TEA152x

SMPS ICs for low-power systems

Rev. 03 — 23 March 2009 Product data sheet

1. General description

The TEA152x family STARplug is a Switched Mode Power Supply (SMPS) controller IC that operates directly from the rectified universal mains. It is implemented in the high-voltage EZ-HV SOI process, combined with a low-voltage BiCMOS process. The device includes a high-voltage power switch and a circuit for start-up directly from the rectified mains voltage.

A dedicated circuit for valley switching is built in, which makes a very efficient slim-line electronic power plug concept possible.

In its most basic version of application, the TEA152x family acts as a voltage source. Here, no additional secondary electronics are required. A combined voltage and current source can be realized with minimum costs for external components. Implementation of the TEA152x family renders an efficient and low cost power supply system.

2. Features

- Designed for general purpose supplies up to 30 W
- Integrated power switch:
  - TEA1520x: 48 Ω; 650 V
  - TEA1521x: 24 Ω; 650 V
  - TEA1522x: 12 Ω; 650 V
  - TEA1523P: 6.5 Ω; 650 V
- Operates from universal AC mains supplies (80 V to 276 V)
- Adjustable frequency for flexible design
- RC oscillator for load insensitive regulation loop constant
- Valley switching for minimum switch-on loss
- Frequency reduction at low power output makes low standby power possible (< 100 mW)
- Adjustable overcurrent protection
- Undervoltage protection
- Temperature protection
- Short-circuit winding protection
- Simple application with both primary and secondary (opto) feedback
- Available in DIP8 and SO14 packages

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3. Applications

- Chargers
- Adapters
- Set Top Box (STB)
- DVD
- CD(R)
- TV/monitor standby supplies
- PC peripherals
- Microcontroller supplies in home applications and small portable equipment, etc.

4. Quick reference data

Table 1. Quick reference data

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{drain}	drain voltage (DMOS power transistor)	T_j > 0 °C	–0.4	-	+650	V
R_{DSon}	drain-source on-state resistance					
	TEA1520x	I_{source} = –0.06 A				
		T_j = 25 °C	-	48	55.2	Ω
		T_j = 100 °C	-	68	78.2	Ω
	TEA1521x	I_{source} = –0.125 A				
		T_j = 25 °C	-	24	27.6	Ω
		T_j = 100 °C	-	34	39.1	Ω
	TEA1522x	I_{source} = –0.25 A				
		T_j = 25 °C	-	12	13.8	Ω
		T_j = 100 °C	-	17	19.6	Ω
	TEA1523P	I_{source} = –0.50 A				
		T_j = 25 °C	-	6.5	7.5	Ω
		T_j = 100 °C	-	9.0	10.0	Ω
V_{CC}	supply voltage	continuous	–0.4	-	+40	V
f_{osc}	oscillator frequency		10	100	200	kHz
I_{drain}	current on pin DRAIN	V_{drain} > 60 V; no auxiliary supply	-	1.5	2	mA
T_{amb}	ambient temperature		–40	-	+85	°C

