DATA SHEET

OQ8844
Digital Servo Driver (DSD-2)

Product specification

File under Integrated Circuits, IC01

1995 Nov 27

Philips
Semiconductors

PHILIPS

Digital Servo Driver (DSD-2)   OQ8844

FEATURES

Servo functions

- 1-bit class-D focus actuator driver (3.3 Ω)
- 1-bit class-D radial actuator driver (3.7 Ω)
- 1-bit class-D sledge motor driver (2.5 Ω).

Other features

- Supply voltage 5 V only
- Small package (SOT163-1)
- Higher efficiency, compared with conventional drivers, due to the class-D principle
- Built-in digital notch filters for higher efficiency
- Enable input for focus and radial driver
- Enable input for sledge driver
- Differential outputs for all drivers
- Separate power supply pins for all drivers.

GENERAL DESCRIPTION

The OQ8844 or Digital Servo Driver 2 (DSD2) consists of 1-bit class-D power drivers, which are specially designed for digital servo applications. Three such amplifiers are integrated in one chip, to drive the focus and radial actuators and the sledge motor of a compact disc optical system.

The main benefits of using this principle are its higher efficiency grade compared to conventional analog power amplifiers, its higher integration level, its differential output and the fact that only a few external components are needed. When using these digital power drivers in a digital servo application, the statement 'complete digital servo loop' becomes more realistic.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{DDD}	digital supply voltage	4.5	–	5.5	V
$V_{DD(F)}$	supply voltage focus actuator	4.5	–	5.5	V
$V_{DD(R)}$	supply voltage radial actuator	4.5	–	5.5	V
$V_{DD(S)}$	supply voltage sledge actuator	4.5	–	5.5	V
I_{DDDq}	quiescent supply current digital part	–	–	10	μA
$I_{DD(F)}$	supply current focus	–	126	250	mA
$I_{DD(R)}$	supply current radial	–	20	250	mA
$I_{DD(S)}$	supply current sledge	–	150	560	mA
$f_{i(clk)}$	input clock frequency	–	4.2336	5	MHz
P_{tot}	total power dissipation	–	110	–	mW
T_{amb}	operating ambient temperature	–40	–	+85	°C

ORDERING INFORMATION

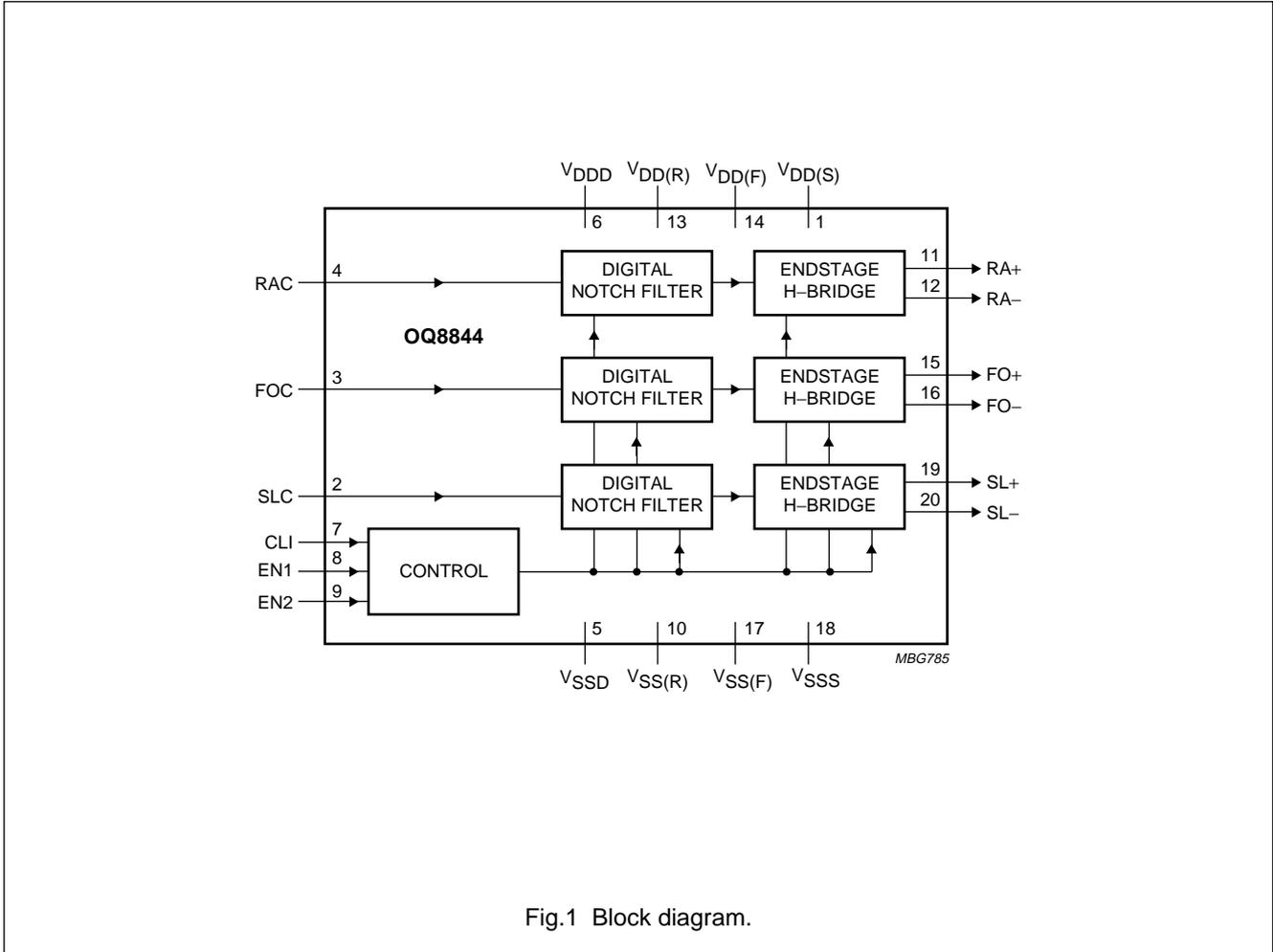| TYPE NUMBER	PACKAGE		
	NAME	DESCRIPTION	VERSION
OQ8844	SO20	plastic small outline package; 20 leads; body width 7.5 mm	SOT163-1

