120V Bidirectional, Precision Current Sense Amplifiers

Features

- Wide Common-Mode Range: 0 to +120V
- Wide Power Supply Range: 3.0V to 20V
- Bidirectional Operation
- High PWM Rejection
- Low Quiescent Current: 500μA typical
- Low Offset Voltage: ±50μV max
- Low Gain Error: 2% max
- Low Gain Error Drift: 10 ppm/°C max
- Rail-to-Rail Output
- Packaging: SOT23-8/MSOP8/SOP8
- Choice of Gains:
  - 10V/V (COSINA241A1)
  - 20V/V (COSINA241A2)
  - 50V/V (COSINA241A3)
  - 100V/V (COSINA241A4)
  - 200V/V (COSINA241A5)

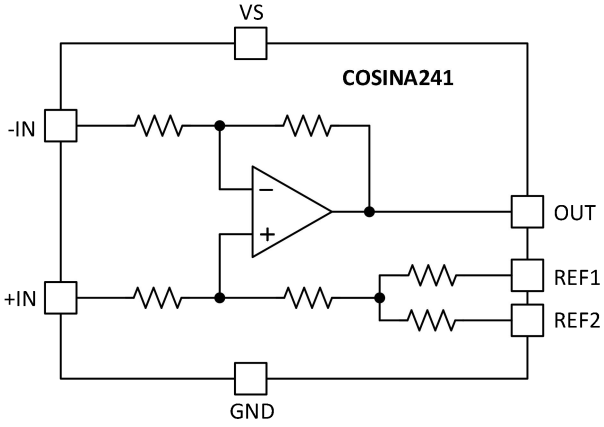
Applications

- Current Sensing
- Battery Charging and Discharging
- Overcurrent Protection
- Cordless Power Tools
- Motor Control

General Description

The COSINA241x family are voltage output, current sense amplifiers (also called current shunt monitors) which can measure voltage across shunts at common−mode voltages from 0V to +120V, independent of supply voltage. The low offset of the zero−drift architecture enables current sensing across the shunt with maximum voltage drop as low as 10mV full−scale.

These devices can operate from a single +3.0V to +20V power supply, drawing a typical 500 μA of supply current, and are specified over the extended operating temperature range (–40°C to +125°C). The COSINA241x family feature high CMRR and are commonly used for over-current protection, precision-current measurement for system optimization or in closed-loop feedback circuitry.



Simplified Schematic

Rev1.0

1 Pin Configuration and Functions

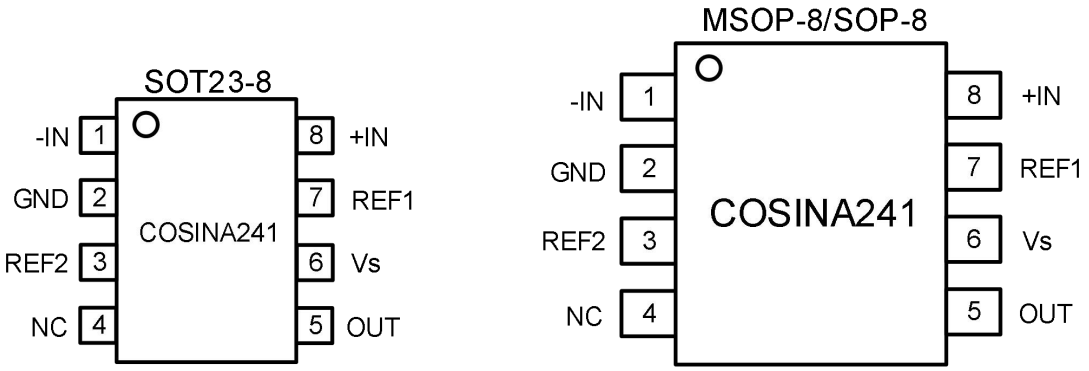


Figure 1 Pin Diagram

Pin Description

Pin No.	Pin Name	Description
1	-IN	Negative input. For high-side applications, connect to load side of sense resistor. For low-side applications, connect to ground side of sense resistor.
2	GND	Ground
3	REF2	Reference 2 voltage. Connect to voltage potential from 0 to Vs.
4	NC	No connection or connect to ground.
5	OUT	Output voltage
6	Vs	Power supply, 3.0V to 20V
7	REF1	Reference 1 voltage. Connect to voltage potential from 0 to Vs.
8	+IN	Positive input. For high-side applications, connect to bus side of sense resistor. For low-side applications, connect to load side of sense resistor.

