_{IF} = 175 MHz; B = 200 kHz (TDA8768BH/5):
    SFDR = 83 dB, S/N = 71 dB
  - ◆ 80 Msps at f_{IF} = 20 MHz; Nyquist bandwidth (TDA8768BH/8):
    SFDR = 65 dB, S/N = 62 dB
  - ◆ 80 Msps at f_{IF} = 50 MHz; B = 5 MHz (TDA8768BH/8/S1):
    SFDR = 72 dB, S/N = 64 dB
- −3 dB bandwidth of 250 MHz
- 5 V power supplies and 3.3 V output power supply
- Binary or twos complement CMOS outputs
- In-range CMOS compatible output
- TTL and CMOS compatible static digital inputs
- TTL and CMOS compatible digital outputs
- Single or differential clock input; TTL and CMOS compatible
- Power dissipation 570 mW (typical)
- Low analog input capacitance (typical 2 pF), no buffer amplifier required
- Integrated sample-and-hold amplifier
- Differential analog input
- External amplitude range control
- Voltage controlled regulator included
- Ambient temperature from −40 °C to +85 °C.

PHILIPS

3. Applications

- High-speed analog-to-digital conversion for:
  - ◆ Cellular infrastructure (EDGE and W-CDMA)
  - ◆ Professional telecommunication
  - ◆ Advanced FM radio
  - ◆ Radar
  - ◆ Imaging (camera scanner)
  - ◆ Set Top Box (STB)
  - ◆ Medical imaging.

4. Quick reference data

Table 1:   Quick reference data

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CCA}	analog supply voltage		4.75	5.0	5.25	V
V_{CCD}	digital supply voltage		4.75	5.0	5.25	V
V_{CCO}	output supply voltage		3.0	3.3	3.6	V
I_{CCA}	analog supply current		-	78	87	mA
I_{CCD}	digital supply current		-	27	30	mA
I_{CCO}	output supply current	f_{CLK} = 20 MHz; f_i = 400 kHz	-	3	4	mA
INL	integral non-linearity	f_{CLK} = 20 MHz; f_i = 400 kHz	-	±2.8	±4.5	LSB
DNL	differential non-linearity (no missing code)	f_{CLK} = 20 MHz; f_i = 400 kHz	-	±0.65	+1.1 − 0.95	LSB
$f_{CLK(max)}$	maximum clock frequency					
	TDA8768BH/5		52	-	-	MHz
	TDA8768BH/8		80		-	MHz
	TDA8768BH/8/S1		80	-	-	MHz
P_{tot}	total power dissipation	f_{CLK} = 80 MHz; f_i = 20 MHz	-	570	675	mW

5. Ordering information

Table 2:   Ordering information

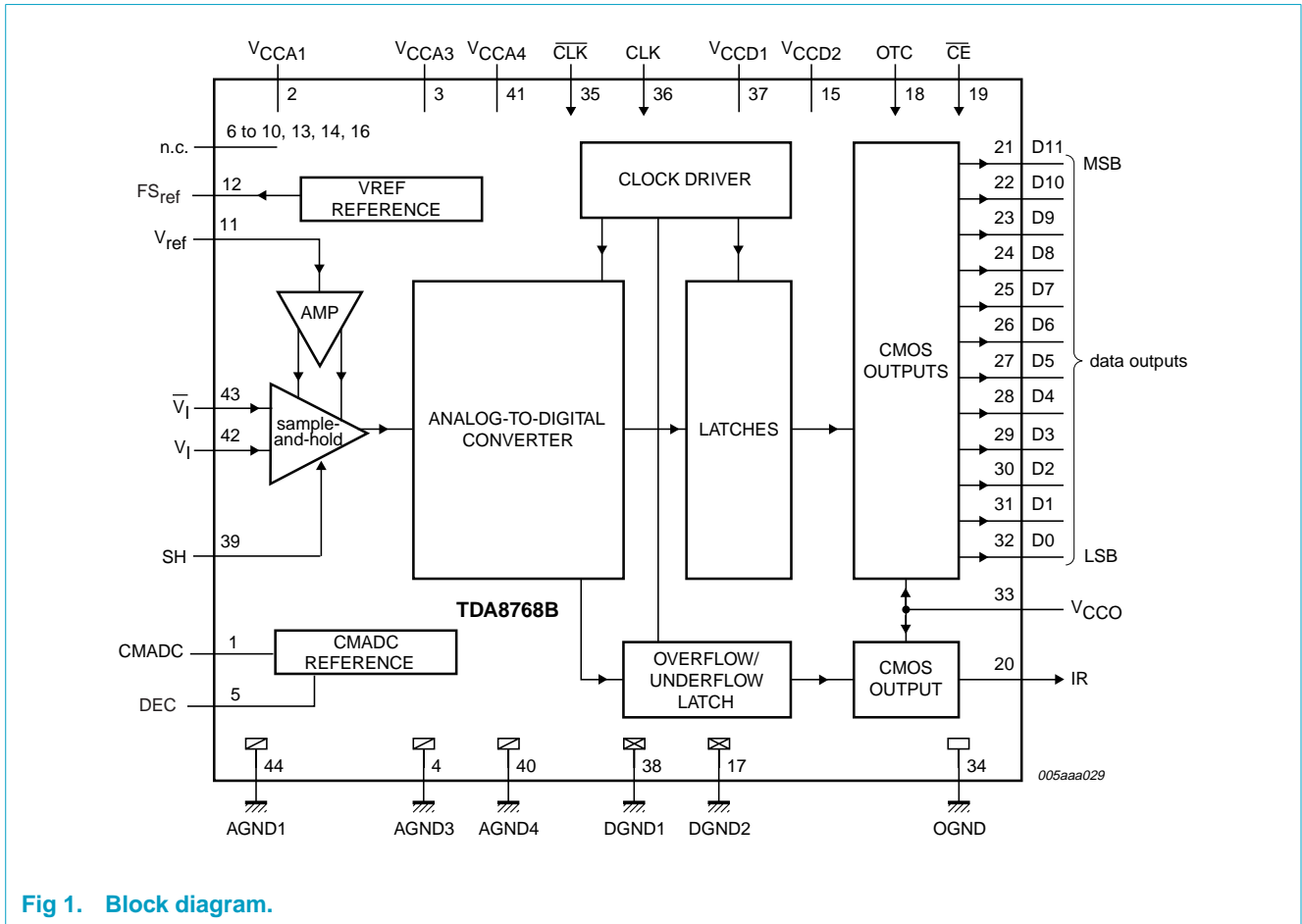| Type number	Package				Sampling frequency (MHz)
	Name	Description		Version	
TDA8768BH/5/C3	QFP44	plastic quad flat package; 44 leads (lead length 1.3 mm); body 10 × 10 × 1.75 mm		SOT307-2	50
TDA8768BH/8/C3					80
TDA8768BH/8/C3/S1					80

6. Block diagram

Fig 1.   Block diagram.

7. Pinning information

7.1 Pinning
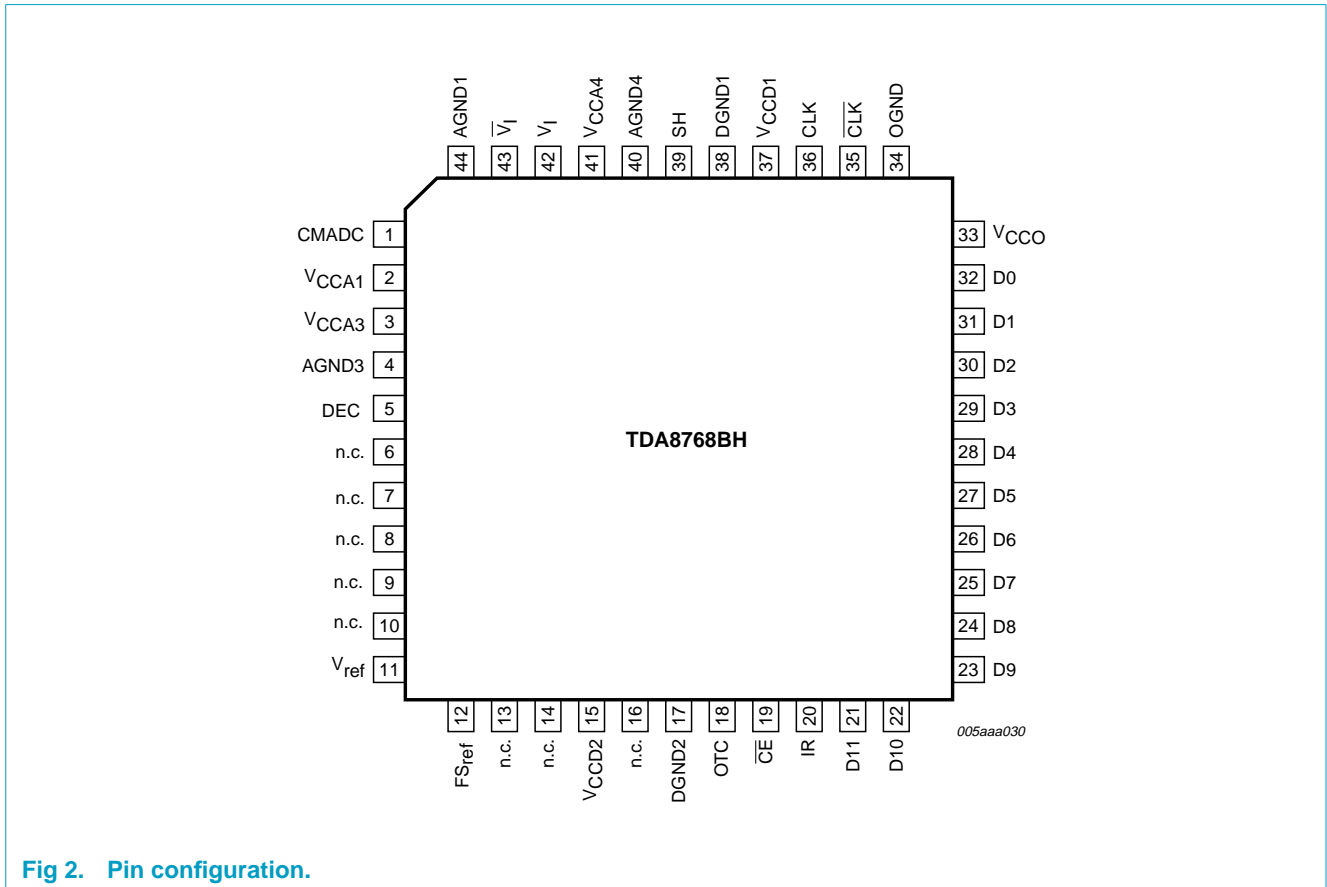
Fig 2. Pin configuration.

7.2 Pin description

Table 3: **Pin description**

Symbol	Pin	Description
CMADC	1	regulator output common mode ADC input
V_{CCA1}	2	analog supply voltage 1 (+5 V)
V_{CCA3}	3	analog supply voltage 3 (+5 V)
AGND3	4	analog ground 3
DEC	5	decoupling node
n.c.	6	not connected
n.c.	7	not connected
n.c.	8	not connected
n.c.	9	not connected
n.c.	10	not connected
V_{ref}	11	reference voltage input
FS_{ref}	12	full-scale reference output