Digital Servo Driver (DSD-2)

OQ8844

BLOCK DIAGRAM

Fig.1 Block diagram.

Digital Servo Driver (DSD-2)

OQ8844

PINNING

| SYMBOL	PIN	DESCRIPTION
$V_{DD(S)}$	1	supply voltage for sledge motor driver
SLC	2	PDM input for sledge driver
FOC	3	PDM input for focus driver
RAC	4	PDM input for radial driver
V_{SSD}	5	digital ground
V_{DDD}	6	digital supply voltage
CLI	7	clock input
EN1	8	enable input 1
EN2	9	enable input 2
$V_{SS(R)}$	10	radial driver ground
RA+	11	radial driver (positive output)
RA−	12	radial driver (negative output)
$V_{DD(R)}$	13	radial supply voltage
$V_{DD(F)}$	14	focus supply voltage
FO+	15	focus driver (positive output)
FO−	16	focus driver (negative output)
$V_{SS(F)}$	17	focus ground
V_{SSS}	18	sledge driver ground
SL+	19	sledge driver (positive output)
SL−	20	sledge driver (negative output)
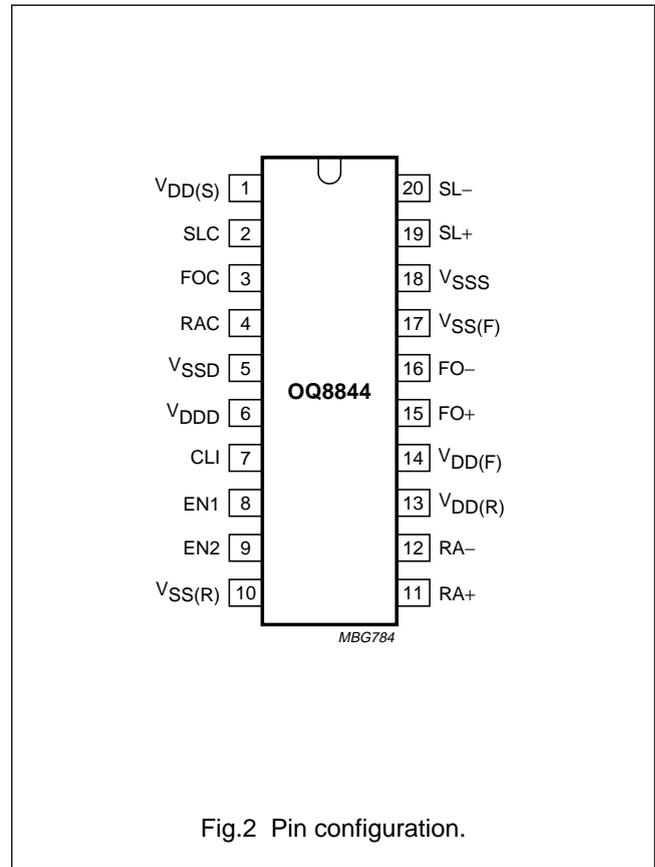
Fig.2 Pin configuration.

