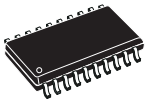
L9333

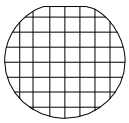
QUAD LOW SIDE DRIVER

- WIDE OPERATING SUPPLY VOLTAGE RANGE FROM 4.5V UP TO 32V FOR TRANSIENT 45V
- VERY LOW STANDBY QUIESCENT CURRENT TYPICALLY < 2µA
- INPUT TO OUTPUT SIGNAL TRANSFER FUNCTION PROGRAMMABLE
- HIGH SIGNAL RANGE FROM -14V UP TO 45V FOR ALL INPUTS
- 3.3V CMOS COMPATIBLE INPUTS
- DEFINED OUTPUT OFF STATE FOR OPEN INPUTS
- FOUR OPEN DRAIN DMOS OUTPUTS, WITH R_{DSon} = 1.5Ω FOR V_S > 6V AT 25°C
- OUTPUT CURRENT LIMITATION
- CONTROLLED OUTPUT SLOPE FOR LOW EMI
- OVERTEMPERATURE PROTECTION FOR EACH CHANNEL
- INTEGRATED OUTPUT CLAMPING FOR FAST INDUCTIVE RECIRCULATION V_{FB} > 45V

MULTIPOWER BCD TECHNOLOGY



SO20 (12+4+4)



DIE

ORDERING NUMBERS:

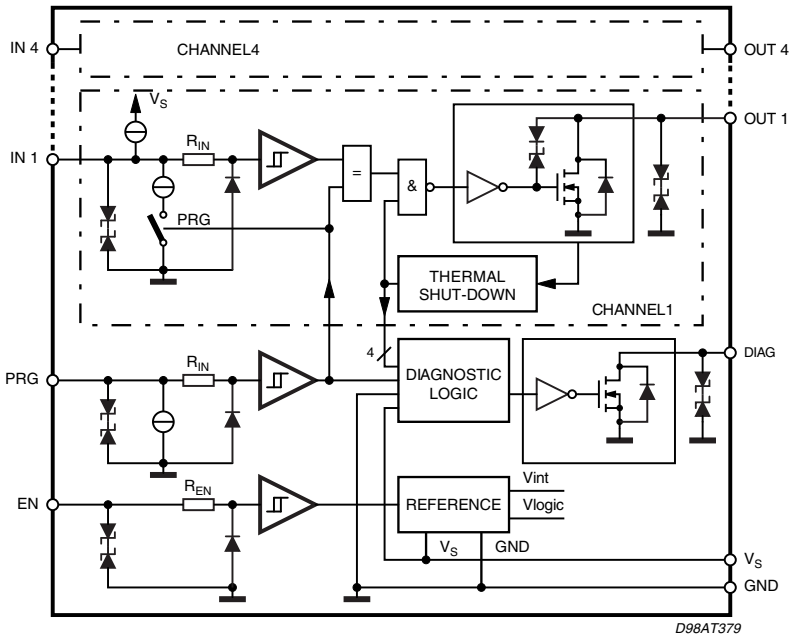
L9333MD	(SO20 12+4+4)
L9333DIE1	(DIE)

- STATUS MONITORING FOR
  - OVERTEMPERATURE
  - DISCONNECTED GROUND OR SUPPLY VOLTAGE

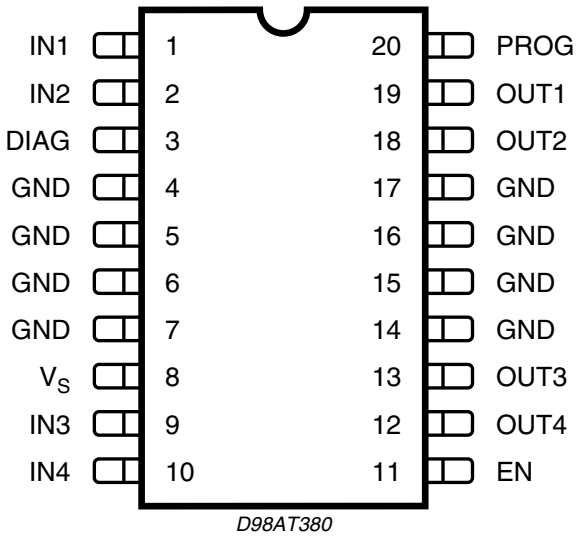
DESCRIPTION

The L9333 is a monolithic integrated quad low side driver. It is intended to drive lines, lamps or relais in automotive or industrial applications.

