AUTOMOTIVE GRADE 20V HIGH-SIDE CURRENT MONITOR

Description

The ZXCT1008Q is a high-side current sense monitor. Using this device eliminates the need to disrupt the ground plane when sensing a load current.

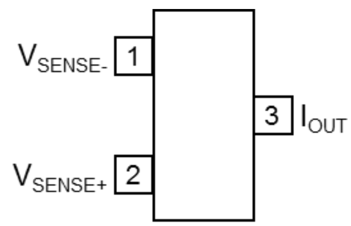
It takes a high-side voltage developed across a current shunt resistor and translates it into a proportional output current. A user defined output resistor scales the output current into a ground-referenced voltage.

The wide input voltage range of 20V down to as low as 2.5V makes it suitable for a range of applications. The ability to withstand high voltage transients and reverse polarity connection makes this part very suitable for automotive and other transient rich environment.

The ZXCT1008Q has been qualified to AEC-Q100 Grade 1 and is Automotive Grade supporting PPAPs.

Pin Assignments

SOT23 (Type DN)

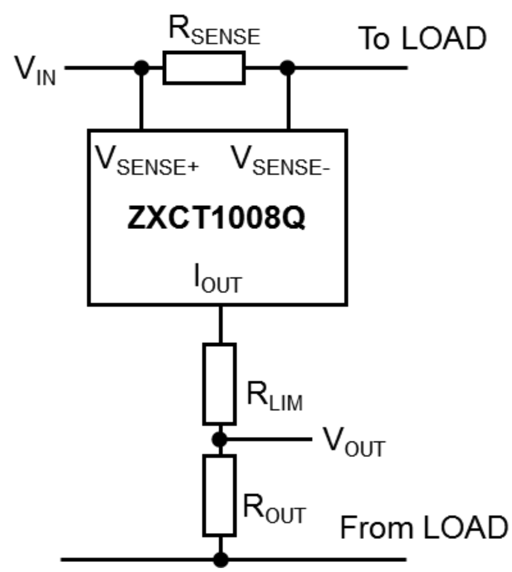


Top View

Features

- Low Cost, Accurate High-Side Current Sensing
- -40 to +125°C Temperature Range
- Up to 500mV Sense Voltage
- 2.5V to 20V Supply Range
- 4µA Quiescent Current
- 1% Typical Accuracy
- SOT23 (Type DN)
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. “Green” Device (Note 3)**
- **The ZXCT1008Q is suitable for automotive applications requiring specific change control; this part is AEC-Q100 qualified, PPAP capable, and manufactured in IATF 16949 certified facilities.**
  https://www.diodes.com/quality/product-definitions/

Application Circuit



Applications

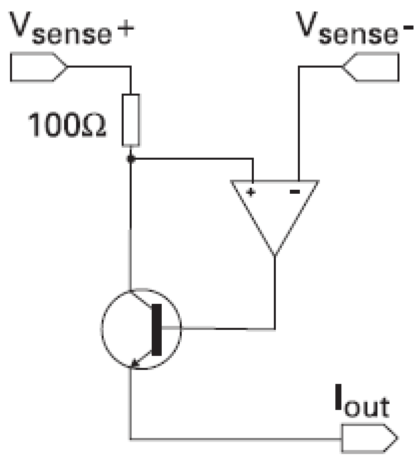
- Automotive current measurements
- Automotive DC motor stall detections
- Overcurrent monitors

Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated’s definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green” products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

Pin Descriptions

Pin Name	Pin Function
V_{SENSE+}	Connection to Supply Voltage
V_{SENSE-}	Connection to Load
I_{OUT}	Output Current, Proportional to Measured Current

Functional Block Diagram



Absolute Maximum Ratings (@T_A = +25°C, unless otherwise specified. Note 4)

Description		Rating	Unit
Voltage on Any Pin (Relative to I_{OUT})		-0.6 to 20	V
Continous Output Current, I_{OUT}		25	mA
Continuous Sense Voltage, V_{SENSE} (Note 5)		-0.5 to 5	V
Operating Temperature, T_A		-40 to +125	°C
Storage Temperature		-55 to +125	°C
Package Power Dissipation @ T_A = +25°C (Derate to Zero @ +125°C)		360	mW
ESD Susceptibility			
HBM	Human Body Model	2	kV
MM	Machine Model	300	V
CDM	Charged Device Model	1	kV

Notes: 4. Stresses greater than those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in this specification is not implied. Exposure to *Absolute Maximum Ratings* for extended periods can affect device reliability.