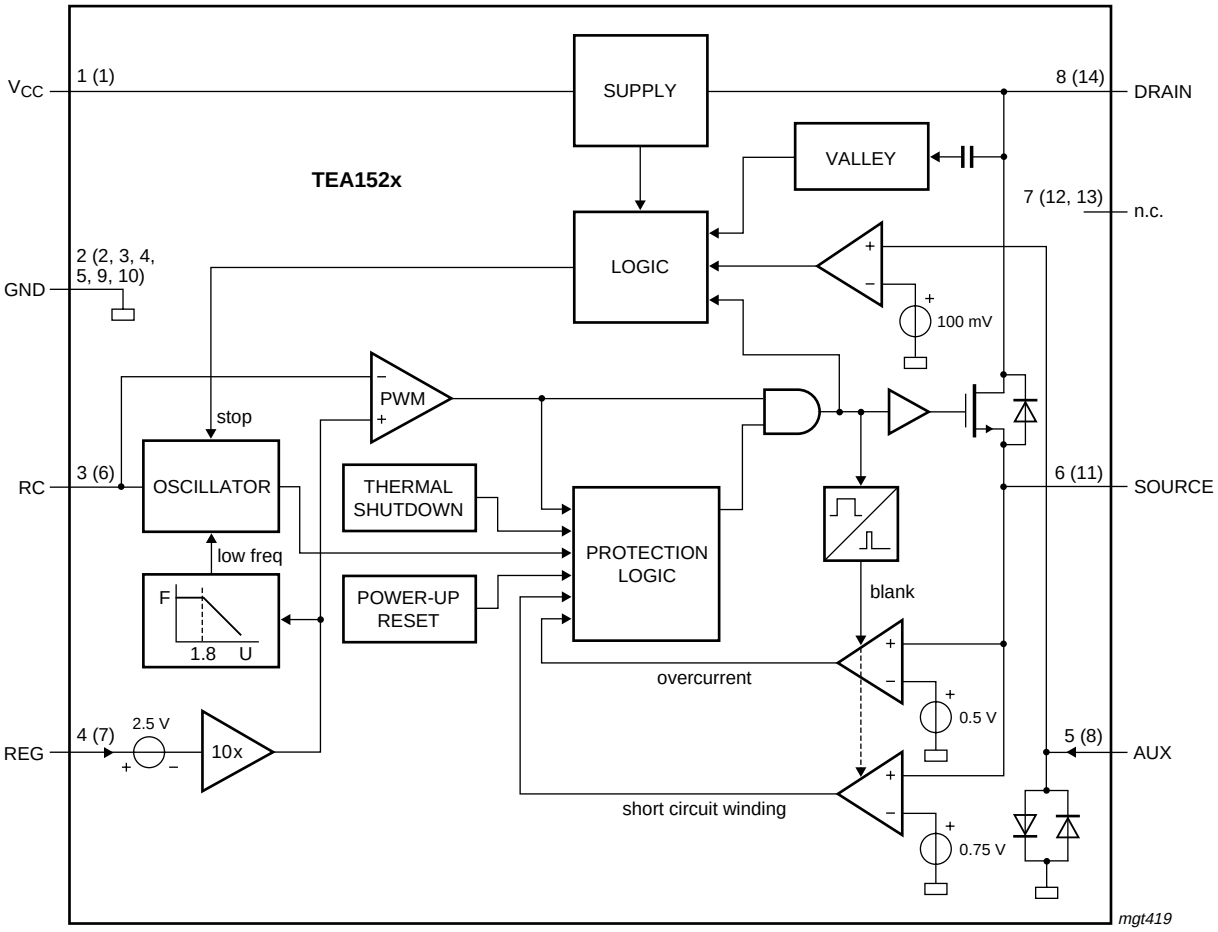
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5. Ordering information

Table 2. Ordering information

Type number	Package		
	Name	Description	Version
TEA1520P	DIP8	plastic dual in-line package; 8 leads (300 mil)	SOT97-1
TEA1521P	DIP8	plastic dual in-line package; 8 leads (300 mil)	SOT97-1
TEA1522P	DIP8	plastic dual in-line package; 8 leads (300 mil)	SOT97-1
TEA1523P	DIP8	plastic dual in-line package; 8 leads (300 mil)	SOT97-1
TEA1520T	SO14	plastic small outline package; 14 leads; body width 3.9 mm	SOT108-1
TEA1521T	SO14	plastic small outline package; 14 leads; body width 3.9 mm	SOT108-1
TEA1522T	SO14	plastic small outline package; 14 leads; body width 3.9 mm	SOT108-1

6. Block diagram



Pin numbers without parenthesis refer to DIP8 packages and within parenthesis refer to SO14 packages.

Fig 1. Block diagram

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7. Pinning information

7.1 Pinning

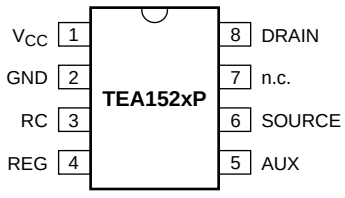


Fig 2. Pin configuration DIP8

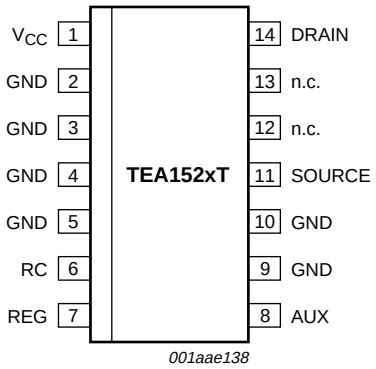


Fig 3. Pin configuration SO14

7.2 Pin description

Table 3. Pin description

Symbol	Pin		Description
	DIP8	SO14	
V_{CC}	1	1	supply voltage
GND	2	2	ground
GND	-	3	ground
GND	-	4	ground
GND	-	5	ground
RC	3	6	frequency setting
REG	4	7	regulation input
AUX	5	8	input for voltage from auxiliary winding for timing (demagnetization)
GND	-	9	ground
GND	-	10	ground
SOURCE	6	11	source of internal MOS switch
n.c.	7	12	not connected
n.c.	-	13	not connected
DRAIN	8	14	drain of internal MOS switch; input for start-up current and valley sensing