BLOCK DIAGRAM



PIN CONNECTION (Top view)



PIN FUNCTION

Pin N°	Pin Name	Description
1	IN 1	Input 1
2	IN 2	Input 2
3	DIAG	Diagnostic
4, 5, 6, 7, 14, 15, 16, 17	GND	Ground
8	VS	Supply Voltage
9	IN 3	Input 3
10	IN 4	Input 4
11	EN	Enable
12	OUT4	OUTPUT4
13	OUT 3	OUTPUT 3
18	OUT 2	OUTPUT 2
19	OUT 1	OUTPUT 1
20	PRG	Programming

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	Supply voltage DC Supply voltage Pulse (T = 400ms)	-0.3 to 32 -0.3 to 45	V V
dV_S/dt	Supply voltage transient	-10 to +10	V/µs
V_{IN}, V_{EN}, V_{PRG}	Input, Enable, Programming Pin voltage	-14 to 45	V
V_{OUT}	Output voltage	-0.3 to 45 [1)]	V
V_{DIAG}	Diagnostic output voltage	-0.3 to 45	V

Note 1) : In flyback phase the output voltage can reach 60V.

ESD - PROTECTION

Parameter	Value against GND	Unit
Supply pins and signal pins	± 2	KV
Output pins	± 4	KV

Note: Human-Body-Model according to MIL 883C. The device widthstand ST1 class level.

THERMAL DATA

Symbol	Parameter	Min	Typ	Max	Unit
T_{JSD}	Temperature shutdown threshold	175		220	°C
T_{JSDhys}	Temperature shutdown hysteresis		20		K
SO 12+4+4					
$R_{th\ (j-p)}$	Thermal resistance junction to pins			15	°C/W
$R_{th\ (j-a)}$	Thermal resistance junction to ambient [2)]			50	°C/W

Note 2) : With $6cm^2$ on board heat sink area.

LIFE TIME

Symbol	Parameter	Condition	Value	Unit
t_B	useful life time	$V_S \leq 14V$ EN = low	20	years
t_b	operating life time	$4.5V \leq V_S \leq 32V$ EN = high	5000	hours

OPERATING RANGE:

Within the operating range the IC operates as described in the circuit description, including the diagnostic table.

Symbol	Parameter	Condition	Min	Max	Unit
V_S	Supply voltage		4.5	32	V
V_{IN}, V_{EN}, V_{PRG}	Input voltage		-14	45	V
V_{OUT}	Output voltage	Voltage will be limited by internal Z-Diode clamping	-0.3	60	V
V_{DIAG}	Diagnostic output voltage		-0.3	45	V
T_J	Junction temperature		-40	150	°C

ELECTRICAL CHARACTERISTCS

The electrical characteristics are valid within the defined Operating Conditions, unless otherwise specified. The function is guaranteed by design until T_{JSDon} switch-on-threshold.

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
SUPPLY						
I_Q	Quiescent current	$V_S \leq 14V$; $V_{EN} \leq 0.3V$ T_{amb} 85 °C		< 2	10	µA
		$V_S \leq 14V$; $V_{EN} \leq 0.3V$ T_a 150°C			50	µA
		$V_S \leq 14V$; EN = high, Output = off EN = high, Output = on		1	2 3.5	mA mA
Inputs, IN1 - IN4; Programming, PRG						
V_{INlow}	Input voltage LOW		-14		1	V
V_{INhigh}	Input voltage HIGH		2		45	V
I_{IN}	Input current	$0V \leq V_{IN} \leq 45V$ 3)	-25		50	µA
R_{IN}	Input impedance	$V_{IN} < 0V$; $V_{IN} > V_S$	10	60		kΩ

Note 3) : Current direction depends on the programming setting (PRG=high leads into a positive current see also Blockdiagram page 1)