2 Product Specification

2.1 Absolute Maximum Ratings (1)

Parameter	Min	Max	Unit
Supply Voltage, Vs		+25	V
Differential Analog Inputs, $(V_{IN+}) - (V_{IN-})$	-25	+25	V
Common Mode Analog Inputs, V_{IN+}, V_{IN-}	-0.7	+130	V
REF1, REF2 Inputs	GND-0.3	Vs+0.3	V
Output Voltage, V_{OUT}	GND-0.3	Vs+0.3	V
Maximum Output Current, I_{OUT}		8	mA
Maximum Junction Temperature, $T_{J(max)}$		+150	°C
Storage temperature, T_{STG}	-55	+150	°C

(1) Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

2.2 Thermal Data

Parameter	Rating	Unit
Package Thermal Resistance, $R_{\theta JA}$ (Juntion-to-Ambient)	190 (SOT23-8) 206 (MSOP8) 155 (SOP8)	°C/W

2.3 Recommended Operating Conditions

Parameter	Min.	Typ.	Max.	Unit
Common-mode Input Voltage, V_{CM}	0	48	120	V
Supply Voltage, Vs	3.0	5	20	V
Operating Ambient Temperature, T_A	-40		+125	°C

2.4 Electrical Characteristics

(at T_A=25°C, V_S=5V, V_{CM}=V_{IN-}=48V, V_{SENSE}=V_{IN+} - V_{IN-}, and V_{REF1}=V_{REF2}=V_S/2, unless otherwise noted)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
INPUT						
Common-mode Input Range	V_{CM}	V_{SENSE}= 10 mV T_A= -40°C to +125°C	0		120	V
Common-mode Rejection Ratio	CMRR	V_{IN+} = 0V to +110V, V_{SENSE} = 0 mV		80		dB
Offset Voltage, RTI (input referred)	V_{OS}	V_{SENSE} = 0 mV		±5	±50	μV
Vos Temperature Drift	$\Delta V_{OS}/\Delta T$	V_{SENSE} = 0 mV T_A= -40°C to +125°C		0.1	0.5	μV/°C
Vos vs Power Supply Ratio	PSRR	V_{SENSE}= 0 mV		±0.2	±20	μV/V
Input Bias Current	I_B	V_{SENSE} = 0 mV			150	μA
Reference Input Range	V_{REF}	V_{SENSE} = 0 mV	0		Vs	V
OUTPUT						
Gain	G	COSINA241A1		10		V/V
		COSINA241A2		20		
		COSINA241A3		50		
		COSINA241A4		100		
		COSINA241A5		200		
Gain Error	E_G	V_{SENSE} = -5mV to 5mV T_A= -40°C to +125°C		±0.5	±2	%
Gain Error vs Temperature		T_A=-40°C to +125°C		3	20	ppm/°C
Non-linearity Error		V_{SENSE} = -5mV to 5mV		±0.01		%
Maximum Capacitive Load	C_L	No sustained oscillation		0.5		nF
Swing to Vs Power Supply Rail	V_{OH}	R_{LOAD}=10kΩ to GND T_A= -40°C to +125°C		Vs-0.07	Vs-0.2	V
Swing to GND	V_{OL}			V_{GND} +0.002	V_{GND} +0.01	V