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8. Functional description

The TEA152x family is the heart of a compact flyback converter, with the IC placed at the primary side. The auxiliary winding of the transformer can be used for indirect feedback to control the isolated output. This additional winding also powers the IC. A more accurate control of the output voltage and/or current can be implemented with an additional secondary sensing circuit and opto coupler feedback.

The TEA152x family uses voltage mode control. The frequency is determined by the maximum transformer demagnetizing time and the time of the oscillator. In the first case, the converter operates in the Self Oscillating Power Supply (SOPS) mode. In the latter case, it operates at a constant frequency, which can be adjusted with external components R_{RC} and C_{RC}. This mode is called Pulse Width Modulation (PWM). Furthermore, a primary stroke is started only in a valley of the secondary ringing. This valley switching principle minimizes capacitive switch-on losses.

8.1 Start-up and undervoltage lockout

Initially, the IC is self supplying from the rectified mains voltage. The IC starts switching as soon as the voltage on pin V_{CC} passes the $V_{CC(start)}$ level. The supply is taken over by the auxiliary winding of the transformer as soon as V_{CC} is high enough and the supply from the line is stopped for high efficiency operation.

When for some reason the auxiliary supply is not sufficient, the high-voltage supply also supplies the IC. As soon as the voltage on pin V_{CC} drops below the $V_{CC(stop)}$ level, the IC stops switching and restarts from the rectified mains voltage.

8.2 Oscillator

The frequency of the oscillator is set by the external resistor and capacitor on pin RC. The external capacitor is charged rapidly to the $V_{RC(max)}$ level and, starting from a new primary stroke, it discharges to the $V_{RC(min)}$ level. Because the discharge is exponential, the relative sensitivity of the duty factor to the regulation voltage at low duty factor is almost equal to the sensitivity at high duty factors. This results in a more constant gain over the duty factor range compared to PWM systems with a linear sawtooth oscillator. Stable operation at low duty factors is easily realized. For high efficiency, the frequency is reduced as soon as the duty factor drops below a certain value. This is accomplished by increasing the oscillator charge time.

To ensure that the capacitor can be charged within the charge time, the value of the oscillator capacitor should be limited to approximately 1 nF.

8.3 Duty factor control

The duty factor is controlled by the internal regulation voltage and the oscillator signal on pin RC. The internal regulation voltage is equal to the external regulation voltage (minus 2.5 V) multiplied by the gain of the error amplifier (typically 20 dB which is 10 ×).

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8.4 Valley switching

A new cycle is started when the primary switch is switched on (see Figure 4). After a certain time (determined by the oscillator voltage RC and the internal regulation level), the switch is turned off and the secondary stroke starts. The internal regulation level is determined by the voltage on pin REG.

After the secondary stroke, the drain voltage shows an oscillation with a frequency of approximately:

$$\frac{1}{2 \times \pi \times \sqrt{(L_p \times C_p)}} \quad (1)$$

where:

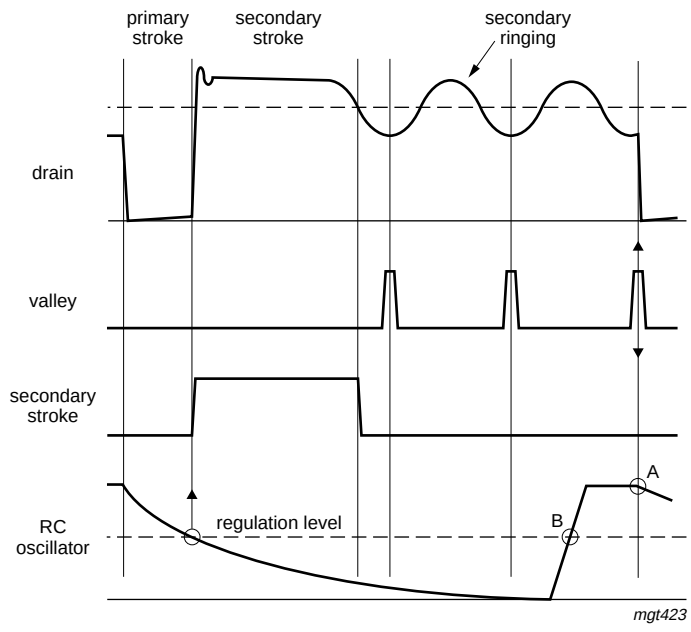
L_p = primary self inductance

C_p = parasitic capacitance on drain node

As soon as the oscillator voltage is high again and the secondary stroke has ended, the circuit waits for a low drain voltage before starting a new primary stroke.

