L6370

2.5A high-side driver industrial intelligent power switch

Features

- 2.5A output current
- 9.5V to 35V supply voltage range
- Internal current limiting
- Thermal shutdown
- Open ground protection
- Internal negative voltage clamping to V_S - 50V for fast demagnetization
- Differential inputs with large common mode range and threshold hysteresis
- Undervoltage lockout with hysteresis
- Open load detection
- Two diagnostic outputs
- Output status led driver
- Non dissipative short circuit protection
- Protection against and surge transient (IEC 61000-4-5)
- Immunity against burst transient (IEC 61000-4-4)
- ESD protection (human body model ±2kV)

PowerSO-20

Description

The L6370 is a monolithic Intelligent Power Switch in Multipower BCD Technology, for driving inductive or resistive loads. An internal Clamping Diode enables the fast demagnetization of inductive loads. Diagnostic for CPU feedback and extensive use of electrical protections make this device extremely rugged and specially suitable for industrial automation applications.

Table 1. Device summary

Part number	Op. Temp. range, °C	Package	Packaging
L6370D	-25 to +85	PowerSO-20	Tube
L6370D013TR	-25 to +85	PowerSO-20	Tape & Reel

Contents

1 Block diagram and pin description

Figure 1. Block diagram

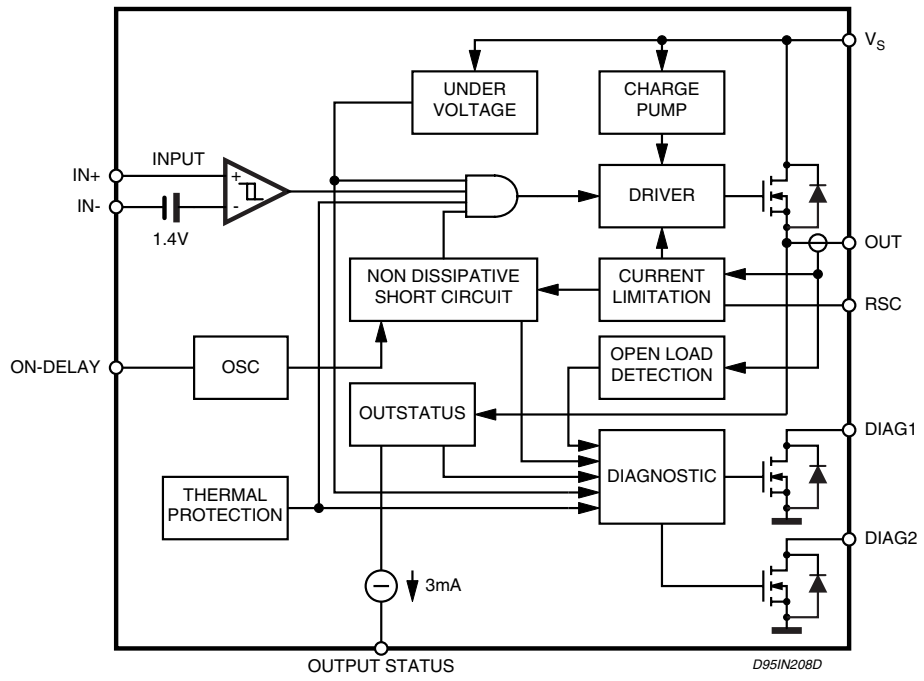
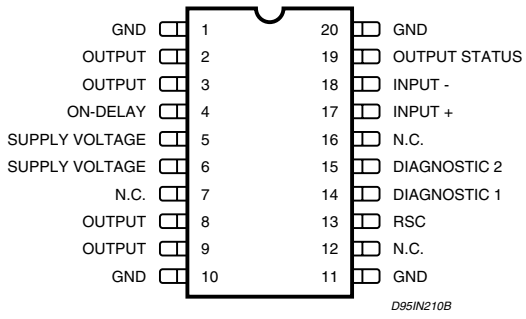


Figure 2. Pin connection (top view)



PowerSO-20

Note: Output pins must be connected externally to the package to use all leads for the output current (Pin 2, 3, 8 and 9 for PowerSO20 package).