Digital Servo Driver (DSD-2) OQ8844

FUNCTIONAL DESCRIPTION

Principle of a class-D digital power driver

Figure 3 shows the block diagram of one of the digital drivers integrated in the DSD2. It consists of a timing block and four CMOS switches. The input signal is a 1-bit Pulse Density Modulated (PDM) signal, the output of the digital servo ICs.

The maximum operating clock frequency of the device is 5 MHz. With the mentioned digital servo ICs, the operating frequency of the digital drivers is 4.2336 MHz (96×44.1 kHz). The sampling frequency of the 1-bit code however is 1.0584 MHz, so internally in the DSD2 the clock speed of the switches will be 1.0584 MHz. The higher input clock frequency is used to make non-overlapping pulses to prevent short-circuits between the supply voltages. For the control of the switches, two states can be distinguished. If the 1-bit code contains a logic 1, switches A and D are closed and current will flow in the direction as shown in Fig.4.

If the 1-bit code contains a logic 0, switches B and C are closed and current will flow in the opposite direction, as shown in Fig.5.

This indicates that the difference between the mean number of ones and zeros in the PDM signal determines the direction in which the actuator or motor will rotate.

If the mean number of ones and zeros is equal (Idle mode) the current through the motor or actuator is alternated between the positive and negative direction at a speed of half the sample frequency of 1.0584 MHz. This results in a high dissipation and the motor does not move.