Figure 4 shows the drain voltage together with the valley signal, the signal indicating the secondary stroke and the RC voltage.

The primary stroke starts some time before the actual valley at low ringing frequencies, and some time after the actual valley at high ringing frequencies.



A: Start of new cycle with valley switching.

B: Start of new cycle in a classical PWM system.

Fig 4. Signals for valley switching

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Figure 5 shows a typical curve for a reflected output voltage $N \times V_o$ of 80 V. This voltage is the output voltage V_o (see Figure 6) transferred to the primary side of the transformer with the factor N (determined by the turns ratio of the transformer). Figure 5 shows that the system switches exactly at minimum drain voltage for ringing frequencies of 480 kHz, thus reducing the switch-on losses to a minimum. At 200 kHz, the next primary stroke is started at 33° before the valley. The switch-on losses are still reduced significantly.

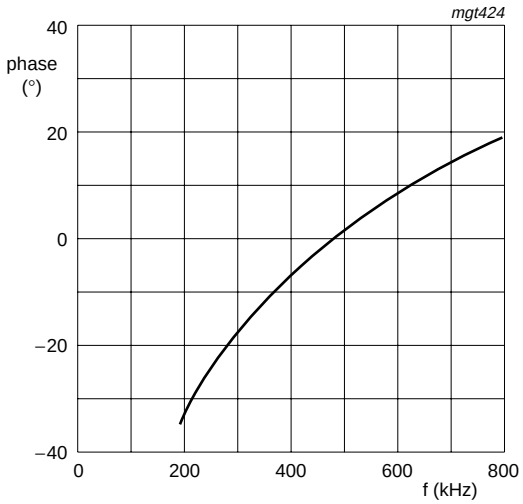


Fig 5. Typical phase of drain ringing at switch-on (at $N \times V_o$ = 80 V)

8.5 Demagnetization

The system operates in discontinuous conduction mode all the time. As long as the secondary stroke has not ended, the oscillator will not start a new primary stroke. During the first t_{suppr} seconds, demagnetization recognition is suppressed. This suppression may be necessary in applications where the transformer has a large leakage inductance and at low output voltages.

8.6 Minimum and maximum duty factor

The minimum duty factor of the switched mode power supply is 0 %. The maximum duty factor is set to 75 % (typical value at 100 kHz oscillation frequency).

8.7 OverCurrent Protection (OCP)

The cycle-by-cycle peak drain current limit circuit uses the external source resistor R_I to measure the current. The circuit is activated after the leading edge blanking time t_{leb}. The protection circuit limits the source voltage to $V_{source(max)}$, and thus limits the primary peak current.

8.8 Short-circuit winding protection

The short-circuit winding protection circuit is also activated after the leading edge blanking time. If the source voltage exceeds the short-circuit winding protection voltage V_{swp}, the IC stops switching. Only a power-on reset will restart normal operation. The short-circuit winding protection also protects in case of a secondary diode short circuit.

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8.9 OverTemperature Protection (OTP)

An accurate temperature protection is provided in the device. When the junction temperature exceeds the thermal shut-down temperature, the IC stops switching. During thermal protection, the IC current is lowered to the start-up current. The IC continues normal operation as soon as the over temperature situation has disappeared.

8.10 OverVoltage Protection (OVP)

Overvoltage protection can be achieved in the application by pulling pin REG above its normal operation level. The current primary stroke is terminated immediately, and no new primary stroke is started until the voltage on pin REG drops to its normal operation level. Pin REG has an internal clamp. The current feed into this pin must be limited.

