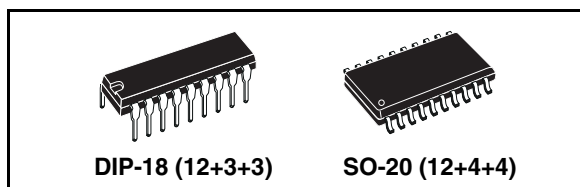


3.5 A step down switching regulator

Features

- Up to 3.5 A step down converter
- Operating input voltage from 8 V to 55 V
- 3.3 V and 5.1 V ($\pm 1\%$) fixed output, and adjustable outputs from:
 - 0.5 V to 50 V (3.3 type)
 - 5.1 V to 50 V (5.1 type)
- Frequency adjustable up to 300 kHz
- Voltage feed forward
- Zero load current operation (min. 1 mA)
- Internal current limiting (pulse by pulse and HICCUP mode)
- Precise 5.1 V (1.5%) reference voltage externally available
- Input/output synchronization function
- Inhibit for zero current consumption (100 mA typ. at $V_{CC} = 24$ V)
- Protection against feedback disconnection
- Thermal shutdown
- Output over voltage protection
- Soft-start function

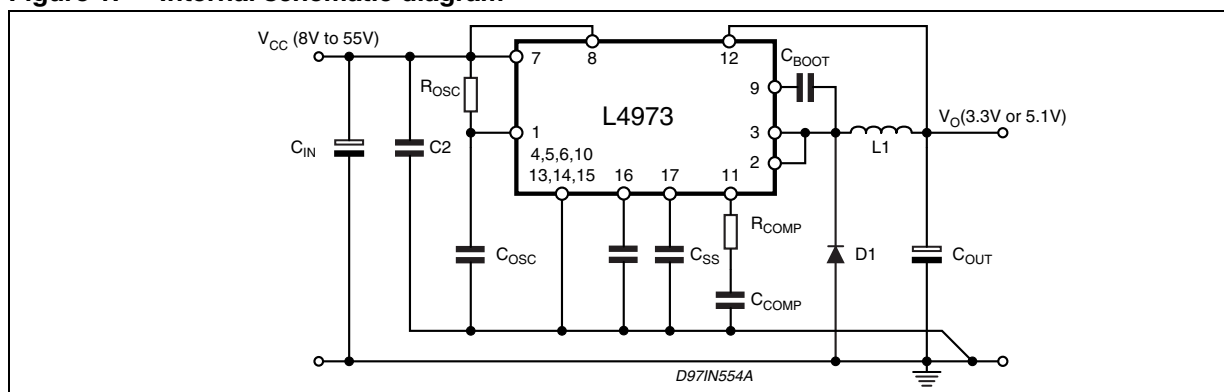


Description

The L4973 is a step down monolithic power switching regulator delivering 3.5 A at fixed voltages of 3.3 V or 5.1 V and using a simple external divider output adjustable voltage up to 50V. Realized in BCD mixed technology, the device uses an internal power D-MOS transistor (with a typical $R_{DS(on)}$ of 0.15Ω) to obtain very high efficiency and very fast switching times. Switching frequency up to 300 kHz are achievable (the maximum power dissipation of the packages must be observed).

A wide input voltage range between 8 V to 55 V and output voltages regulated from 3.3 V to 40 V cover the majority of the today applications. Features of this new generation of DC-DC converter includes pulse by pulse current limit, hiccup mode for output short circuit protection, voltage feed forward regulation, soft-start, input/output synchronization, protection against feedback loop disconnection, inhibit for zero current consumption and thermal shutdown. Packages available are in plastic dual in line, DIP-18 (12+3+3) for standard assembly, and SO20 (12+4+4) for SMD assembly.

Figure 1. Internal schematic diagram

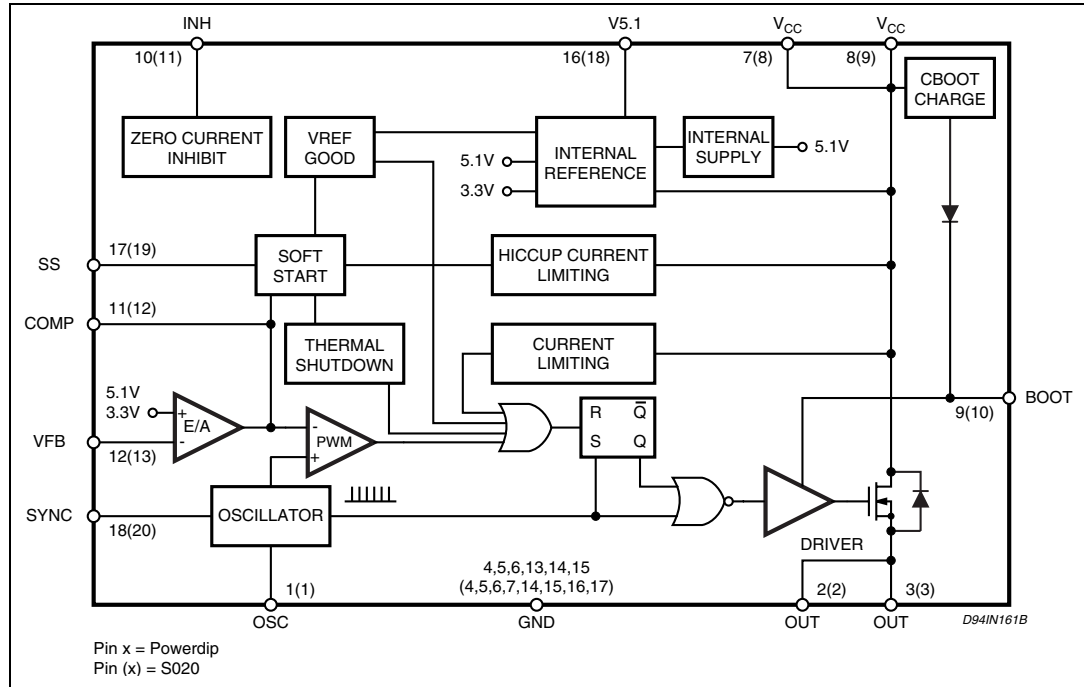


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1 Block diagram

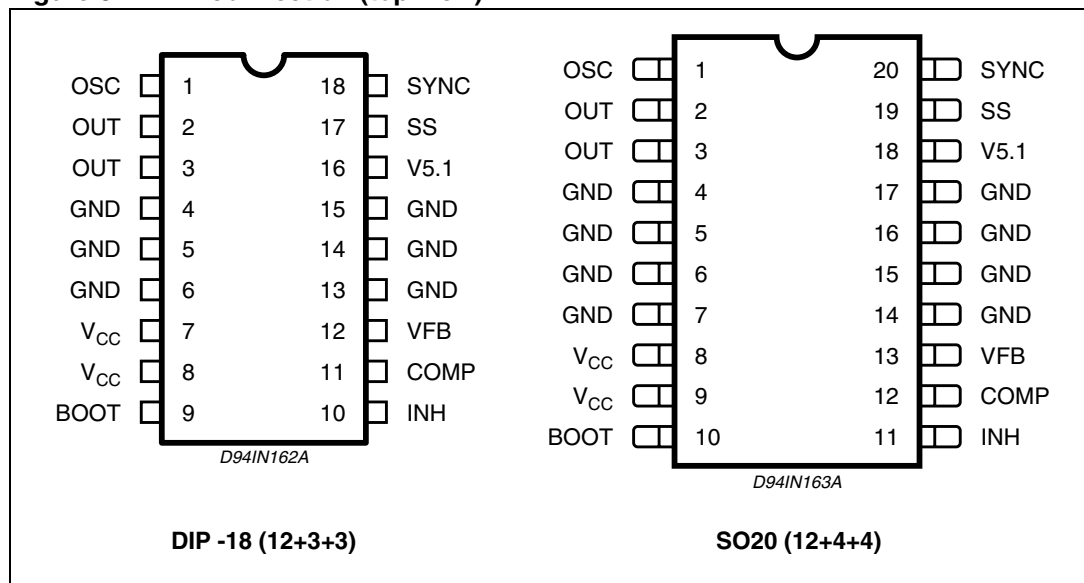
Figure 2. Block diagram



2 Pin settings

2.1 Pin connection

Figure 3. Pin connection (top view)



2.2 Pin description

Table 1. Pin description

N° Pin		Name	Description
DIP-18	SO-20		
11	12	COMP	E/A output to be used for frequency compensation
10	11	INH	A logic signal (active high) disables the device (sleep mode operation). If not used it must be connected to GND; if floating the device is disabled.
9	10	BOOT	A capacitor connected between this pin and the output allows to drive the internal D-MOS.
18	20	SYNC	Input/Output synchronization.
7,8	8,9	V _{CC}	Unregulated DC input voltage
2,3	2,3	OUT	Stepdown regulator output.
12	13	VFB	Stepdown feedback input. Connecting the output directly to this pin results in an output voltage of 3.3 V for the L4973V3.3 and 5.1 V for L4973V5.1. An external resistive divider is required for higher output voltages. For output voltage resistive divider is required for higher output voltages. For output voltage less than 3.3 V, see Note: 1 and Figure 33 .
16	18	V5.1	Reference voltage externally available.
4,5,6 13,14,15	4,5,6,7 14,15,16,17	GND	Signal ground
1	1	OSC	An external resistor connected between the unregulated input voltage and Pin 1 and a capacitor connected from Pin 1 to ground fixes the switching frequency. (Line feed forward is automatically obtained)

Note: 1 The maximum power dissipation of the package must be observed.