To improve the efficiency, a digital notch filter is added at the input of the digital drivers. This filters the Idle mode pattern (1010101010 etc.) see Fig.6.
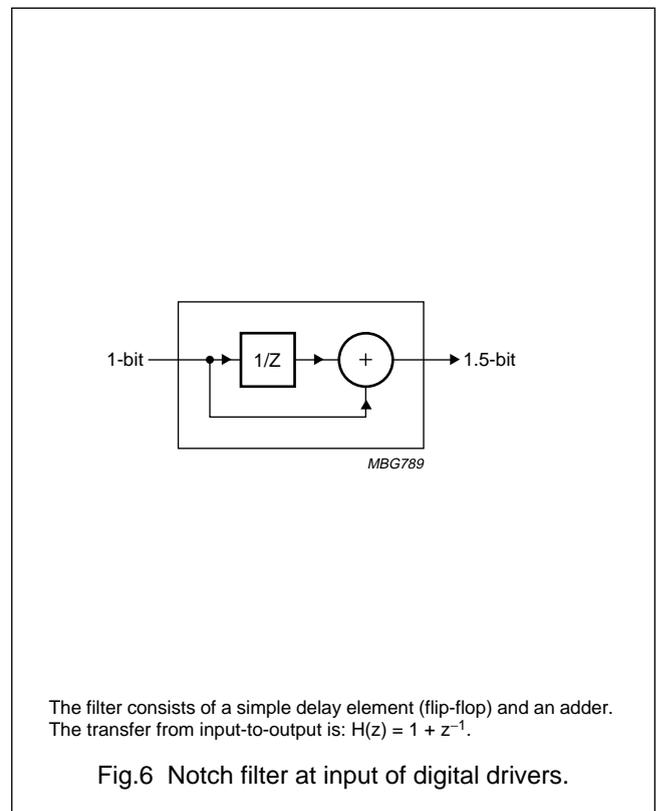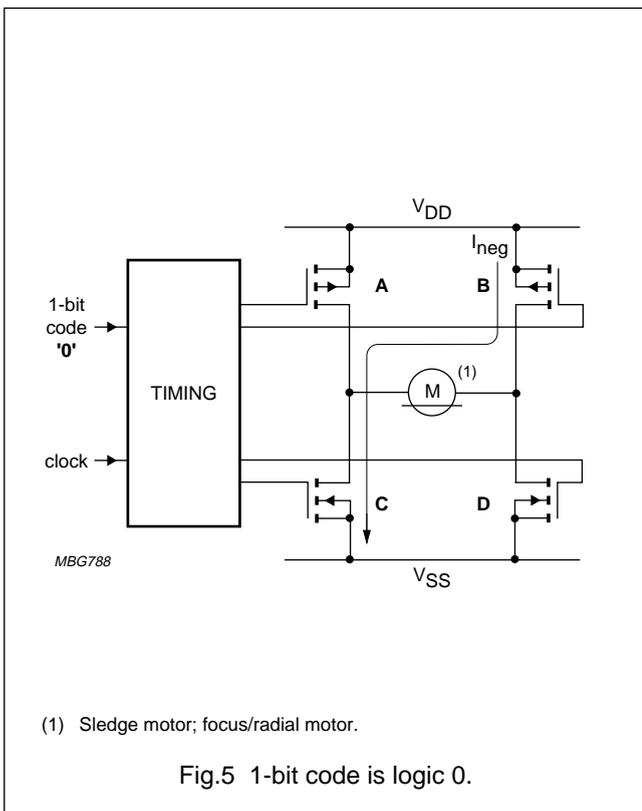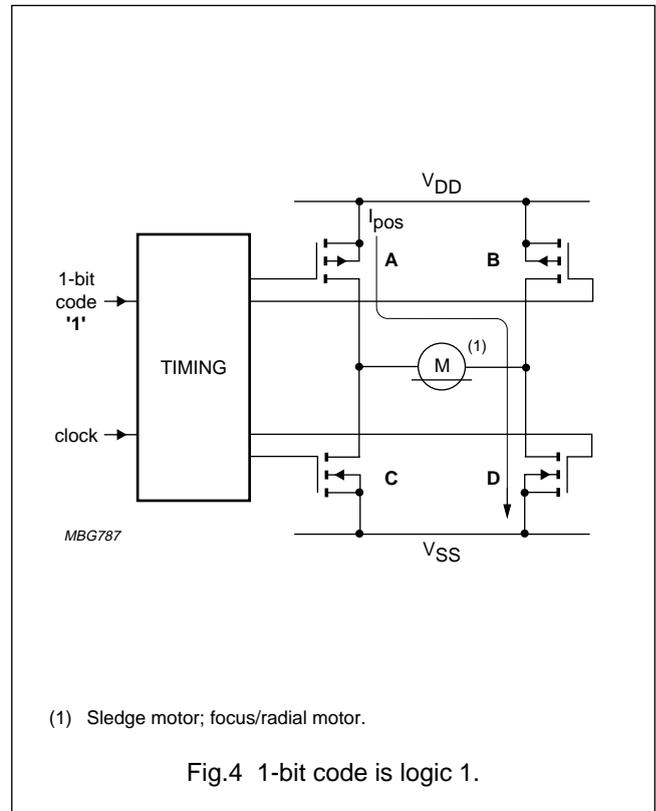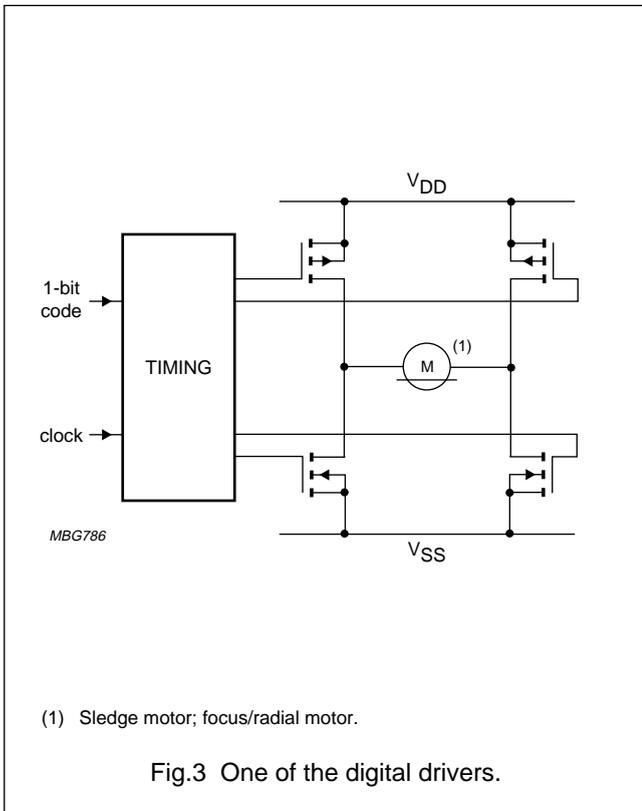
The amplitude transfer as a function of frequency is given in Fig.7.

Figure 7 shows that the filter has a zero on $\frac{1}{2}f_s$, consequentially filtering out the idle pattern (101010). The output of this filter is a three-level code (1.5-bit). For the control of the switches three states (1.5-bit) can be distinguished: the two states as described earlier and a third one. This state is used when an idling pattern is supplied.

Switches C and D are closed (see Fig.8). In this idle mode, no current will flow and thus the efficiency will be improved. This mode is also used to short-circuit the inductive actuator/motor. In this way, high induction voltages are prevented because the current can commutate via the filter and the short-circuit in the switches. All three drivers (radial, focus and sledge) contain a digital notch filter as described. Each driver has its own power supply pins to reduce crosstalk because of the relative high current flowing through the pins.

Digital Servo Driver (DSD-2)

OQ8844

MBG786

(1) Sledge motor; focus/radial motor.

Fig.3 One of the digital drivers.

MBG787

(1) Sledge motor; focus/radial motor.

Fig.4 1-bit code is logic 1.