Table 3: **Pin description**…*continued*

Symbol	Pin	Description
n.c.	13	not connected
n.c.	14	not connected
V_{CCD2}	15	digital supply voltage 2 (+5 V)
n.c.	16	not connected
DGND2	17	digital ground 2
OTC	18	control input twos complement output; active HIGH
$\overline{CE}$	19	chip enable input (CMOS level; active LOW)
IR	20	in-range output
D11	21	data output; bit 11 (MSB)
D10	22	data output; bit 10
D9	23	data output; bit 9
D8	24	data output; bit 8
D7	25	data output; bit 7
D6	26	data output; bit 6
D5	27	data output; bit 5
D4	28	data output; bit 4
D3	29	data output; bit 3
D2	30	data output; bit 2
D1	31	data output; bit 1
D0	32	data output; bit 0 (LSB)
V_{CCO}	33	output supply voltage (+3.3 V)
OGND	34	output ground
$\overline{CLK}$	35	complementary clock input
CLK	36	clock input
V_{CCD1}	37	digital supply voltage 1 (+5 V)
DGND1	38	digital ground 1
SH	39	sample-and-hold enable input (CMOS level; active HIGH)
AGND4	40	analog ground 4
V_{CCA4}	41	analog supply voltage 4 (+5 V)
V_I	42	analog input
$\overline{V}_I$	43	complementary analog input
AGND1	44	analog ground 1

9397 750 12338

Product data **Rev. 02 — 20 January 2004** 5 of 30

8. Limiting values

Table 4: **Limiting values**

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

Symbol	Parameter	Conditions	Min	Max	Unit
V_{CCA}	analog supply voltage	[1]	−0.3	+7.0	V
V_{CCD}	digital supply voltage	[1]	−0.3	+7.0	V
V_{CCO}	output supply voltage	[1]	−0.3	+7.0	V
ΔV_{CC}	supply voltage difference				
	$V_{CCA} - V_{CCD}$		−1.0	+1.0	V
	$V_{CCD} - V_{CCO}$		−1.0	+4.0	V
	$V_{CCA} - V_{CCO}$		−1.0	+4.0	V
$V_I, \overline{V}_I$	input voltage at pins 42 and 43	referenced to AGND	0.3	V_{CCA}	V
$V_{CLK(p-p)}$	input voltage at pins 35 and 36 for differential clock drive (peak-to-peak value)		-	V_{CCD}	V
I_O	output current		-	10	mA
T_{stg}	storage temperature		−55	+150	°C
T_{amb}	ambient temperature		−40	+85	°C
T_j	junction temperature		-	150	°C

[1] The supply voltages V_{CCA}, V_{CCD} and V_{CCO} may have any value between −0.3 V and +7.0 V provided that the supply voltage differences ΔV_{CC} are respected.

9. Thermal characteristics

Table 5: **Thermal characteristics**

Symbol	Parameter	Condition	Value	Unit
$R_{th(j-a)}$	thermal resistance from junction to ambient	in free air	75	K/W

10. Characteristics

Table 6: **Characteristics**

V_{CCA} = 4.75 V to 5.25 V (V_2 to V_{44}, V_3 to V_4 and V_{41} to V_{40}); V_{CCD} = 4.75 V to 5.25 V (V_{37} to V_{38} and V_{15} to V_{17});
V_{CCO} = 3.0 V to 3.6 V (V_{33} to V_{34}); AGND and DGND shorted together; T_{amb} = −40 °C to +85 °C; $V_{i(p-p)} - \overline{V}_{i(p-p)}$ = 1.9 V;
V_{ref} = V_{CCA3} − 1.75 V; $V_{I(CM)}$ = V_{CCA3} − 1.6 V; typical values measured at V_{CCA} = V_{CCD} = 5 V, V_{CCO} = 3.3 V, T_{amb} = 25 °C and
C_L = 10 pF; unless otherwise specified.

Symbol	Parameter	Conditions	Test[1]	Min	Typ	Max	Unit
Supplies							
V_{CCA}	analog supply voltage			4.75	5.0	5.25	V
V_{CCD}	digital supply voltage			4.75	5.0	5.25	V
V_{CCO}	output supply voltage			3.0	3.3	3.6	V
I_{CCA}	analog supply current		I	-	78	87	mA
I_{CCD}	digital supply current		I	-	27	30	mA
I_{CCO}	output supply current	f_{CLK} = 20 MHz; f_i = 400 kHz	I	-	3	4	mA
		f_{CLK} = 40 MHz; f_i = 4.43 MHz	C	-	6.2	9	mA
		f_{CLK} = 80 MHz; f_i = 20 MHz	I	-	13.5	17	mA
Inputs							
CLK and $\overline{CLK}$ (referenced to DGND)[2]							
$\Delta V_{CLK(p-p)}$	differential AC input voltage for switching ($V_{CLK(p-p)} - V_{\overline{CLK}(p-p)}$)	AC driving mode; DC voltage level = 2.5 V	C	1	1.5	2.0	V
V_{IL}	LOW-level input voltage	TTL mode	I	0	-	0.8	V
V_{IH}	HIGH-level input voltage	TTL mode	I	2.0	-	V_{CCD}	V
R_i	input resistance	f_{CLK} = 80 MHz	D	2	-	-	kΩ
C_i	input capacitance	f_{CLK} = 80 MHz	D	-	-	2	pF
OTC, SH and $\overline{CE}$ (referenced to DGND); see Tables 8 and 9							
V_{IL}	LOW-level input voltage		I	0	-	0.8	V
V_{IH}	HIGH-level input voltage		I	2.0	-	V_{CCD}	V
I_{IL}	LOW-level input current	V_{IL} = 0.8 V	I	−20	-	-	μA
I_{IH}	HIGH-level input current	V_{IH} = 2.0 V	I	-	-	20	μA
V_I and $\overline{V}_I$ (referenced to AGND); see Table 7							
I_{IL}	LOW-level input current	SH = HIGH	C	-	10	-	μA
I_{IH}	HIGH-level input current	SH = HIGH	C	-	10	-	μA
R_i	input resistance	f_i = 20 MHz	D	-	14	-	MΩ
C_i	input capacitance	f_i = 20 MHz	D	-	450	-	fF
$V_{I(CM)}$	common mode input voltage	$V_I = \overline{V}_I$; output code 2047	C	V_{CCA3} − 1.7	V_{CCA3} − 1.6	V_{CCA3} − 1.2	V
Voltage controlled regulator output CMADC							
$V_{o(CM)}$	common mode output voltage		I	-	V_{CCA3} − 1.6	-	V
I_L	load current		I	-	1	2	mA

9397 750 12338

Product data

Rev. 02 — 20 January 2004

7 of 30

Table 6: **Characteristics**…*continued*

V_{CCA} = 4.75 V to 5.25 V (V_2 to V_{44}, V_3 to V_4 and V_{41} to V_{40}); V_{CCD} = 4.75 V to 5.25 V (V_{37} to V_{38} and V_{15} to V_{17}); V_{CCO} = 3.0 V to 3.6 V (V_{33} to V_{34}); AGND and DGND shorted together; T_{amb} = −40 °C to +85 °C; $V_{i(p-p)}$ − $\overline{V}_{i(p-p)}$ = 1.9 V; V_{ref} = V_{CCA3} − 1.75 V; $V_{I(CM)}$ = V_{CCA3} − 1.6 V; typical values measured at V_{CCA} = V_{CCD} = 5 V, V_{CCO} = 3.3 V, T_{amb} = 25 °C and C_L = 10 pF; unless otherwise specified.

Symbol	Parameter	Conditions	Test[1]	Min	Typ	Max	Unit
Reference voltage input V_{ref}[3]							
V_{ref}	full-scale fixed voltage	f_i = 20 MHz; f_{CLK} = 80 Msps	C	-	V_{CCA3} − 1.75	-	V
I_{ref}	input current at V_{ref}		C	-	0.3	10	µA
$\Delta V_{dif(p-p)}$	differential input voltage (peak-to-peak value)	$\Delta V_{dif(p-p)}$ = $V_{i(p-p)}$ − $\overline{V}_{i(p-p)}$; V_{ref} = V_{CCA3} − 1.75 V; $V_{I(CM)}$ = V_{CCA3} − 1.6 V	C	-	1.9	-	V
Voltage controlled regulator output FS_{ref}							
$V_{o(ref)}$	1.9 V full-scale output voltage		I	-	V_{CCA3} − 1.75	-	V
Outputs (referenced to OGND)							
Digital outputs D11 to D0 and IR (referenced to OGND)							
V_{OL}	LOW-level output voltage	I_{OL} = 2 mA	I	0	-	0.5	V
V_{OH}	HIGH-level output voltage	I_{OH} = −0.4 mA	I	V_{CCO} − 0.5	-	V_{CCO}	V
$I_{o(Z)}$	output current in 3-state	output level between 0.5 V and V_{CCO}	I	−20	-	+20	µA
Switching characteristics							
Clock frequency f_{CLK}; see Figure 3							
$f_{CLK(min)}$	minimum clock frequency	SH = HIGH	C	-	-	7	MHz
$f_{CLK(max)}$	maximum clock frequency						
	TDA8768BH/5		C	52	-	-	MHz
	TDA8768BH/8		I	80	-	-	MHz
	TDA8768BH/8/S1		C	80	-	-	MHz
t_{CLKH}	clock pulse width HIGH	f_i = 20 MHz	C	6	-	-	ns
t_{CLKL}	clock pulse width LOW	f_i = 20 MHz	C	5.6	-	-	ns
Analog signal processing; 50% clock duty factor; V_I − $\overline{V}_I$ = 1.9 V; V_{ref} = V_{CCA3} − 1.75 V; see Table 7							
Linearity							
INL	integral non-linearity	f_{CLK} = 20 MHz; f_i = 400 kHz	I	-	±2.8	4.5	LSB
DNL	differential non-linearity	f_{CLK} = 20 MHz; f_i = 400 kHz (no missing code guaranteed)	I	-	±0.65	+1.1 − 0.95	LSB
ΔV_{err}	offset error voltage	V_{CCA} = V_{CCD} = 5 V; V_{CCO} = 3.3 V; T_{amb} = 25 °C; output code = 2047	C	−25	5	+25	mV
ΔG_E	gain error amplitude; spread from device to device	V_{CCA} = V_{CCD} = 5 V; V_{CCO} = 3.3 V; T_{amb} = 25 °C	C	−7	-	+7	%FS
Bandwidth (f_{CLK} = 80 MHz)[4]							
B	analog bandwidth	−3 dB; full-scale input	C	220	245	-	MHz

Table 6: **Characteristics**…*continued*

V_{CCA} = 4.75 V to 5.25 V (V_2 to V_{44}, V_3 to V_4 and V_{41} to V_{40}); V_{CCD} = 4.75 V to 5.25 V (V_{37} to V_{38} and V_{15} to V_{17}); V_{CCO} = 3.0 V to 3.6 V (V_{33} to V_{34}); AGND and DGND shorted together; T_{amb} = −40 °C to +85 °C; $V_{i(p-p)}$ − $\overline{V}_{i(p-p)}$ = 1.9 V; V_{ref} = V_{CCA3} − 1.75 V; $V_{I(CM)}$ = V_{CCA3} − 1.6 V; typical values measured at V_{CCA} = V_{CCD} = 5 V, V_{CCO} = 3.3 V, T_{amb} = 25 °C and C_L = 10 pF; unless otherwise specified.