1.1 Pin description

Table 2. Pin description

Pin N°	Pin name	Function
14	DIAG1	DIAGNOSTIC 1 output. This open drain reports the IC working conditions. (See Diagnostic truth *Table 7*)
15	DIAG2	DIAGNOSTIC 2 output. This open drain reports the IC working conditions. (See Diagnostic truth *Table 7*)
18	IN-	Comparator non inverting input
17	IN+	Comparator inverting input
19	OUTSTATUS	This current source output is capable of driving a LED to signal the status of the output pin. The pin is active (source current) when the output pin is considered high (See *Figure 3*)
1, 10, 11, 20	GND	Ground
4	ON-DELAY	Programmable ON time interval duration during short circuit operation
13	RSC	Current limitation setting.
8, 9	OUTPUT	High Side output with built-in current limitation
5, 6	V_S	Supply Volatge Input, the value of the supply voltage is monitored to detect under voltage condition

2 Electrical specifications

2.1 Absolute maximum ratings

Table 3. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_S	Supply Voltage (T_W< 10ms)	50	V
V_S– V_O	Supply to Output Differential Voltage. See also V_{CI}	internally limited	V
V_{od}	Externally Forced Voltage	-0.3 to 7	V
I_{od}	Externally Forced Voltage	+1	mA
V_i	Input Voltage	-10 to V_S+10	V
V_i	Differential Input Voltage	43	V
I_i	Input Current	20	mA
I_O	Output Current . See also ISC	internally limited	A
P_{TOT}	Power Dissipation. See also Thermal Characteristics.	internally limited	W
T_{OP}	Operating Temperature Range (T_{amb})	-25 to +85	°C
T_{STG}	Storage Temperature	-55 to 150	°C
E_I	Energy Induct. Load T_J= 85°C	1	J

2.2 Thermal data

Table 4. Thermal data

Symbol	Description		Value	Unit
R_{thJC}	Thermal Resistance Junction to case	Max.	1.5	°C/W
R_{thJA}	Thermal Resistance Junction to ambient	Max.	-	

2.3 Electrical characteristics

Table 5. Electrical characteristics
(V_S = 24V; T_J = –25 to +125°C, unless otherwise specified)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
V_{smin}	Supply Voltage for Valid Diagnostics	I_{diag}> 0.5mA ; V_{dg1}= 1.5V	4		35	V
V_s	Supply Voltage (operative)		9.5	24	35	V
I_q	Quiescent Current $I_{out} = I_{os} = 0$	V_{il} V_{ih}		0.8 3	1.4 4	mA
V_{sth1}	Undervoltage Threshold 1	(See *Figure 3*), T_{amb} = 0 to +85°C	8.5	9	9.5	V
V_{sth2}	Undervoltage Threshold 2		8	8.5	9	V
V_{sth3}	Supply Voltage Hysteresis		300	500	700	mV
I_{sc}	Short Circuit Current	V_S = 9.5 to 35V; R_L= 2Ω 5kΩ< R_{SC}< 30kΩ	15/R_{SC}(kΩ)			A
		0< R_{SC}< 5kΩ	2.6	3.2	4	A
V_{don}	Output Voltage Drop	I_{out} = 2.0A T_j = 25°C T_j = 25°C		200 320	280 440	mV
		I_{out} = 2.5A T_j = 25°C T_j = 25°C		250 400	350 550	mV
I_{oslk}	Output Leakage Current	$V_i = V_{il}$; V_o = 0V			500	µA
V_{ol}	Low State Out Voltage	$V_i = V_{il}$; $R_L = \infty$		0.8	1.5	V
V_{cl}	Internal Voltage Clamp (V_S- V_O)	I_O = 1A Single Pulsed: T_p = 300µs	48	53	58	V
I_{old}	Open Load Detection Current	$V_i = Vi_h$; T_{amb} = 0 to +85°C	1	3	6	mA
V_{id}	Common Mode Input Voltage Range (Operative)	V_S = 18 to 35V	-7		15	V
I_{ib}	Input Bias Current	V_i = -7 to 15V; -In = 0V	-250		250	µA
V_{ith}	Input Threshold Voltage	V +In > V -In	0.8	1.4	2	V
V_{iths}	Input Threshold Hysteresis Voltage	V +In > V -In	50		400	mV
R_{id}	Diff. Input Resistance	0 < +In < +16V ; -In = 0V -7 < +In < 0V ; -In = 0V		400 150		KΩ
I_{ilk}	Input Offset Current	V +In = V -In +Ii 0V < Vi < 5.5V -Ii	-20 -75	-25	+20	µA
		-In = GND +Ii 0V < V+In <5.5V -Ii	-250	+10 -125	+50	
		+In = GND +Ii 0V < V-In <5.5V -Ii	-100 -50	-30 -15		