MBG788

(1) Sledge motor; focus/radial motor.

Fig.5 1-bit code is logic 0.

MBG789

The filter consists of a simple delay element (flip-flop) and an adder. The transfer from input-to-output is: $H(z) = 1 + z^{-1}$.

Fig.6 Notch filter at input of digital drivers.

Digital Servo Driver (DSD-2)

OQ8844

Fig.7 Amplitude transfer.

(1) Sledge motor; focus/radial motor.

Fig.8 Idling pattern.

Switches

The digital part of the power drivers consists of standard cells. The power switches are specifically designed for CD applications. The most important feature is their on-resistance. In the applications, they have to drive very low-ohmic actuators and/or motors. The switches are designed to have an on-resistance of 2 Ω for the actuator drivers and 1 Ω for the sledge motor driver. In any mode, there are always two switches in series with the actuator/motor. The total loss due to the switches is 4 Ω for the actuators and 2 Ω for the sledge motor.

Timing of input and output signals

All internal timing signals are derived from the externally supplied CLI signal.

Sampling of the data inputs (SLC, FOC and RAC) occurs at a frequency of $\frac{1}{4}$CL. For each channel, the clocking-in occurs at a different positive edge of CLI. Because there are only 3 channels, and the clock frequency CLI is divided-by-4, only 3 out of 4 positive edges are effective for sampling one of the inputs.

The switching of the outputs occurs in a similar way, except that in this event the negative edge of CLI is used. In this way, the input signals are immune to the noise radiated by the switching of the outputs. It is possible that an output transition will have a noticeable effect on the power supply voltage or the ground voltage. To avoid simultaneous transitions of all outputs, the outputs of each bridge are also clocked at a different phase of CLI. Consequentially there are only 3 out of 4 negative edges effective.

To reset the circuit, both the reset condition and the clock should be present, because all flip-flops are reset synchronously. The clock signal is also required to obtain one of the possible modes of operation indicated in Table 1.

Digital Servo Driver (DSD-2)

OQ8844

Table 1 Possible modes of operation

EN1	EN2	SLEDGE DRIVER	FOCUS/RADIAL DRIVER	MODE
0	0	off	off	standby
0	1	off	on	partly operating
1	0	off	off	reset
1	1	on	on	operating

The timing diagram as shown in Fig.9 gives the relation between the different clocks.

The negative edge of the signals called nc10 to nc12 is used to process the incoming data (see Table 2).

The negative edge of all signals called c10s to c12s is used to trigger the outputs (see Table 2).

Table 2 Signals nc10 to nc12 and c10s to c12s

SIGNAL	DESCRIPTION
ncl0	sledge input sampling clock
ncl1	focus input sampling clock
ncl2	radial input sampling clock
cl0s	sledge output trigger clock
cl1s	focus output trigger clock
cl2s	radial output trigger clock

LIMITING VALUES

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

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
V_{DDD}	digital supply voltage	−0.5	+6.5	V
V_{DDA}	analog supply voltage	−0.5	+6.5	V
$V_{SSD} - V_{SSA}$	ground supply voltage difference	−5	+5	mV
P_{tot}	total power dissipation	−	730	mW
T_{stg}	storage temperature	−55	+150	°C
T_{amb}	operating ambient temperature	−40	+85	°C

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	VALUE	UNIT
$R_{th\,j-a}$	thermal resistance from junction to ambient in free air	75	K/W

Digital Servo Driver (DSD-2)   OQ8844

CHARACTERISTICS

V_{DDD} = V_{DDA} = 5 V; V_{SSD} = V_{SSA} = 0 V; T_{amb} = 25 °C; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V_{DDD}	supply voltage digital part		4.5	–	5.5	V
V_{DDA}	supply voltage analog part		4.5	–	5.5	V
I_{DDDq}	quiescent supply current digital part		–	–	10	µA
$I_{DD(F)max}$	maximum supply current focus	note 1	–	126	250	mA
$I_{DD(R)max}$	maximum supply current radial	note 1	–	20	250	mA
$I_{DD(S)max}$	maximum supply current sledge	note 1	–	150	560	mA
$f_{i(clk)}$	input clock frequency		–	4.2336	5	MHz
P_{tot}	totalpower dissipation		–	110	–	mW
T_{amb}	operating ambient temperature		–40	–	+85	°C
Digital inputs; SLC, FOC, RAC, CLI, EN1 and EN2						
V_{IL}	LOW level input voltage	T_{amb} = –40 to 85 °C	–	–	$0.2V_{DDD}$	V
V_{IH}	HIGH level input voltage	T_{amb} = –40 to 85 °C	$0.8V_{DDD}$	–	–	V
I_{LI}	input leakage current		–	–	1	µA
Clock input; CLI						
f_{clk}	clock frequency		–	4.2336	5	MHz
Analog outputs; FO+ and FO–						
I_O	output current		–	–	250	mA
R_O	output resistance	note 2	–	3.3	4.1	Ω
Analog outputs; RA+ and RA–						
I_O	output current		–	–	250	mA
R_O	output resistance	note 2	–	3.7	4.6	Ω
Analog outputs; SL+ and SL–						
I_O	output current		–	–	560	mA
R_O	output resistance	note 2	–	2.5	3.1	Ω

