SY24632

36V High-speed Zero-drift Voltage Output Current Shunt Monitor with High-speed over Current Comparator

General Description

SY24632 include both a high common mode, current sensing amplifier and a high-speed comparator configured to detect overcurrent conditions through measuring the voltage developed across a current-sensing resistor and comparing that voltage with a defined threshold limit. The device features an adjustable limit threshold range that is set using a single external resistor. This current shunt monitor can measure differential voltage signals on common-mode voltages that can vary from 0V up to 36V, independent of the supply voltage.

The open drain alert output can be configured to operate in either a transparent mode where the output status follows the input state or in a latched mode where the alert output is cleared when the latch is reset. The device alert response time is under 0.75µs, allowing for quick detection of overcurrent events.

SY24632 operates from a single 2.7V to 5.5V supply, drawing a maximum supply current of 400µA. The device is specified over the extended operating temperature range (–40°C to +125°C), and is available in an 8-pin MSOP package.

Features

- Wide Common Mode Range: 0V to 36V
- Dual Output: Amplifier and Comparator Output
- High Accuracy Amplifier:
  - Offset Voltage: 50µV (Max)
  - Offset Voltage Drift: 0.5µV/°C (Max)
  - Gain Error: 0.15% (Max)
  - Gain Error Drift: 10ppm/°C (Max)
- Available Amplifier Gain: 50V/V
- Programmable Alert Threshold Setting Through a Single Resistor
- Total Alert Response Time: 0.75µs
- Open Drain Output with Latching Mode
- Package: MSOP8

Applications

- Overcurrent Protection
- Power-Supply Protection
- Circuit Breakers
- Computers and Servers
- Telecom Equipment
- Battery Management

Ordering Information

SY24632 □(□□□)

Package Code

Optional Spec Code

Ordering Number	Package type	Note
SY24632CAP	MSOP8	

Typical Application

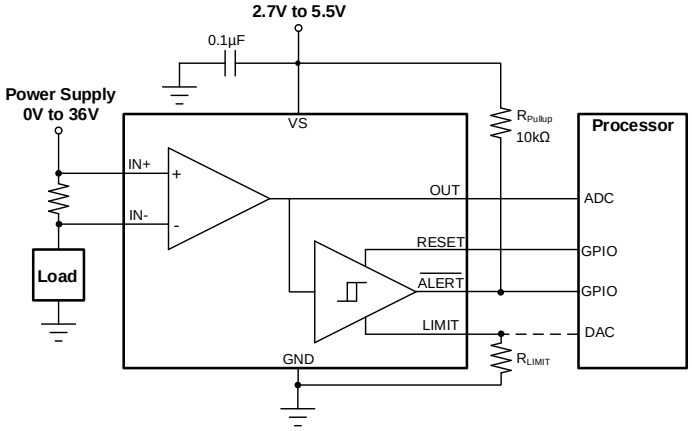
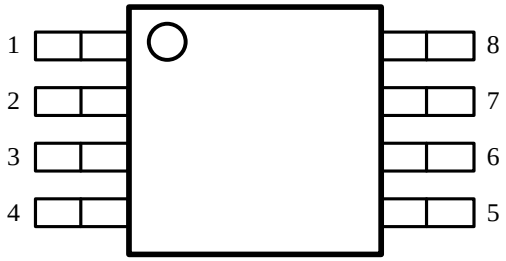


Figure 1. Typical Application

Pin out (Top View)



(MSOP8)

Top mark: **DYW*xyz*** (Device code: **DYW**, ***x=year code, y=week code, z= lot number code***)

Pin Number	Pin Name	Function Description
1	VS	Power supply, 2.7V to 5.5V.
2	OUT	Output voltage.
3	LIMIT	Alert threshold limit input.
4	GND	Ground.
5	RESET	Transparent or latch mode selection input.
6	ALERT	Overlimit alert, active low, open drain output.
7	IN-	Connect to load side of shunt resistor.
8	IN+	Connect to supply side of shunt resistor.