Semiconductor devices are ESD sensitive and can be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices.

5. V_{SENSE} is defined as the differential voltage between V_{SENSE+} and V_{SENSE-} pins.

$$V_{SENSE} = V_{SENSE+} - V_{SENSE-}$$
$$= V_{IN} - V_{LOAD}$$
$$= I_{LOAD} \times R_{SENSE}$$

Electrical Characteristics (@T_A = +25°C, V_{IN} = 5V, R_{OUT} = 100Ω, unless otherwise specified.)

Symbol	Parameter	Conditions (Note 5)	Min	Typ	Max	Unit
V_{IN}	V_{CC} Range	—	2.5	—	20	V
I_{OUT}	Output Current (Note 6)	V_{SENSE} = 0V V_{SENSE} = 10mV V_{SENSE} = 100mV V_{SENSE} = 200mV V_{SENSE} = 500mV	1 90 0.975 1.95 4.8	4 104 1.0 2.0 5.0	15 120 1.025 2.05 5.2	µA µA mA mA mA
V_{SENSE}	Sense Voltage (Note 5)	—	0	—	500	mV
I_{SENSE-}	V_{SENSE-} Input Current	—	—	—	100	nA
A_{CC}	Accuracy	R_{SENSE} = 0.1Ω V_{SENSE} = 200mV	-2.5	—	+2.5	%
G_M	Transconductance, I_{OUT}/V_{SENSE}	—	—	10000	—	µA/V
BW	Bandwidth	$V_{SENSE(DC)}$ = 10mv, RF P_{IN} = -40dBm (Note 7) $V_{SENSE(DC)}$ = 100mv, RF P_{IN} = -20dBm	— —	300 2	— —	kHz MHz

Notes: 5. V_{SENSE} is defined as the differential voltage between V_{SENSE+} and V_{SENSE-} pins.
$V_{SENSE} = V_{SENSE+} - V_{SENSE-}$
$= V_{IN} - V_{LOAD}$
$= I_{LOAD} \times R_{SENSE}$

6. Includes input offset voltage contribution.
7. -20dBm = 63mV_{PP} into 50Ω.

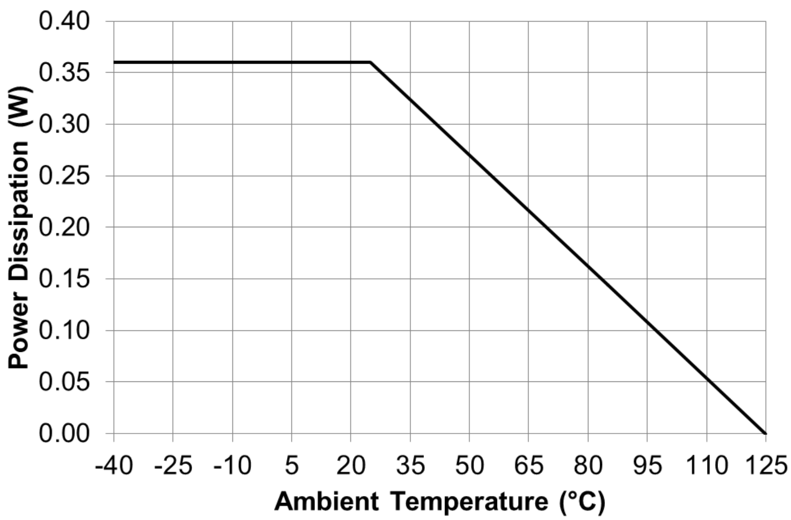
Power Dissipation

The maximum allowable power dissipation of the device for normal operation (P_{MAX}), is a function of the package junction to ambient thermal resistance (θ_{JA}), maximum junction temperature (T_{JMAX}), and ambient temperature (T_{AMB}), according to the expression:

