SA56202

One-chip motor driver

Rev. 01 — 19 July 2004 Preliminary data sheet

1. General description

The SA56202 is a one-chip motor driver IC that is capable to drive all motors of CD or DVD systems: spindle, sled and loading motors and actuators on the optical pick-up unit. The driver intended for the 3-phase, brushless, Hall-commutated spindle motor uses True-Silent PWM. This proprietary technology ensures that all 3-phase motor currents are sinusoidal resulting in an optimally silent driver. Internal regeneration of the back-EMF of the spindle motor enables the driver to operate in current-steering mode without using external power-dissipating sense resistors. The driver intended for the 2-phase sled stepper motor operates in current-steering PWM mode. In addition the IC contains four full-bridge linear channels that can be used to drive a loading motor and 3D actuators (focus, tracking and tilt).

The SA56202 is available in an exposed die pad HTSSOP56 package.

2. Features

- True-Silent PWM spindle motor driver
- Low heat generation due to power-efficient direct full-bridge switching of spindle motor driver
- Controlled spindle motor current during acceleration and brake
- Reverse torque brake function (full bridge)
- Adjustable spindle motor current limiter
- Internal regeneration for EMF of spindle motor
- Current-steering PWM controlled stepper motor driver for sled
- Four class-AB linear channels for loading motor and 3D actuators (focus, tracking and tilt)
- Low on-resistance D-MOSFET output power stages
- Built-in thermal shutdown, thermal warning and temperature diode
- Interfaces to 3 V and 5 V logic
- Package with low thermal resistance to heatsink (reflowable die pad).

3. Applications

- DVD+RW, DVD-RW, DVD-ROM and DVD-RAM
- Combi
- CD-ROM and CD-RW
- Other compact disk media.

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4. Ordering information

Table 1: Ordering information

Type number	Package		
	Name	Description	Version
SA56202TW	HTSSOP56	plastic thermal enhanced thin shrink small outline package; 56 leads; body width 6.1 mm; exposed die pad	SOT793-1

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5. Block diagram

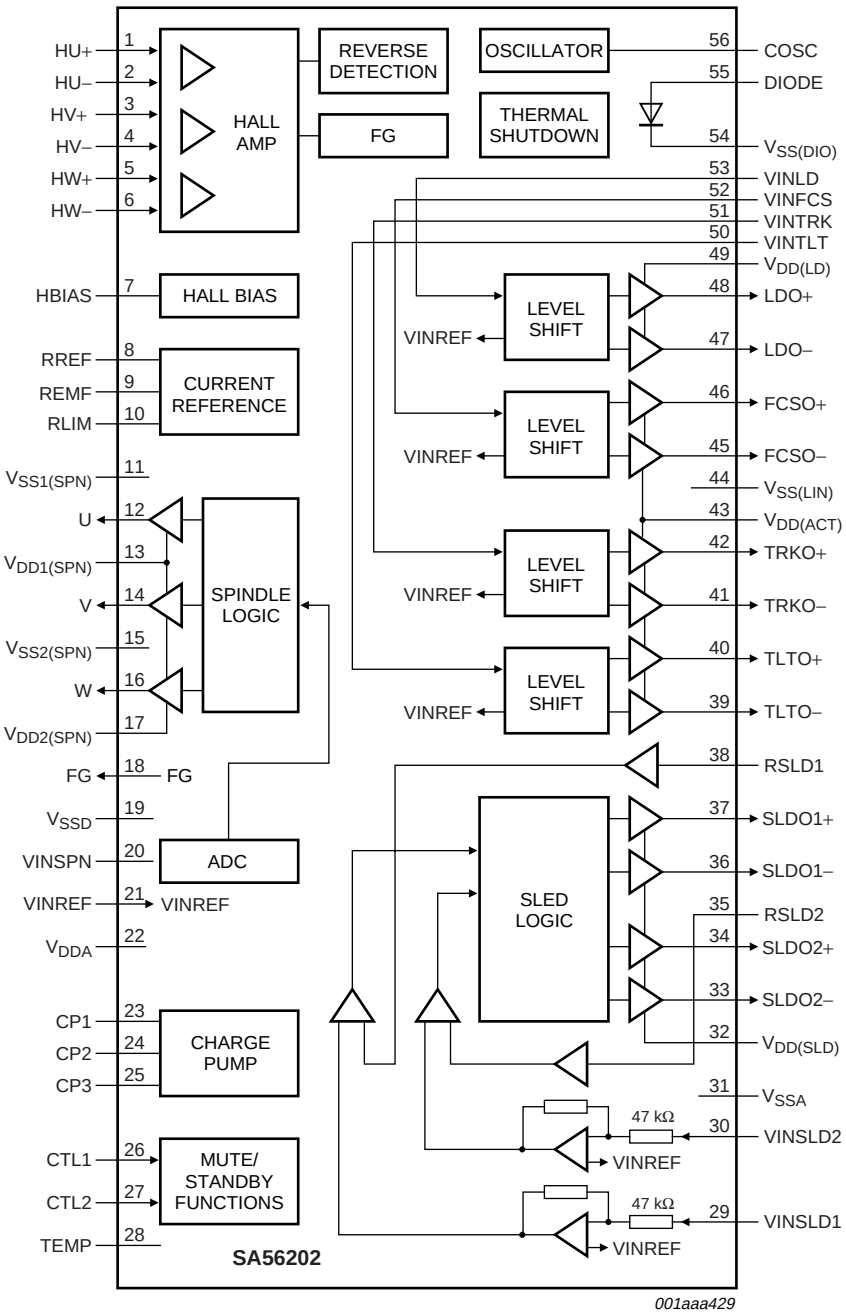


Fig 1. Block diagram.