Notes

1. Maximum supply current depends on the value of R_L: $I_{max} = \dfrac{V_{DDA\,max}}{(R_O + R_L)}$

2. Output resistance is defined as the series resistance of the complete bridge.

Digital Servo Driver (DSD-2)

OQ8844

Timing diagram

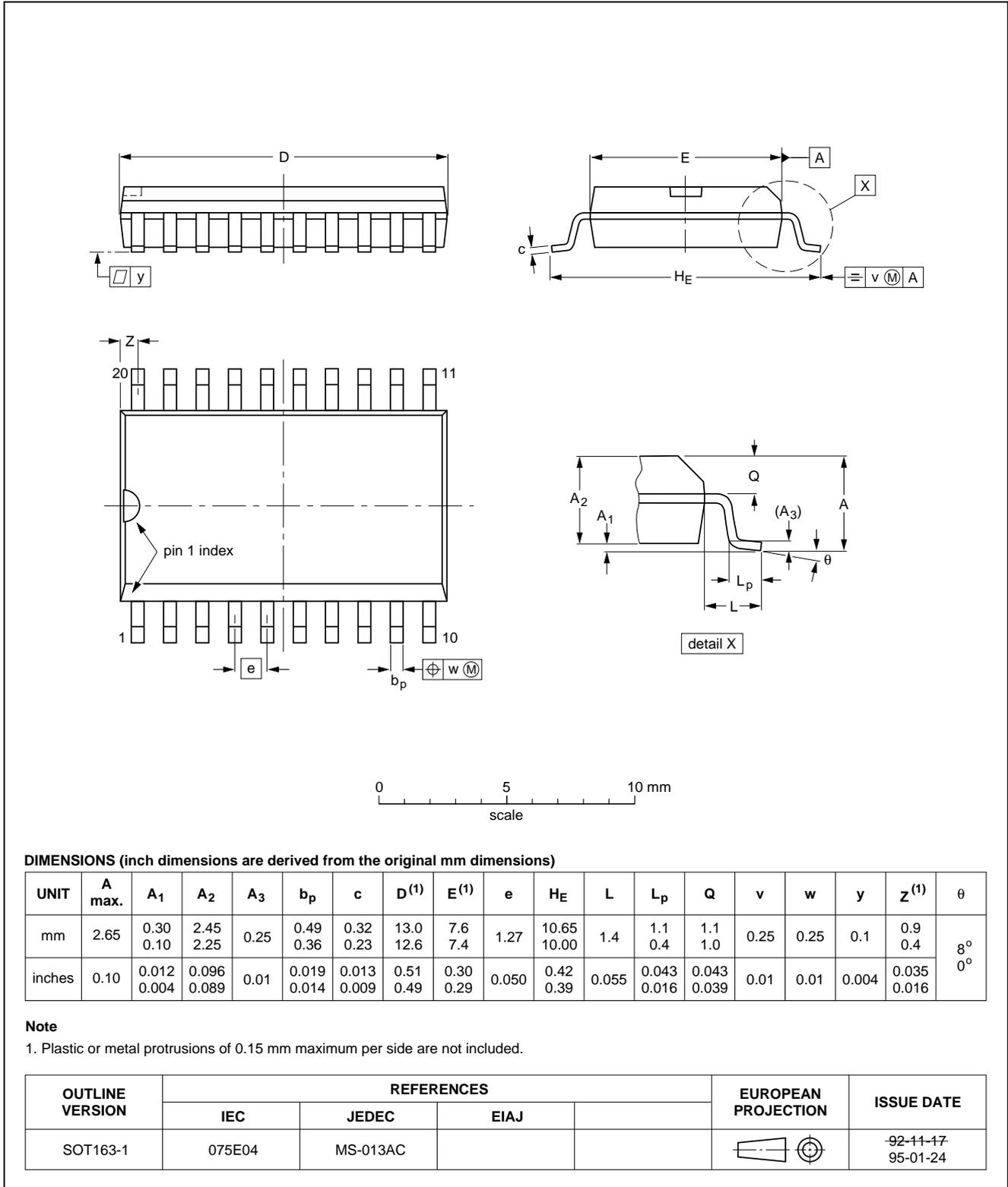Fig.9 Timing diagram.