Absolute Maximum Ratings (Note 1)

V_S ---------- -0.3V~6V
Differential V_{IN+} - V_{IN-} ---------- -40V~40V
Common mode, V_{IN+}, V_{IN-} ---------- -0.3V~40V
Alert output V_{ALERT} ---------- -0.3V~6V
Input voltage at Any Pin ---------- -0.3V~V_S+0.3V
Package Thermal Resistance (Note 2)
θ_{JA} ---------- 175°C/W
$\theta_{JC(top)}$ ---------- 40°C/W
Maximum Junction Temperature ---------- 150°C
Storage Temperature Range ---------- -65°C~150°C

ESD Susceptibility
HBM (Human-body model) ---------- ±2000V
CDM (Charged-device model) ---------- ±1000V

Recommended Operating Conditions

V_S ---------- 5V
Common mode, V_{IN+}, V_{IN-} ---------- 12V
Operation Temperature ---------- -40~125°C

Electrical Characteristics

At T_A=25°C, V_{IN}=V_{IN+}–V_{IN-}=10mV, V_S=5V, V_{IN+}=12V and V_{LIMIT}=2V, unless otherwise noted.

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Input						
Common Mode Input Voltage	V_{CM}		0		36	V
Differential Input Voltage	V_{IN}	V_{IN}=V_{IN+}-V_{IN-}	0		100	mV
Common Mode Rejection	CMR	V_{IN}=0V~36V, T_A=-40°C~+125°C	106	118		dB
Offset Voltage, RTI	V_{OS}			±15	±50	μV
Offset Voltage Drift, RTI	dV_{OS}/dT	T_A=-40°C~+125°C		0.1	0.5	μV/°C
Power Supply Rejection Ratio	PSR	V_S=2.7V~5.5V, V_{IN+}=12V, T_A=-40°C~+125°C		±0.1	±10	μV/V
Input Bias Current (Note 3)	I_B			125		μA
Input Offset Current (Note 4)	I_{OS}			±0.1		μA
Output						
Gain	G			50		V/V
Gain Error		V_{OUT}=0.5V~V_S-0.5V		±0.05	±0.15	%
		T_A=-40°C~+125°C		3	10	ppm/°C
Nonlinearity Error		V_{OUT}=0.5V~V_S-0.5V		±0.01		%
Maximum Capacitive Load		No sustained oscillation		1		nF
Voltage Output						
Swing to V_S Power Supply Rail		R_L=10kΩ to GND, T_A=-40°C~+125°C		V_S-0.05	V_S-0.1	V
Swing to GND		R_L=10kΩ to GND, T_A=-40°C~+125°C		V_{GND}+20	V_{GND}+30	mV
Frequency Response						
Band Width	BW			500		kHz
Slew Rate	SR			4		V/μs
Noise, RTI						
Voltage Noise Density				30		nV/ √ Hz
Comparator						
Total Alert Propagation Delay	t_p	Input overdrive=1mV (Note 5) V_{IN} to Alert Propagation		0.75		μs
Slew-rate-limited t_p		V_{OUT} step=0.5V ~ 4.5V, V_{LIMIT}=4V		1		
Limit Threshold Output Current	I_{LIMIT}		79.4	80	80.6	μA
		T_A=-40°C~+125°C	78.8		81.2	
Comparator Offset Voltage	V_{OS}			1	4	mV
Hysteresis	HYS			50		mV
High Level Input Voltage	V_{IH}		1.4		VS+0.3	V
Low Level Input Voltage	V_{IL}		0		0.4	V
Alert Low Level Output Voltage	V_{OL}	I_{OL}=3mA		70	300	mV
ALERT Terminal Leakage Input Current		V_{OH}=3.3V		0.1	1	μA
Digital Leakage Input Current		0<V_{IN}<V_S		1		μA

Power Supply						
Operating Supply Range	V_S	T_A=-40°C~+125°C	2.7		5.5	V
Quiescent Current	I_Q	V_{IN}=0mV, T_A=25°C		300	380	μA
		T_A=-40°C~+125°C			400	

Note 1: Stresses beyond the "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Note 2: R_{JA} is measured on low effective single layer PCB under natural convection; $R_{JC(top)}$ is measured in accordance with JESD51-14

Note 3: Input bias current is decided by the average of the input currents of the pin IN+ and IN-.

Note 4: Input offset current is decided by the error between the input currents of the pin IN+ and IN-.

Note 5: Overdrive= (V_{OUT} – V_{LIMIT}) / Gain.