FREQUENCY RESPONSE						
-3dB Bandwidth	BW	A1 device		3.0		MHz
		A2 device		2.2		
		A3 device		1.8		
		A4 device		1.4		
		A5 device		1.0		
Slew Rate	SR	Rising		2		V/μs
NOISE						
Input Referred Voltage Noise	e_n	A1 device		70		nV/ √Hz
		A2 device		55		
		A3 device		45		
		A4 device		40		
		A5 device		35		
POWER SUPPLY						
Operating Voltage Range	Vs		3.0	-	20	V
Quiescent Current	I_Q	V_{SENSE}=0mV		500		μA
		V_{SENSE}=0mV, T_A= -40°C to +125°C			800	μA

3 Application Information

The COSINA241x series of devices can be configured for both low-side and high-side current sensing. While at times the application requires low−side sensing, only high−side sensing can detect a short from the positive supply line to ground. Furthermore, high−side sensing avoids adding resistance to the ground path of the load being measured. The application below focus primarily on high−side current sensing.

Figure 2 shows the basic connections of the COSINA241x with reference set to mid-supply voltage. The devices amplify the voltage developed across a current-sensing resistor as current flows through the resistor to the load or ground. When the input signal increases, the output voltage at the OUT pin increases. For the best measurement accuracy, connect the input pins (IN+ and IN-) as close as possible to the shunt resistor to minimize any resistance in series with the shunt resistor.

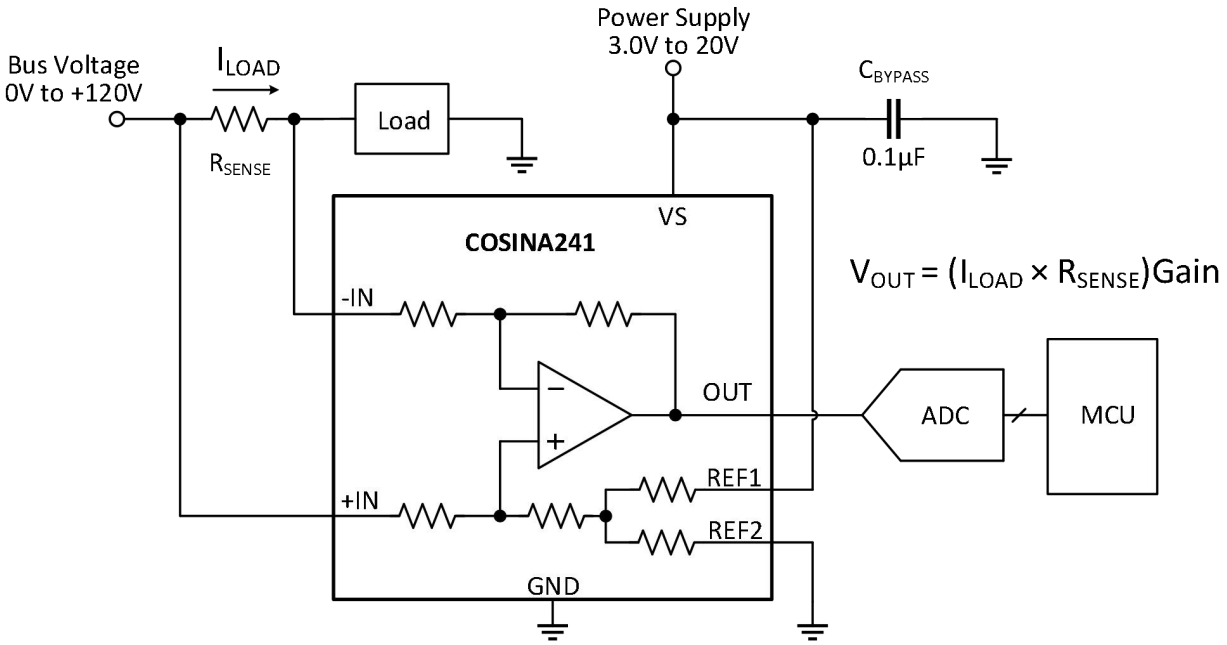


Figure 2 Typical Application Schematic with Reference Set to Mid-Supply Voltage

The COSINA241x is configurable to allow for unidirectional or bidirectional operation. The output voltage is set by applying a voltage or voltages to the reference inputs, REF1 and REF2 as shown in Figure 3. There is no operational difference between the two reference pins.