Table 5. Electrical characteristics (continued)
(V_S = 24V; T_J = –25 to +125°C, unless otherwise specified)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
V_{oth1}	Output Status Threshold 1 Voltage	(See *Figure 3*)	4.5	5	5.5	V
V_{oth2}	Output Status Threshold 2 Voltage		4	4.5	5.0	V
V_{ohys}	Output Status Threshold Hysteresis		300	500	700	mV
I_{osd}	Output Status Source Current	$V_{out} > V_{oth1}$; V_{os} = 2.5V	2		4	mA
V_{osd}	Active Output Status Driver Drop Voltage	$V_s - V_{os}$; I_{os} = 2mA T_{amb} = 0 to +85°C		1.5	3	V
I_{oslk}	Output Status Driver Leakage Current	$V_{out} < V_{oth2}$; V_{os} = 0V V_S = 9.5 to 35V			25	µA
V_{dgl}	Diagnostic Drop Voltage	D1 / D2 = L ; Idiag= 0.5mA D1 / D2 = L ; Idiag= 3mA		40 250		mV
I_{dglk}	Diagnostic Leakage Current	D1 / D2 = H ; 0 < Vdg < V_s V_S = 9.5 to 35V			5	µA
Source drain NDMOS diode						
V_{fsd}	Forward On Voltage	@ I_{fsd} = 2.5A		1	1.5	V
I_{fp}	Forward Peak Current	t = 10ms; d = 20%			6	A
t_{rr}	Reverse Recovery Time	I_f = 2.5A di/dt = 25A/µs		200		ns
t_{fr}	Forward Recovery Time			100		ns
Thermal characteristics						
ΘLim	Junction Temp. Protect.		135	150		°C
ΘTH	Thermal Hysteresis			20		°C

Note: $V_{il} \leq 0.8V$, $V_{ih} \geq 2V$ @ (V+In > V-In)

2.4 AC operation

Table 6. AC operation

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
t_r - t_f	Rise or Fall Time	V_S = 24V; R_l = 70Ω; R_l to ground		20		µs
t_d	Delay Time			5		µs
dV/dt	Slew Rate (Rise and Fall Edge)		0.7	1	1.5	V/µs
t_{ON}	On time during Short Circuit Condition	50pF < C_{DON} < 2nF		1.28		µs/pF
t_{OFF}	Of time during hort Circuit Condition			64		t_{ON}
f_{max}	Maximum Operating Frequency			25		KHz