Application Information

Operation

SY24632 is a 36V common mode, zero drift topology, current sensing amplifier that can be used in both low side and high side configurations. These specially designed, current sensing amplifiers are able to accurately measure voltages developed across current sensing resistors on common mode voltages that far exceed the supply voltage powering the device. Current can be measured on input voltage rails as high as 36V, and the device can be powered from supply voltages as low as 2.7V. The device can also withstand the full 36V common mode voltage at the input pins when the supply voltage is removed without causing damage.

The zero-drift topology enables high precise measurements with typical input offset voltages as low as 50μV with a temperature contribution of only 0.5μV/°C over the full temperature range of –40°C to +125°C. The low total offset voltage of the SY24632 enables smaller current sensing resistor values to be used, and allows for a more efficient system operation without sacrificing measurement accuracy resulting from the smaller input signal.

SY24632 uses a single external resistor to allow for a simple method of setting the corresponding current threshold level for the device to use for out-of-range comparison. Combining the precise measurement of the current sensing amplifier and the on-board comparator enables an all-in-one overcurrent detection device. This combination creates a highly accurate solution that is capable of fast detection of out-of-range conditions and allows the system to take corrective actions to prevent potential component or system-wide damage.

Alert Output

ALERT pin is an active low, open drain output that is designed to be pulled low when the input conditions are detected to be out of range. This open drain output pin is recommended to include a 10kΩ, pull-up resistor to the supply voltage. This open drain pin can be pulled up to a voltage beyond the supply voltage V_S, but must not exceed 5.5 V.

When the output voltage of the amplifier is lower than the voltage developed at the LIMIT pin, the comparator output is in the default high state. When the amplifier output voltage exceeds the threshold voltage set at the LIMIT pin, the comparator output becomes active and pulls low. This active low output indicates that the measured signal at the amplifier input has exceeded the programmed threshold level, indicating an overcurrent or out-of-range condition has occurred.

Alert Mode

The device has two output operating modes, transparent and latched, that are selected based on the RESET pin setting. These modes change how the ALERT pin responds following an alert when the overcurrent condition is removed.

Transparent Output Mode

The device is set to transparent mode when the RESET pin is pulled low, thus allowing the output alert state to change and follow the input signal with respect to the programmed alert threshold. For example, when the differential input signal rises above the alert threshold, the alert output pin is pulled low. As soon as the differential input signal drops below the alert threshold, the output returns to the default high output state.

A common implementation using the device in transparent mode is to connect the ALERT pin to a hardware interrupt input on a microcontroller. As soon as an overcurrent condition is detected and the ALERT pin is pulled low, the controller interrupt pin detects the output state change and can begin making changes to the system operation required to address the overcurrent condition. Under this configuration, the ALERT pin transition from high to low is captured by the microcontroller so the output can return to the default high state when the overcurrent event is removed.

Latch Output Mode

Some applications do not have the functionality available to continuously monitor the state of the output ALERT pin to detect an overcurrent condition as described in the Transparent Output Mode section. Latch mode is specifically intended to accommodate these applications.

In latch mode (RESET = high), when an overlimit condition is detected and the ALERT pin is pulled low, the ALERT pin does not return to the default high state when the differential input signal drops below the alert threshold level. In order to clear the alert, the RESET pin must be pulled low for at least 100 ns. Pulling the RESET pin low allows the ALERT pin to return to the default high level provided that the differential input signal has dropped below the alert threshold. If the input signal is still above the threshold limit when the RESET pin is pulled low, the ALERT pin remains low. When the alert condition is detected by the system controller,

the RESET pin can be set back to high in order to place the device back in latch mode.

The device is placed into the corresponding output modes based on the signal connected to RESET, as shown in Table 1. The difference between latch mode and transparent mode is how the alert output responds when an overcurrent event ends.

Table 1. Output Mode Settings

Output Mode	RESET Terminal Setting
Transparent mode	RESET = low
Latch mode	RESET = high

The latch and transparent modes are represented in Fig.2When V_{OUT} drops back below the V_{LIMIT}-Hysteresis threshold for the first time, the RESET pin is pulled high. With the RESET pin is pulled high, the device is set to latch mode so that the alert output state does not return high when the V_{OUT} drops below the V_{LIMIT}-Hysteresis threshold. Only when the RESET pin is pulled low does the ALERT pin return to the default high level, thus indicating that the V_{OUT} is below the V_{LIMIT}-Hysteresis threshold. When the V_{OUT} drops below the V_{LIMIT}-Hysteresis threshold for the second time, the RESET pin is already pulled low. The device is set to transparent mode at this point and the ALERT pin is pulled back high as soon as the V_{OUT} drops below the V_{LIMIT}-Hysteresis threshold.