Sampling of the incoming data is marked by a '*'.

Digital Servo Driver (DSD-2)

OQ8844

PACKAGE OUTLINE

SO20: plastic small outline package; 20 leads; body width 7.5 mm

SOT163-1

0   5   10 mm

scale

DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A$_1$	A$_2$	A$_3$	b$_p$	c	D[1]	E[1]	e	H$_E$	L	L$_p$	Q	v	w	y	Z[1]	θ
mm	2.65	0.30 0.10	2.45 2.25	0.25	0.49 0.36	0.32 0.23	13.0 12.6	7.6 7.4	1.27	10.65 10.00	1.4	1.1 0.4	1.1 1.0	0.25	0.25	0.1	0.9 0.4	8° 0°
inches	0.10	0.012 0.004	0.096 0.089	0.01	0.019 0.014	0.013 0.009	0.51 0.49	0.30 0.29	0.050	0.42 0.39	0.055	0.043 0.016	0.043 0.039	0.01	0.01	0.004	0.035 0.016	

Note

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT163-1	075E04	MS-013AC				~~92-11-17~~ 95-01-24

Digital Servo Driver (DSD-2)   OQ8844

SOLDERING

Introduction

There is no soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and surface mounted components are mixed on one printed-circuit board. However, wave soldering is not always suitable for surface mounted ICs, or for printed-circuits with high population densities. In these situations reflow soldering is often used.

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our *"IC Package Databook"* (order code 9398 652 90011).

Reflow soldering

Reflow soldering techniques are suitable for all SO packages.

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 techniques exist for reflowing; for example, thermal conduction by heated belt. Dwell times vary between 50 and 300 seconds depending on heating method. Typical reflow temperatures range from 215 to 250 °C.

Preheating is necessary to dry the paste and evaporate the binding agent. Preheating duration: 45 minutes at 45 °C.

Wave soldering

Wave soldering techniques can be used for all SO packages if the following conditions are observed:

- A double-wave (a turbulent wave with high upward pressure followed by a smooth laminar wave) soldering technique should be used.
- The longitudinal axis of the package footprint must be parallel to the solder flow.
- The package footprint must incorporate solder thieves at the downstream end.

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.

Maximum permissible solder temperature is 260 °C, and maximum duration of package immersion in solder is 10 seconds, if cooled to less than 150 °C within 6 seconds. 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.

Repairing soldered joints

Fix the component by first soldering two diagonally-opposite end leads. Use only a low voltage soldering iron (less than 24 V) 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.

Digital Servo Driver (DSD-2)   OQ8844

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.	

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.

NOTES

NOTES

Philips Semiconductors – a worldwide company

Argentina: IEROD, Av. Juramento 1992 - 14.b, (1428)
BUENOS AIRES, Tel. (541)786 7633, Fax. (541)786 9367

Australia: 34 Waterloo Road, NORTH RYDE, NSW 2113,
Tel. (02)805 4455, Fax. (02)805 4466

Austria: Triester Str. 64, A-1101 WIEN, P.O. Box 213,
Tel. (01)60 101-1236, Fax. (01)60 101-1211

Belgium: Postbus 90050, 5600 PB EINDHOVEN, The Netherlands,
Tel. (31)40-2783749, Fax. (31)40-2788399

Brazil: Rua do Rocio 220 - 5th floor, Suite 51,
CEP: 04552-903-SÃO PAULO-SP, Brazil.
P.O. Box 7383 (01064-970),
Tel. (011)821-2333, Fax. (011)829-1849

Canada: PHILIPS SEMICONDUCTORS/COMPONENTS:
Tel. (800) 234-7381, Fax. (708) 296-8556

Chile: Av. Santa Maria 0760, SANTIAGO,
Tel. (02)773 816, Fax. (02)777 6730

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: IPRELENSO LTDA, Carrera 21 No. 56-17,
77621 BOGOTA, Tel. (571)249 7624/(571)217 4609,
Fax. (571)217 4549

Denmark: Prags Boulevard 80, PB 1919, DK-2300
COPENHAGEN S, Tel. (032)88 2636, Fax. (031)57 1949

Finland: Sinikalliontie 3, FIN-02630 ESPOO,
Tel. (358)0-615 800, Fax. (358)0-61580 920

France: 4 Rue du Port-aux-Vins, BP317,
92156 SURESNES Cedex,
Tel. (01)4099 6161, Fax. (01)4099 6427

Germany: P.O. Box 10 63 23, 20043 HAMBURG,
Tel. (040)3296-0, Fax. (040)3296 213.