3 Circuit description

Figure 3. Output status hysteresis

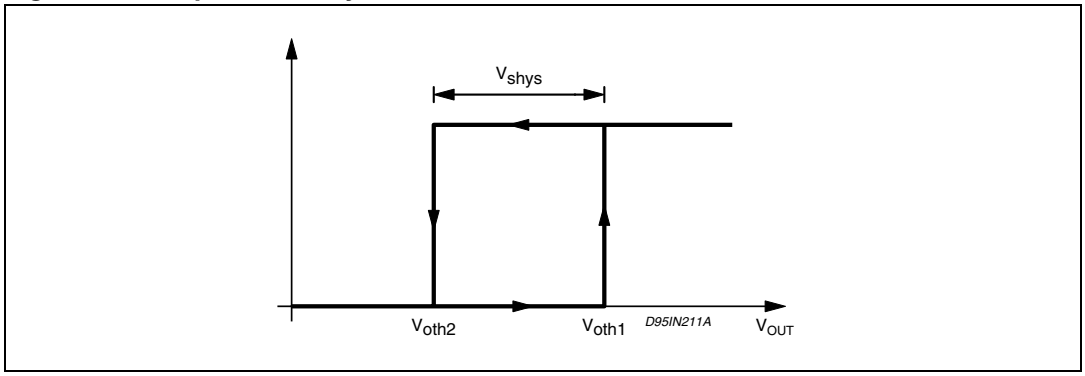


Figure 4. Undervoltage comparator hysteresis

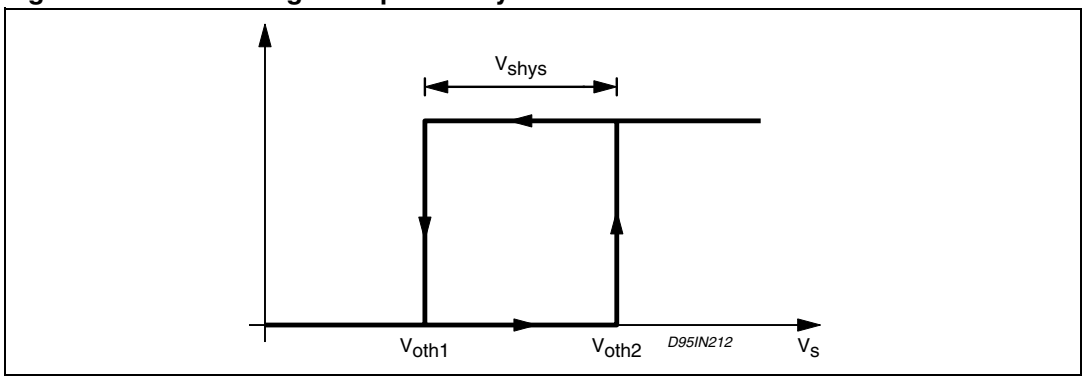
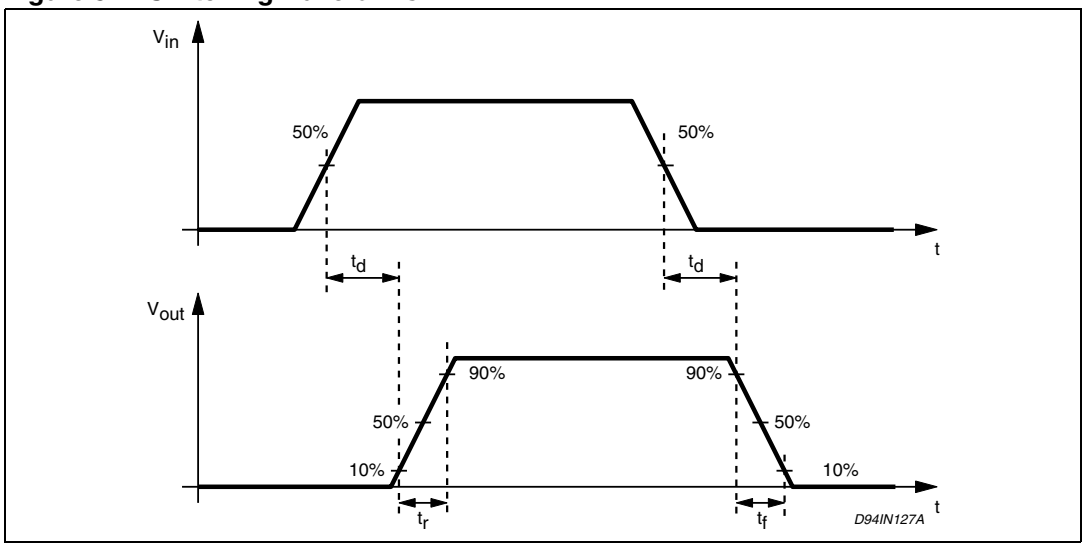


Figure 5. Switching waveforms



3.1 Diagnostic truth table

Table 7. Diagnostic truth table

Diagnostic conditions	Input	Output	Diag1	Diag2
Normal Operation	L H	L H	H H	H H
Open Load Condition (I_o< I_{old})	L H	L H	H L	H H
Short to V_S	L H	H H	L L	H H
Short Circuit to Ground (I_O = I_{SC}) (1) (pin ON-DELAY grounded)	H L	X L	H H	H H
Output DMOS Open	L H	L L	H L	H H
Overtemperature	L H	L L	H H	L L
Supply Undervoltage (V_S< V_{sth2})	L H	L L	L L	L L

1. A cold lamp filament, or a capacitive load may activate the current limiting circuit of the IPS, when the IPS is initially turned on.

3.2 Input section

The input section is an high impedance differential stage with high common and differential mode range. There's built-in offset of +1.4V (typical value) and an hysteresis of 400mV (maximum value), to ensure high noise immunity.

3.3 Diagnostic logic

The operating conditions of the device are permanently monitored and the following occurences are signalled via the DIAG1/DIAG2 open-drain output pins:

- Short Circuit versus ground. A current limiting circuit fixes at I_{sc} = 3.2A (typical value) the maximum current that can be sourced from the OUTPUT pin (for more details see short circuit operation section).
- Short Circuit versus Vs.
- Under Voltage(UV)
- Over Temperature (OVT)
- Open Load, if the output current is less than 3mA (typical value).
- Output DMOS Open according to the diagnostic Truth *Table 7*

3.4 Short circuit operation

In order to minimise the power dissipation when the output is shorted to grounded, an innovative, non dissipative short cicuit protection (patent pending) is implemented, avoiding, thus the intervention of the thermal protection in most cases.