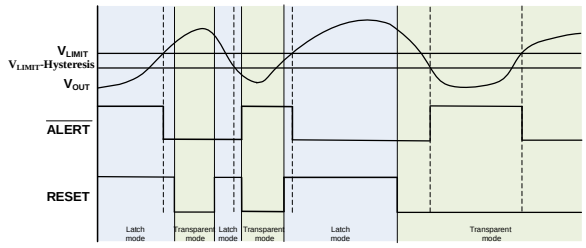


Figure 2. Transparent versus Latch Mode

Current Limit Threshold Setting

SY24632 determines if an overcurrent event is present by comparing the amplified measured voltage developed across the current sensing resistor with the corresponding signal developed at the LIMIT pin. The threshold voltage for the LIMIT pin can be set using a single external resistor or by connecting an external voltage source to the LIMIT pin.

Resistor Controlled Current Limit

The typical approach for setting the limit threshold voltage is to connect a resistor from the LIMIT pin to ground. The value of this resistor R_{LIMIT} is chosen in order to create a corresponding voltage at the LIMIT pin equivalent to the output voltage V_{OUT}, when the maximum desired load current is flowing through the current sensing resistor. An internal 80µA current source is connected to the LIMIT pin to create a corresponding voltage used to compare to the amplifier output voltage, depending on the value of the R_{LIMIT} resistor.

Voltage Source Controlled Current Limit

The second method for setting the limit voltage is to connect the LIMIT pin to a programmable digital-to-analog converter or other external voltage source. The benefit of this method is the ability to adjust the current limit threshold to account for different threshold voltages that are used for different system operating conditions. For example, this method can be used in a system that has one current limit threshold level that must be monitored during a power-up sequence but different threshold levels that must be monitored during other system operating modes.

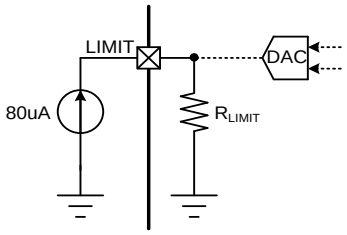


Figure 3. Typical Circuit for Setting V_{LIMIT}

Hysteresis

The on-board comparator in the SY24632 is designed to reduce the possibility of oscillations in the alert output when the measured signal level is near the overlimit threshold level because of noise. When the output voltage (V_{OUT}) exceeds the voltage developed at the LIMIT pin, the ALERT pin is asserted and pulls low. The output voltage must drop below the LIMIT pin threshold voltage by the gain-dependent hysteresis level in order for the ALERT pin to de-assert and return to the nominal high state, as shown in Fig.4

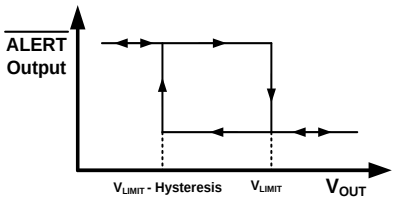
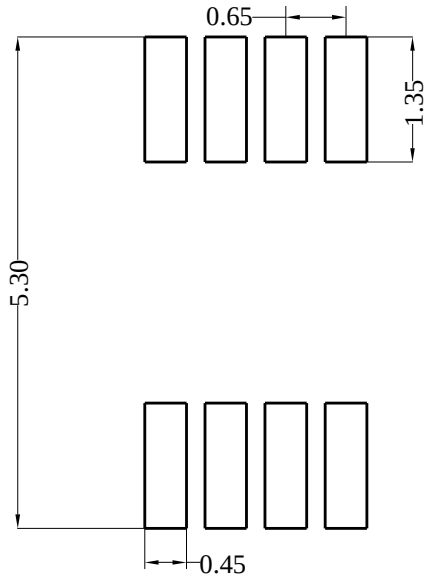
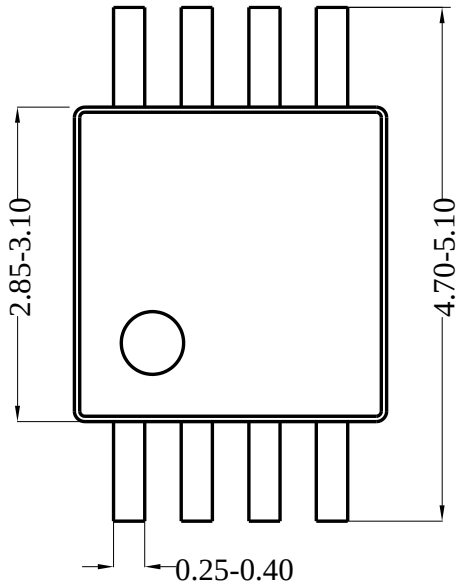