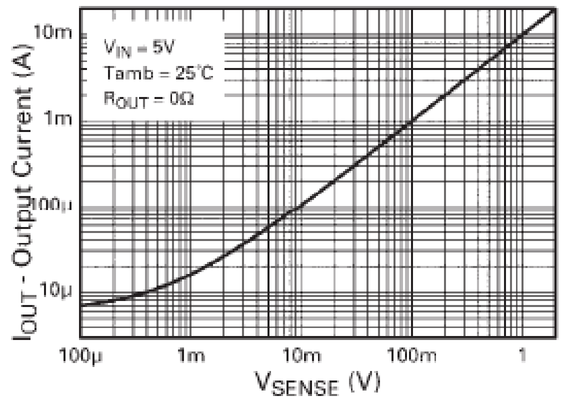
$P_{MAX} = (T_{JMAX} - T_{AMB}) / \theta_{JA}$

The device power dissipation, P_D is given by the expression:

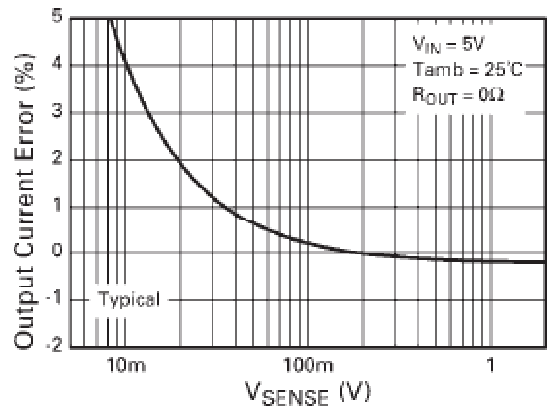
$P_D = I_{OUT} \times (V_{IN} - V_{OUT})$ W