Whenever the output is shorted to ground, or, generally speaking, an over current is sinked by the load, the output devices is driven in linear mode, sourcing the Isc current (typically 3.2A) for a time interval (ton) defined by means of the external CON capacitor connected between the ONDELAY pin and GND. Whether the short circuit crease within the ton interval the DIAG2 output status is not affected, acting as a Programmable Diagnostic Delay.

This function allow the device to drive a capacitive load or a filament lamp (that exhibits a very low resistance during the initial heading phase) without the intervention of the diagnostic. If the short circuit lasts for the whole t_{ON} interval, the output DMOS is switched OFF and the DIAG2 goes low, for a time interval t_{OFF} lasting 64 times t_{ON}.

At the end of the t_{OFF} interval if the short circuit condition is still present, the output DMOS is turned ON (and the DIAG2 goes high - see *Figure 7*) for another t_{ON} interval and the sequence starts again, or, whether not, the normal condition operation is resumed.

The t_{ON} interval can be set to lasts between 64ms and 2.56ms for a C_{ON} capacitor value ranging between 50pF and 2nF to have:

$$t_{ON}\ (\mu s) = 1.28\ C_{ON}\ (pF)$$

If the ON-DELAY pin is grounded the non dissipative short circuit protection is disabled, and the Isc current is delivered until the Overtemperature Protection shuts the device off. The behaviour of the DIAG2 output is, in this situation, showed in the Diagnostic Truth *Table 7*.

3.5 Overtemperature protection (OVT)

If the chip temperature exceeds Qlim (measured in a central position in the chip) the chip deactivates itself.

The following actions are taken:

all the output stage is switched off;

the signal DIAG2 is activated (active low).

Normal operation is resumed as soon as (typically after some seconds) the chip temperature monitored goes back below Θ_{lim}-Θ_H.

The different thresholds with hysteretic behavior assure that no intermittent conditions can be generated.

3.6 Undervoltage protection (UV)

The supply voltage is expected to range from 9.5V to 35V, even if its reference value is considered to be 24V.

In this range the device operates correctly. Below 9.5V the overall system has to be considered not reliable.

Protection will thus shut off the output whenever the supply voltage falls below the mask fixed by the V_{sth1}(9V typ.) and V_{sth2} (8.5V typ.).

The hysteresis (see *Figure 4*) ensures a non intermittent behavior at low supply voltage with a superimposed ripple. The Under Voltage status is signalled via the DIAG1 and DIAG2 outputs (see the Diagnostic Truth *Table 7*) .

3.7 Demagnetization of inductive loads

An internal zener diode, limiting the voltage across the Power MOS to between 50 and 60V (V_{cl}), provides safe and fast demagnetization of inductive loads without external clamping devices. The maximum energy that can be absorbed from an inductive load is specified as 1J (at T_j = 85°C) (see *Figure 4*).