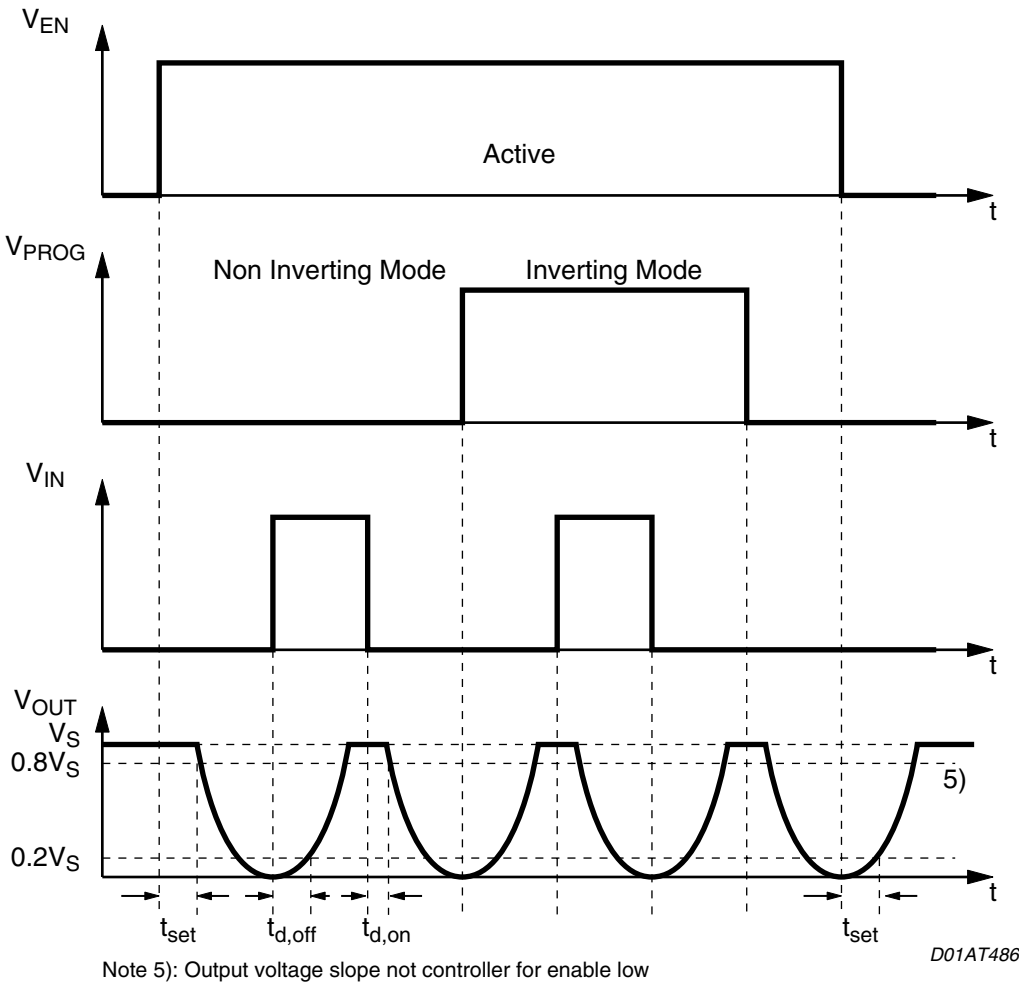
Enable EN						
V_{ENlow}	Input voltage LOW		-14		1	V
V_{ENhigh}	Input voltage HIGH		2		45	V
R_{EN}	Input impedance	$-14V < V_{EN} < 1.5V$	5			kΩ
I_{EN}	Input current	$1.5V < V_{EN} < 45V$	5		80	µA

ELECTRICAL CHARACTERISTCS (continued)

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
Outputs OUT1- OUT4						
R_{DSon}	Output ON-resistor	V_S > 6V, I_O = 0.3A		1.7	3.8	Ω
I_{OLeak}	Leakage current	$V_O = V_S$ = 14V; T_a < 125°C		1	5	µA
		$V_O = V_S$ = 14V; T_a < 150°C			25	µA
V_{OClamp}	Output voltage during clamping	$E_{FB} \leq$ 2mJ; 10 mA < I_O < 0.3A	45	52	60	V
I_{OSC}	Short-circuit current	V_S > 6V	400	700	1000	mA
C_O	internal output capacities	V_O > 4.5V			100	pF
Diagnostic Output DIAG						
V_{Dlow}	Output voltage LOW	I_{DL} = 0.6mA			0.8	V
I_{Dmax}	Max. output current	internal current limitation; V_D = 14V	1	5	15	mA
I_{DLeak}	Leakage current	$V_D = V_S$ = 14 V; T_a < 125 °C		0.1	1	µA
		$V_D = V_S$ = 14 V; T_a < 150 °C			5	µA
Timing Characteristics [4]						
$t_{d,on}$	On delay time	V_S = 14V		2	3.5	µs
$t_{d,off}$	Off delay time	C_{ext} = 0F; L_{ext} = 0H		3	4.5	µs
t_{set}	Enable settling time	only testing condition			20	µs
$t_{d,DIAG}$	ON or OFF Diagnostic delay time	10mA $\leq$ I_0 $\leq$ 200mA			10	µs
S_{out}	Output voltage slopes		2.5	9	16	V/µs

Note : All parameters are measured at 125°C.
Note 4) : See also Fig.3 Timing Characteristics

Figure 1. Timing Characteristics



Note 5): Output voltage slope not controller for enable low

Note 5) : Output voltage slope not controlled for enable low!