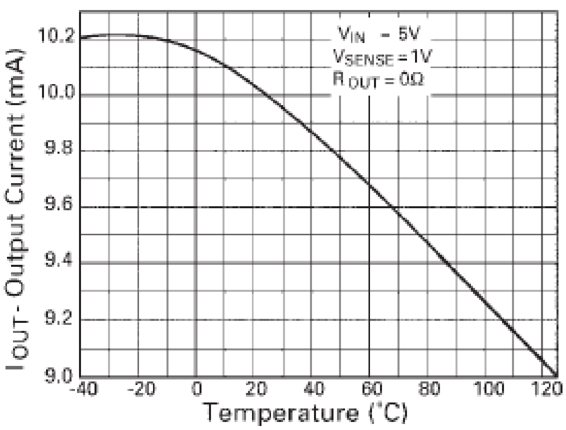
Typical Characteristics



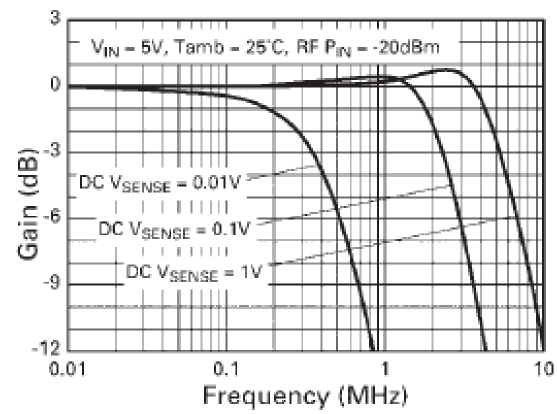
Typical Output v Sense Voltage



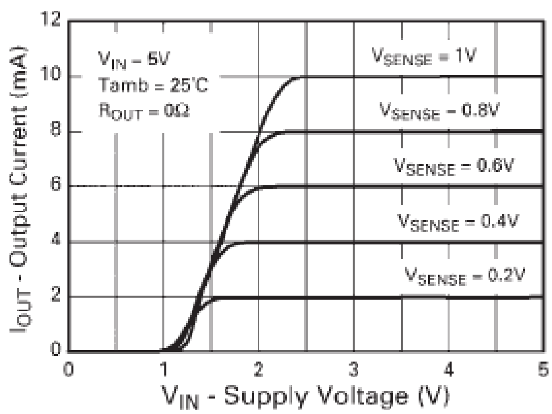
Error v Sense Voltage



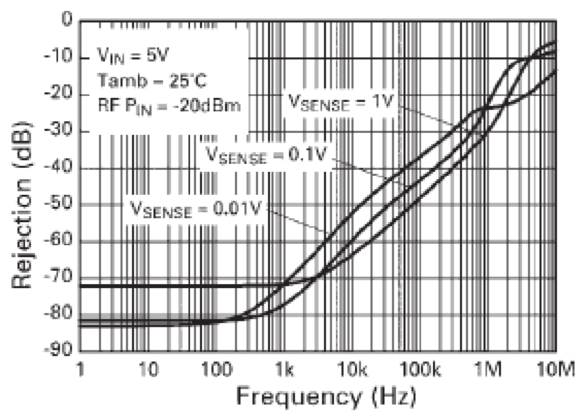
Output Current Temperature



Frequency Response

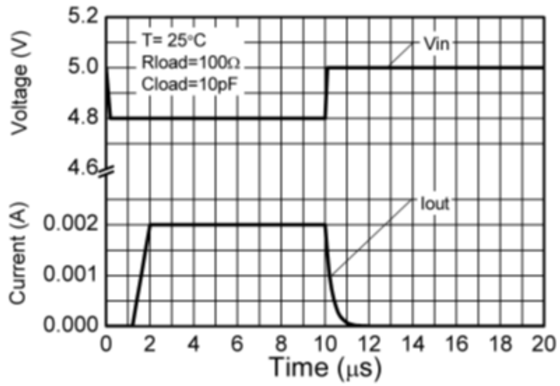


Transfer Characteristic



Common Mode Rejection

Typical Characteristics (continued)



Step Response

Application Information

The following text describes how to scale a load current to an output voltage.

$V_{SENSE} = V_{IN} - V_{LOAD}$

$= R_{SENSE} \times I_{LOAD}$ (1)

$I_{OUT} = V_{SENSE} \times 10mA/V$ (2)

$V_{OUT} = I_{OUT} \times R_{OUT}$ (3)

Combining (2) and (3) V_{OUT} can be determined to be:

$V_{OUT} = 0.01 \times V_{SENSE} \times R_{OUT}$ (4)

Example:

A 1A current is to be represented by a 1V output voltage:

1) Choose the value of R_{SENSE} to give 50mV > V_{SENSE} > 500mV at full load.

   For example set V_{SENSE} = 100mV at 1.0A.

   Rearranging (1) gives:

$$R_{SENSE} = \frac{V_{SENSE}}{I_{LOAD}}$$

$$= 0.1/1.0 = 0.1\Omega.$$

2) Choose R_{OUT} to give V_{OUT} = 1V, when V_{SENSE} = 100mV.

   Rearranging (4) for R_{OUT} gives:

$$R_{OUT} = \frac{V_{OUT}}{V_{SENSE} \times 0.01}$$

$$= \frac{1}{0.1 \times 0.01} = 1k\Omega$$

Application Information (continued)

Referring to Figure 1, where R_{LOAD} represents any load including DC motors, a charging battery or further circuitry that requires monitoring, R_{SENSE} can be selected on specific requirements of accuracy, size and power rating.

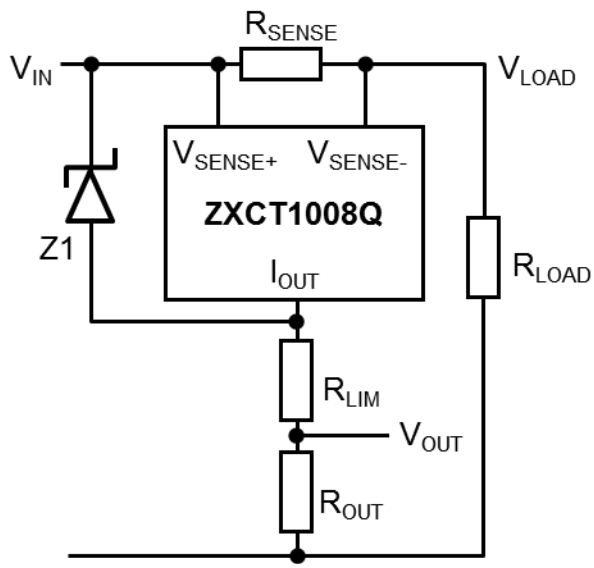


Figure 1. ZXCT1008Q with Additional Current Limiting Resistor R_{LIM} and Zener Z1