Greece: No. 15, 25th March Street, GR 17778 TAVROS,
Tel. (01)4894 339/4894 911, Fax. (01)4814 240

India: Philips INDIA Ltd, Shivsagar Estate, A Block,
Dr. Annie Besant Rd. Worli, Bombay 400 018
Tel. (022)4938 541, Fax. (022)4938 722

Indonesia: Philips House, Jalan H.R. Rasuna Said Kav. 3-4,
P.O. Box 4252, JAKARTA 12950,
Tel. (021)5201 122, Fax. (021)5205 189

Ireland: Newstead, Clonskeagh, DUBLIN 14,
Tel. (01)7640 000, Fax. (01)7640 200

Italy: PHILIPS SEMICONDUCTORS S.r.l.,
Piazza IV Novembre 3, 20124 MILANO,
Tel. (0039)2 6752 2531, Fax. (0039)2 6752 2557

Japan: Philips Bldg 13-37, Kohnan 2 -chome, Minato-ku, TOKYO 108,
Tel. (03)3740 5130, Fax. (03)3740 5077

Korea: Philips House, 260-199 Itaewon-dong,
Yongsan-ku, SEOUL, Tel. (02)709-1412, Fax. (02)709-1415

Malaysia: No. 76 Jalan Universiti, 46200 PETALING JAYA,
SELANGOR, Tel. (03)750 5214, Fax. (03)757 4880

Mexico: 5900 Gateway East, Suite 200, EL PASO, TX 79905,
Tel. 9-5(800)234-7381, Fax. (708)296-8556

Netherlands: Postbus 90050, 5600 PB EINDHOVEN, Bldg. VB,
Tel. (040)2783749, Fax. (040)2788399

New Zealand: 2 Wagener Place, C.P.O. Box 1041, AUCKLAND,
Tel. (09)849-4160, Fax. (09)849-7811

Norway: Box 1, Manglerud 0612, OSLO,
Tel. (022)74 8000, Fax. (022)74 8341

Pakistan: Philips Electrical Industries of Pakistan Ltd.,
Exchange Bldg. ST-2/A, Block 9, KDA Scheme 5, Clifton,
KARACHI 75600, Tel. (021)587 4641-49,
Fax. (021)577035/5874546

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

Portugal: PHILIPS PORTUGUESA, S.A.,
Rua dr. António Loureiro Borges 5, Arquiparque - Miraflores,
Apartado 300, 2795 LINDA-A-VELHA,
Tel. (01)4163160/4163333, Fax. (01)4163174/4163366

Singapore: Lorong 1, Toa Payoh, SINGAPORE 1231,
Tel. (65)350 2000, Fax. (65)251 6500

South Africa: S.A. PHILIPS Pty Ltd.,
195-215 Main Road Martindale, 2092 JOHANNESBURG,
P.O. Box 7430, Johannesburg 2000,
Tel. (011)470-5911, Fax. (011)470-5494

Spain: Balmes 22, 08007 BARCELONA,
Tel. (03)301 6312, Fax. (03)301 42 43

Sweden: Kottbygatan 7, Akalla. S-164 85 STOCKHOLM,
Tel. (0)8-632 2000, Fax. (0)8-632 2745

Switzerland: Allmendstrasse 140, CH-8027 ZÜRICH,
Tel. (01)488 2211, Fax. (01)481 77 30

Taiwan: PHILIPS TAIWAN Ltd., 23-30F, 66, Chung Hsiao West
Road, Sec. 1. Taipeh, Taiwan ROC, P.O. Box 22978,
TAIPEI 100, Tel. (886) 2 382 4443, Fax. (886) 2 382 4444

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

Turkey: Talatpasa Cad. No. 5, 80640 GÜLTEPE/ISTANBUL,
Tel. (0212)279 27 70, Fax. (0212)282 67 07

Ukraine: Philips UKRAINE, 2A Akademika Koroleva str., Office 165,
252148 KIEV, Tel. 380-44-4760297, Fax. 380-44-4766991

United Kingdom: Philips Semiconductors LTD.,
276 Bath Road, Hayes, MIDDLESEX UB3 5BX,
Tel. (0181)730-5000, Fax. (0181)754-8421

United States: 811 East Arques Avenue, SUNNYVALE,
CA 94088-3409, Tel. (800)234-7381, Fax. (708)296-8556

Uruguay: Coronel Mora 433, MONTEVIDEO,
Tel. (02)70-4044, Fax. (02)92 0601

Internet: http://www.semiconductors.philips.com/ps/

For all other countries apply to: Philips Semiconductors,
International Marketing and Sales, Building BE-p,
P.O. Box 218, 5600 MD EINDHOVEN, The Netherlands,
Telex 35000 phtcnl, Fax. +31-40-2724825

Printed in The Netherlands

Let's make things better.

**Philips
Semiconductors**

PHILIPS