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6. Pinning information

6.1 Pinning

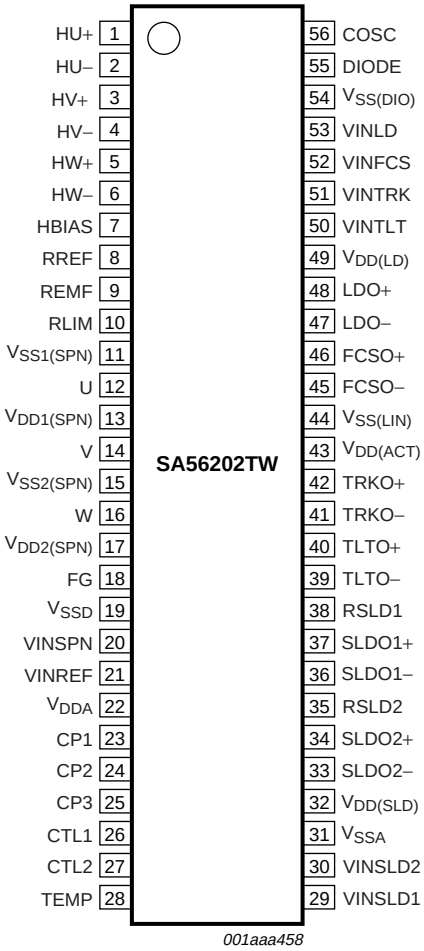


Fig 2. Pin configuration.

6.2 Pin description

Table 2: Pin description

Symbol	Pin	Description
HU+	1	Hall input U positive
HU–	2	Hall input U negative
HV+	3	Hall input V positive
HV–	4	Hall input V negative
HW+	5	Hall input W positive
HW–	6	Hall input W negative
HBIAS	7	Hall element bias
RREF	8	external resistor for current reference

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Table 2: Pin description *…continued*

Symbol	Pin	Description
REMF	9	external resistor for EMF regeneration
RLIM	10	external resistor for current limit
$V_{SS1(SPN)}$	11	spindle driver ground 1
U	12	spindle driver output U
$V_{DD1(SPN)}$	13	spindle driver supply voltage 1
V	14	spindle driver output V
$V_{SS2(SPN)}$	15	spindle driver ground 2
W	16	spindle driver output W
$V_{DD2(SPN)}$	17	spindle driver supply voltage 2
FG	18	frequency generator output
V_{SSD}	19	digital ground
VINSPN	20	spindle driver input voltage for spindle motor current
VINREF	21	reference input voltage for all motor drivers
V_{DDA}	22	analog supply voltage
CP1	23	charge pump capacitor connection 1
CP2	24	charge pump capacitor connection 2
CP3	25	charge pump capacitor connection 3
CTL1	26	driver logic control input 1
CTL2	27	driver logic control input 2
TEMP	28	thermal warning
VINSLD1	29	sled driver 1 input voltage for sled motor current
VINSLD2	30	sled driver 2 input voltage for sled motor current
V_{SSA}	31	analog ground
$V_{DD(SLD)}$	32	sled driver supply voltage
SLD2O–	33	sled driver output 2 negative
SLDO2+	34	sled driver output 2 positive
RSLD2	35	external sense resistor for sled driver 2 current sense
SLDO1–	36	sled driver output 1 negative
SLDO1+	37	sled driver output 1 positive
RSLD1	38	external sense resistor for sled driver 1 current sense
TLTO–	39	tilting driver output negative
TLTO+	40	tilting driver output positive
TRKO–	41	tracking driver output negative
TRKO+	42	tracking driver output positive
$V_{DD(ACT)}$	43	actuator drivers supply voltage
$V_{SS(LIN)}$	44	linear drivers ground
FCSO–	45	focus driver output negative
FCSO+	46	focus driver output positive
LDO–	47	loading driver output negative
LDO+	48	loading driver output positive
$V_{DD(LD)}$	49	loading driver supply voltage

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Table 2: Pin description *...continued*

Symbol	Pin	Description
VINTLT	50	tilting driver input for tilt actuator voltage
VINTRK	51	tracking driver input for tracking actuator voltage
VINFCS	52	focus driver input for focus actuator voltage
VINLD	53	loading driver input for loading motor voltage
$V_{SS(DIO)}$	54	temperature diode ground
DIODE	55	diode for temperature readout
COSC	56	external capacitor for internal oscillator

7. Functional description

7.1 Spindle motor control

The control input voltage on pin VINSPN is converted into a digital value by the ADC where the voltage on pin VINREF is the midpoint reference. The transconductance gain from input voltage V_{VINSPN} to output motor current I_{MOT} is:

$$g_{m(SPN)} = \frac{I_{MOT}}{V_{VINSPN} - V_{VINREF}} = \frac{I_{LIM}}{V_{VINREF}}$$

where I_{LIM} can be programmed by means of external resistor R_{LIM}; see Section 7.4. The motor current is described by Figure 3.

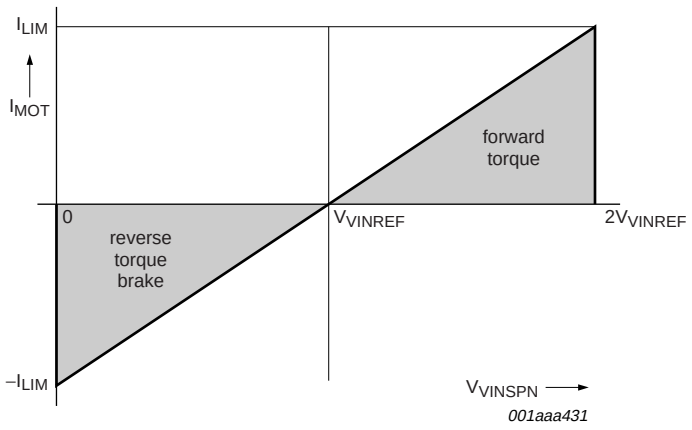


Fig 3. Spindle motor current as a function of control input voltage on pin VINSPN.

For VINSPN voltages larger than V_{VINREF} the motor will accelerate with forward torque control. For VINSPN voltages smaller than V_{VINREF} the motor will brake with reverse torque control. Because the U, V and W half-bridges of the spindle motor driver use a direct PWM full-bridge switching scheme, the motor current can also be controlled and limited during brake. Note that because of this active brake mechanism energy of the motor can be recuperated back to the supply. Especially at large speeds, this can result in currents delivered back to the supply. If the supply and/or other circuits than the motor

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driver do not use this recuperated current, than the supply voltage can possibly rise to unacceptable values. In that case it is recommended to lower the spindle current during brake by means of the VINSPN setting.