Symbol	Parameter	Conditions	Test[1]	Min	Typ	Max	Unit
Harmonics							
H_2	second harmonic TDA8768BH/8 (f_{CLK} = 80 MHz)	f_i = 4.43 MHz	C	-	−74	-	dBFS
		f_i = 10 MHz	C	-	−74	-	dBFS
		f_i = 15 MHz	C	-	−70	-	dBFS
		f_i = 20 MHz	I	-	− 69	-	dBFS
H_3	third harmonic TDA8768BH/8 (f_{CLK} = 80 MHz)	f_i = 4.43 MHz	C	-	−71	-	dBFS
		f_i = 10 MHz	C	-	−71	-	dBFS
		f_i = 15 MHz	C	-	−70	-	dBFS
		f_i = 20 MHz	I	-	−66	-	dBFS
Total harmonic distortion[5]							
THD	total harmonic distortion TDA8768BH/8 (f_{CLK} = 80 MHz)	f_i = 4.43 MHz	C	-	−67	-	dBFS
		f_i = 10 MHz	C	-	−67	-	dBFS
		f_i = 15 MHz	C	-	−66	-	dBFS
		f_i = 20 MHz	I	-	−63	-	dBFS
Thermal noise (f_{CLK} = 80 MHz)							
$N_{th(rms)}$	thermal noise (RMS value)	shorted input; SH = HIGH; f_{CLK} = 80 MHz	C	-	0.45	-	LSB
Signal-to-noise ratio[6]							
S/N	signal-to-noise ratio TDA8768BH/5 (f_{CLK} = 52 MHz)	f_i = 175.4 MHz; B = 200 kHz; −15 dBFS	C	-	71	-	dBFS
	signal-to-noise ratio TDA8768BH/8 (f_{CLK} = 80 MHz)	f_i = 4.43 MHz	C	-	63	-	dBFS
		f_i = 10 MHz	C	-	62	-	dBFS
		f_i = 15 MHz	C	-	62	-	dBFS
		f_i = 20 MHz	I	-	62	-	dBFS
	signal-to-noise ratio TDA8768BH/8/S1 (f_{CLK} = 80 MHz)	f_i = 50 MHz; B = 5 MHz	C	-	64	-	dBFS
Spurious free dynamic range							
SFDR	spurious free dynamic range TDA8768BH/5 (f_{CLK} = 52 MHz)	f_i = 175.4 MHz; B = 200 kHz; −15 dBFS	C	-	83	-	dBFS
	spurious free dynamic range TDA8768BH/8 (f_{CLK} = 80 MHz)	f_i = 4.43 MHz	C	-	69	-	dBFS
		f_i = 10 MHz	C	-	69	-	dBFS
		f_i = 15 MHz	C	-	67	-	dBFS
		f_i = 20 MHz	I	-	65	-	dBFS
	spurious free dynamic range TDA8768BH/8/S1 (f_{CLK} = 80 MHz)	f_i = 50 MHz; B = 5 MHz	C	-	72	-	dBFS

9397 750 12338

Product data **Rev. 02 — 20 January 2004** **9 of 30**

Table 6: **Characteristics**…continued

V_{CCA} = 4.75 V to 5.25 V (V_2 to V_{44}, V_3 to V_4 and V_{41} to V_{40}); V_{CCD} = 4.75 V to 5.25 V (V_{37} to V_{38} and V_{15} to V_{17});
V_{CCO} = 3.0 V to 3.6 V (V_{33} to V_{34}); AGND and DGND shorted together; T_{amb} = −40 °C to +85 °C; $V_{i(p-p)} - \overline{V}_{i(p-p)}$ = 1.9 V;
V_{ref} = V_{CCA3} − 1.75 V; $V_{I(CM)}$ = V_{CCA3} − 1.6 V; typical values measured at V_{CCA} = V_{CCD} = 5 V, V_{CCO} = 3.3 V, T_{amb} = 25 °C and
C_L = 10 pF; unless otherwise specified.

Symbol	Parameter	Conditions	Test[1]	Min	Typ	Max	Unit
Effective number of bits[7]							
ENOB	effective number of bits TDA8768BH/5 (f_{CLK} = 52 MHz)	f_i = 4.43 MHz	C	-	11.7	-	bits
		f_i = 10 MHz	C	-	11.7	-	bits
		f_i = 15 MHz	C	-	11.7	-	bits
		f_i = 20 MHz	C	-	9.6	-	bits
	effective number of bits TDA8768BH/8 (f_{CLK} = 80 MHz)	f_i = 4.43 MHz	C	-	9.8	-	bits
		f_i = 10 MHz	C	-	9.8	-	bits
		f_i = 15 MHz	C	-	9.8	-	bits
		f_i = 20 MHz	I	-	9.6	-	bits
	effective number of bits TDA8768BH/8/S1 (f_{CLK} = 80 MHz)	f_i = 4.43 MHz	C	-	10.4	-	bits
		f_i = 10 MHz	C	-	10.4	-	bits
		f_i = 15 MHz	C	-	10.4	-	bits
Intermodulation; (f_{CLK} = 55 MHz; f_i = 20 MHz)[8]							
TTIR	two-tone intermodulation rejection	f_{CLK} = 80 MHz at −7 dBFS	C	-	−62	-	dB
d_3	third-order intermodulation distortion	f_{CLK} = 80 MHz at −7 dBFS	C	-	−67	-	dB
Bit error rate (f_{CLK} = 55 MHz)							
BER	bit error rate	f_i = 20 MHz; V_I = ±16 LSB at code 2047	C	-	10^{-14}	-	times/ sample
Timing (C_L = 10 pF); see **Figure 3**; [9]							
$t_{d(s)}$	sampling delay time		C	-	0.25	1	ns
t_h	output hold time		C	4	6.4	-	ns
t_d	output delay time		C	-	9.0	13	ns
3-state output delay times; see **Figure 4**							
t_{dZH}	enable HIGH		C	-	5.1	9.0	ns
t_{dZL}	enable LOW		C	-	7.0	11	ns
t_{dHZ}	disable HIGH		C	-	9.7	14	ns
t_{dLZ}	disable LOW		C	-	9.5	13	ns

[1] D = guaranteed by design; C = guaranteed by characterization; I = 100% industrially tested.

[2] The circuit has two clock inputs: CLK and $\overline{CLK}$. There are 2 modes of operation:

   a) Differential AC driving mode: When driving the CLK input directly and with any AC signal of minimum 1 V (p-p) and with a DC level of 2.5 V, the sampling takes place at the falling edge of the clock signal. When driving the $\overline{CLK}$ input with the same signal, sampling takes place at the rising edge of the clock signal. It is recommended to decouple the $\overline{CLK}$ or CLK input to DGND via a 100 nF capacitor.

   b) TTL mode: CLK input is at TTL level and sampling is taken on the falling edge of the clock input signal. In this event pin $\overline{CLK}$ has to be connected to ground.

[3] The ADC input range can be adjusted with an external reference voltage connected to pin V_{ref}. This voltage has to be referenced to V_{CCA}; see Figure 8.

[4] The −3 dB analog bandwidth is determined by the 3 dB reduction in the reconstructed output, the input being a full-scale sine wave.

9397 750 12338

Product data **Rev. 02 — 20 January 2004** **10 of 30**

[5]   Total Harmonic Distortion (THD) is obtained with the addition of the first five harmonics:

$$THD = 20 \log \sqrt{\frac{(2nd)^2 + (3rd)^2 + (4th)^2 + (5th)^2 + (6th)^2}{F^2}}$$

where F is the fundamental harmonic referenced at 0 dB for a full-scale sine wave input.

[6]   Signal-to-noise ratio (S/N) takes into account all harmonics above five and noise up to Nyquist frequency.

[7]   Effective number of bits are obtained via a Fast Fourier Transform (FFT). The calculation takes into account all harmonics and noise up to half of the clock frequency (Nyquist frequency). Conversion to SINAD is given by SINAD = ENOB × 6.02 + 1.76 dB.

[8]   Intermodulation measured relative to either tone with analog input frequencies of 20 MHz and 20.1 MHz. The two input signals have the same amplitude and the total amplitude of both signals provides full-scale to the converter (−6 dB below full-scale for each input signal). $d3_{(IM3)}$ is the ratio of the RMS value of either input tone to the RMS value of the worst case 3rd-order intermodulation product.

[9]   Output data acquisition: the output data is available after the maximum delay of t_d; see Figure 3.