8.11 Output characteristics of complete power plug

Typical characteristics:

- Output power: A wide range of output power levels can be handled by choosing the $R_{DS(on)}$ and package of the TEA152x family. Power levels up to 30 W can be realized.
- Accuracy: The accuracy of the complete converter, functioning as a voltage source with primary sensing, is approximately 8 % (mainly dependent on the transformer coupling). The accuracy with secondary sensing is defined by the accuracy of the external components. For safety requirements in case of opto coupler feedback loss, the primary sensing remains active when an overvoltage circuit is connected.
- Efficiency: An efficiency of 75 % at maximum output power can be achieved for a complete converter designed for universal mains.
- Ripple: A minimum ripple is obtained in a system designed for a maximum duty factor of 50 % under normal operating conditions, and a minimized dead time. The magnitude of the ripple in the output voltage is determined by the frequency and duty factor of the converter, the output current level and the value and ESR of the output capacitor.

8.12 Input characteristics of complete power plug

Typical characteristics:

- The input voltage range comprises the universal AC mains (80 V to 276 V).

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9. Limiting values

Table 4. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134). All voltages are measured with respect to ground; positive currents flow into the device; pins V_{CC} and RC are not allowed to be current driven and pins REG and AUX are not allowed to be voltage driven.

Symbol	Parameter	Conditions		Min	Max	Unit
Voltages						
V_{CC}	supply voltage	continuous		–0.4	+40	V
V_{RC}	voltage on pin RC			–0.4	+3	V
V_{SOURCE}	voltage on pin SOURCE	DMOS power transistor		–0.4	+5	V
V_{drain}	drain voltage (DMOS power transistor)	T_j > 0 °C		–0.4	+650	V
Currents						
I_{REG}	current on pin REG			-	6	mA
I_{AUX}	current on pin AUX			–10	+5	mA
I_{source}	source current					
	TEA1520x			–0.25	+0.25	A
	TEA1521x			–0.5	+0.5	A
	TEA1522x			–1	+1	A
	TEA1523P			–2	+2	A
I_{drain}	drain current					
	TEA1520x			–0.25	+0.25	A
	TEA1521x			–0.5	+0.5	A
	TEA1522x			–1	+1	A
	TEA1523P			–2	+2	A
General						
P_{tot}	total power dissipation					
	DIP8 package	T_{amb} < 45 °C		-	1.0	W
	SO14 package	T_{amb} < 50 °C		-	1.0	W
T_{stg}	storage temperature			–55	+150	°C
T_{amb}	ambient temperature			–40	+85	°C
T_j	junction temperature			–40	+145	°C
V_{esd}	electrostatic discharge voltage	human body model	[1]	-	±2500	V
		machine model	[2]	-	±200	V

[1] Human body model: equivalent to discharging a 100 pF capacitor through a 1.5 kΩ series resistor. All pins are 2500 V maximum, except pin DRAIN, which is 1000 V maximum.

[2] Machine model: equivalent to discharging a 200 pF capacitor through a 0.75 µH coil and a 10 Ω series resistor.

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10. Thermal characteristics

Table 5. Thermal characteristics

Symbol	Parameter	Conditions	Typ	Unit
$R_{th(j-a)}$	thermal resistance from junction to ambient	in free air	[1]	
	DIP8 package		100	K/W
	SO14 package		91	K/W

[1] Thermal resistance $R_{th(j-a)}$ can be lower when the GND pins are connected to sufficient copper area on the printed-circuit board. See the TEA152x application notes for details.

11. Characteristics

Table 6. Characteristics

T_{amb} = 25 °C; no over temperature; all voltages are measured with respect to ground; currents are positive when flowing into the IC; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Supply						
$I_{CC(oper)}$	operating supply current	normal operation	-	1.3	1.9	mA
$I_{CC(startup)}$	start-up supply current	start-up	-	180	400	µA
$I_{CC(ch)}$	charge supply current	V_{drain} > 60 V	–6	–4	–3	mA
$V_{CC(start)}$	start voltage		9	9.5	10	V
$V_{CC(stop)}$	stop supply voltage	undervoltage lockout	7.0	7.5	8.0	V
I_{drain}	current on pin DRAIN	V_{drain} > 60 V				
		no auxiliary supply	-	1.5	2	mA
		with auxiliary supply	-	30	125	µA
Pulse width modulator						
δ_{min}	minimum duty factor		-	0	-	%
δ_{max}	maximum duty cycle	f = 100 kHz	-	75	-	%
SOPS						
$V_{det(demag)}$	demagnetization detection voltage		50	100	150	mV
$t_{sup(xfmr_ring)}$	transformer ringing suppression time	start of 2nd stroke	1.0	1.5	2.0	µs
RC oscillator						
$V_{RC(min)}$	minimum voltage on pin RC		60	75	90	mV
$V_{RC(max)}$	maximum voltage on pin RC		2.4	2.5	2.6	V
$t_{ch(RC)}$	charge time on pin RC		-	1	-	µs
f_{osc}	oscillator frequency		10	100	200	kHz
Duty factor regulator: pin REG						
V_{REG}	voltage on pin REG		2.4	2.5	2.6	V
G_v	voltage gain	error amplifier	-	20	-	dB
$V_{clamp(REG)}$	clamp voltage on pin REG	I_{REG} = 6 mA	-	-	7.5	V