Upon detection of reverse detection all U, V and W driver outputs are connected to $V_{DD(SPN)}$. This short brake prevents the motor of spinning backwards.

7.2 Internal regeneration of back-EMF spindle motor

The spindle motor driver uses the information from the Hall sensors to internally regenerate the back-EMF of the motor. See Figure 4.

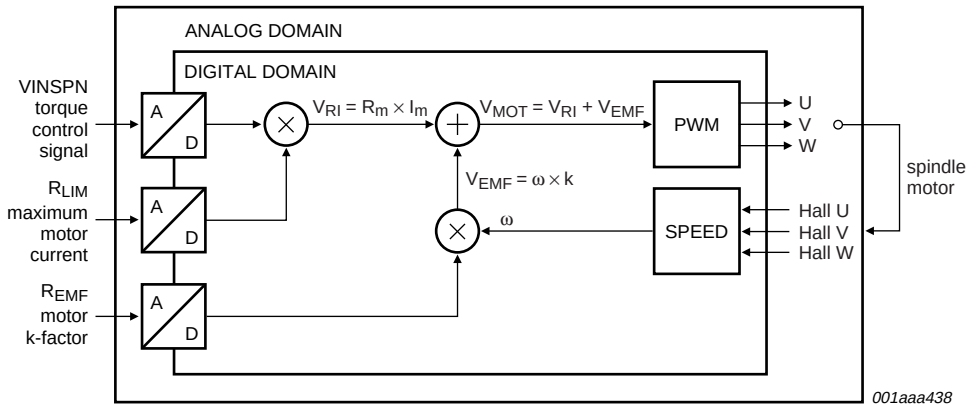


Fig 4. Regeneration of back-EMF voltage spindle motor.

Rotational speed ω is derived from the Hall event frequency. Multiplying ω with the k-factor of the motor gives the back-EMF voltage V_{EMF}. This V_{EMF} is added to the current-limit scaled spindle input voltage V_{VINSPN}. This sum V_{MOT} steers the PWM outputs U, V and W. The result is that the input voltage V_{VINSPN} sets the current through the motor. This explains how the SA56202 spindle motor driver exhibits a current control transfer function without using external sense resistors.

The simplified motor schematic in Figure 5 shows the series resistance and back-EMF voltage of the motor.

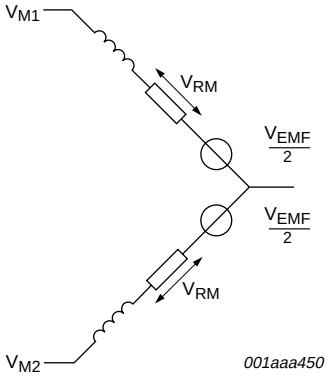


Fig 5. Simplified spindle motor schematic.

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Figure 6 depicts the motor voltages V_{M1} and V_{M2} during accelerating and braking. The back-EMF voltage is part of these motor voltages.

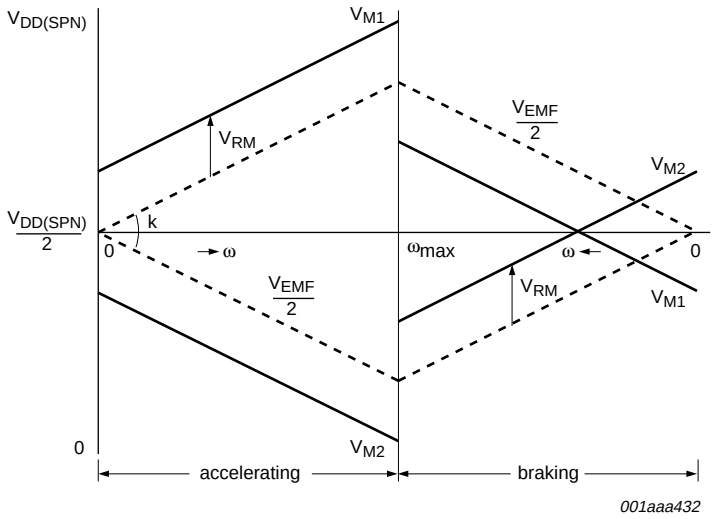


Fig 6. Motor voltages when accelerating and braking with constant motor current.

7.3 Sine generation using True-Silent signals

For the phase relation between the Hall inputs and the spindle outputs in forward rotation, see Figure 7. These are the signal shapes in sine mode using our True-Silent PWM technology. The particular shape of the 120° symmetrical U, V and W steering voltages are because of improved drive strength and improved power efficiency. The drive strength is improved because with this signal shape a 15 % larger sine can be fit within the supply rails compared to direct-written sine signals. Also the power efficiency is improved because this signal shape has 33 % less switching losses compared to a direct-written sine.

The result is that the motor currents (and motor torques) are pure sine waves generated in such a way that the motor is driven optimally silent, optimally power efficient and with maximum driving strength.