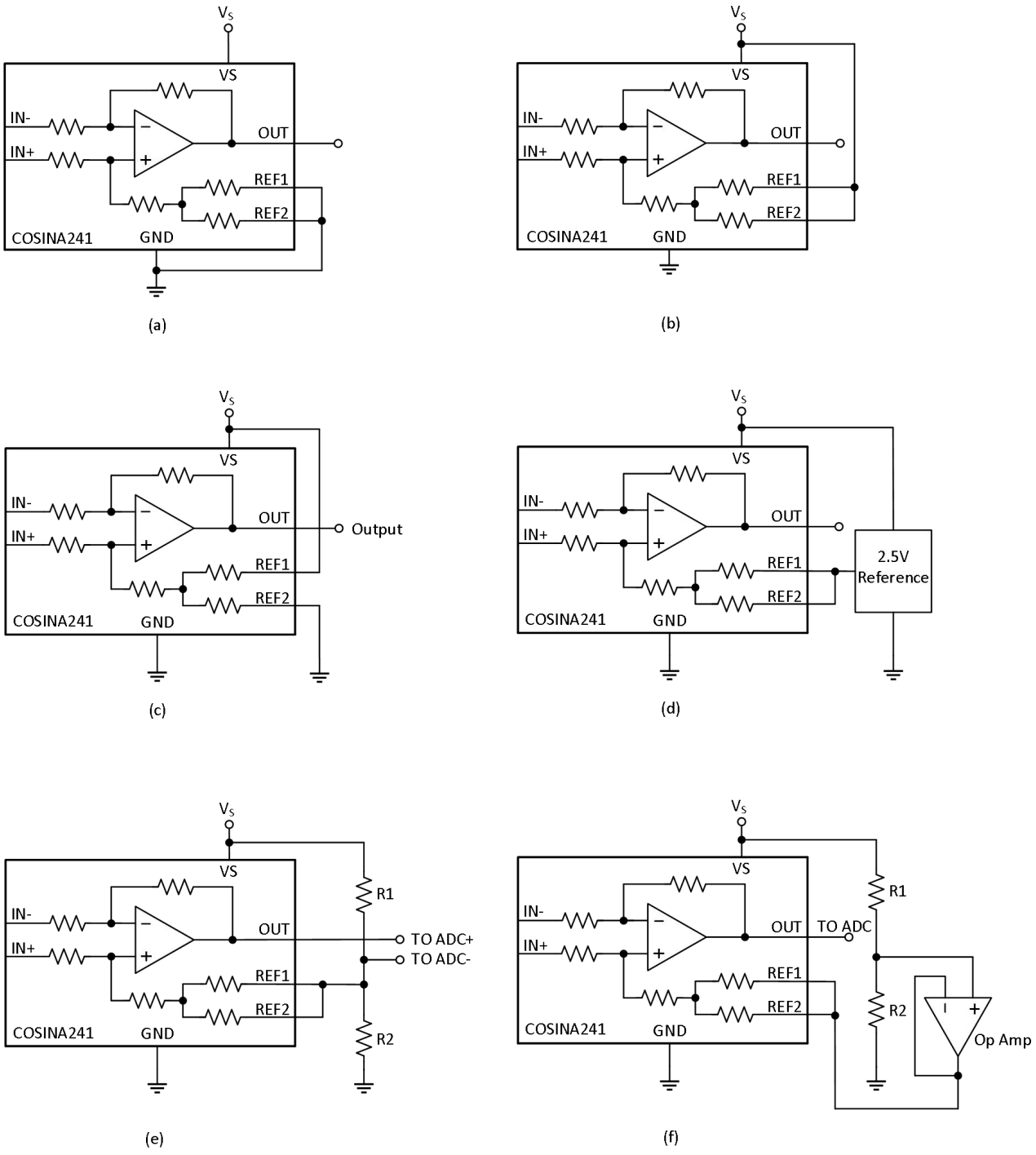


Figure 3 Adjusting the Output with the Reference Pins

(a) Ground referenced output, (b) Vs referenced output, (c) Mid-Supply referenced output, (d) External referenced output, (e) Generate a reference using a resistor divider for differential output, (f) Generate a reference using a resistor divider and an opamp buffer.

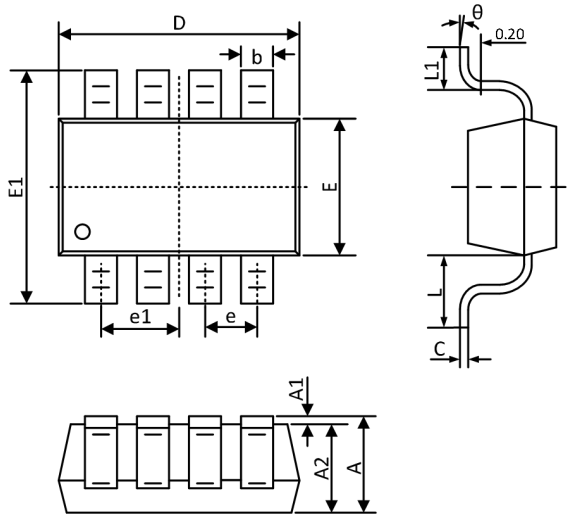
A typical non-zero-drift current shunt monitors typically require a full-scale drop of 100 mV on shunt resistor. The COSINA241x zero-drift series gives equivalent accuracy at a full-scale range on the order of 10 mV. This accuracy reduces shunt resistor power dissipation by an order of magnitude with many additional benefits.

The input circuitry of the COSINA241x can accurately measure beyond the power-supply voltage, Vs. For example, the Vs power supply can be +5 V, whereas the load power-supply voltage can be as high as +120V. However, the output voltage range of the OUT pin is limited by the voltages on the power-supply pin. Note also that the COSINA241x can withstand the full input signal range up to +120V at the input pins, regardless of whether the device has power applied or not.

A power-supply bypass capacitor of at least 0.1 μF is required for proper operation. Applications with noisy or high-impedance power supplies may require additional decoupling capacitors to reject power-supply noise. Connect bypass capacitors as close as possible to the device pins.