Figure 6. L6370 short circuit operation waveforms

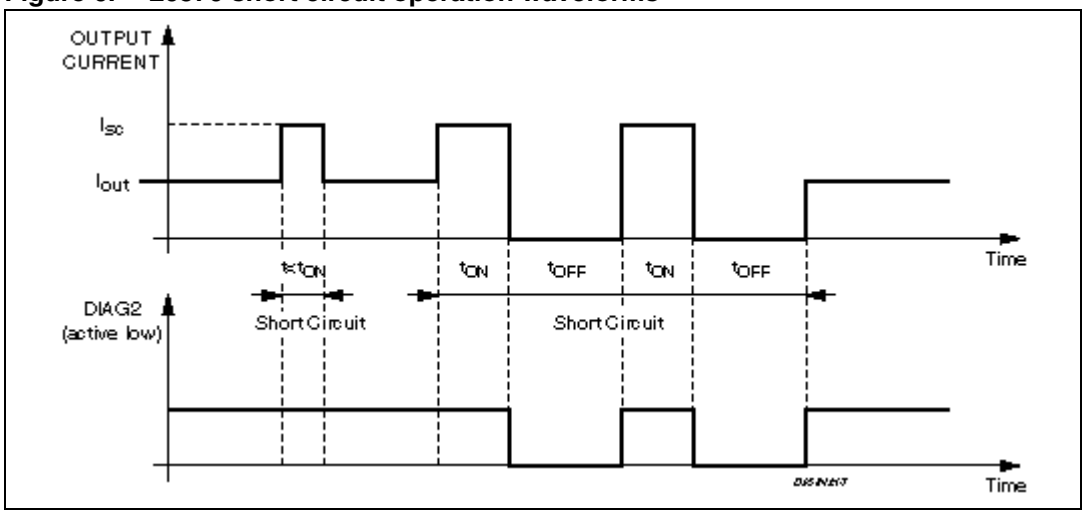
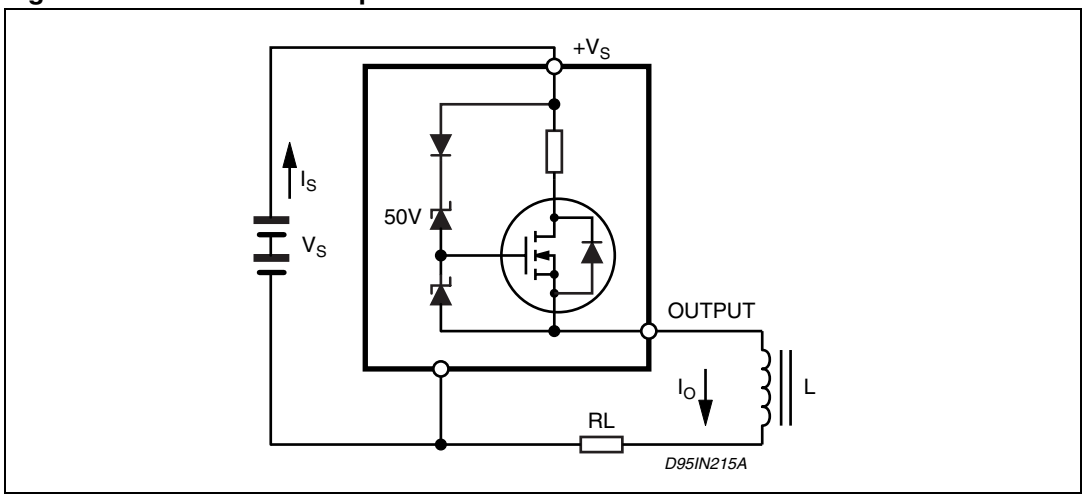


Figure 7. Inductive load equivalent circuit



4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect . The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: www.st.com

4.1 PowerSO-20 mechanical data & package dimensions

Figure 8. PowerSO-20 mechanical data & package dimensions

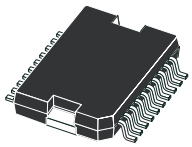
DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			3.6			0.142
a1	0.1		0.3	0.004		0.012
a2			3.3			0.130
a3	0		0.1	0.000		0.004
b	0.4		0.53	0.016		0.021
c	0.23		0.32	0.009		0.013
D (1)	15.8		16	0.622		0.630
D1 (2)	9.4		9.8	0.370		0.386
E	13.9		14.5	0.547		0.570
e		1.27			0.050	
e3		11.43			0.450	
E1 (1)	10.9		11.1	0.429		0.437
E2			2.9			0.114
E3	5.8		6.2	0.228		0.244
G	0		0.1	0.000		0.004
H	15.5		15.9	0.610		0.626
h			1.1			0.043
L	0.8		1.1	0.031		0.043
N	8°(typ.)					
S	8°(max.)					
T		10			0.394	

(1) "D and E1" do not include mold flash or protusions.
- Mold flash or protusions shall not exceed 0.15mm (0.006")
- Critical dimensions: "E", "G" and "a3".