FUNCTIONAL DESCRIPTION

The L9333 is a quad low side driver for lines, lamps or inductive loads in automotive and industrial applications.

The logic input levels are 3.3V CMOS compatible. This allows the device to be driven directly by a microcontroller. For the noise immunity, all input thresholds have a hysteresis of typ. 100mV. Each input (IN, EN and PRG) is protected to withstand voltages from -14V to 45V. The device is activated with a 'high' signal on ENable. ENable 'low' switches the device into the sleep mode. In this mode the quiescent current is typically less than 2µA. A high signal on PRoGramming input changes the signal transfer polarity from noninverting to the inverting mode. This pin can be connected either to V_S or GND. If these pins are not connected, the forced status of the PRG and EN pin is low. For packaged applications it is still recommended to connect all input pins to ground respective VS to avoid EMC influence. The forced condition leads to a mode change if the PRG pin was high before the interruption. Independent of the PRoGramming input, the OUTput switches off, if the signal INput pin is not connected. This function is verified using a leakage current of 5µA (sink for PRG=high; source for PRG=low) during circuit test.

Each output driver has a current limitation of min 0.4A and an independent thermal shut-down. The thermal shut-down deactivates that output, which exceeds temperature switch off level. When the junction temperature decreases 20K below this temperature threshold the output will be activated again. This 20K is the hysteresis of the thermal shutdown function. The Gates, of the output DMOS transistors are charged and discharged with a current source. Therefore the output slope is limited. This reduces the electromagnetic radiation. For inductive loads an output voltage clamp of typically 52V is implemented.

The DIAGnostic is an open drain output. The logic status depends on the PRoGramming pin. If the PRG pin is 'low' the DIAG output becomes low, if the device works correctly. At thermal shut-down of one channel or if the ground is disconnected the DIAGnostic output becomes high. If the PRG pin is 'high' this output is switched off at normal function and switched on at overtemperature. For the fault condition of interrupted ground, the potential of VS and Diagnostic should be equal.

DIAGNOSTIC TABLE

Pins	EN	PRG	IN	OUT	DIAG
Normal function	H	L	L	L (on)	L (on)
	H	L	H	H (off)	L (on)
	H	H	L	H (off)	H (off)
	H	H	H	L (on)	H (off)
	L	X	X	H (off)	H (off)
Overtemperature, disconnected ground or supply voltage	H	L	X	H (off) *	H (off)
Overtemperature	H	H	X	H(off) *	L(on)