3 Electrical data

3.1 Maximum ratings

Table 2. Absolute maximum ratings

Symbol		Parameter	Value	Unit
DIP-18	SO-20			
V ₇ , V ₈	V ₉ , V ₈	Input voltage	58	V
V ₂ , V ₃	V ₂ , V ₃	Output DC voltage	-1	V
		Output peak voltage at t = 0.1 μs f = 200 kHz	-5	V
I ₂ , I ₃	I ₂ , I ₃	Maximum output current	int. limit.	
V ₉ -V ₈	V ₁₀ -V ₈		14	V
V ₉	V ₁₀	Bootstrap voltage	70	V
V ₁₁	V ₁₂	Analog input voltage (V _{CC} = 24 V)	12	V
V ₁₇	V ₁₉	Analog input voltage (V _{CC} = 24 V)	13	V
V ₁₂	V ₁₃	(V _{CC} = 20 V)	6	V
			-0.3	V
V ₁₈	V ₂₀	(V _{CC} = 20 V)	5.5	V
			0.3	V
V ₁₀	V ₁₁	Inhibit	V _{CC}	V
			-0.3	V
P _{tot}		DIP 12+3+3		
		Power dissipation a T _{pins} ≤ 90 °C	5	W
		(T _A = 70 °C no copper area)	1.3	W
		(T _A = 70 °C 4 cm copper area on PCB)	2	W
		SO-20		
		Power dissipation a T _{pins} = 90 °C	4	W
T _J , T _{STG}		Junction and storage temperature	-40 to 150	°C

3.2 Thermal data

Table 3. Thermal data

Symbol	Parameter	DIP-18	SO-20	Unit
R _{thJP}	Maximum thermal resistance junction-pin	12	15	°C/W
R _{thJA}	Maximum thermal resistance junction-ambient	60 ⁽¹⁾	80 ⁽¹⁾	°C/W

1. Package mounted on board

4 Electrical characteristics

Table 4. Electrical characteristics
 (Refer to the test circuit, $V_{CC} = 24\text{ V}$; $T_J = 25\text{ °C}$, $C_{OSC} = 2.7\text{ nF}$;
 $R_{OSC} = 20\text{ k}\Omega$; unless otherwise specified)

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
Dynamic characteristics						
	Input voltage range ⁽¹⁾	$V_O = V_{REF}$ to 40 V; $I_O = 3.5\text{ A}$ ⁽²⁾	8		55	V
	Output voltage L4973V5.1	$I_O = 1\text{ A}$	5.05	5.1	5.15	V
		$I_O = 0.5\text{ A to }3.5\text{ A}$ $V_{CC} = 8\text{ V to }55\text{ V}$ ⁽²⁾	4.95	5.1	5.25	V
	Output voltage L4973V3.3	$I_O = 1\text{ A}$	3.326	3.36	3.393	V
		$I_O = 0.5\text{ A to }3.5\text{ A}$ $V_{CC} = 8\text{ V to }40\text{ V}$ ⁽²⁾	3.292	3.36	3.427	V
	$R_{DS(on)}$	$V_{CC} = 10.5\text{ V}$ $I_O = 3.5\text{ A}$		0.15	0.22	Ω
		⁽²⁾			0.35	Ω
	Maximum limiting current	$V_{CC} = 8\text{ V to }55\text{ V}$ ⁽²⁾	3.8	4.5	5.5	A
			4	4.5	5.5	A
η	Efficiency	$V_O = 5.1\text{ V}$; $I_O = 3.5\text{ A}$		90		%
		$V_O = 3.3\text{ V}$; $I_O = 3.5\text{ A}$		85		%
	Switching frequency	⁽²⁾	90	100	110	kHz
	Supply voltage ripple rejection	$V_i = V_{CC} + 2 V_{RMS}$ $V_O = V_{ref}$; $I_O = 1\text{ A}$; $f_{ripple} = 100\text{ Hz}$	60			dB
Δf_{sw}	Switching frequency stability vs., supply voltage	$V_{CC} = 8\text{ V to }55\text{ V}$		2	5	%
Reference section						
	Reference voltage	$I_{ref} = 0\text{ to }20\text{ mA}$; $V_{CC} = 8\text{ to }55\text{ V}$	5.025	5.1	5.175	V
		⁽²⁾	4.950	5.1	5.250	V
	Line regulation	$I_{ref} = 0\text{ mA}$; $V_{CC} = 8\text{ to }55\text{ V}$		5	10	mV
	Load regulation	$V_{ref} = 0\text{ to }5\text{ mA}$; $V_{CC} = 0\text{ to }20\text{ mA}$		2	10	mV
				6	25	mV
	Short circuit current		30	65	100	mA

Table 4. Electrical characteristics (continued)
 (Refer to the test circuit, $V_{CC} = 24\text{ V}$; $T_J = 25\text{ }^\circ\text{C}$, $C_{OSC} = 2.7\text{ nF}$;
 $R_{OSC} = 20\text{ k}\Omega$; unless otherwise specified)

Symbol	Parameter	Test condition	Min	Typ	Max	Unit	
Soft-start							
	Soft-start charge current		30	45	60	μA	
	Soft-start discharge current		15	22	30	μA	
Inhibit							
	High level voltage		(2)	3.0		V	
	Low level voltage		(2)		0.8	V	
	I_{source} high level	$V_{\text{INH}} = 3\text{ V}$	(2)	10	16	50	μA
	I_{source} low level	$V_{\text{INH}} = 0.8\text{ V}$	(2)	10	15	50	μA
DC characteristics							
	Total operating quiescent current	Duty cycle = 50 %		4	6	mA	
	Quiescent current	Duty cycle = 0		2.7	4	mA	
	Total stand-by quiescent current	$V_{CC} = 24\text{ V}$; $V_{\text{INH}} = 5\text{ V}$		100	200	μA	
		$V_{CC} = 55\text{ V}$; $V_{\text{INH}} = 5\text{ V}$		150	300	μA	
Error amplifier							
	High level output voltage		11.0			V	
	Low level output voltage				0.65	V	
	Source bias current		1	2	3	μA	
	Source output current		200	300	600	μA	
	Sink output current		200	300		μA	
	Supply voltage ripple rejection	$V_{\text{COMP}} = \text{VFB}$ $C_{\text{REF}} = 4.7\text{ }\mu\text{F}$ 1-5 mA load current	60	80		dB	
	DC open loop gain	$R_L = \infty$	50	60		dB	
	Transconductance	$I_{\text{comp}} = -0.1\text{ to }0.1\text{ mA}$; $V_{\text{comp}} = 6\text{ V}$		2.5		mS	
Oscillator section							
	Ramp valley		0.78	0.85	0.92	V	
	Ramp peak	$V_{CC} = 8\text{ V}$	1.9	2.1	2.3	V	
		$V_{CC} = 55\text{ V}$	9	9.6	10.2	V	
	Maximum duty cycle		95	97		%	

Table 4. Electrical characteristics (continued)
 (Refer to the test circuit, $V_{CC} = 24\text{ V}$; $T_J = 25\text{ °C}$, $C_{OSC} = 2.7\text{ nF}$;
 $R_{OSC} = 20\text{ k}\Omega$; unless otherwise specified)

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
	Maximum frequency	Duty cycle = 0%; $R_{OSC} = 13\text{ k}\Omega$; $C_{OSC} = 820\text{ pF}$;			300	kHz
Sync function						
	High input voltage	$V_{CC} = 8\text{ V to }55\text{ V}$	3.5			V
	Low input voltage	$V_{CC} = 8\text{ V to }55\text{ V}$			0.9	V
	Slave sink current		0.15	0.25	0.45	mA
	Master output amplitude	$I_{source} = 3\text{ mA}$	4	4.5		V
	Output pulse width	No load, $V_{sync} = 4.5\text{ V}$	0.20	0.35		μs