(2) For subcontractors, the limit is the one quoted in jedec MO-166

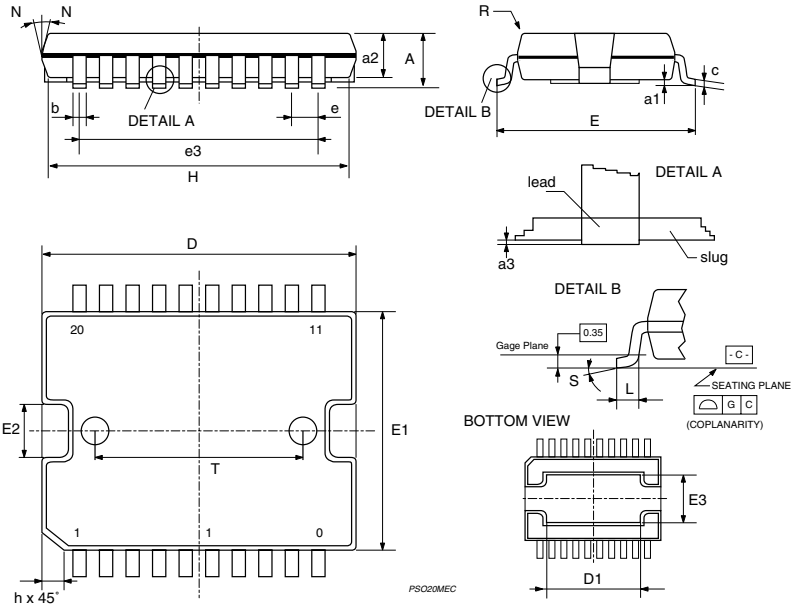
OUTLINE AND MECHANICAL DATA

Weight: 1.9gr



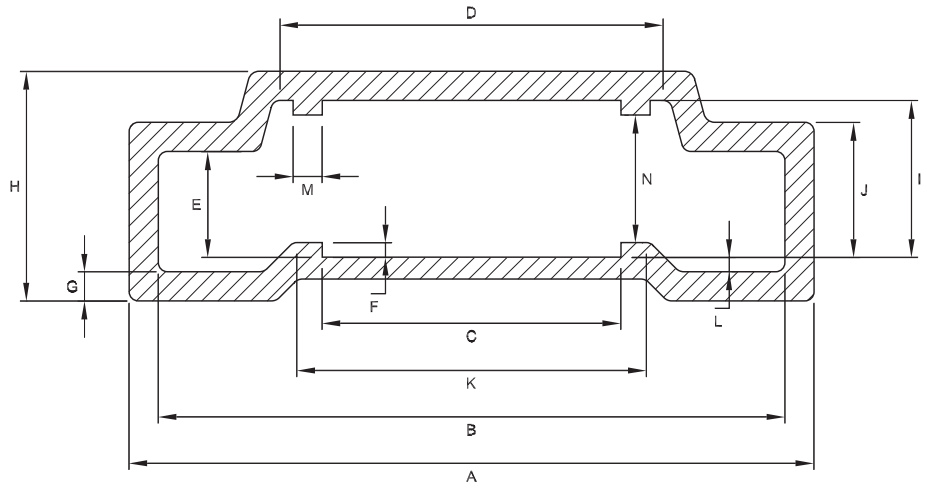
JEDEC MO-166

PowerSO-20



4.2 PowerSO-20 packing information

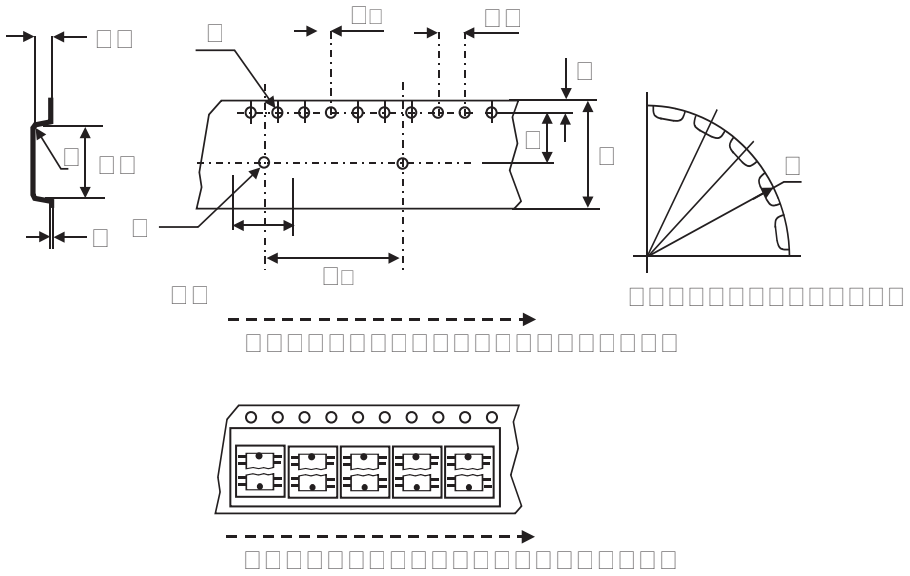
Figure 9. PowerSO-20 tube shipment information



TUBE MECHANICAL DATA		
	mm.	inch
A	18.80	0.740
B	17.2 ±0.2	0.677 ±0.008
C	8.20 ±0.2	0.323 ±0.008
D	10.90 ±0.2	0.429 ±0.008
E	2.90 ±0.2	0.114 ±0.008
F	0.40	0.016
G	0.80	0.031
H	6.30	0.248
I	4.30 ±0.2	0.165 ±0.008
J	3.7 ±0.2	0.146 ±0.008
K	9.4	0.370
L	0.40	0.016
M	0.80	0.031
N	3.50 ±0.2	0.138 ±0.008

BASE QUANTITY	31 pcs.
BULK QUANTITY	310 pcs.