X = not relevant
* selective for each channel at overtemperature

Figure 2. Application for Inverting Transfer Polarity

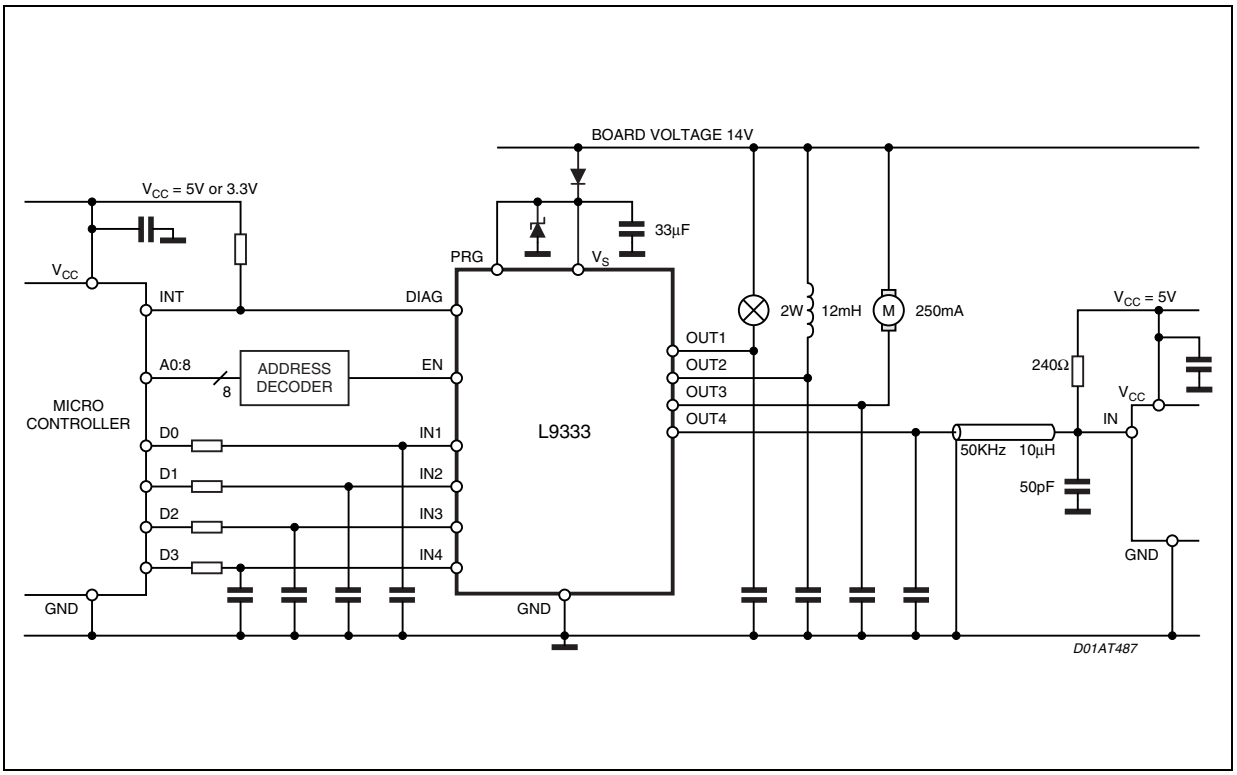
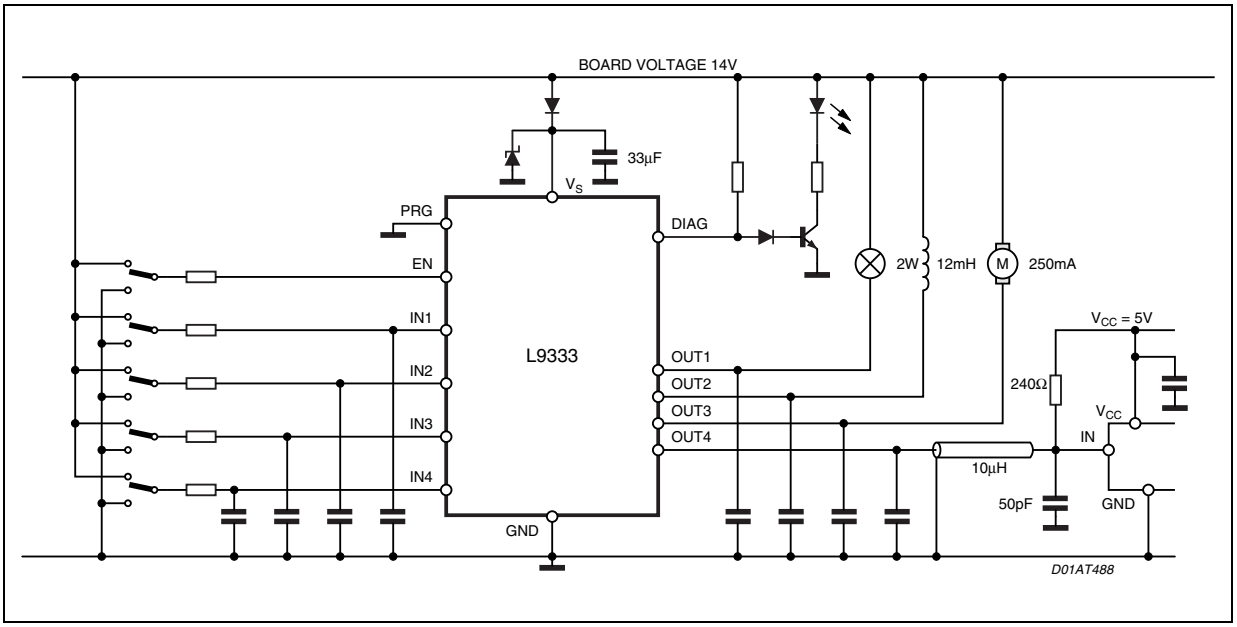


Figure 3. Application for non Inverting Transfer Polarity



Note We recommend to use the device for driving inductive loads with flyback energy $E_{FB} \leq 2mJ$.