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Table 6. Characteristics *...continued*

T_{amb} = 25 °C; no over temperature; all voltages are measured with respect to ground; currents are positive when flowing into the IC; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Valley switching						
$(\Delta V/\Delta t)_{vrec}$	valley recognition voltage change with time		–102	-	+102	V/µs
f_{valley}	ringing frequency for valley switching	$N \times V_o$ = 100 V	200	550	800	kHz
$t_{d(vrec\text{-}swon)}$	valley recognition to switch-on delay time		-	150	-	ns
Current and short-circuit winding protection						
$V_{source(max)}$	maximum source voltage	$\Delta V/\Delta t$ = 0.1 V/µs	0.47	0.50	0.53	V
$t_{d(prop)}$	delay from detecting $V_{source(max)}$ to switch-off	$\Delta V/\Delta t$ = 0.5 V/µs	-	160	185	ns
V_{swp}	short circuit winding protection voltage	$\Delta V/\Delta t$ = 0.5 V/µs	0.7	0.75	0.8	V
t_{leb}	leading edge blanking time		250	350	450	ns
FET output stage						
$I_{L(drain)}$	drain leakage current	V_{drain} = 650 V	-	-	125	µA
$V_{BR(DRAIN)}$	breakdown voltage on pin DRAIN	T_j > 0 °C	650	-	-	V
R_{DSon}	drain-source on-state resistance					
	TEA1520x	I_{source} = –0.06 A				
		T_j = 25 °C	-	48	55.2	Ω
		T_j = 100 °C	-	68	78.2	Ω
	TEA1521x	I_{source} = –0.125 A				
		T_j = 25 °C	-	24	27.6	Ω
		T_j = 100 °C	-	34	39.1	Ω
	TEA1522x	I_{source} = –0.25 A				
		T_j = 25 °C	-	12	13.8	Ω
		T_j = 100 °C	-	17	19.6	Ω
	TEA1523P	I_{source} = –0.50 A				
		T_j = 25 °C	-	6.5	7.5	Ω
		T_j = 100 °C	-	9.0	10.0	Ω
$t_{f(DRAIN)}$	fall time on pin DRAIN	V_i = 300 V; no external capacitor at drain	-	75	-	ns
Temperature protection						
$T_{prot(max)}$	maximum threshold temperature		150	160	170	°C
$T_{prot(hys)}$	hysteresis of protection temperature		-	2	-	°C

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12. Application information

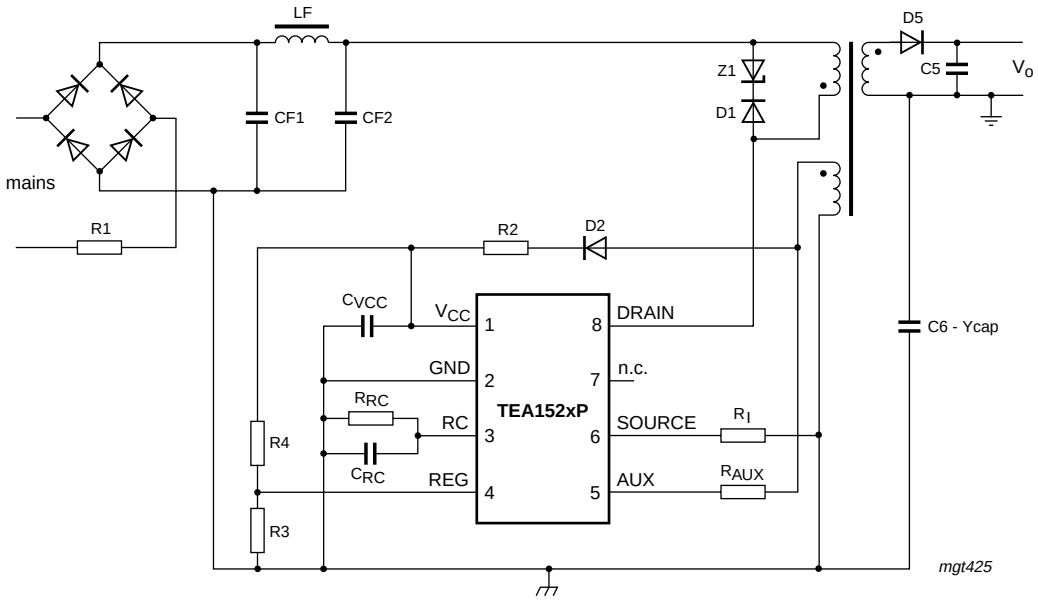


Fig 6. Primary sensed application; configuration for TEA152xP

Further application information can be found in the TEA152x application notes.