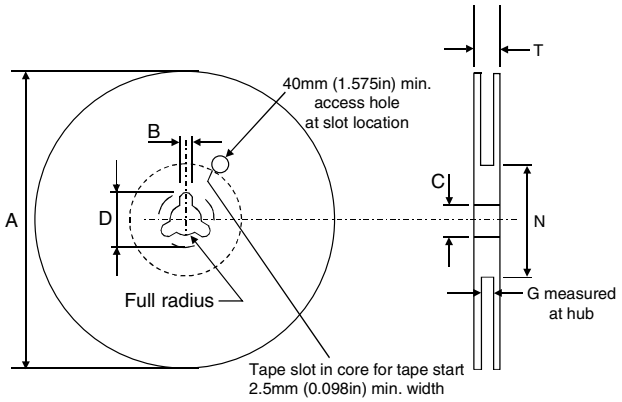
Figure 10. PowerSO-20 tape shipment specification



TAPE MECHANICAL DATA		
	mm.	inch
D	1.50 +0.1/0	0.059 +0.004/0
E	1.75 ±0.1	0.069 ±0.004
Po	4.00 ±0.1	0.157 ±0.004
T max.	0.40	0.016
D1 min.	1.50	0.059
F	11.5 ±0.05	0.453 ±0.002
K max.	6.50	0.256
P2	2.00 ±0.1	0.079 ±0.004
R	50	1.968
W	24.00 ±0.30	0.945 ±0.012
P1	24.00	0.945
Ao, Bo, Ko	0.05 min to 1.0 max.	0.002 min to 0.039 max.

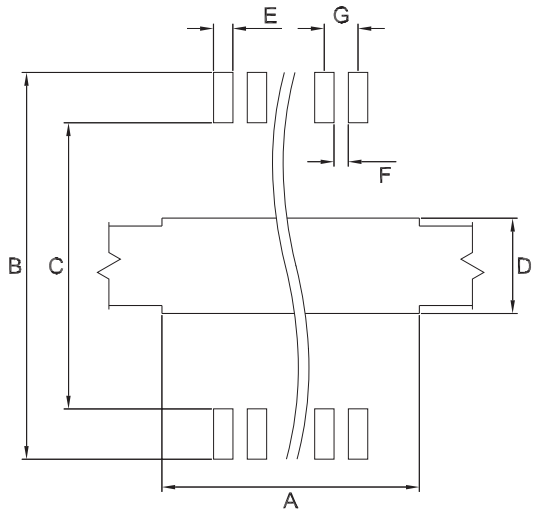
BASE QUANTITY	600 pcs.
BULK QUANTITY	600 pcs.

Figure 11. PowerSO-20 reel shipment specification



REEL MECHANICAL DATA		
	mm.	inch
Tape size	24.0 ±0.30	0.945 ±0.012
A max.	330.0	12.992
B min.	1.5	0.059
C	13.0 ±0.20	0.512 ±0.008
D min.	20.2	0.795
N min.	60	2.362
G	24.4 +2/-0	0.960 +0.079/-0
T max.	30.4	1.197

Figure 12. Footprint recommended data



FOOTPRINT DATA		
	mm.	inch
A	9.5	0.374
B	14.7-15.0	0.579-0.591
C	12.5-12.7	0.492-0.500
D	6.3	0.248
E	0.64	0.026
F	0.71	0.028
G	1.27	0.050

5 Revision history

Table 8. Revision history

Date	Revision	Changes
10-Aug-2003	3	Initial release.
12-Dec-2005	4	Applied new Look & Feel Style Sheet. Added L6370D013TR part number. Updated Package and Packing section.
26-Apr-2006	5	Document has been reformatted
19-Feb-2007	6	Typo in *Figure 2 on page 3*.
19-Jun-2007	7	Truth table updated, deleted Multiwatt mechanical information

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