Table 7:   Output coding with differential inputs (typical values to AGND); $V_{i(p-p)} - \overline{V}_{i(p-p)}$ = 1.9 V, V_{ref} = V_{CCA3} − 1.75 V

Code	$V_{i(p-p)}$	$\overline{V}_{i(p-p)}$	IR	Binary outputs	Twos complement outputs[1]
				D11 to D0	D11 to D0
Underflow	<3.125	>4.075	0	0 0 0 0 0 0 0 0 0 0 0 0	1 0 0 0 0 0 0 0 0 0 0 0
0	3.125	4.075	1	0 0 0 0 0 0 0 0 0 0 0 0	1 0 0 0 0 0 0 0 0 0 0 0
1	–	–	1	0 0 0 0 0 0 0 0 0 0 0 1	1 0 0 0 0 0 0 0 0 0 0 1
↓	–	–	↓	↓	↓
2047	3.6	3.6	1	0 1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1
↓	–	–	↓	↓	↓
4094	–	–	1	1 1 1 1 1 1 1 1 1 1 1 0	0 1 1 1 1 1 1 1 1 1 1 0
4095	4.075	3.125	1	1 1 1 1 1 1 1 1 1 1 1 1	0 1 1 1 1 1 1 1 1 1 1 1
Overflow	>4.075	<3.125	0	1 1 1 1 1 1 1 1 1 1 1 1	0 1 1 1 1 1 1 1 1 1 1 1

[1]   Twos complement reference is inverted MSB.

Table 8:   Mode selection

OTC	$\overline{CE}$	D0 to D11	IR
0	0	binary	active
1	0	twos complement	active
X[1]	1	high-impedance	inactive

[1]   X = don't care.

Table 9:   Sample-and-hold selection

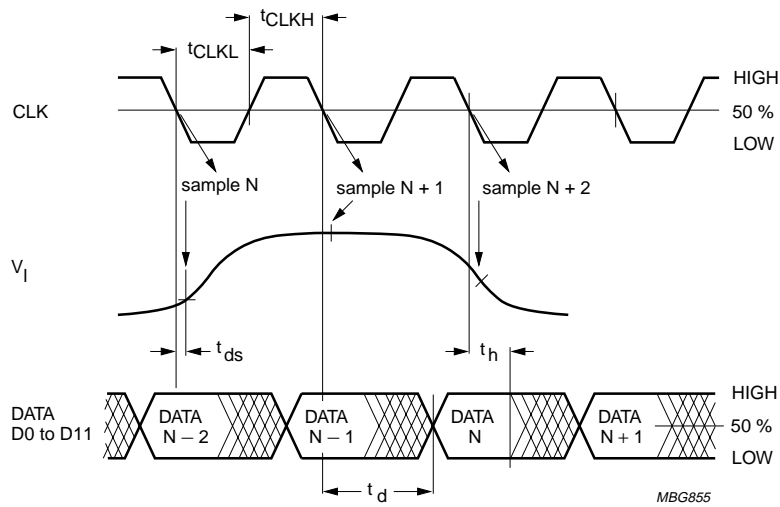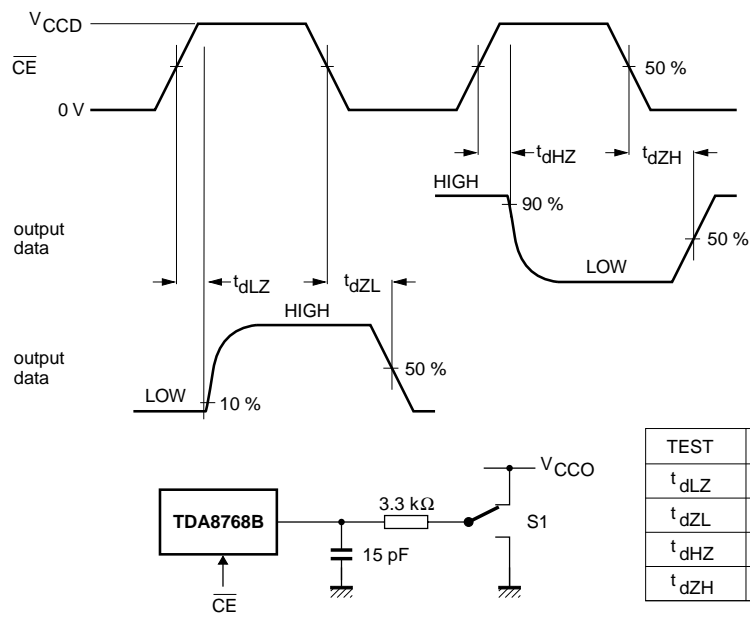| SH	Sample-and-hold
1	active
0	inactive; tracking mode

Fig 3. Timing diagram.

$f_{\overline{CE}}$ = 100 kHz.

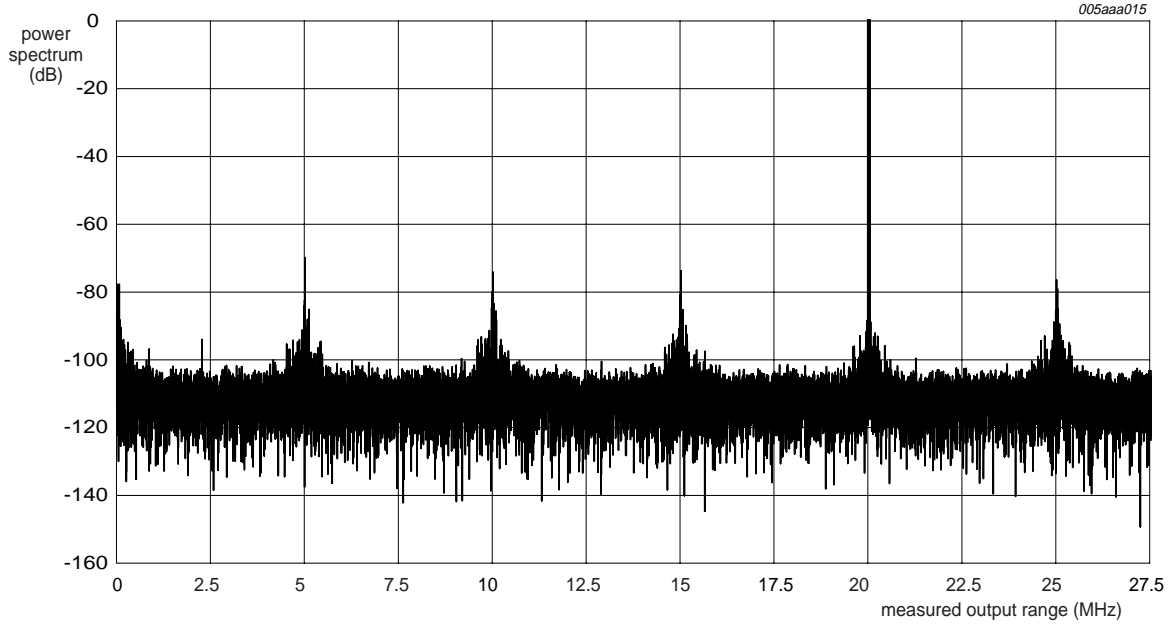**Fig 4. Timing diagram and test conditions of 3-state output delay time.**

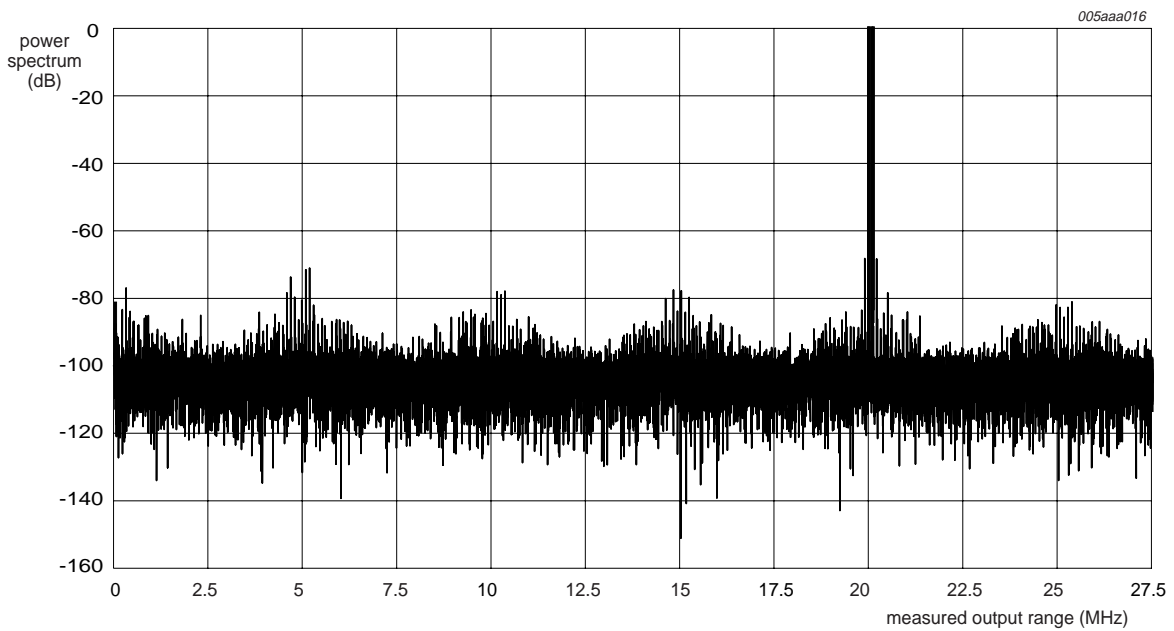**Fig 5.** Single-tone; f_i = 20 MHz; f_{CLK} = 80 Msps.