1. Pulse testing with a low duty cycle
2. Specifications referred to T_J from -40 °C to 125 °C .

5 Evaluation board

Figure 4. Evaluation board circuit

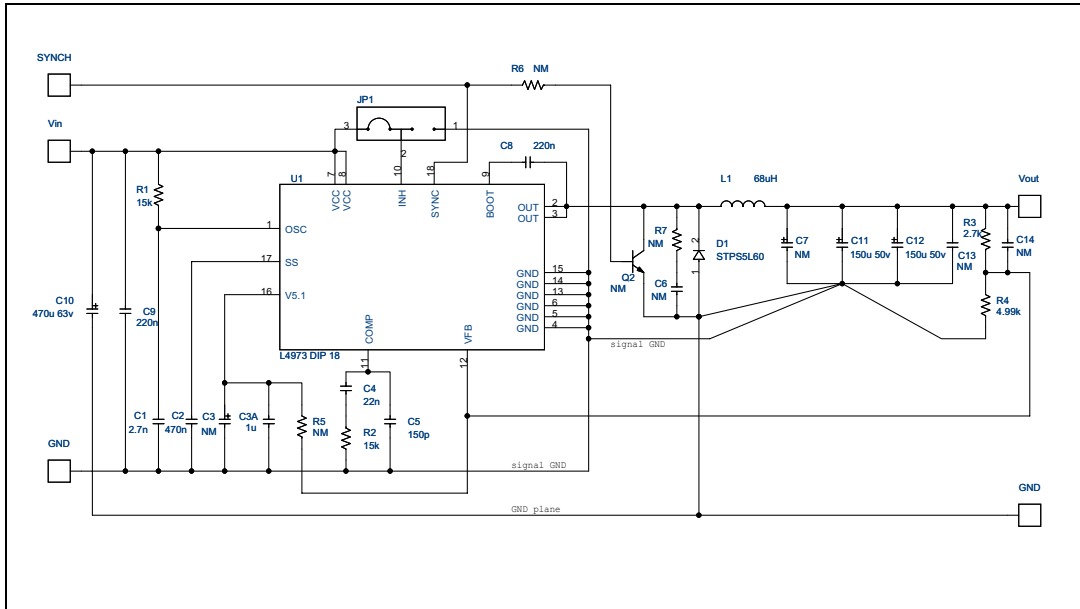


Table 5. Component list (fsw = 150 kHz, VOUT = 5 V)

Reference	Description	Part number	Manufacturer
R1	Resistor 15 kΩ 1%		
R2	Resistor 15 kΩ 1%		
R3	Resistor 2.7 kΩ 1%		
R4	Resistor 4.99 kΩ 1%		
R5	Not mounted		
R6	Not mounted		
R7	Not mounted		
C1	Capacitor 2.7 nF 5%		
C2	Capacitor 470 nF 5%		
C3	Capacitor 1 µF 5%		
C4	Capacitor 22 nF 5%		
C5	Capacitor 150 pF 5%		
C6	Not mounted		
C7	Not mounted		
C8	Capacitor 220 nF 5%		
C9	Capacitor 220 nF 5%		
C10	Capacitor 470 µF 63V	EKY-630ELL471ML20S	Nippon Chemi-con

Table 5. Component list (fsw = 150 kHz, V_{OUT} = 5 V) (continued)

Reference	Description	Part number	Manufacturer
C11	Capacitor 150 μF 35 V	EKY-350ELL151MHB5D	Nippon Chemi-con
C11	Capacitor 150 μF 35 V	EKY-350ELL151MHB5D	Nippon Chemi-con
C13	Capacitor 100 nF 5 %		
C14	Not mounted		
L1	68 μH I _{RMS} = 3.4 A I _{SAT} = 6.7 A	DO5040H-683MLD	Coilcraft
U1		L4973V3.3	STMicroelectronics

Table 6. Resistor divider for V_{OUT} = 12 V

Reference	Description	Part number	Manufacturer
R3	Resistor 2.7 kΩ 1%		
R4	Resistor 1 kΩ 1%		

Table 7. Resistor divider for V_{OUT} = 3.3 V

Reference	Description	Part number	Manufacturer
R3	Resistor 2.7 kΩ 1%		
R4	Not mounted		

Figure 5. Evaluation board (components side)

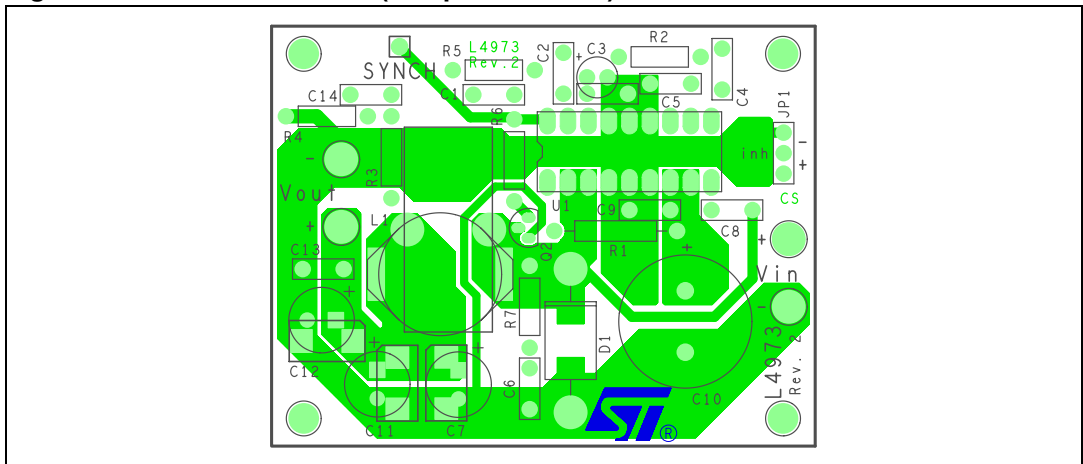
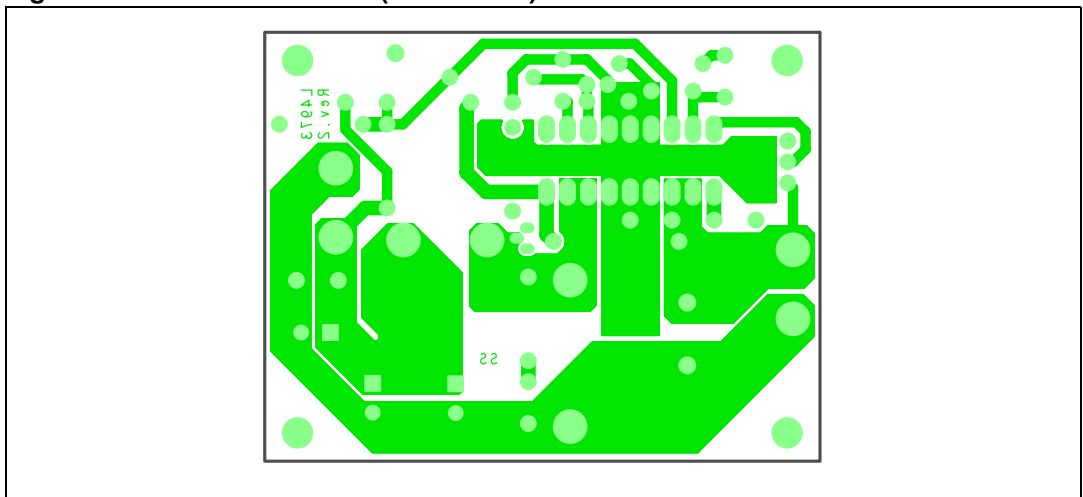


Figure 6. Evaluation board (solder side)



6 Application circuit

Figure 7. Application circuit (see [Figure 4](#) part list)

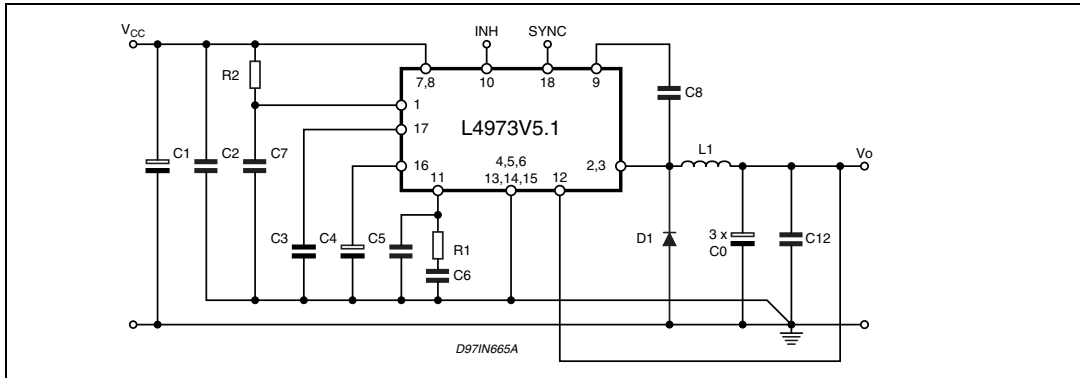
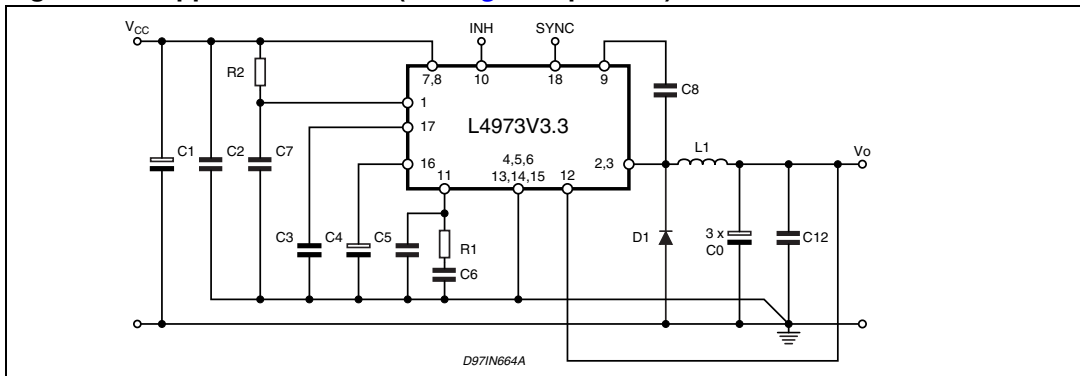