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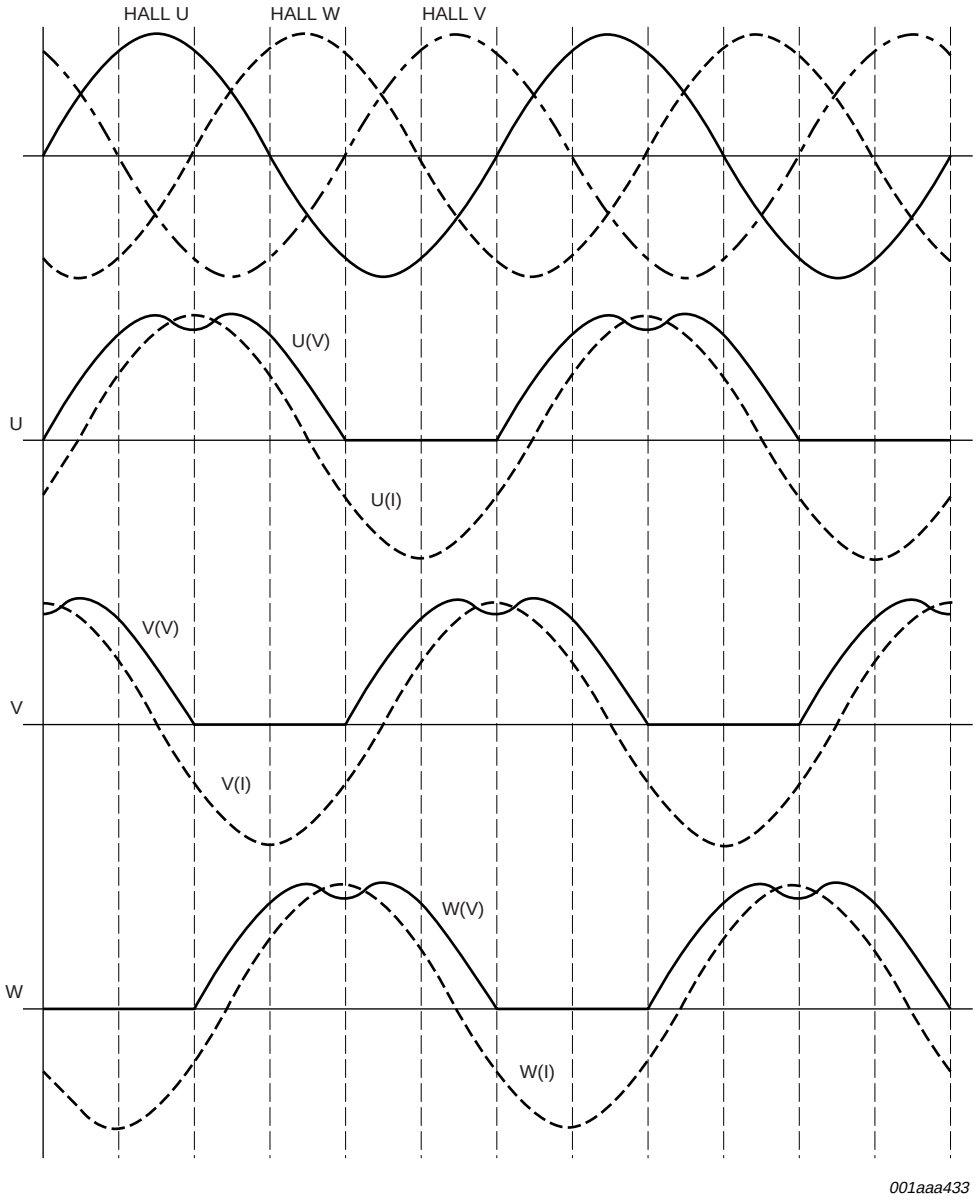


Fig 7. Phase relation between Hall input signals and spindle motor driver output voltages U(V), V(V), W(V) and motor currents U(I), V(I), W(I) in forward rotation mode.

7.4 Programming R_{LIM}

If the supply is connected between the terminals of a non-running spindle motor, then usually a current will flow that is too large. The motor current can be limited to a value I_{LIM}. This I_{LIM} can be programmed by means of R_{LIM}. In order to calculate the required R_{LIM} first a typical maximum motor current I_{MAX} needs to be determined:

$$I_{MAX} = \frac{V_{DD(SPN)}}{R_{motor} + R_{switches}}$$

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I_{LIM} can be chosen to be a fraction of this maximum current I_{MAX}. By making the ratio between R_{LIM} (connected to pin 10) and R_{REF} (connected to pin 8) this same fraction, I_{LIM} is programmed as expressed in the following formula: $I_{LIM} = \frac{R_{LIM}}{R_{REF}} \times I_{MAX}$

So by choosing I_{LIM}, R_{LIM} needs to be: $R_{LIM} = \frac{I_{LIM}}{I_{MAX}} \times R_{REF}$

Figure 8 shows the limit current as a function of R_{LIM} with R_{REF} = 47 kΩ.

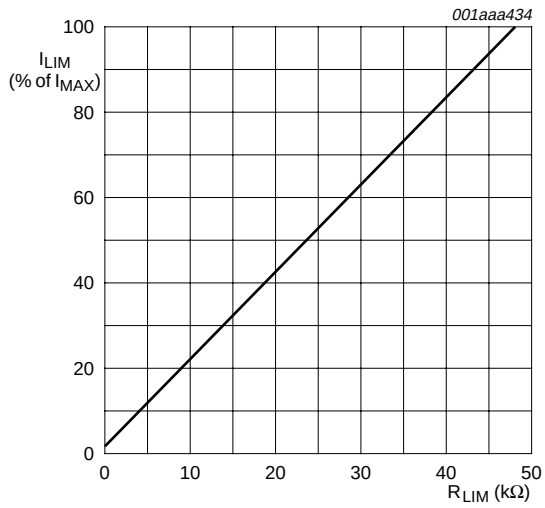


Fig 8. Limit current I_{LIM} as a function of external resistor R_{LIM}.

During accelerating and braking the motor current will not exceed I_{LIM}. I_{LIM} also sets the transconductance gain I_{LIM}/V_{VINREF} of the spindle driver.

7.5 Programming R_{EMF}

The back-EMF voltage is internally regenerated. The ratio between R_{EMF} and R_{REF} is used to scale the internal EMF regeneration. The value of external resistor R_{EMF} depends on the type of motor (k-factor and number of pole pairs N_{PP}) and the motor supply voltage $V_{DD(SPN)}$. The following formula should be used to determine the R_{EMF} resistor:

$$R_{EMF} = \frac{k \times 2.6 \times 10^3 \times R_{REF}}{N_{PP} \times V_{DD(SPN)}}$$ with k in units Nm/A.

7.6 FG generator

The raw zero-crossings of the Hall sensors are first filtered and debounced before being passed to the FG generator. The FG generator toggles its output at every filtered Hall zero-crossing. For three Hall sensors this means that the motor frequency is linked to the FG frequency by: $f_{motor} = \frac{FG}{3 \times N_{PP}}$

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where N_{PP} indicates the number of pole pairs of the motor. FG has an open-drain output for easy interfacing to 3 V and 5 V logic.