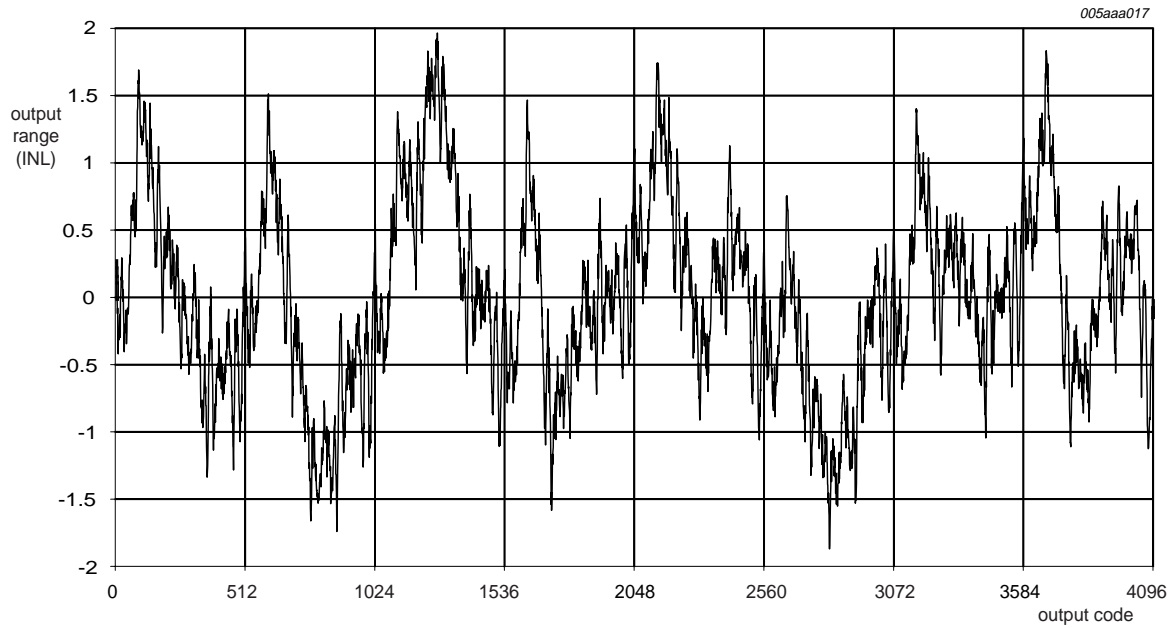**Fig 6.** Two-tone; f_{i1} = 20 MHz; f_{i2} = 20.1 MHz; f_{CLK} = 80 Msps.
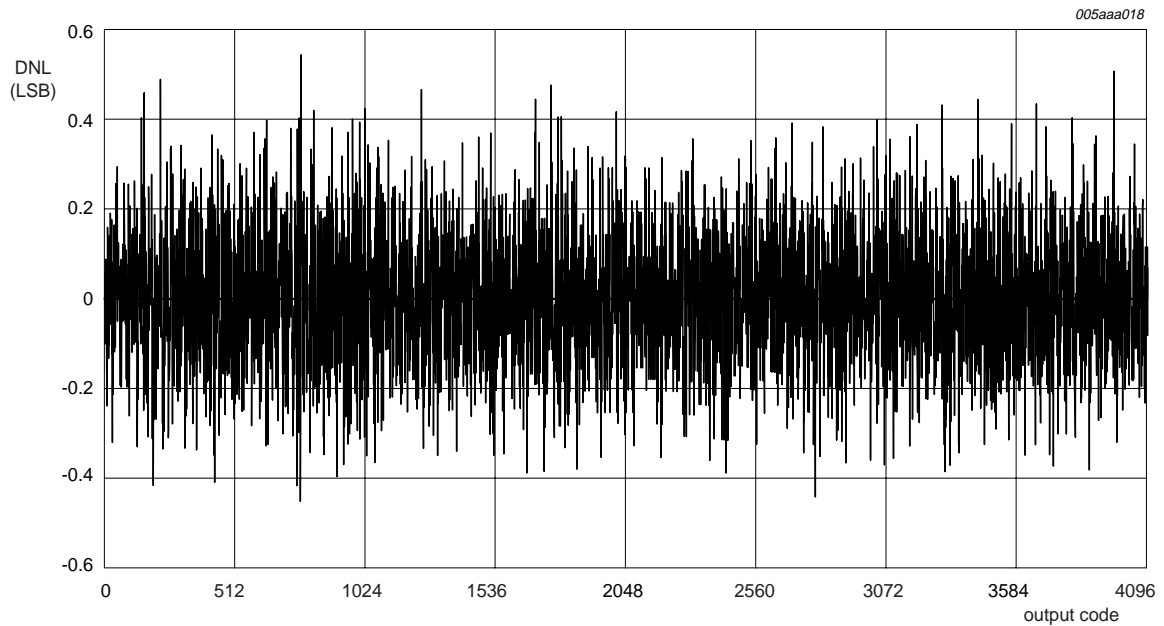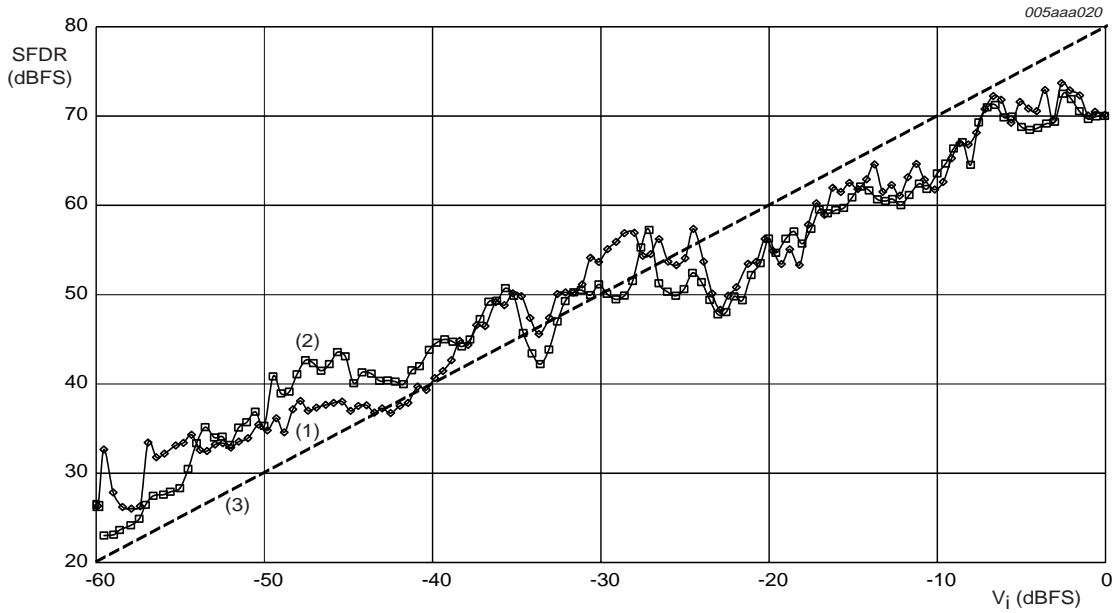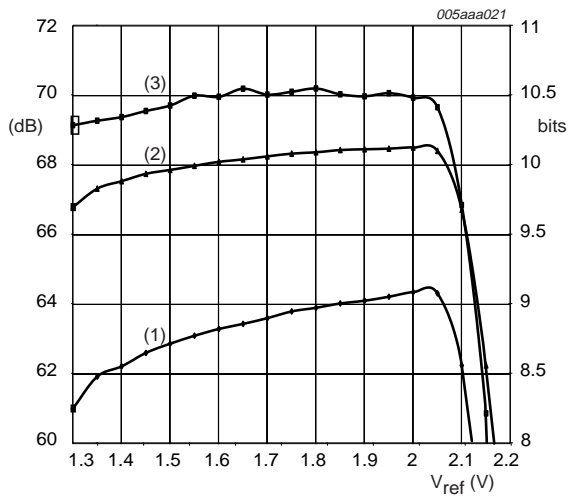
Fig 7.   Integral non-linearity (INL).

Fig 8.   Differential non-linearity (DNL).

(1) f_i = 4.43 MHz

(2) f_i = 20 MHz

(3) SFDR = 80 dB

Fig 9. Spurious free dynamic range (SFDR) as a function of input amplitude; FS_{ref} = 1.9 V; f_{CLK} = 80 MHz.

(1) = S/N

(2) = ENOB

(3) = SFDR

Fig 10. ENOB, SFDR and S/N as a function of V_{ref}; f_{CLK} = 80 MHz; f_i = 4.43 MHz.
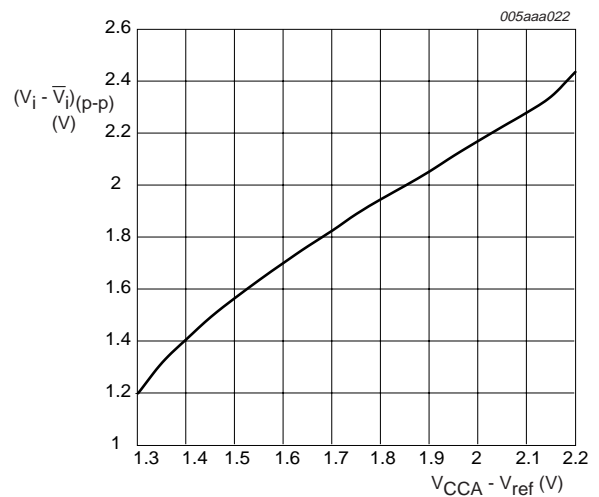
Fig 11. ADC full-scale; $V_{i(p-p)} - \overline{V}_{i(p-p)}$ as a function of $V_{CCA} - V_{ref}$.

11. Application information

11.1 Application diagrams

The analog, digital and output supplies should be separated and decoupled.

Fig 12. Application diagram.

Fig 13. Application diagram for TTL single-ended clock.

11.2 Demonstration board

C8 = close to TR1 pin.