EMC SPECIFICATION

EMS (electromagnetic susceptibility)

Measurement setup:

DUT mounted on a specific application board is driven in a typical application circuit (see below). Two devices are stimulated by a generator to read and write bus signals. They will be monitored externally to ensure proper function.

Measurement method:

a) The two bus lines are transferred 2m under a terminated stripline. That's where they were exposed to the RF-field. Stripline setup and measurement method is described in DIN 40839-4 or ISO 11452-5.

b) DUT mounted on the same application board is exposed to RF through the tophole of a TEM-cell. Measurement method according SAE J1752.

c) The two bus lines are transferred into a BCI current injection probe. Setup and measurement method is described in ISO 11452-4.

Failure criteria:

Failure monitoring is done by envelope measurement of the logic signals with a LeCroy oscilloscope with acceptance levels of 20% in amplitude and 2% time.

Limits:

The device is measured within the described setup and limits without fail function.

The Electromagnetic Susceptivity is not tested in production.

a) Field strength under stripline of > 250V/m in the frequency range 1 - 400MHz modulation: AM 1kHz 80%.

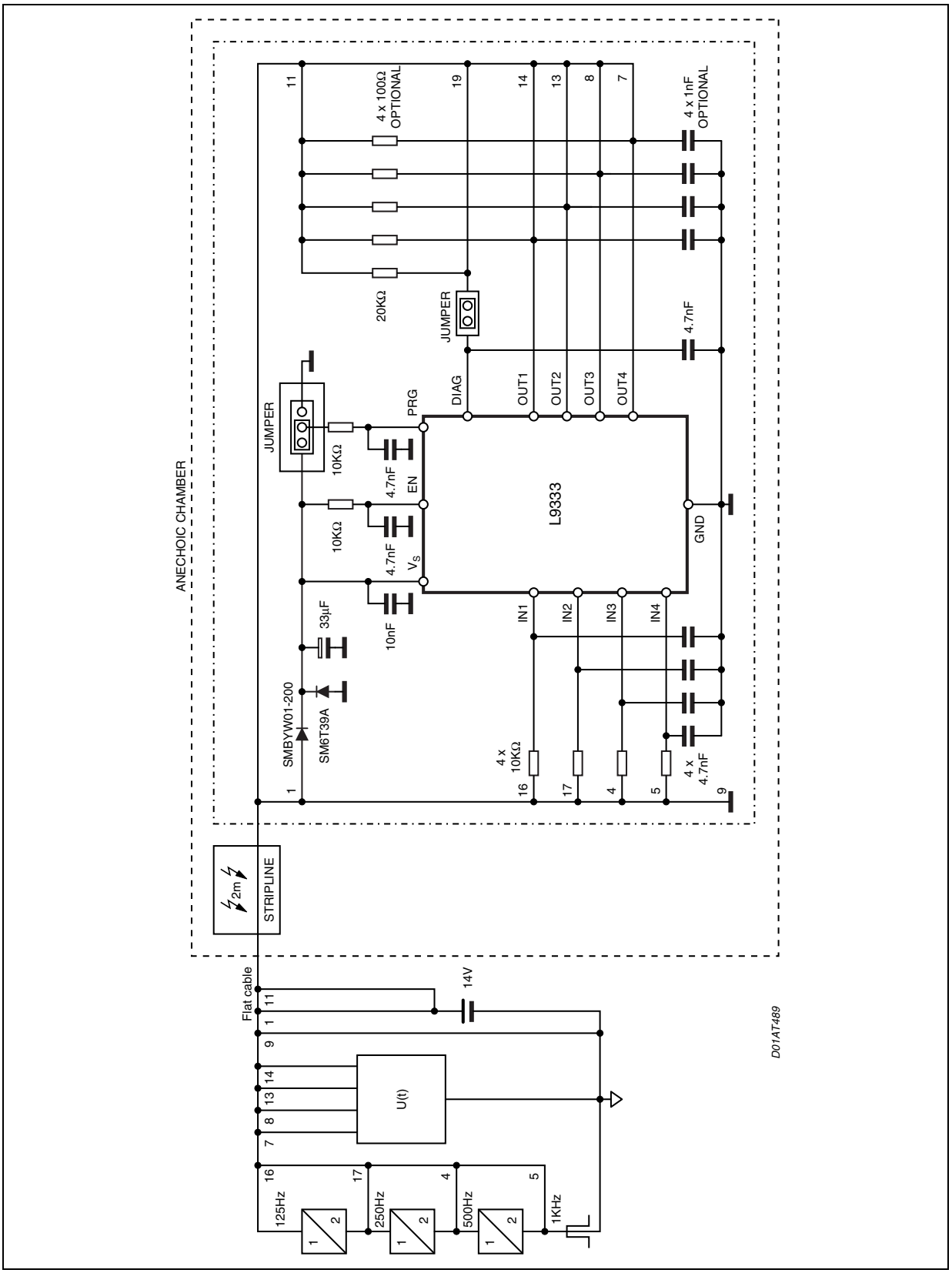
b) Field strength in TEM-cell of > 500V/m in the frequency range 1 - 400MHz modulation: AM 1kHz 80%.