Figure 8. Application circuit (see [Figure 4](#) part list)



7 Typical characteristics

Figure 9. Quiescent drain current vs. input voltage (0% duty cycle)

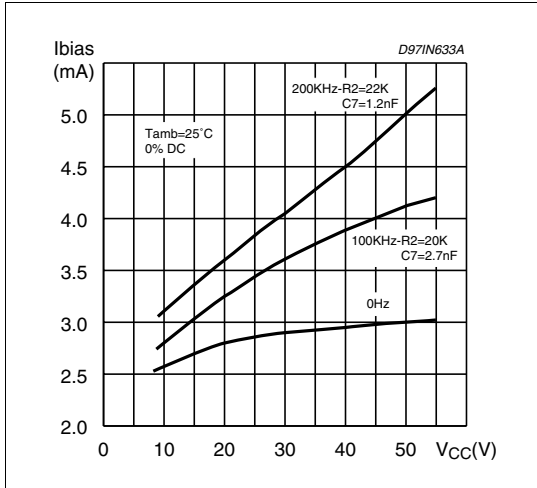


Figure 10. Quiescent drain current vs. junction temperature

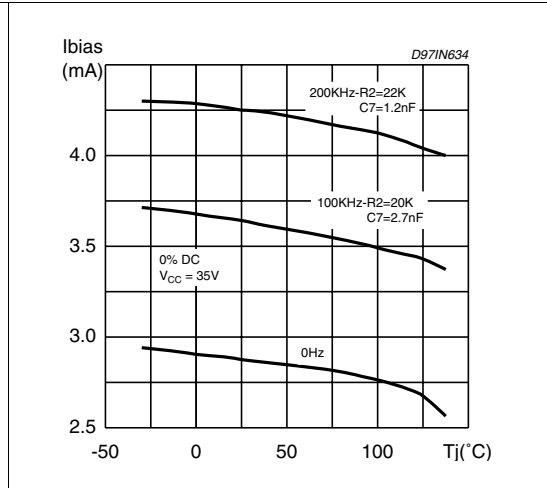


Figure 11. Stand by drain current vs. input voltage

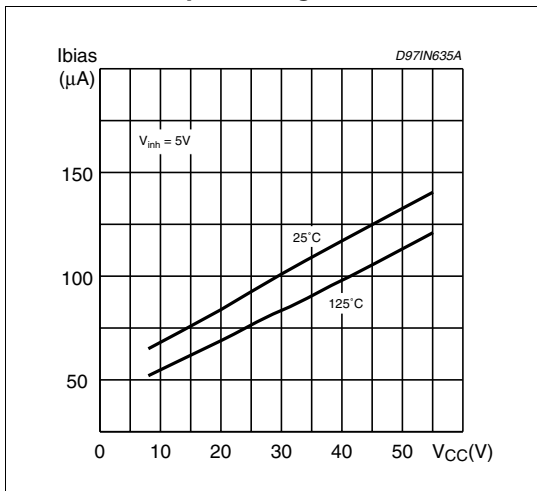


Figure 12. Reference voltage vs. junction temperature (pin 16)

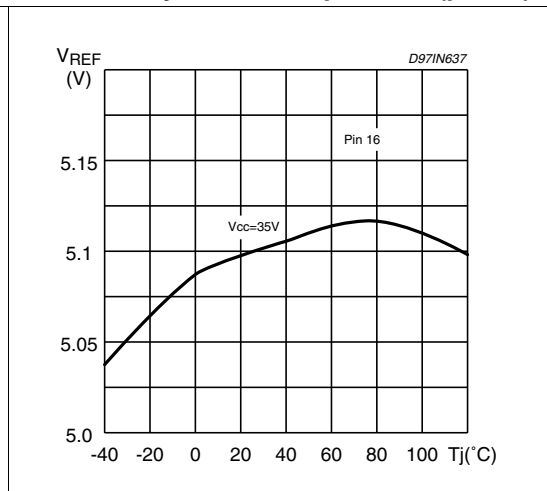


Figure 13. Reference voltage vs. input voltage (pin 16)

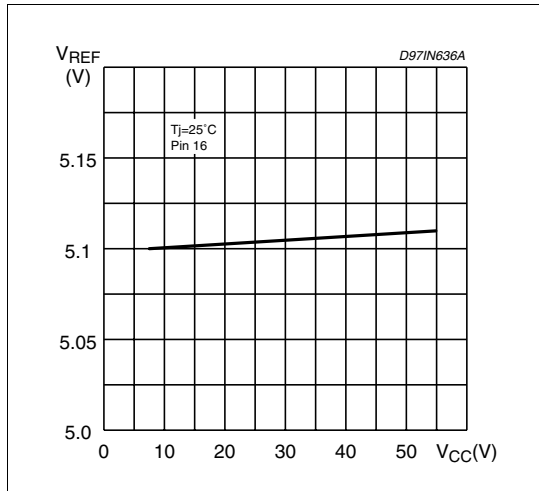


Figure 14. Reference voltage vs. reference input current

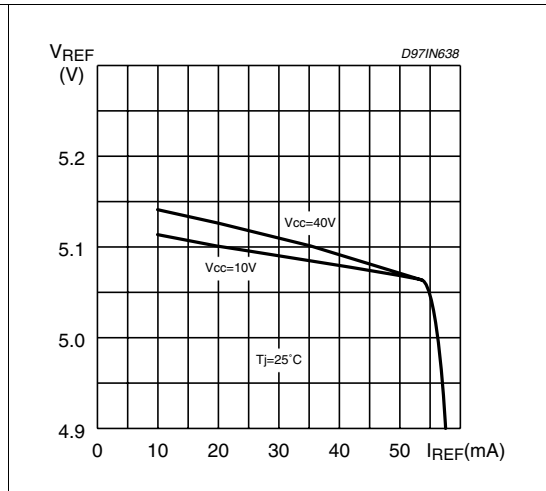


Figure 15. Inhibit current vs. inhibit voltage (pin 10)

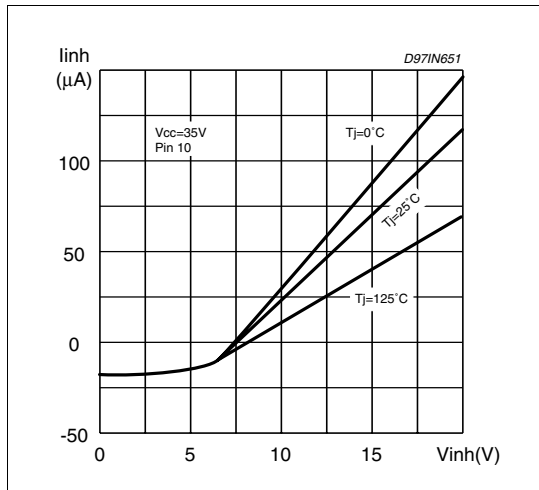


Figure 16. Line regulation (see Figure 7)

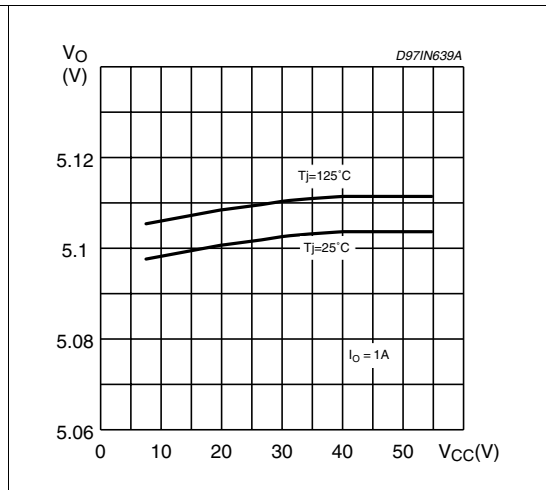


Figure 17. Load regulation (see Figure 7)

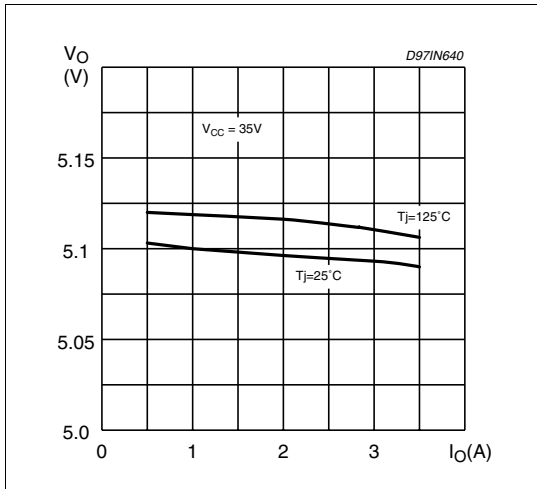


Figure 18. Line regulation (see Figure 8)