7.7 Sled motor driver

Two current-steering PWM channels are available to drive a stepper motor. Per channel an external sense resistor R_{sense} is used that is connected to ground. A peak-current control loop is implemented that modulates the duty cycle of the PWM signal. See Figure 9.

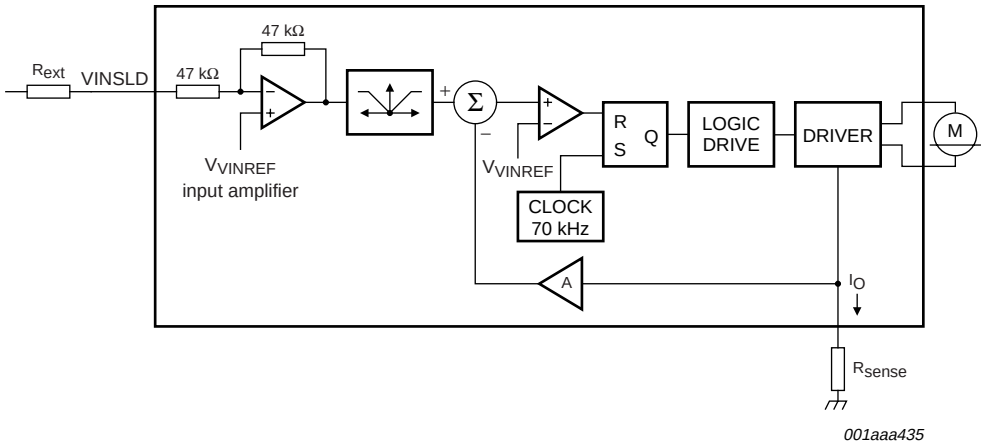


Fig 9. Peak-current control architecture of stepper motor driver.

The clock generator has a nominal frequency of $f_{osc}/256 = 70$ kHz. See Figure 10 for the transfer function from input voltage V_{VINSLD} to output current at a typical R_{sense} of 0.5 Ω. Input-to-output transconductance gain can be scaled down by connecting an external resistor R_{ext} in series with the input VINSLD.

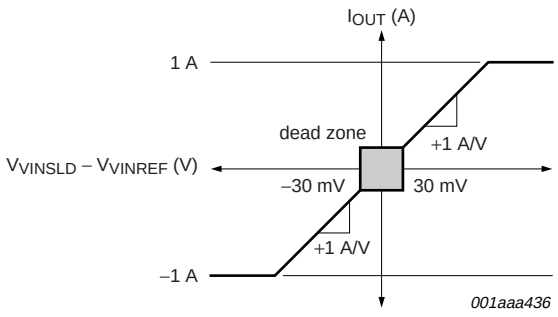


Fig 10. Transfer function of stepper motor driver.

Both limit current and transconductance gain are related to R_{sense} in the following way:

Transconductance gain, $\frac{I_o}{V_{in}} = \frac{1}{2 \times R_{sense}}$

Limit current, $I_{LIM} = \frac{1V}{2 \times R_{sense}}$

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7.8 Loading motor driver

One of the linear channels is available to drive a DC loading motor. Pin $V_{DD(LD)}$ is used to set the supply voltage for the loading motor driver. Figure 11 depicts the voltage-steering bridge topology of the SA56202.

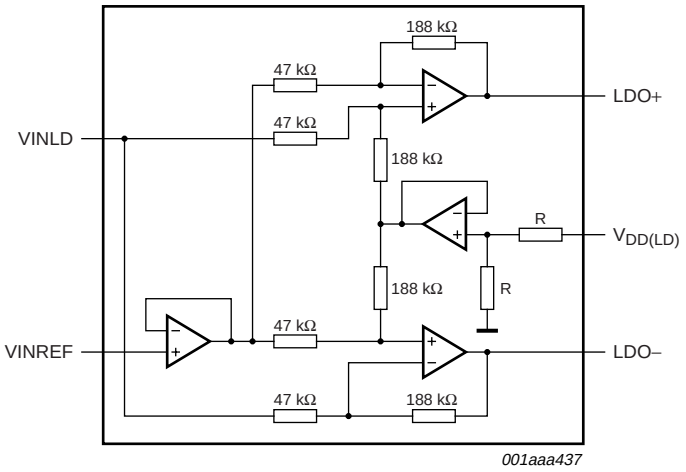


Fig 11. Voltage-steering bridge topology of linear driver.

7.9 Actuator motor drivers

Three linear channels are available to drive 3D actuators: focus, tracking and tilt. A pin $V_{DD(ACT)}$ is used to set the supply voltage for these actuator drivers. The voltage-steering bridge topology is the same as depicted in Figure 11. The mismatch of the voltage gain of these 3 linear channels is guaranteed to be less than 5 %.

7.10 Charge pump

The on-board charge pump generates a regulated voltage of typically 18.2 V by using the $V_{DD(SPN)}$ supply voltage. This boosted voltage is used to turn on the upper n-type DMOS transistors of the output stages of the spindle driver, sled driver, loading driver and actuator drivers. Recommended values for the pump-and-hold capacitor are 10 nF and 22 nF respectively (see also application diagram Figure 13). The charge pump should not be loaded with other components or circuitry than these capacitors.

7.11 Thermal protection

If the junction temperature of the SA56202 exceeds 150 °C, then a thermal warning signal is given at pin TEMP. TEMP has an active-LOW open-drain output for easy interfacing to 3 V and 5 V logic. The temperature hysteresis for the thermal warning is 10 °C. If the junction temperature of the IC rises to 160 °C, then a thermal shutdown is activated that sets all power outputs in 3-state. The temperature hysteresis for the thermal shutdown is 30 °C. As soon as the thermal shutdown deactivates at 130 °C, all motor drivers continue normal operation.

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7.12 Oscillator

The RC oscillator uses two external components (R_{REF} and C_{OSC}) to fix its frequency at 18 MHz. R_{REF} is used to generate a reference current. This reference current is used to charge and discharge C_{OSC}. The nominal oscillation frequency f_{osc} is 18 MHz with R_{REF} = 47 kΩ (2 % tolerance) and C_{OSC} = 70 pF (5 % tolerance). These values are fixed. The oscillator can be overruled by applying an 18 MHz clock to pin COSC. The reference current derived from R_{REF} is also used for R_{LIM} and R_{EMF}. R_{REF} should always be connected.