c) RF-currents with BCI of > 100mA in the frequency range 1 - 400MHz modulation: AM 1kHz 80%.

Measured Circuit

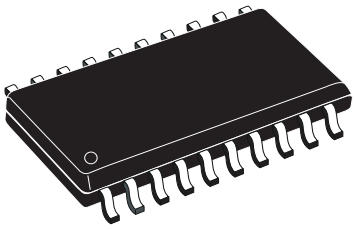
The EMS of the device was verified in the below described setup.

Figure 4.

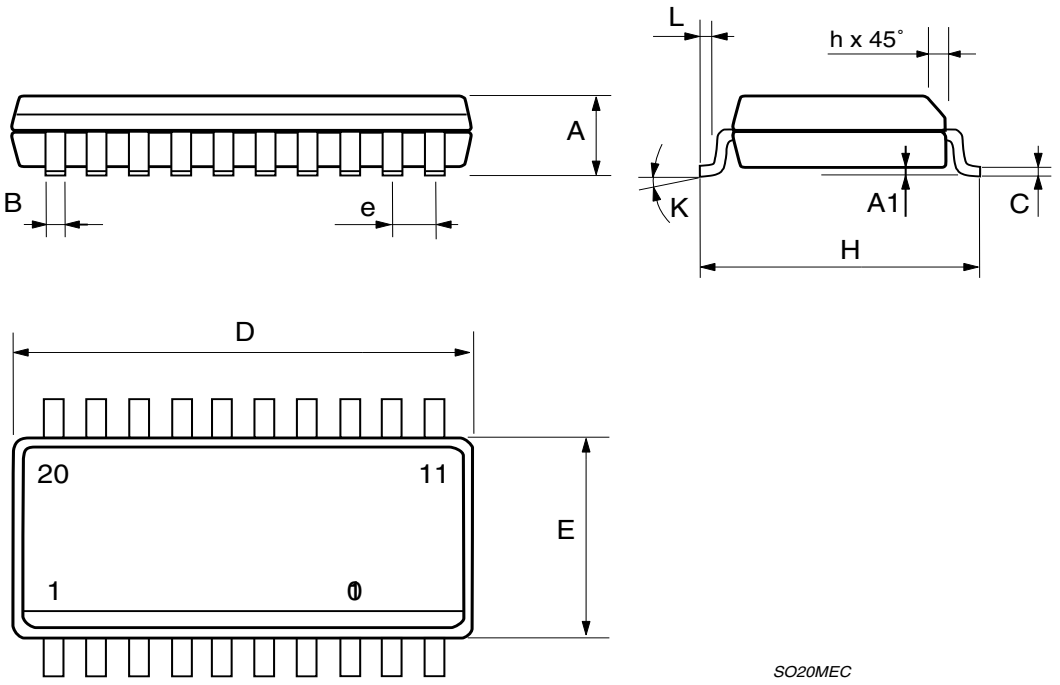

ANECHOIC CHAMBER
L9333
4 x 100Ω OPTIONAL
4 x 1nF OPTIONAL
20KΩ
JUMPER
4.7nF
DIAG
OUT1
OUT2
OUT3
OUT4
PRG
EN
V_S
10KΩ
10nF
33µF
SMBYW01-200
SM6T39A
IN1
IN2
IN3
IN4
GND
4 x 10KΩ
4 x 4.7nF
2m
STRIPLINE
Flat cable
14V
U(t)
125Hz
250Hz
500Hz
1KHz
D01AT489

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	2.35		2.65	0.093		0.104
A1	0.1		0.3	0.004		0.012
B	0.33		0.51	0.013		0.020
C	0.23		0.32	0.009		0.013
D	12.6		13	0.496		0.512
E	7.4		7.6	0.291		0.299
e		1.27			0.050	
H	10		10.65	0.394		0.419
h	0.25		0.75	0.010		0.030
L	0.4		1.27	0.016		0.050
K	0˚ (min.)8˚ (max.)					