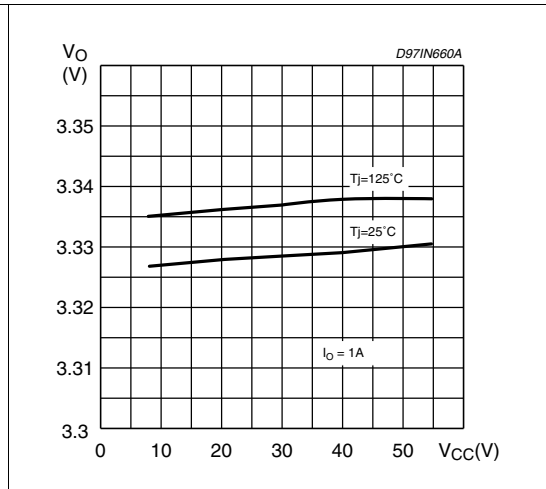


Figure 19. Load regulation (see Figure 4)

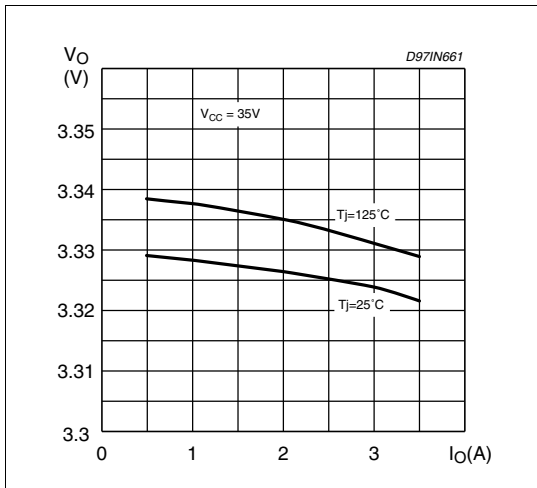


Figure 20. Switching frequency vs. R2 and C7 (Figure 4)

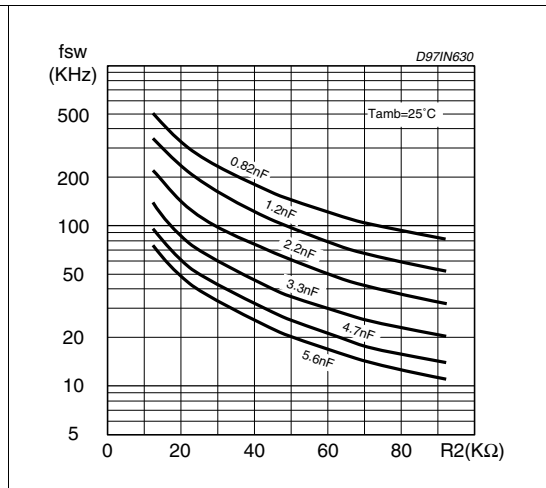


Figure 21. Switching frequency vs. input voltage

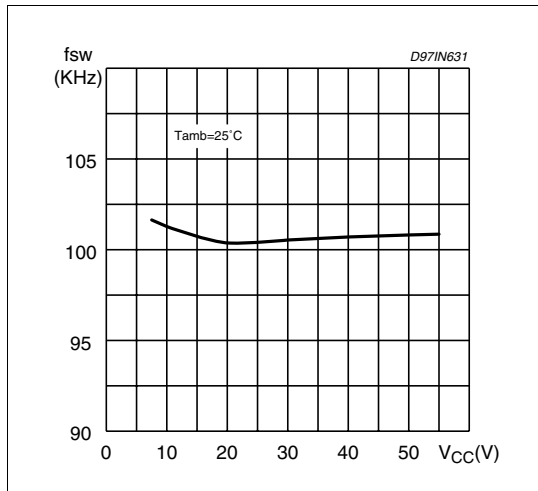


Figure 22. Switching frequency vs. junction temperature (see Figure 4)

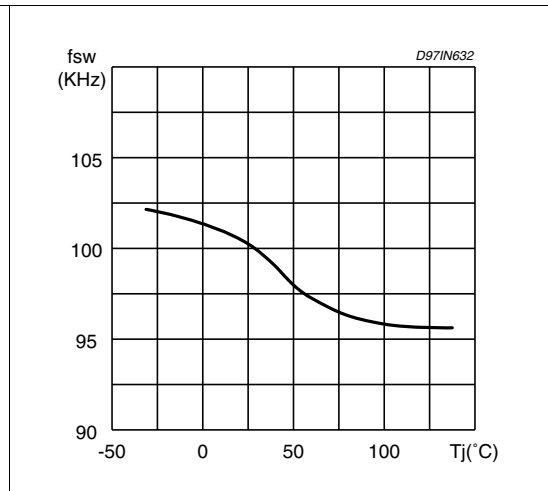


Figure 23. Dropout voltage between pin 7,8 and 2,3

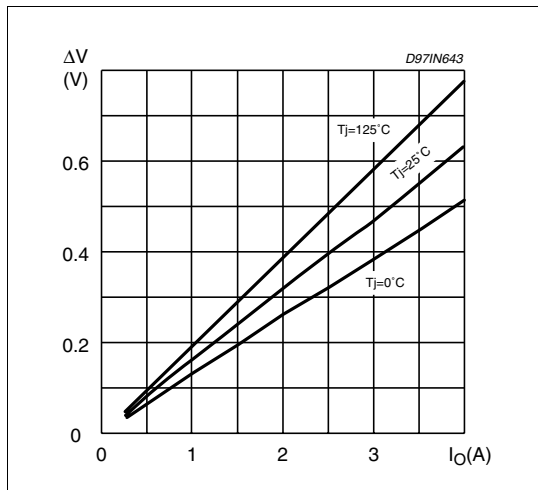


Figure 24. Efficiency vs. output voltage (see Figure 6)

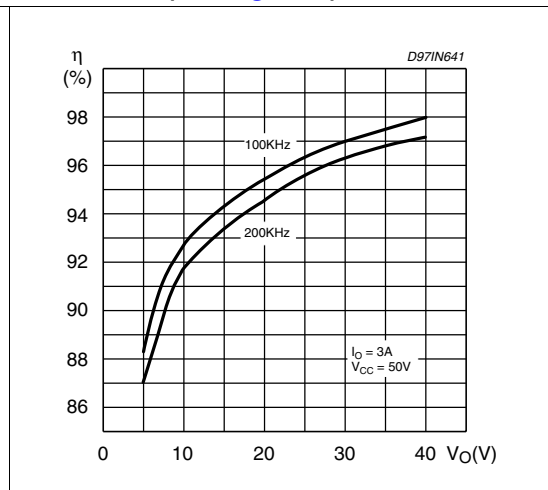


Figure 25. Dropout voltage between pin 7,8 and 2,3

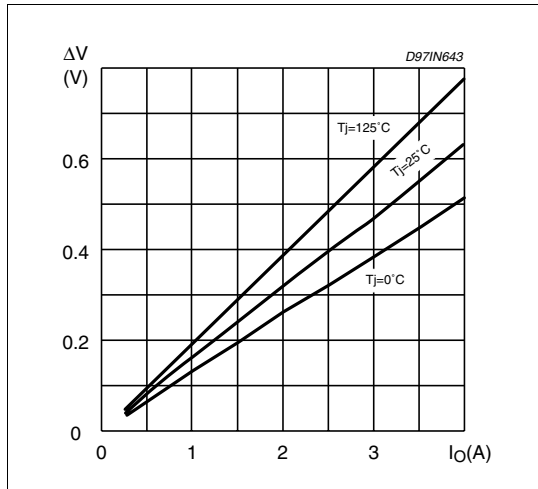


Figure 26. Efficiency vs. output voltage (see Figure 4)

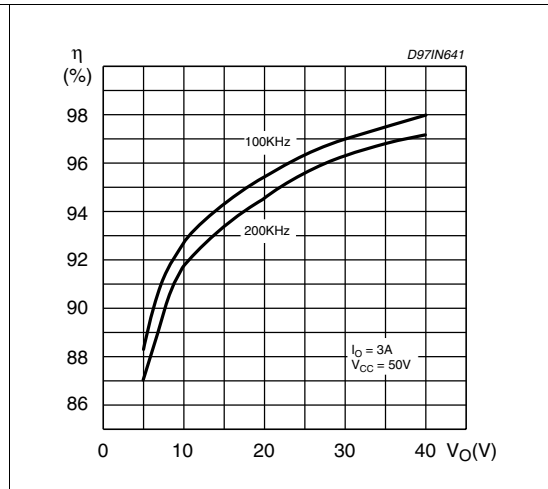


Figure 27. Efficiency vs. output voltage (Diode STPS745D)

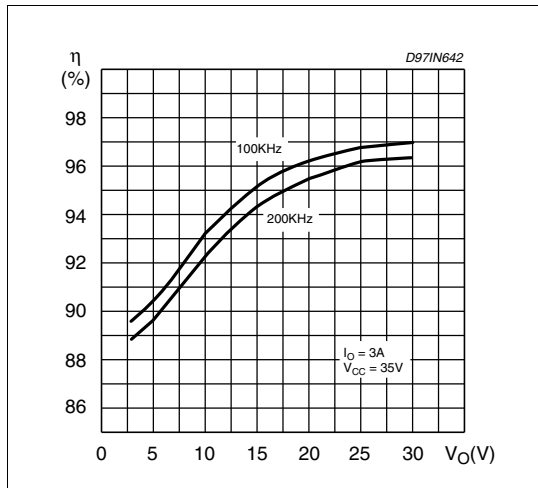


Figure 28. Efficiency vs. output current (see Figure 7)