Fig 14. Demonstration board schematic.
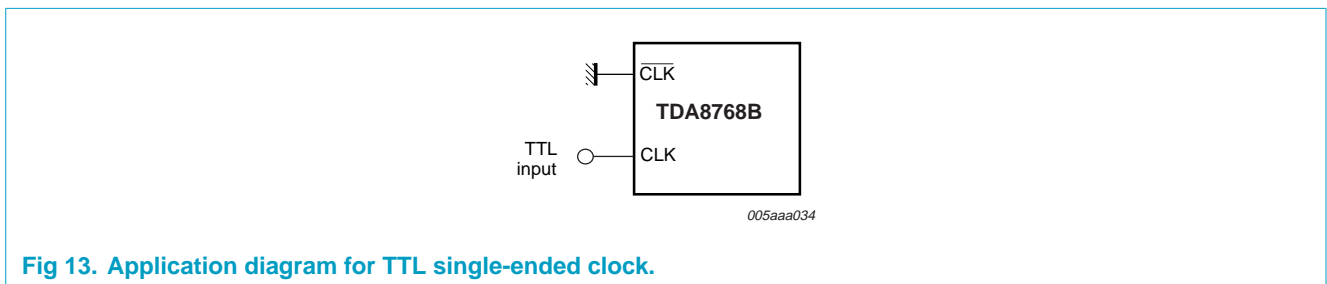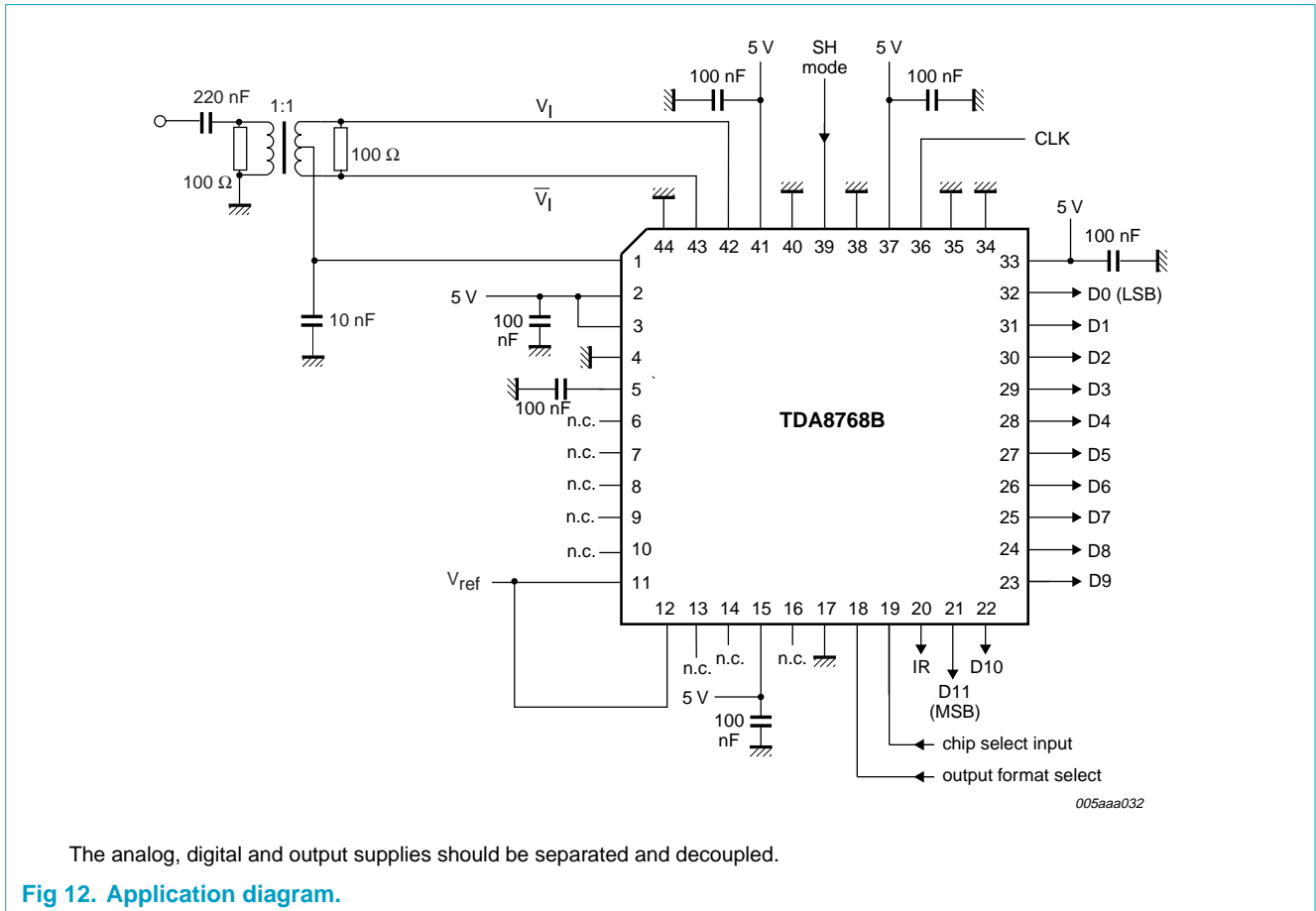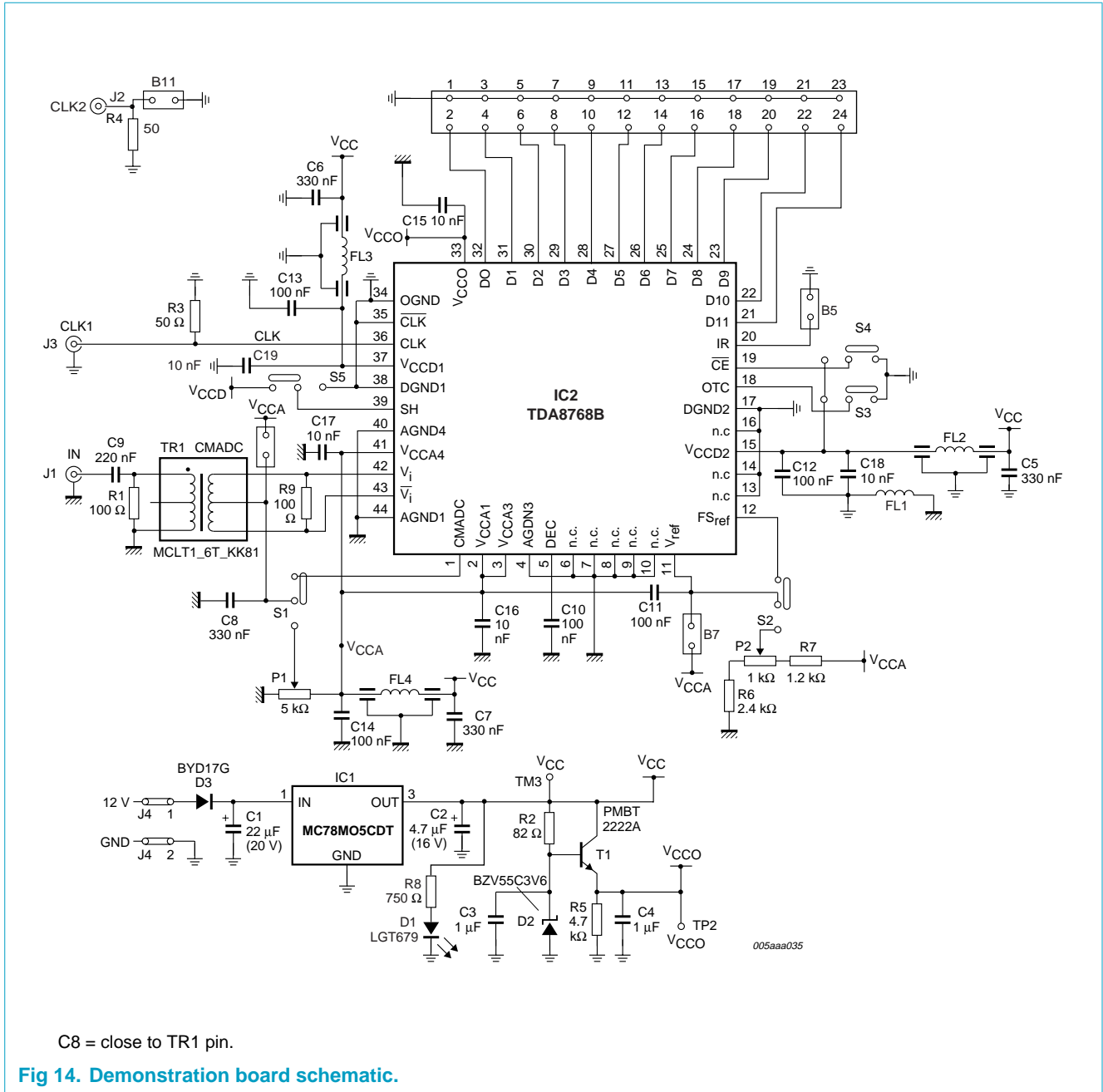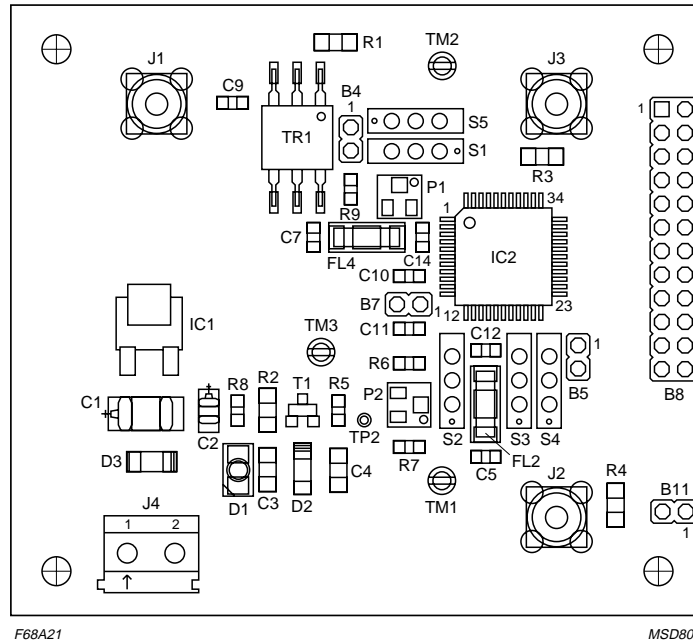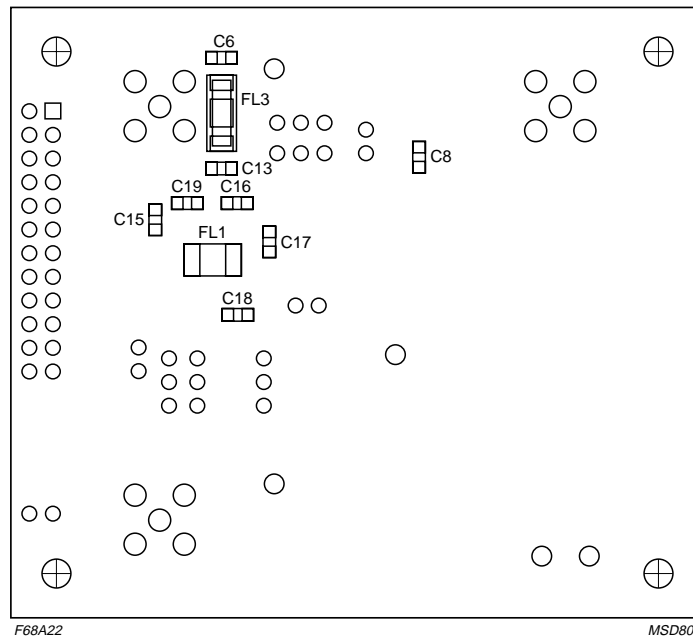
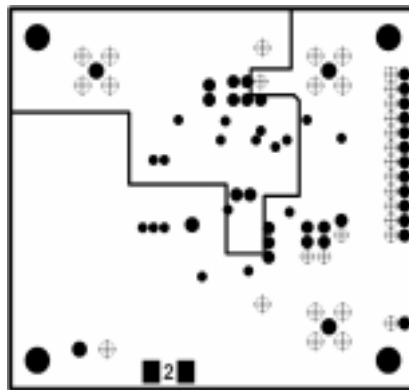**Fig 15. Component placement (top side).**
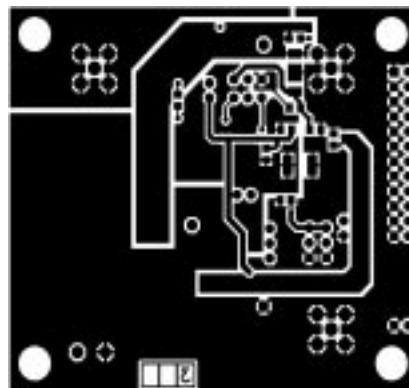

Fig 16. Component placement (underside).
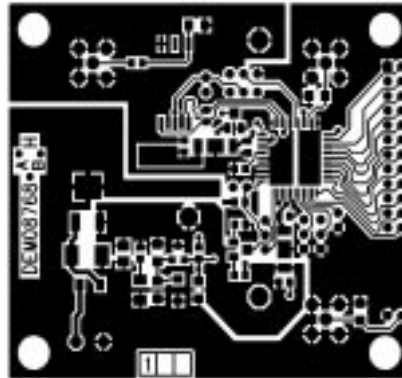
MGU869

Fig 17. PCB layout (top layer).