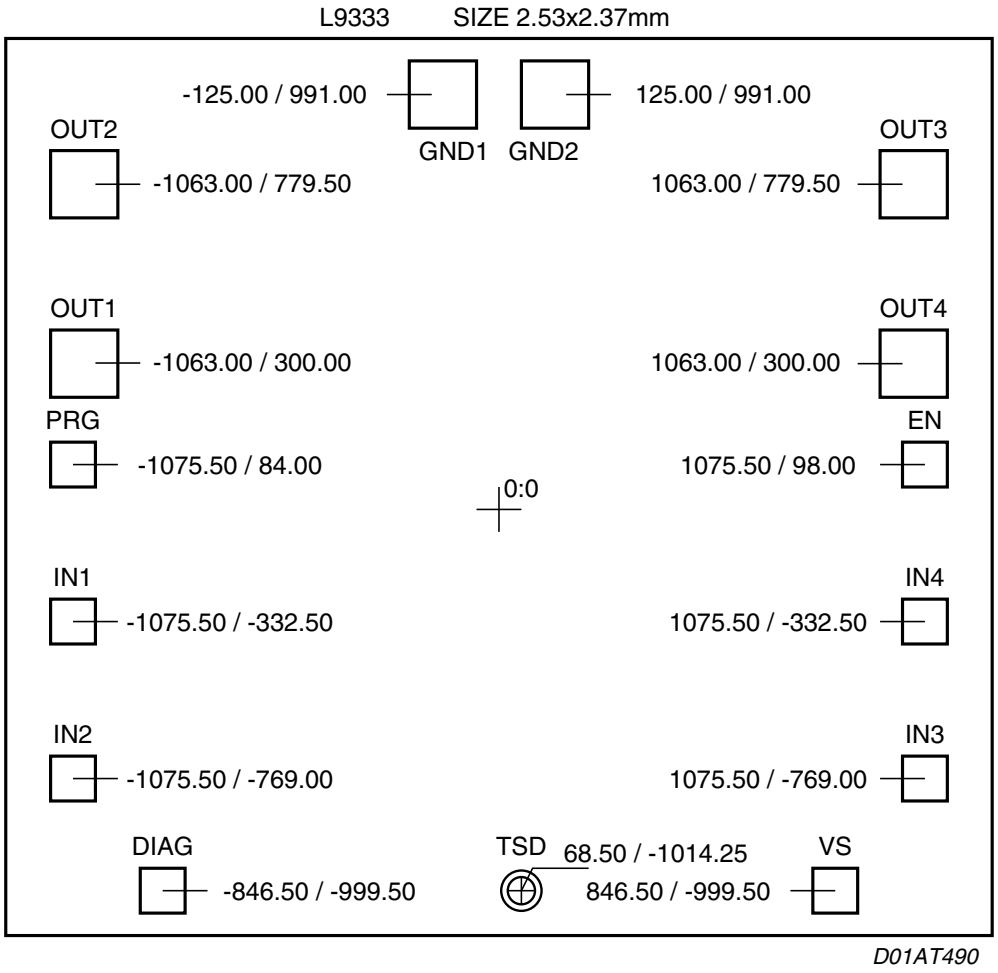
OUTLINE AND MECHANICAL DATA



SO20 (12+4+4)



SO20MEC


L9333 SIZE 2.53x2.37mm
-125.00 / 991.00
GND1
GND2
125.00 / 991.00
OUT2
-1063.00 / 779.50
OUT3
1063.00 / 779.50
OUT1
-1063.00 / 300.00
OUT4
1063.00 / 300.00
PRG
-1075.50 / 84.00
EN
1075.50 / 98.00
0:0
IN1
-1075.50 / -332.50
IN4
1075.50 / -332.50
IN2
-1075.50 / -769.00
IN3
1075.50 / -769.00
DIAG
-846.50 / -999.50
TSD
68.50 / -1014.25
846.50 / -999.50
VS
D01AT490

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