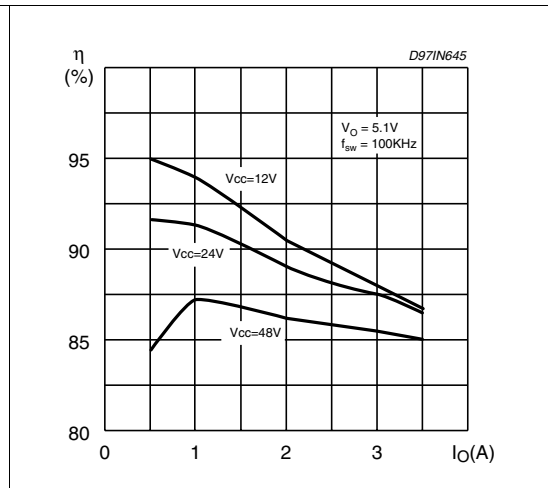


Figure 29. Efficiency vs. output current (see Figure 7)

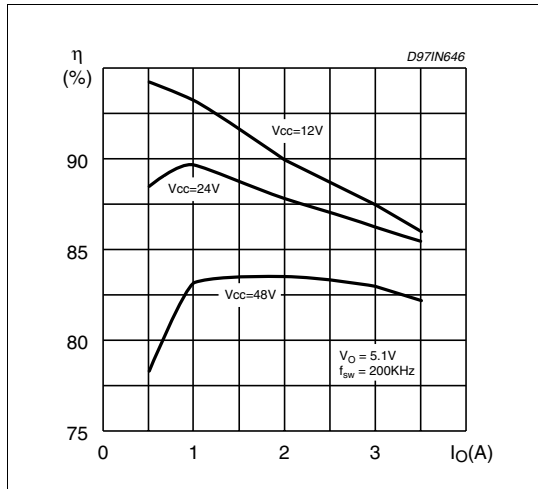


Figure 30. Efficiency vs. output current (see Figure 8)

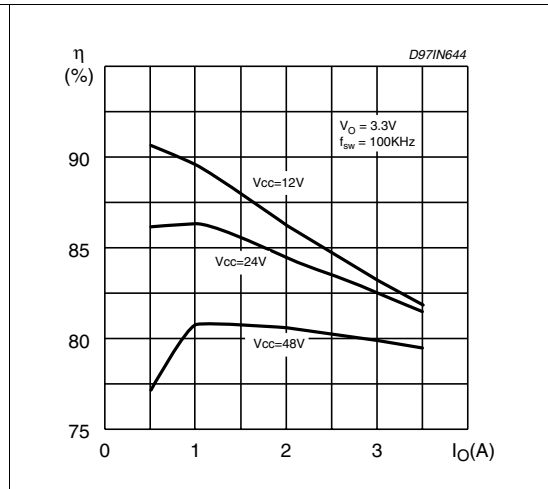


Figure 31. Efficiency vs. output current (see Figure 8)

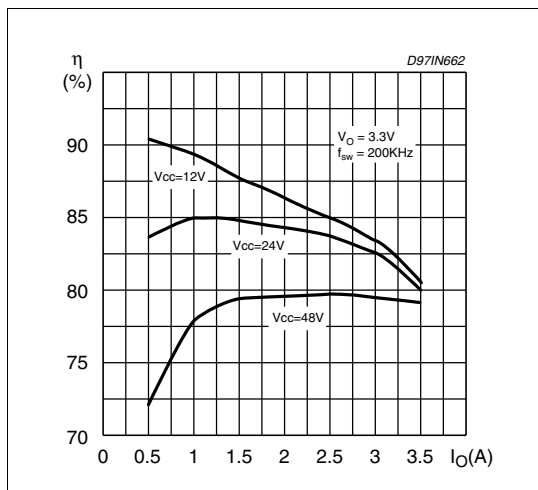


Figure 32. Power dissipation vs. input voltage (device only) (see Figure 7)

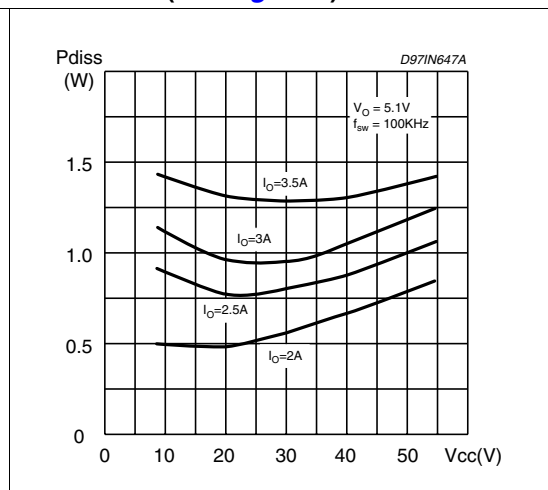


Figure 33. Power dissipation vs. output voltage (device only)

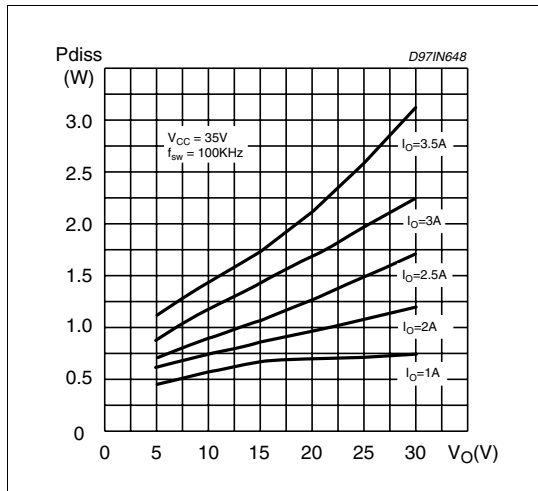


Figure 34. Pulse by pulse limiting current vs. junction temperature

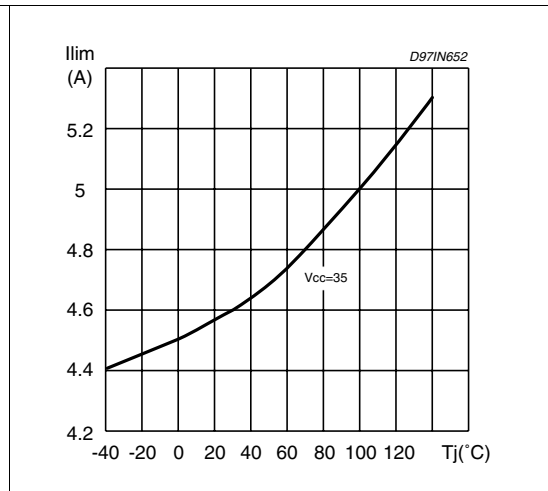


Figure 35. Load transient

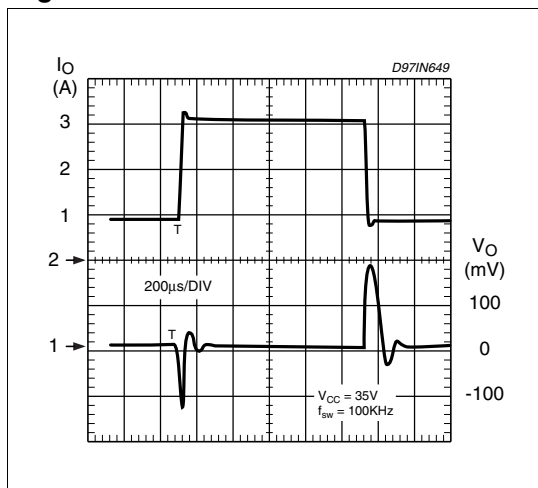


Figure 36. Line transient

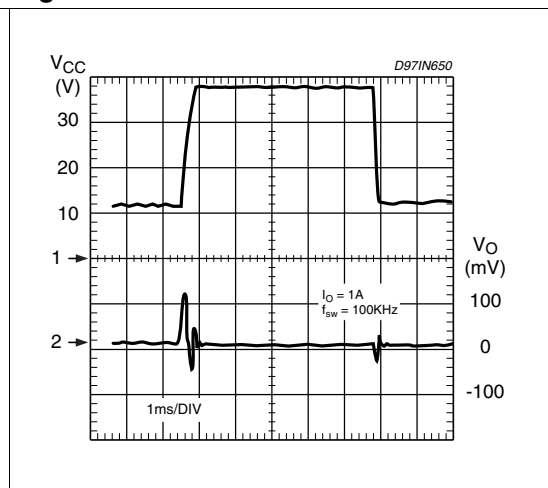


Figure 37. Source current rise and fall time, pin 2, 3 (see Figure 4)