MGU870

Fig 18. PCB layout (ground layer).

MGU871

Fig 19. PCB layout (power plane).

9397 750 12338

Product data　　　　　　**Rev. 02 — 20 January 2004**　　　　　　**19 of 30**

12. Support information

12.1 Definitions

12.1.1 Non-linearities

Integral Non-Linearity (INL): It is defined as the deviation of the transfer function from a best fit straight line (linear regression computation). The INL of the code i is obtained from the equation:

$$INL(i) = \frac{V_{in}(i) - V_{in}(ideal)}{S}$$

where

$$i = 0 \cdot (2^n - 1) \text{ and}$$

S = slope of the ideal straight line = code width; i = code value.

Differential Non-Linearity (DNL): It is the deviation in code width from the value of 1 LSB.

$$DNL(i) = \frac{V_{in}(i+1) - V_{in}(i)}{S} - 1$$

where

$$i = 0 \cdot (2^n - 2)$$

12.1.2 Dynamic parameters (single tone)

Figure 20 shows the spectrum of a full-scale input sine wave with frequency f_t, conforming to coherent sampling (f_t/f_s = M/N, where M is the number of cycles and N is number of samples, M and N being relatively prime), and digitized by the ADC under test.
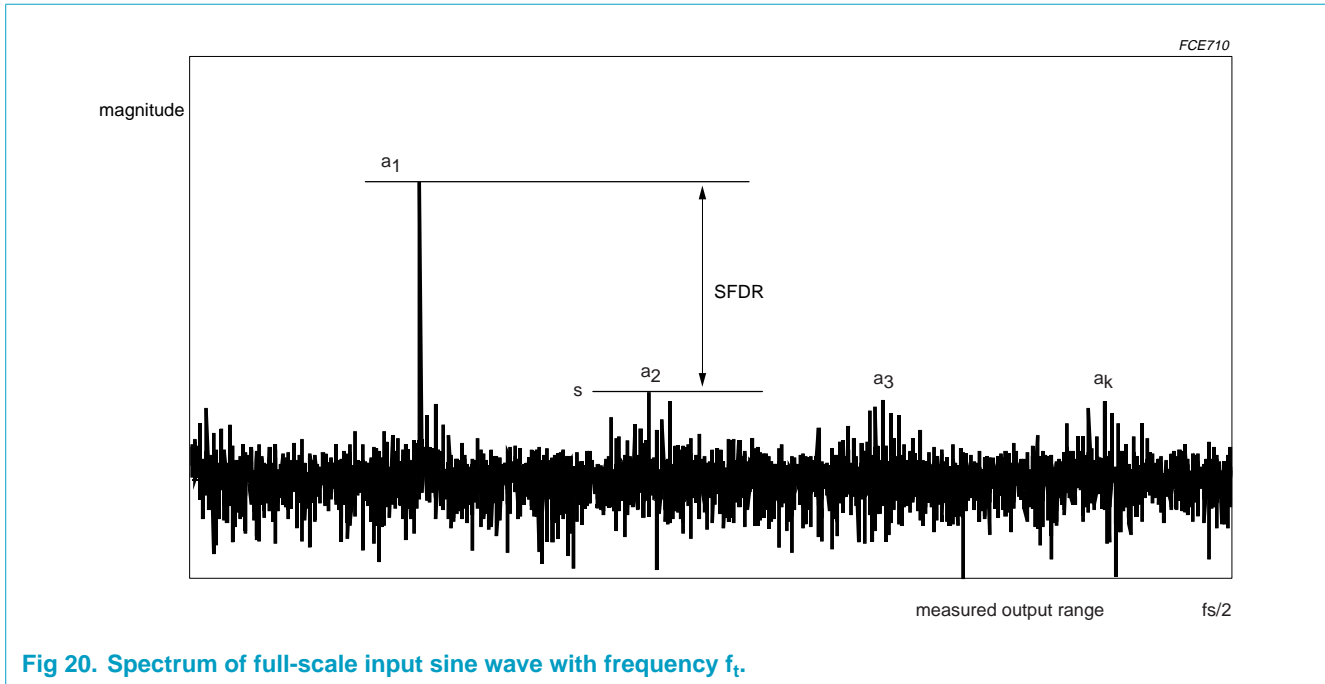
Fig 20. Spectrum of full-scale input sine wave with frequency f_t.

Remark: In the following equations, P_{noise} is the power of the terms which include the effects of random noise, non-linearities, sampling time errors, and "quantization noise".

Signal-to-noise and distortion (SINAD): The ratio of the output signal power to the noise plus distortion power for a given sample rate and input frequency, excluding the DC component:

$$SINAD[db] = 10log\left[\frac{P_{signal}}{P_{noise+distortion}}\right]$$

Effective Number of Bits (ENOB): It is derived from SINAD and gives the theoretical resolution an ideal ADC would require to obtain the same SINAD measured on the real ADC. A good approximation gives:

$$ENOB = (SINAD[dB] - (1 \cdot 76))/(6 \cdot 02)$$

Total Harmonic Distortion (THD): The ratio of the power of the harmonics to the power of the fundamental. For k-1 harmonics the THD is:

$$THD[dB] = 10log\left[\frac{P_{harmonics}}{P_{signal}}\right]$$

where

$$P_{harmonics} = a\Big|_2^2 + a\Big|_3^2 + a\Big|_k^2$$

$$P_{signal} = a\Big|_1^2$$

The value of k is usually 6 (i.e. calculation of THD is done on the first 5 harmonics).

Signal-to-Noise Ratio (S/N): The ratio of the output signal power to the noise power, excluding the harmonics and the DC component. The formula is as follows:

$$SNR[dB] = 10log\left[\frac{P_{signal}}{P_{noise}}\right]$$

Spurious Free Dynamic Range (SFDR): The number SFDR specifies available signal range as the spectral distance between the amplitude of the fundamental and the amplitude of the largest spurious harmonic and non-harmonic, excluding DC component. The formula is as follows:

$$SFDR[dB] = 20log\frac{a_1}{max(s)}$$

12.1.3 Intermodulation distortion

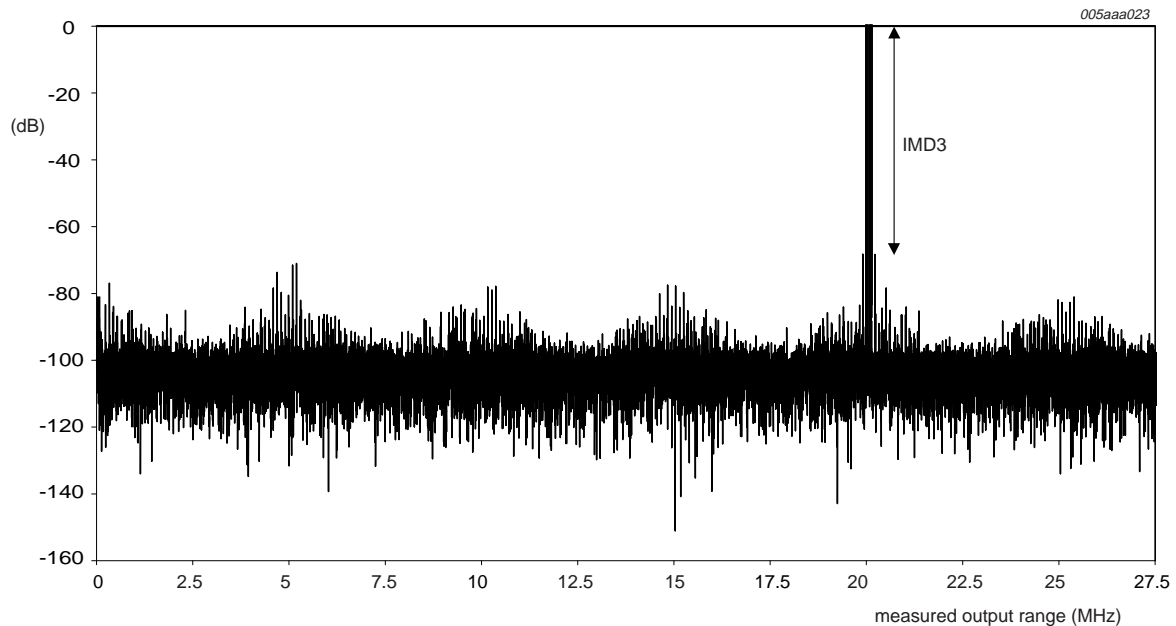**Spectral analysis (dual-tone)**

Fig 21. Spectral analysis (dual-tone)

From a dual-tone input sinusoid (f_{t1} and f_{t2}, these frequencies being chosen according to the coherence criterion), the intermodulation distortion products IMD2 and IMD3 (respectively, 2nd and 3rd-order components) are defined, as follows.

IMD2 (IMD3): The ratio of the RMS value of either tone to the RMS value of the worst second (third) order intermodulation product.

The total intermodulation distortion (IMD) is given by $IMD[dB] = 10log\left[\dfrac{P_{intermod}}{P_{signal}}\right]$

where,

$$P_{intermod} = a|_{im}^2(f_{t1} - f_{t2}) - a|_{im}^2(f_{t1} + f_{t2}) + a|_{im}^2(f_{t1} - 2f_{t2})$$
$$+ a|_{im}^2(f_{t1} + 2f_{t2}) + a|_{im}^2(2f_{t1} - f_{t2}) + a|_{im}^2(2f_{t1} + f_{t2})$$

$$P_{signal} = a^2(f_{t1}) + a^2(f_{t2})$$

and $a|_{im}^2(f_t)$ is the power in the intermodulation component at frequency f_t

12.1.4　Noise Power Ratio (NPR)

When using a notch-filtered broadband white-noise generator as the input to the ADC under test, the Noise Power Ratio is defined as the ratio of the average out-of-notch to the in-notch power spectral density magnitudes for the FFT spectrum of the ADC output sample set.