7.13 Muting functions

Pins CTL1 and CTL2 are used to mute certain parts of the IC. See Table 3. In this table off means 3-state.

Table 3: Muting functions

CTL1	CTL2	Loading motor	Sled motor	Others	Spindle mode
L	L	off	off	off	off
L	H	on	on	off	FG and Hall bias on
H	L	off	on	on	block commutation
H	H	off	on	on	True-Silent commutation

8. Limiting values

Table 4: Limiting values

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

Symbol	Parameter	Conditions	Min	Max	Unit
Voltages					
$V_{DD(SPN)}$	spindle driver supply voltage		–0.5	+16	V
$V_{DD(SLD)}$	sled driver supply voltage		–0.5	+16	V
$V_{DD(LD)}$	loading driver supply voltage		–0.5	+16	V
$V_{DD(ACT)}$	actuator drivers supply voltage		–0.5	+16	V
V_{DDA}	system supply voltage		–0.5	+6.5	V
Currents					
$I_{DD(SPN)}$	current on pins 12, 14 and 16		-	2.1	A
$I_{DD(SLD)}$	current on pins 33, 34, 35, 36, 37 and 38		-	1.2	A
$I_{DD(ACT)}$	current on pins 39, 40, 41, 42, 45, 46, 47 and 48		-	2.0	A
I_{HALL}	current on pins 1, 2, 3, 4, 5 and 6		–1	+1	mA
I_{HBIAS}	current on pin 7		–1	+100	mA
I_{RPROG}	current on pins 8, 9 and 10		–1	+1	mA
I_{OD}	current on pins 18 and 28		–1	+10	mA
I_{DIG}	current on pins 26 and 27		–1	+1	mA
I_{CPUMP}	current on pins 23, 24 and 25		–20	+20	mA

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Table 4: Limiting values *…continued*

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

Symbol	Parameter	Conditions	Min	Max	Unit
I_{STEER}	current on pins 20, 21, 29, 30, 50, 51, 52 and 28		–1	+1	mA
I_{DIODE}	current on pins 54 and 55		–1	+1	mA
I_{OSC}	current on pin 56		–20	+20	mA
General					
T_{stg}	storage temperature		–55	+150	°C
T_{amb}	ambient temperature		–40	+85	°C
T_j	junction temperature		–40	+160	°C
Electrostatic discharge voltage					
$V_{esd(HBM)}$	human body model				
	pins 1 to 6 and 8 to 56	[1]	-	1500	V
	pin 7		-	1000	V
$V_{esd(MM)}$	machine model	[2]	-	150	V

[1] Class 1, equivalent to discharging a 100 pF capacitor through a 1.5 kΩ series resistor.

[2] Class 1, equivalent to discharging a 200 pF capacitor through a 0.75 μH coil and a 10 Ω resistor.

9. Thermal characteristics

Table 5: Thermal characteristics

Symbol	Parameter	Conditions	Typ	Unit
$R_{th(j-a)}$	thermal resistance from junction to ambient	multilayer PCB, no airflow	33	K/W

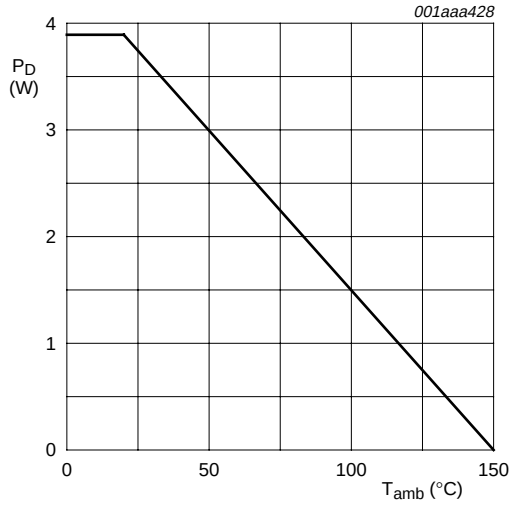


Fig 12. Maximum dissipation as a function of ambient temperature.

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10. Characteristics

Table 6: Characteristics

T_{amb} = 25 °C; V_{DDA} = 5 V; $V_{DD(SPN)}$ = 12 V; $V_{DD(SLD)}$ = 12 V; $V_{DD(ACT)}$ = 5 V; $V_{DD(LD)}$ = 12 V; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Spindle motor driver						
V_{DDA}	system supply voltage		4.5	5.0	5.5	V
$V_{DD(SPN)}$	motor supply voltage		4.5	12	14	V
V_{IO}	input offset voltage Hall amplifier		–3.5	-	+3.5	mV
V_i	input voltage range Hall amplifier		0	-	V_{DDA}	V
$V_{i(dif)(p-p)}$	Hall amplifier differential input voltage (peak-to-peak value)		25	-	-	mV
V_{HBIAS}	voltage on pin HBIAS	I_{HBIAS} = 32 mA	-	0.6	0.9	V
f_{osc}	oscillator frequency	R_{REF} = 47 kΩ; C_{OSC} = 70 pF	-	18	-	MHz
f_{PWM}	PWM frequency	R_{REF} = 47 kΩ; C_{OSC} = 70 pF	-	70	-	kHz
$R_{ds(on)}$	D-MOSFET on-resistance (high or low)		-	0.35	0.50	Ω
V_{VINREF}	reference voltage on pin VINREF		1.2	1.65	2.5	V
V_{VINSPN}	torque control voltage on pin VINSPN		0	-	V_{DDA}	V
Stepper motor driver						
V_{DDA}	supply voltage		4.5	5.0	5.5	V
$V_{DD(SLD)}$	motor supply voltage		4.5	12	14	V
$I_{DD(SLD)}$	motor current limit	R_{sense} = 0.5 Ω	0.85	1.0	1.15	A
f_{PWM}	PWM frequency	R_{REF} = 47 kΩ; C_{OSC} = 70 pF	-	70	-	kHz
$V_{i(trip)}$	input dead-zone trip level		15	30	45	mV
g_m	transconductance gain	R_{sense} = 0.5 Ω	0.85	1.0	1.15	A/V
$R_{ds(on)}$	D-MOSFET on-resistance (high or low)		-	1.0	1.4	Ω
Loading motor driver						
$V_{DD(LD)}$	motor supply voltage		4.5	12	14	V
$I_{DD(LD)}$	current limit (high or low)		0.9	1.2	2.0	A
V_{OO}	output offset voltage		–100	0	+100	mV
G_v	voltage gain		16.8	17.6	18.4	dB
$R_{ds(on)}$	D-MOSFET on-resistance (high or low)		-	0.6	0.9	Ω
Actuator driver (focus, tracking and tilt)						
$V_{DD(ACT)}$	supply voltage		4.5	5	14	V
$I_{DD(ACT)}$	current limit (high or low)		0.9	1.2	2.0	A
V_{OO}	output offset voltage		–55	0	+55	mV
G_v	voltage gain		16.8	17.6	18.4	dB
$G_{v(m)}$	gain mismatch between 3 channels		-	-	5	%