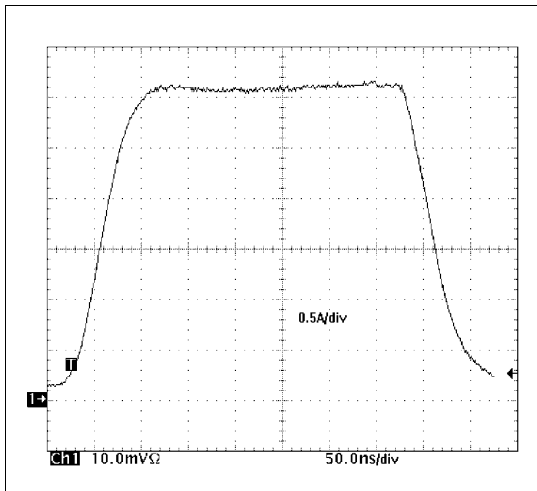


Figure 38. Soft-start capacitor selection vs. inductor and V_{CC} max (ref. AN938)

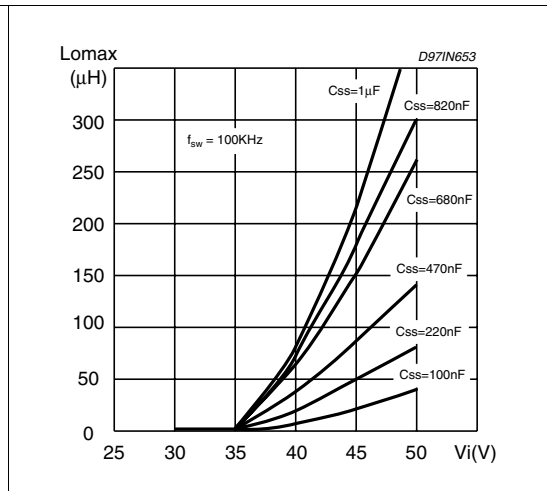


Figure 39. Soft-start capacitor selection vs. inductor and V_{CC} max (ref. AN938)

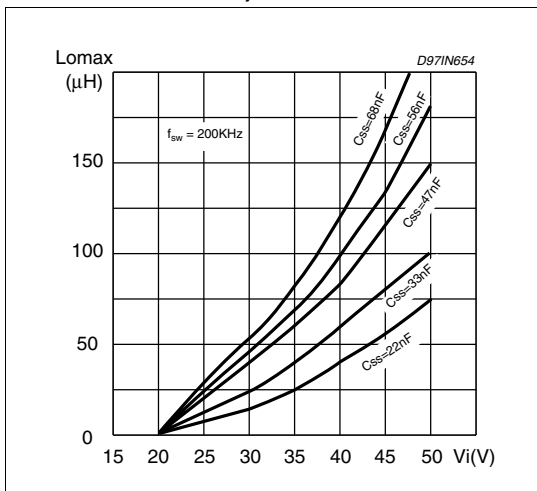
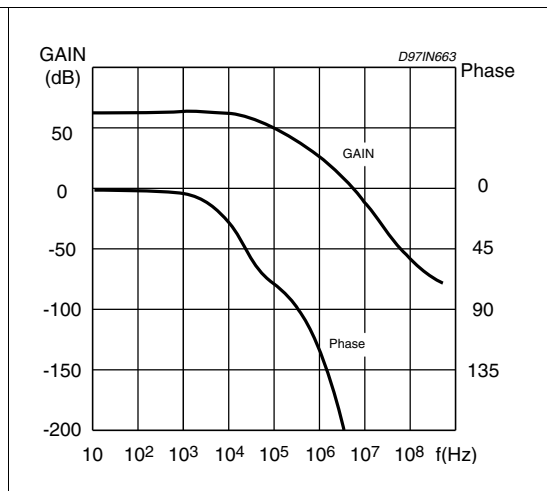


Figure 40. Open loop frequency and phase of error amplifier



8 Application ideas

Figure 41. 3.5 A at $V_O < 3.3$ V (see part list [Figure 4](#))

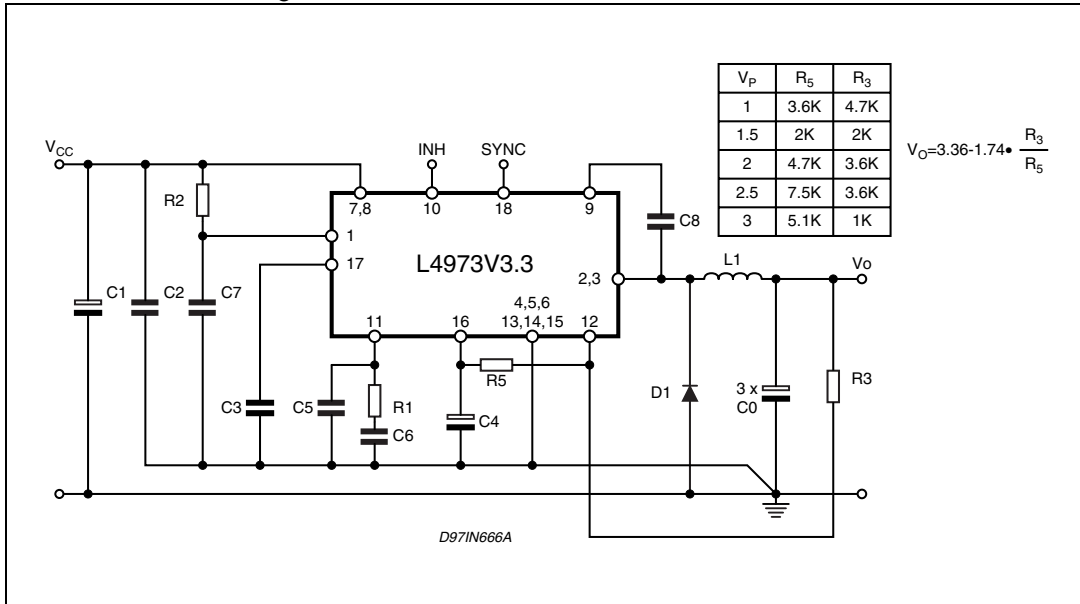


Figure 42. 12 V to 3.3 V high performance buck converter (fsw = 200 kHz)

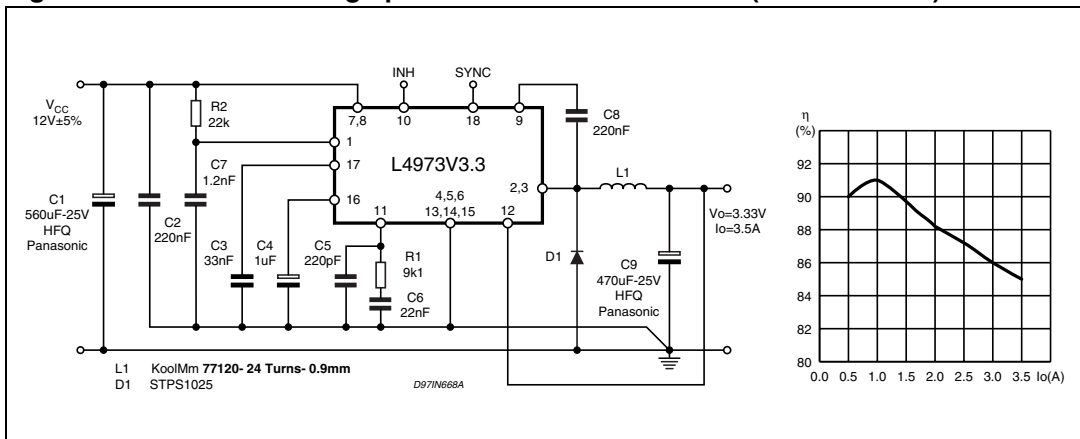


Figure 43. Synchronization example

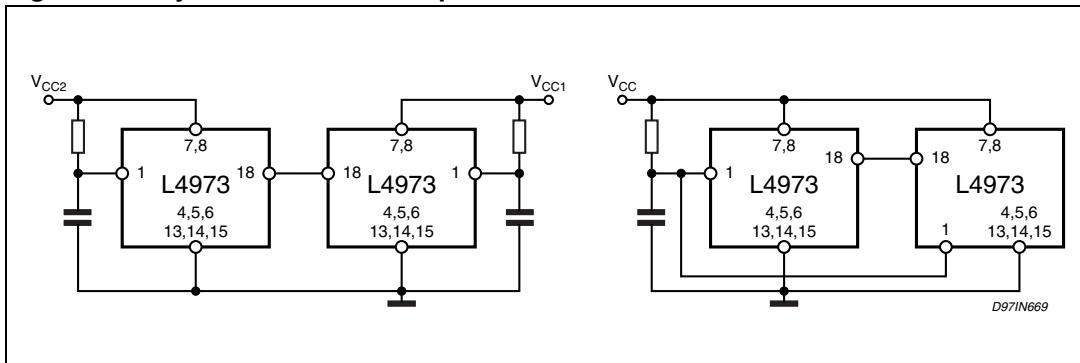
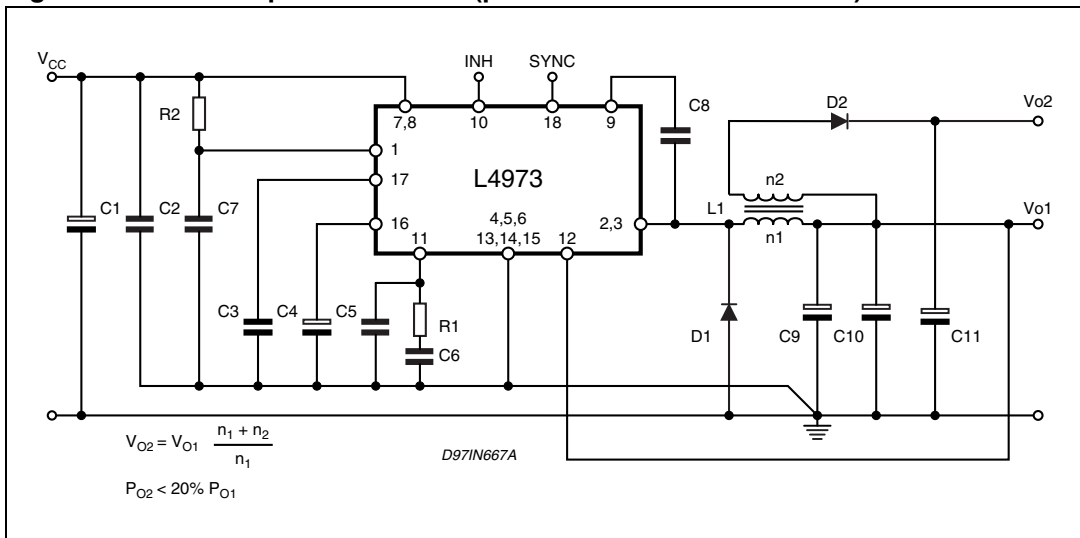