13. Test information

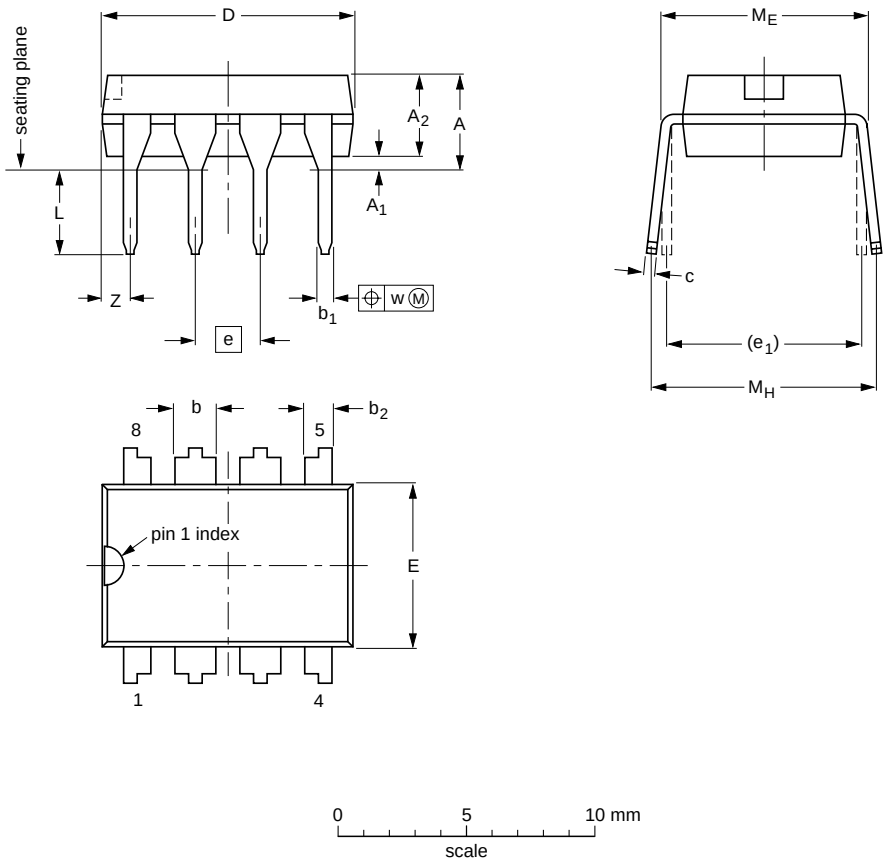
13.1 Quality information

This product has been qualified to the appropriate Automotive Electronics Council (AEC) standard Q100 or Q101 and is suitable for use in automotive applications.

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14. Package outline

DIP8: plastic dual in-line package; 8 leads (300 mil) **SOT97-1**



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

UNIT	A max.	A_1 min.	A_2 max.	b	b_1	b_2	c	D (1)	E (1)	e	e_1	L	M_E	M_H	w	Z (1) max.
mm	4.2	0.51	3.2	1.73 1.14	0.53 0.38	1.07 0.89	0.36 0.23	9.8 9.2	6.48 6.20	2.54	7.62	3.60 3.05	8.25 7.80	10.0 8.3	0.254	1.15
inches	0.17	0.02	0.13	0.068 0.045	0.021 0.015	0.042 0.035	0.014 0.009	0.39 0.36	0.26 0.24	0.1	0.3	0.14 0.12	0.32 0.31	0.39 0.33	0.01	0.045