Figure 4. Typical Comparator Hysteresis

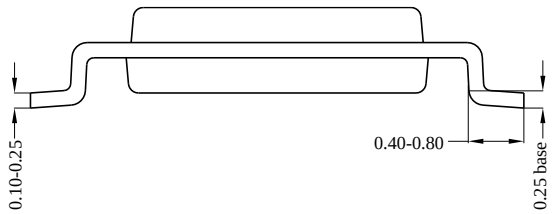
MSOP8 Package outline & PCB layout



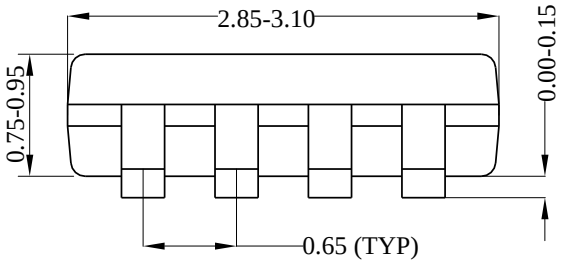
Recommended Pad Layout



Top View



Side View A

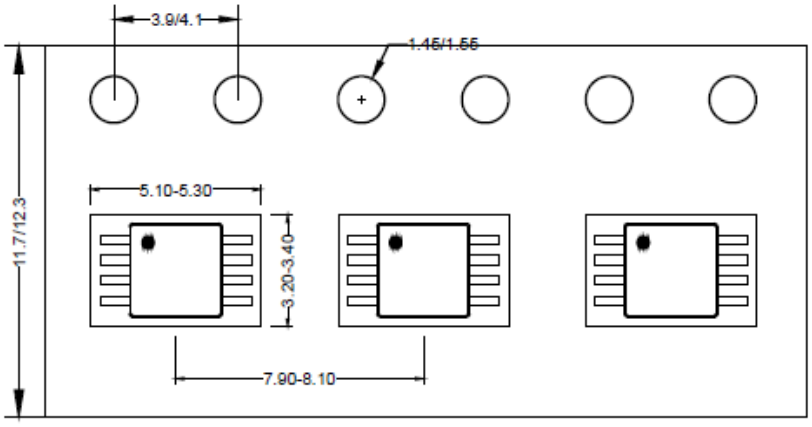


Side View B

Notes: All dimension in millimeter and exclude mold flash & metal burr.

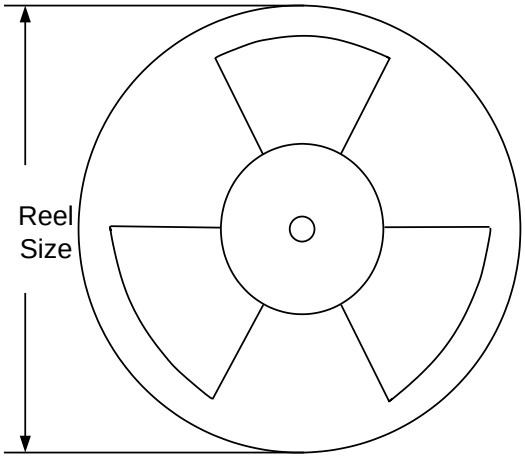
Taping & Reel Specification

1. MSOP8 taping orientation



Feeding direction ⟶

2. Carrier Tape & Reel specification for packages



Package types	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Trailer * length(mm)	Leader * length (mm)	Qty per reel (pcs)
MSOP8	12	8	13"	400	400	3000

3. Others: NA

Revision History

The revision history provided is for informational purpose only and is believed to be accurate, however, not warranted. Please make sure that you have the latest revision.

Date	Revision	Change
Sept.9. 2022	Revision 0.9	Initial Release

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