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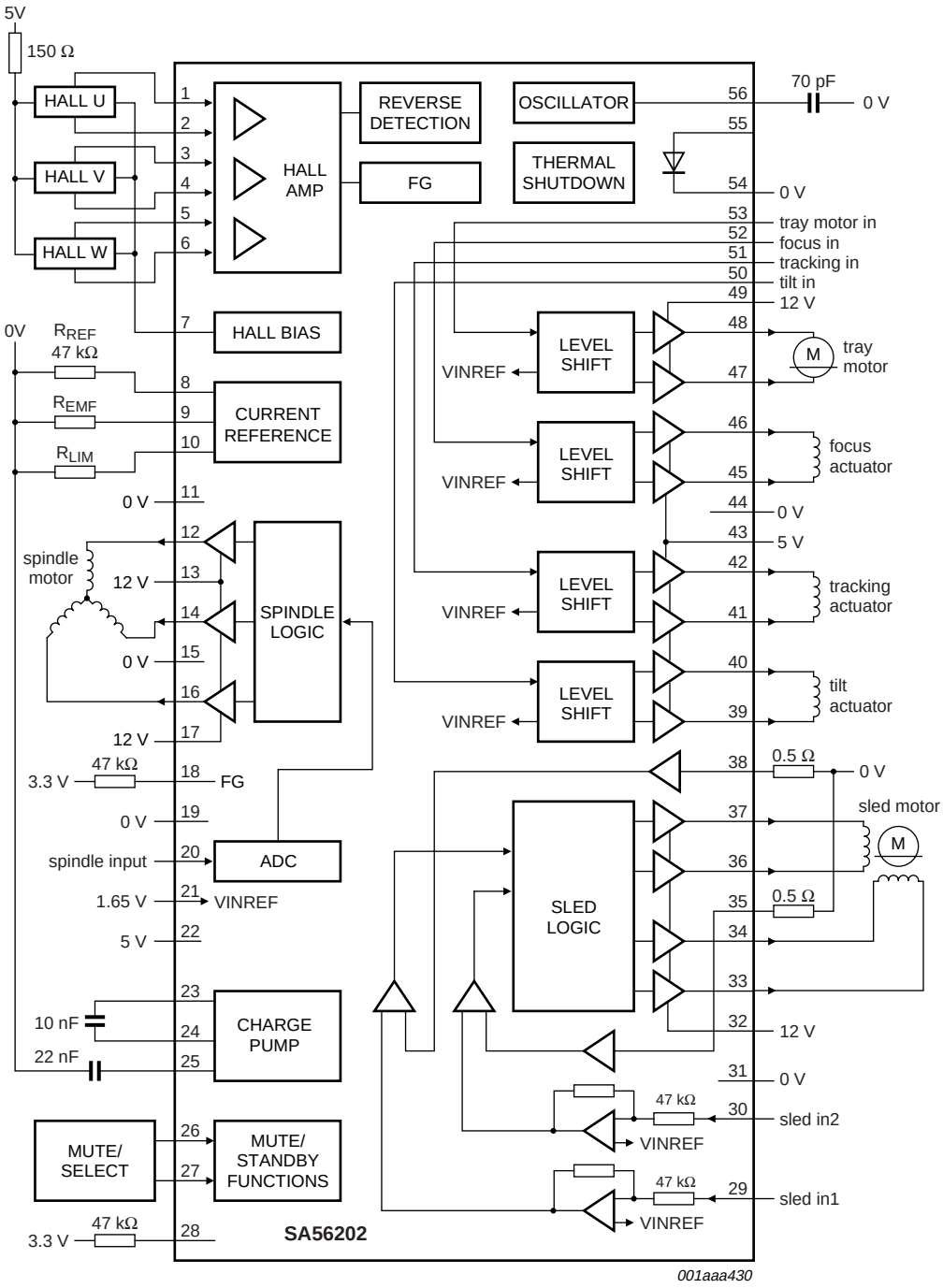
Table 6: Characteristics *...continued*

T_{amb} = 25 °C; V_{DDA} = 5 V; $V_{DD(SPN)}$ = 12 V; $V_{DD(SLD)}$ = 12 V; $V_{DD(ACT)}$ = 5 V; $V_{DD(LD)}$ = 12 V; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$R_{ds(on)}$	D-MOSFET on-resistance (high or low)		-	0.6	0.9	Ω
General						
V_{CP3}	charge pump output voltage		-	18.2	-	V
V_{IH}	HIGH-level input voltage digital on pins 26 and 27		2.0	-	-	V
V_{IL}	LOW-level input voltage digital on pins 26 and 27		-	-	0.8	V
V_{OL}	LOW-level output voltage digital on pins 18 and 28	I_{OL} = 2 mA	-	-	0.5	V
$I_{DDA(q)}$	V_{DDA} quiescent current	CTL1 = H; CTL2 = H	-	14	20	mA
$I_{DD(SPN)(q)}$	$V_{DD(SPN)}$ quiescent current	CTL1 = H; CTL2 = H	-	9	15	mA
$I_{DD(SLD)(q)}$	$V_{DD(SLD)}$ quiescent current	CTL1 = H; CTL2 = H	-	0	1	mA
$I_{DD(ACT)(q)}$	$V_{DD(ACT)}$ quiescent current	CTL1 = H; CTL2 = H	-	16	25	mA
$I_{STB(tot)}$	total standby current	CTL1 = L; CTL2 = L	-	4.5	8	mA
T_{TEMP}	thermal warning temperature		-	150	-	°C
$T_{hys(TEMP)}$	thermal warning hysteresis		-	10	-	°C
T_{SD}	thermal shutdown temperature		-	160	-	°C
$T_{hys(SD)}$	thermal shutdown hysteresis		-	30	-	°C