An additional resistor, R_{LIM} can be added in series with R_{OUT} (Figure 1), to limit the current from I_{OUT}. Any circuit connected to V_{OUT} will be protected from input voltage transients. This can be of particular use in automotive applications where load dump and other common transients need to be considered. The Zener Z1 provides additional protection for local dump, reverse battery and high-voltage transient incidents.

Assuming the worst case condition of V_{OUT} = 0V; providing a low impedance to a transient, the minimum value of R_{LIM} is given by:

$R_{LIM(min)} = (V_{PK} – V_{MAX})/ I_{PK}$
V_{PK} = Peak transient voltage to be withstood
V_{MAX} = Maximum working voltage = 20V
I_{PK} = Peak output current = 40mA

The maximum value of R_{LIM} is set by $V_{IN(MIN)}$, $V_{OUT(MAX)}$ and the dropout voltage (see transfer characteristic on page 4) of the ZXCT1008Q:

$$R_{(LIM(MAX))} = \frac{R_{OUT} \times [V_{IN(MIN)} - \{V_{DP} + V_{OUT(MAX)}\}]}{V_{OUT(MAX)}}$$

Where:

$V_{IN(MIN)}$ = Minimum Supply Operating Voltage
V_{DP} = Dropout Voltage
$V_{OUT(MAX)}$ = Maximum Operating Output Voltage

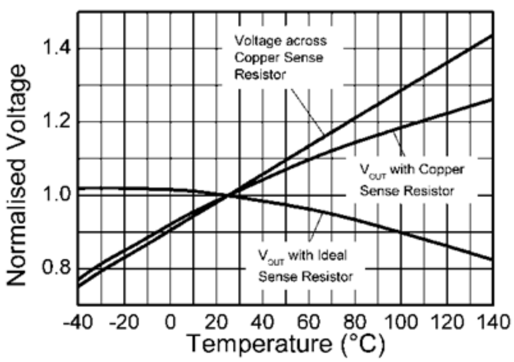
Application Information (continued)

PCB Trace Shunt Resistor for Low-Cost Solution

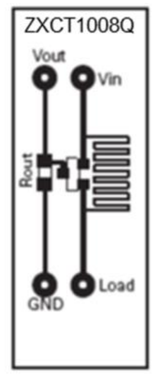
The figure below shows output characteristics of the device when using a PCB resistive trace for a low-cost solution in replacement for a conventional shunt resistor. The graph shows the linear rise in voltage across the resistor due to the PTC of the material and demonstrates how this rise in resistance value over temperature compensates for the NTC of the device.

The figure opposite shows a PCB layout suggestion. The resistor section is 25mm x 0.25mm giving approximately 150mΩ using 1oz copper.

The data for the normalized graph was obtained using a 1A load current and a 100Ω output resistor. An electronic version of the PCB layout is available through Diodes Incorporated’s applications group.

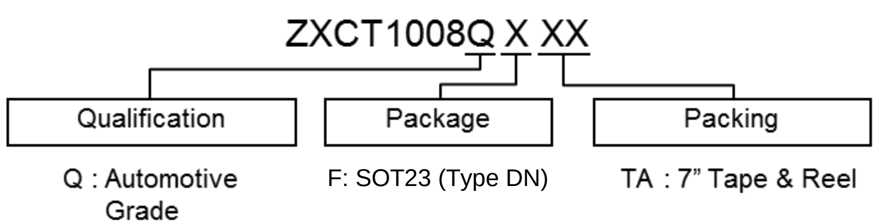


Effect of Sense Resistor Material on Temperature Performance



Layout shows area of shunt resistor compared to SOT23 package.
Not actual size.