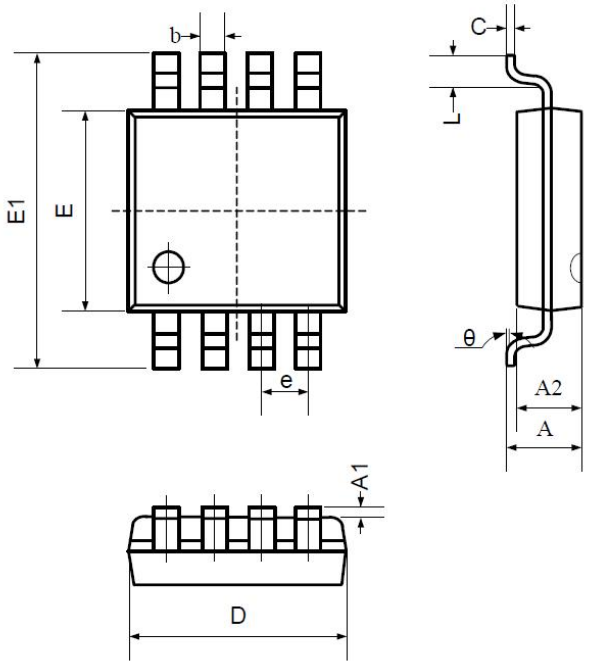
4 Package Information

4.1 SOT23-8 (Package Outline Dimensions)



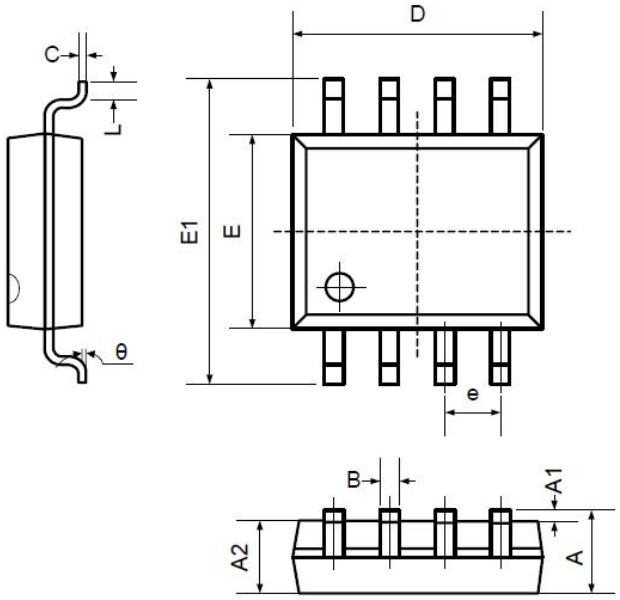
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.650BSC		0.026BSC	
e1	0.975BSC		0.038BSC	
L	0.700REF		0.028REF	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

4.2 MSOP-8 (Package Outline Dimensions)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.800	1.200	0.031	0.047
A1	0.000	0.200	0.000	0.008
A2	0.760	0.970	0.030	0.038
b	0.30 TYP		0.012 TYP	
c	0.15 TYP		0.006 TYP	
D	2.900	3.100	0.114	0.122
e	0.65 TYP		0.026 TYP	
E	2.900	3.100	0.114	0.122
E1	4.700	5.100	0.185	0.201
L	0.410	0.650	0.016	0.026
θ	0°	6°	0°	6°

4.3 SOP-8 (Package Outline Dimensions)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
B	0.330	0.510	0.013	0.020
C	0.190	0.250	0.007	0.010
D	4.780	5.000	0.188	0.197
E	3.800	4.000	0.150	0.157
E1	5.800	6.300	0.228	0.248
e	1.270TYP		0.050TYP	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

5 Ordering Information

Package	Gain (V/V)	Model	Order Number	Package Option	Marking
SOT23-8	10	COSINA241A1	COSINA241A1TR	Tape and Reel, 3000	COS241A1
	20	COSINA241A2	COSINA241A2TR	Tape and Reel, 3000	COS241A2
	50	COSINA241A3	COSINA241A3TR	Tape and Reel, 3000	COS241A3
	100	COSINA241A4	COSINA241A4TR	Tape and Reel, 3000	COS241A4
	200	COSINA241A5	COSINA241A5TR	Tape and Reel, 3000	COS241A5
MSOP-8	10	COSINA241A1	COSINA241A1MR	Tape and Reel, 3000	COS241A1
	20	COSINA241A2	COSINA241A2MR	Tape and Reel, 3000	COS241A2
	50	COSINA241A3	COSINA241A3MR	Tape and Reel, 3000	COS241A3
	100	COSINA241A4	COSINA241A4MR	Tape and Reel, 3000	COS241A4
	200	COSINA241A5	COSINA241A5MR	Tape and Reel, 3000	COS241A5
SOP-8	10	COSINA241A1	COSINA241A1SR	Tape and Reel, 4000	COS241A1
	20	COSINA241A2	COSINA241A2SR	Tape and Reel, 4000	COS241A2
	50	COSINA241A3	COSINA241A3SR	Tape and Reel, 4000	COS241A3
	100	COSINA241A4	COSINA241A4SR	Tape and Reel, 4000	COS241A4
	200	COSINA241A5	COSINA241A5SR	Tape and Reel, 4000	COS241A5