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11. Application information



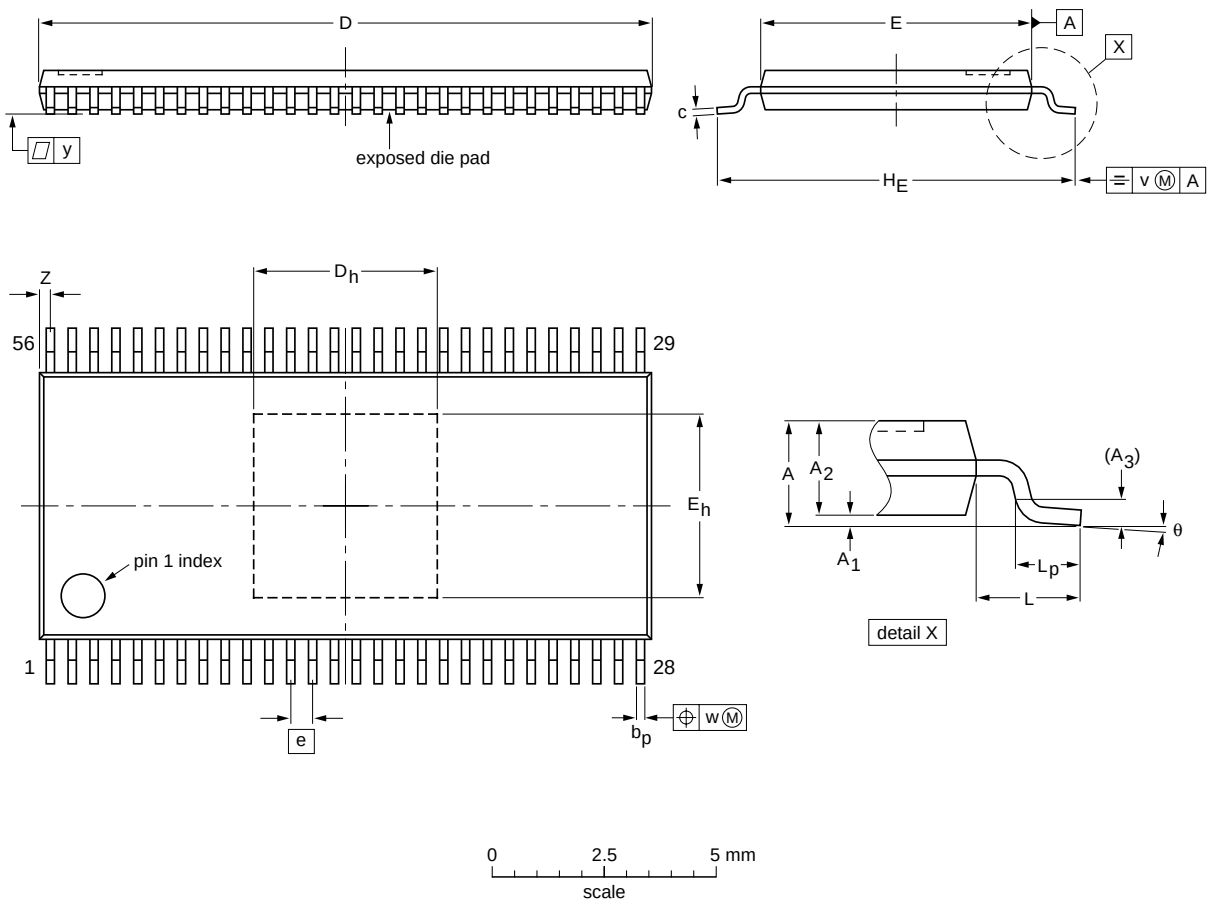
For R_{EMF} and R_{LIM} see Section 7.

Fig 13. Application diagram.

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12. Package outline

HTSSOP56: plastic thermal enhanced thin shrink small outline package; 56 leads; body width 6.1 mm; exposed die pad **SOT793-1**



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	$D^{(1)}$	D_h	$E^{(2)}$	E_h	e	H_E	L	L_p	v	w	y	$Z^{(1)}$	θ
mm	1.2	0.15 0.05	1.05 0.80	0.25	0.27 0.17	0.20 0.09	14.1 13.9	4.3 4.1	6.2 6.0	4.3 4.1	0.5	8.3 7.9	1	0.8 0.4	0.2	0.08	0.1	0.4 0.1	8^o 0^o

Notes

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT793-1	143E36T	MO-153				03-03-04

Fig 14. Package outline.

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13. Soldering

13.1 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.

13.2 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 seconds and 200 seconds depending on heating method.

Typical reflow peak temperatures range from 215 °C 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 ≥ 2.5 mm
  - for packages with a thickness < 2.5 mm and a volume ≥ 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.

13.3 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;

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– 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 seconds 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.

13.4 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 seconds to 5 seconds between 270 °C and 320 °C.

13.5 Package related soldering information

Table 7: 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, VFBGA, XSON	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
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 ± 10 °C measured in the atmosphere of the reflow oven. The package body peak temperature must be kept as low as possible.

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[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.

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14. Revision history

Table 8: Revision history

Document ID	Release date	Data sheet status	Change notice	Order number	Supersedes
SA56202_1	20040719	Preliminary data sheet	-	9397 750 12772	-

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15. 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.
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[3] For data sheets describing multiple type numbers, the highest-level product status determines the data sheet status.

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