Note

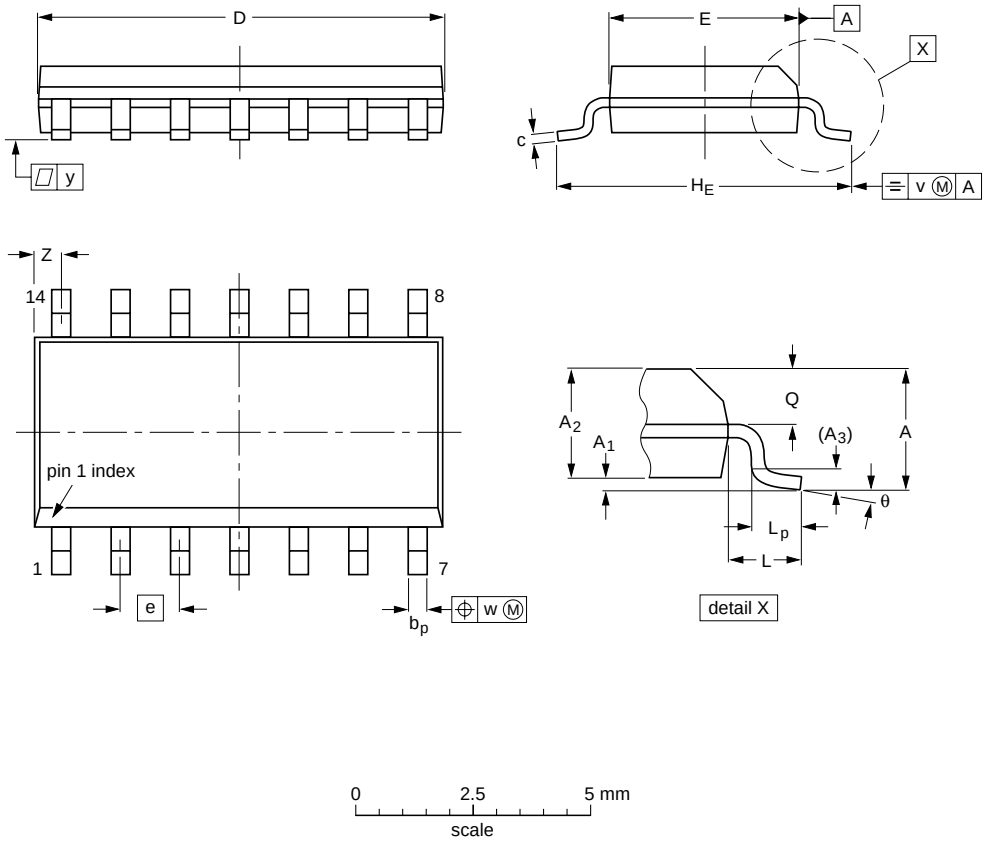
1. Plastic or metal protrusions of 0.25 mm (0.01 inch) maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT97-1	050G01	MO-001	SC-504-8			~~99-12-27~~ 03-02-13

Fig 7. Package outline SOT97-1 (DIP8)

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SO14: plastic small outline package; 14 leads; body width 3.9 mm **SOT108-1**



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	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	8.75 8.55	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8^o 0^o
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.35 0.34	0.16 0.15	0.05	0.244 0.228	0.041	0.039 0.016	0.028 0.024	0.01	0.01	0.004	0.028 0.012	

Note

1. Plastic or metal protrusions of 0.15 mm (0.006 inch) maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT108-1	076E06	MS-012				~~99-12-27~~ 03-02-19

Fig 8. Package outline SOT108-1 (SO14)

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15. Abbreviations

Table 7. Abbreviations

Acronym	Description
BiCMOS	Bipolar Complementary Metal Oxide Semiconductor
DMOS	Diffusion Metal-Oxide Semiconductor
ESR	Equivalent Series Resistance
EZ-HV SOI	Easy High Voltage Silicon-On-Insulator
FET	Field-Effect Transistor
PWM	Pulse Width Modulation
SMPS	Switched Mode Power Supply
SOPS	Self Oscillating Power Supply

16. Revision history

Table 8. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
TEA152X_3	20090323	Product data sheet	-	TEA152X_FAM_2
Modifications:	• The format of this data sheet has been redesigned to comply with the new identity guidelines of NXP Semiconductors. • Legal texts have been adapted to the new company name where appropriate. • The minimum value of T_{amb} has changed in Table 1 and Table 4. • The minimum value of T_j has changed in Table 4.			
TEA152X_FAM_2	20060125	Product data sheet	-	TEA152X_FAMILY_1
TEA152X_FAMILY_1	20000908	Product specification	-	-

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17. Legal information

17.1 Data sheet status

Document status[1][2]	Product status[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL http://www.nxp.com.

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