13. Package outline

QFP44: plastic quad flat package; 44 leads (lead length 1.3 mm); body 10 x 10 x 1.75 mm   **SOT307-2**
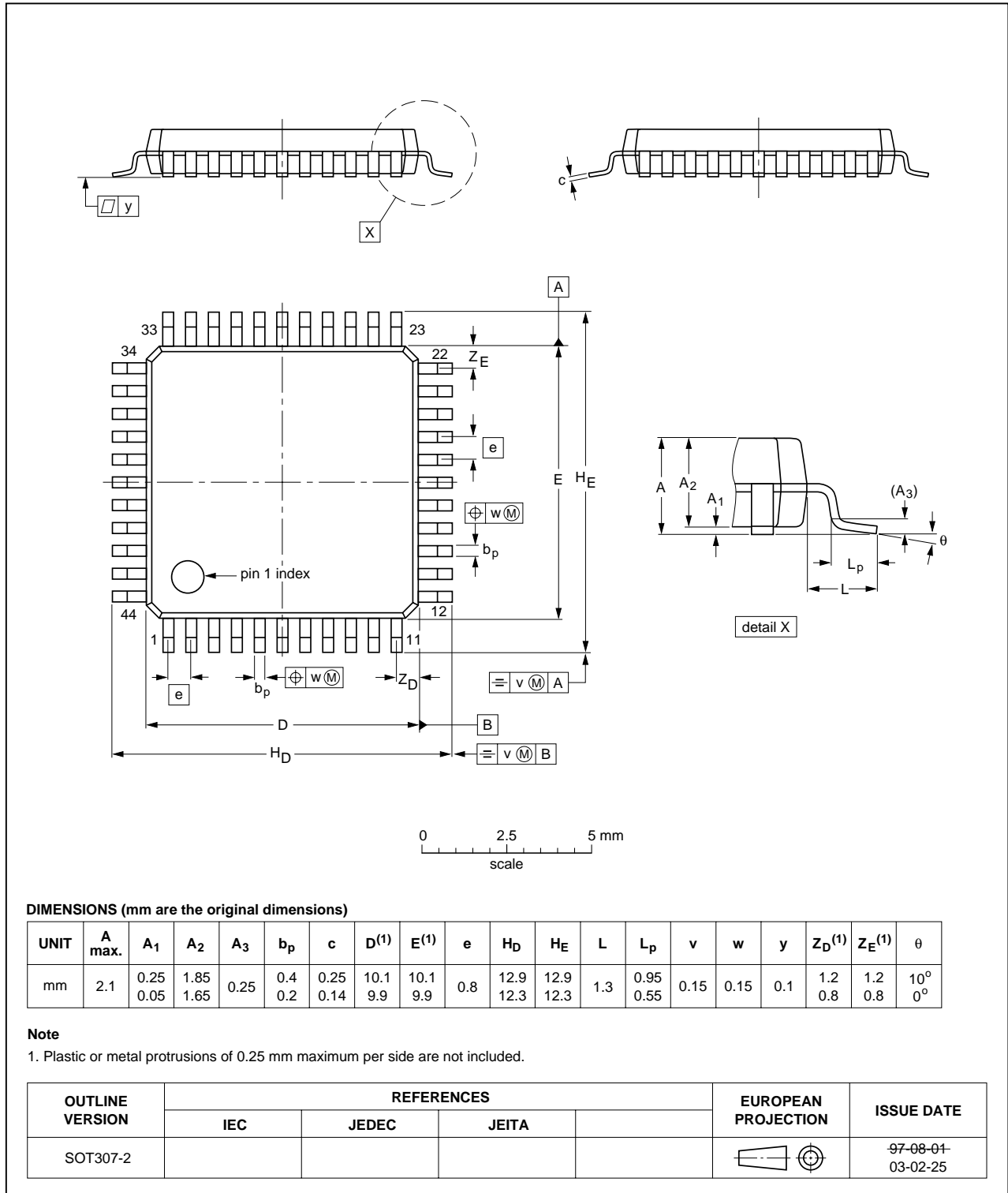

DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A₁	A₂	A₃	bₚ	c	D(1)	E(1)	e	H_D	H_E	L	Lₚ	v	w	y	Z_D(1)	Z_E(1)	θ
mm	2.1	0.25 / 0.05	1.85 / 1.65	0.25	0.4 / 0.2	0.25 / 0.14	10.1 / 9.9	10.1 / 9.9	0.8	12.9 / 12.3	12.9 / 12.3	1.3	0.95 / 0.55	0.15	0.15	0.1	1.2 / 0.8	1.2 / 0.8	10° / 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	JEITA			
SOT307-2						~~97-08-01~~ 03-02-25

Fig 22. SOT307-2.

9397 750 12338

Product data   **Rev. 02 — 20 January 2004**   **24 of 30**

14. Handling information

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

15. Soldering

15.1 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 can still be used for certain surface mount ICs, but it is not suitable for fine pitch SMDs. In these situations reflow soldering is recommended. In these situations reflow soldering is recommended.

15.2 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. Driven by legislation and environmental forces the worldwide use of lead-free solder pastes is increasing.

Several methods exist for reflowing; for example, convection or convection/infrared 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 270 °C depending on solder paste material. The top-surface temperature of the packages should preferably be kept:

- below 225 °C (SnPb process) or below 245 °C (Pb-free process)
  - for all BGA, HTSSON..T and SSOP..T packages
  - for packages with a thickness $\geq$ 2.5 mm
  - for packages with a thickness < 2.5 mm and a volume $\geq$ 350 mm^3 so called thick/large packages.
- below 240 °C (SnPb process) or below 260 °C (Pb-free process) for packages with a thickness < 2.5 mm and a volume < 350 mm^3 so called small/thin packages.

Moisture sensitivity precautions, as indicated on packing, must be respected at all times.

15.3 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 of the leads in the wave ranges from 3 to 4 seconds at 250 °C or 265 °C, depending on solder material applied, SnPb or Pb-free respectively.

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

15.4 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.

15.5 Package related soldering information

Table 10: **Suitability of surface mount IC packages for wave and reflow soldering methods**

Package[1]	Soldering method	
	Wave	**Reflow**[2]
BGA, HTSSON..T[3], LBGA, LFBGA, SQFP, SSOP..T[3], TFBGA, USON, VFBGA	not suitable	suitable
DHVQFN, HBCC, HBGA, HLQFP, HSO, HSOP, HSQFP, HSSON, HTQFP, HTSSOP, HVQFN, HVSON, SMS	not suitable[4]	suitable
PLCC[5], SO, SOJ	suitable	suitable

Table 10: **Suitability of surface mount IC packages for wave and reflow soldering methods**…*continued*

Package[1]	Soldering method	
	Wave	**Reflow**[2]
LQFP, QFP, TQFP	not recommended[5][6]	suitable
SSOP, TSSOP, VSO, VSSOP	not recommended[7]	suitable
CWQCCN..L[8], PMFP[9], WQCCN..L[8]	not suitable	not suitable

[1] For more detailed information on the BGA packages refer to the *(LF)BGA Application Note* (AN01026); order a copy from your Philips Semiconductors sales office.

[2] 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*.

[3] These transparent plastic packages are extremely sensitive to reflow soldering conditions and must on no account be processed through more than one soldering cycle or subjected to infrared reflow soldering with peak temperature exceeding $217\ °C \pm 10\ °C$ measured in the atmosphere of the reflow oven. The package body peak temperature must be kept as low as possible.

[4] These packages are not suitable for wave soldering. On versions with the heatsink on the bottom side, the solder cannot penetrate between the printed-circuit board and the heatsink. On versions with the heatsink on the top side, the solder might be deposited on the heatsink surface.

[5] 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.

[6] Wave soldering is suitable for LQFP, QFP and TQFP packages with a pitch (e) larger than 0.8 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.65 mm.

[7] Wave soldering is suitable for SSOP, TSSOP, VSO and VSOP 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.

[8] Image sensor packages in principle should not be soldered. They are mounted in sockets or delivered pre-mounted on flex foil. However, the image sensor package can be mounted by the client on a flex foil by using a hot bar soldering process. The appropriate soldering profile can be provided on request.

[9] Hot bar soldering or manual soldering is suitable for PMFP packages.

16. Revision history

Table 11: Revision history

Rev	Date	CPCN	Description
02	20040120	-	**Product data (9397 750 12338)**
			Modifications:
			• Section 4: Characteristics changed
			• Section 10: Characteristics changed.
01	20021105	-	**Objective data (9397 750 09958)**

17. Data sheet status

Level	Data sheet status[1]	Product status[2][3]	Definition
I	Objective data	Development	This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.
II	Preliminary data	Qualification	This data sheet contains data from the preliminary specification. Supplementary data will be published at a later date. Philips Semiconductors reserves the right to change the specification without notice, in order to improve the design and supply the best possible product.
III	Product data	Production	This data sheet contains data from the product specification. Philips Semiconductors reserves the right to make changes at any time in order to improve the design, manufacturing and supply. Relevant changes will be communicated via a Customer Product/Process Change Notification (CPCN).

[1]   Please consult the most recently issued data sheet before initiating or completing a design.

[2]   The product status of the device(s) described in this data sheet may have changed since this data sheet was published. The latest information is available on the Internet at URL http://www.semiconductors.philips.com.

[3]   For data sheets describing multiple type numbers, the highest-level product status determines the data sheet status.

18. Definitions

Short-form specification — The data in a short-form specification is extracted from a full data sheet with the same type number and title. For detailed information see the relevant data sheet or data handbook.

Limiting values definition — 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 — Applications that are described herein for any of these products are for illustrative purposes only. Philips Semiconductors make no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

19. Disclaimers

Life support — 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 Semiconductors customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Philips Semiconductors for any damages resulting from such application.

Right to make changes — Philips Semiconductors reserves the right to make changes in the products - including circuits, standard cells, and/or software - described or contained herein in order to improve design and/or performance. When the product is in full production (status 'Production'), relevant changes will be communicated via a Customer Product/Process Change Notification (CPCN). Philips Semiconductors assumes no responsibility or liability for the use of any of these products, conveys no licence or title under any patent, copyright, or mask work right to these products, and makes no representations or warranties that these products are free from patent, copyright, or mask work right infringement, unless otherwise specified.

Contact information

For additional information, please visit **http://www.semiconductors.philips.com**.

For sales office addresses, send e-mail to: **sales.addresses@www.semiconductors.philips.com**.

Fax: +31 40 27 24825

9397 750 12338

Contents

PHILIPS

Let's make things better.