Ordering Information

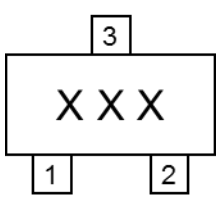


Part Number	Package (Note 8)	Package Code	Identification Code	Qualification Grade (Note 9)	Tape Width (mm)	Packing	
						Qty.	Carrier
ZXCT1008QFTA	SOT23 (Type DN)	F	108	Grade 1	8	3000 Units	7” Tape & Reel

Notes: 8. For packaging details, go to our website at https://www.diodes.com/design/support/packaging/diodes-packaging/.
9. ZXCT1008Q has been qualified to AEC-Q100 grade 1 and is classified as “Automotive Grade” which supports PPAP documentation. See ZXCT1008 datasheet for commercial qualified version.

Marking Information

Package Type: SOT23 (Type DN)

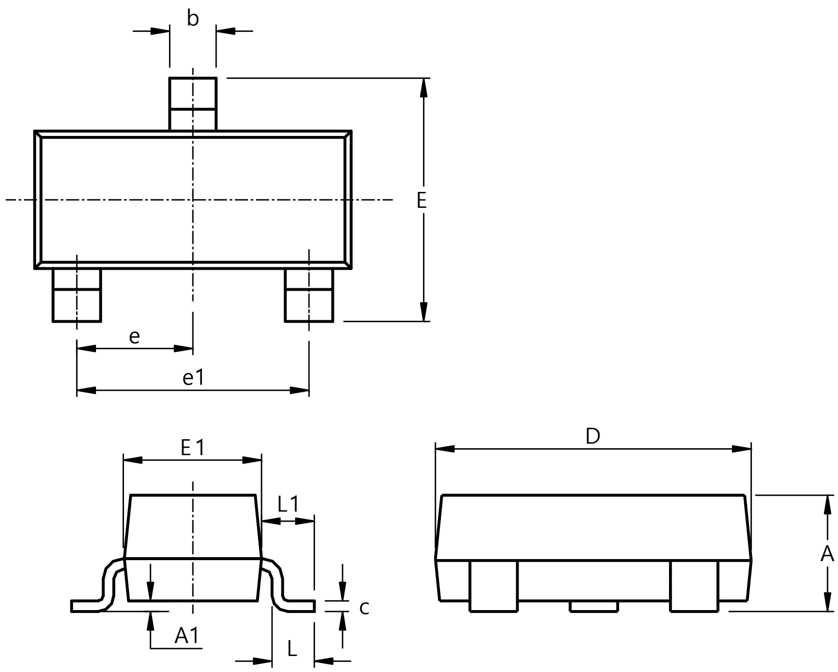


XXX: 108 (Identification Code)

Package Outline Dimensions

Please see http://www.diodes.com/package-outlines.html for the latest version.

SOT23 (Type DN)

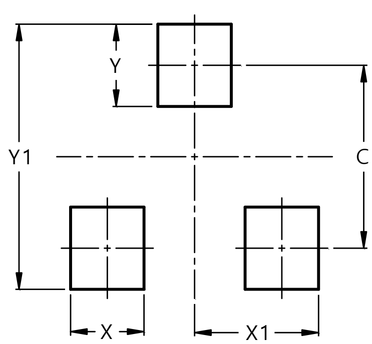


SOT23 Type DN			
Dim	**Min**	**Max**	**Typ**
A	0.89	1.12	1.00
A1	0.01	0.10	0.05
b	0.30	0.51	0.45
c	0.08	0.20	0.10
D	2.80	3.04	3.00
E	2.10	2.64	2.42
E1	1.20	1.40	1.37
e	0.95 REF		
e1	1.90 REF		
L	0.25	0.60	0.30
L1	0.45	0.62	0.54
All Dimensions in mm			

Suggested Pad Layout

Please see http://www.diodes.com/package-outlines.html for the latest version.

SOT23 (Type DN)



Dimensions	Value (in mm)
C	2.0
X	0.8
X1	1.35
Y	0.9
Y1	2.9

Mechanical Data

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish — Matte Tin Plated Leads, Solderable per MIL-STD-202, Method 208 e3
- Weight: 0.009 grams (Approximate)

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