Figure 44. Multi output not isolated (pin out referred to DIP12+3+3)



9 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK[®] packages, depending on their level of environmental compliance. ECOPACK[®] specifications, grade definitions and product status are available at: www.st.com. ECOPACK is an ST trademark.

Table 8. DIP-18 mechanical data

Dim.	mm.			inch		
	Min	Typ	Max	Min	Typ	Max
a1	0.51			0.020		
B	0.85		1.40	0.033		0.055
b		0.50			0.020	
b1	0.38		0.50	0.015		0.020
D			24.80			0.976
E		8.80			0.346	
e		2.54			0.100	
e3		20.32			0.800	
F			7.10			0.280
l			5.10			0.201
L		3.30			0.130	
Z			2.54			0.100

Figure 45. Package dimensions

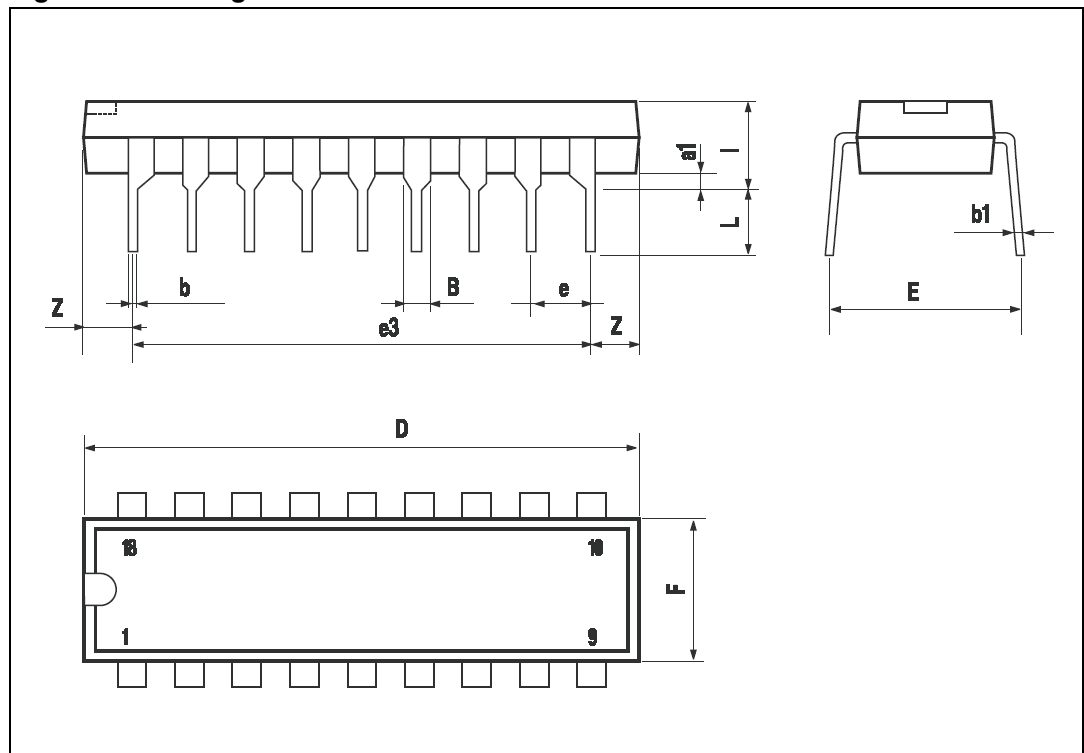
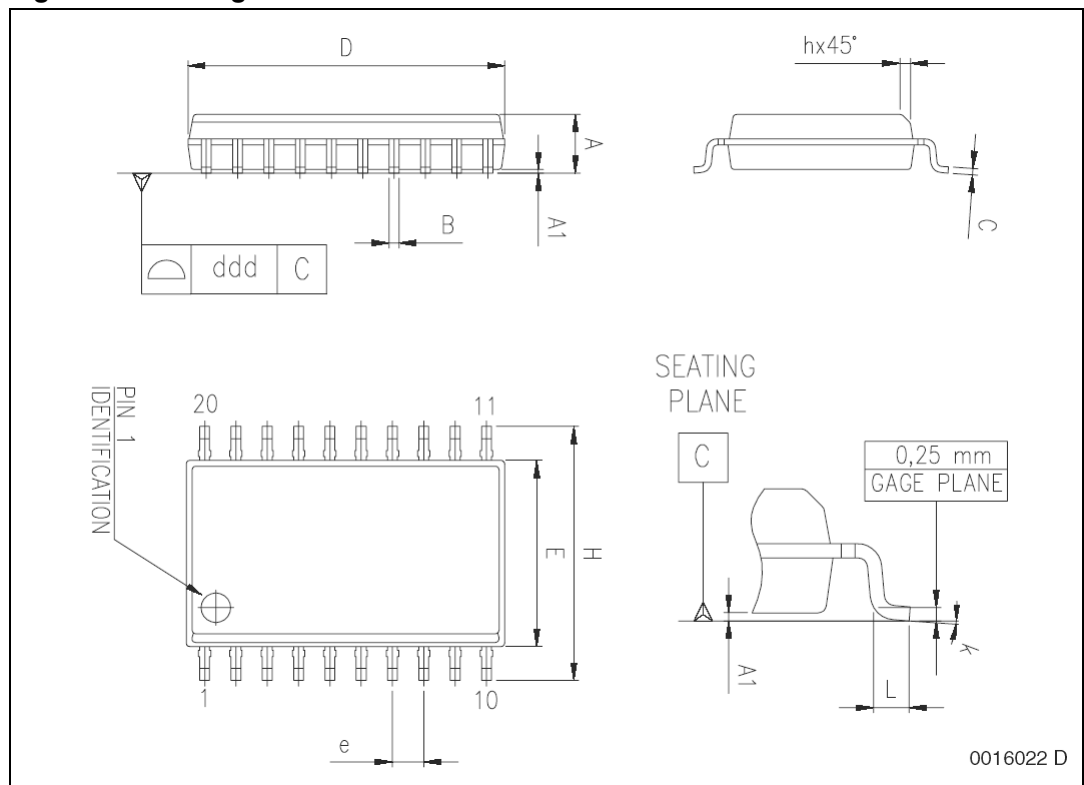


Table 9. SO-20 mechanical data

Dim.	mm.			inch		
	Min	Typ	Max	Min	Typ	Max
A	2.35		2.65	0.093		0.104
A1	0.10		0.30	0.004		0.012
B	0.33		0.51	0.013		0.200
C	0.23		0.32	0.009		0.013
D ⁽¹⁾	12.60		13.00	0.496		0.512
E	7.40		7.60	0.291		0.299
e		1.27			0.050	
H	10.0		10.65	0.394		0.419
h	0.25		0.75	0.010		0.030
L	0.40		1.27	0.016		0.050
k	0° (min.), 8° (max.)					
ddd			0.10			0.004

Figure 46. Package dimensions



10 Order code

Table 10. Order code

Part number	Package	Packaging
L4973D3.3, E-L4973D3.3	SO-20	Tube
L4973D3.3-013TR, E-L4973D3.3-TR	SO-20	Tape and reel
L4973D5.1	SO-20	Tube
L4973D5.1-013TR	SO-20	Tape and reel
L4973V3.3, E-L4973V3.3	DIP-18	Tube
L4973V5.1, E-L4973V5.1	DIP-18	Tube

11 Revision history

Table 11. Document revision history

Date	Revision	Changes
12-Sep-2001	13	First Issue
07-May-2005	14	Updated the Layout look & feel. Changed name of the D1 on the fig. 5.
14-Dec-2005	15	Added the ECOPACK part numbers in the Table 1. Order Codes.
06-Dec-2006	16	The document has been reformatted, and order codes updated
07-May-2007	17	New data on Table 4
26-Feb-2009	18	Updated Section 5: Evaluation board on page 9

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