



钜地半导体
Tudi Semiconductor

Product Specification

TUDI-LM324, LM324A, LM324E,
LM224, LM2902, LM2902E, LM2902V, NCV2902

Single Supply Quad Operational Amplifiers

网址 www.sztdbdt.com Q

用芯智造 · 卓越品质

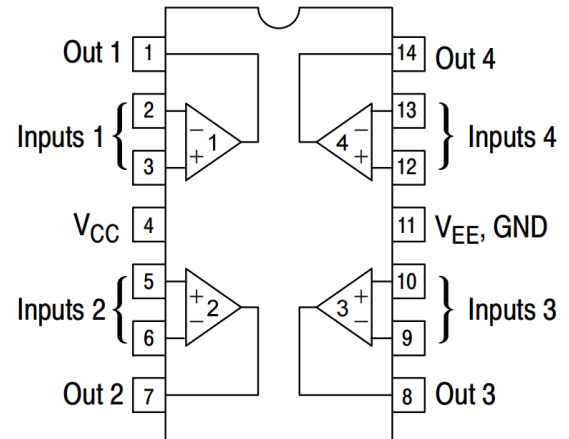
**semiconductor device
manufacturer**

- Design
- research and development
- production
- and sales



Features

- Short Circuited Protected Outputs
- True Differential Input Stage
- Single Supply Operation: 3.0 V to 32 V
- Low Input Bias Currents: 100 nA Maximum (LM324A)
- Four Amplifiers Per Package
- Internally Compensated
- Common Mode Range Extends to Negative Supply
- Industry Standard Pinouts
- ESD Clamps on the Inputs Increase Ruggedness without Affecting Device Operation
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant



Description

The LM324 series are low-cost, quad operational amplifiers with true differential inputs. They have several distinct advantages over standard operational amplifier types in single supply applications. The quad amplifier can operate at supply voltages as low as 3.0 V or as high as 32 V with quiescent currents about one-fifth of those associated with the MC1741 (on a per amplifier basis). The common mode input range includes the negative supply, thereby eliminating the necessity for external biasing components in many applications. The output voltage range also includes the negative power supply voltage.



MAXIMUM RATINGS (T_A = +25°C, unless otherwise noted.)

Rating	Symbol	Value	Unit
Power Supply Voltages Single Supply Split Supplies	V _{CC} V _{CC} , V _{EE}	32 ±16	Vdc
Input Differential Voltage Range (Note 1)	V _{IDR}	±32	Vdc
Input Common Mode Voltage Range	V _{ICR}	-0.3 to 32	Vdc
Output Short Circuit Duration	t _{SC}	Continuous	
Junction Temperature	T _J	150	°C
Thermal Resistance, Junction-to-Air (Note 2) Case 646 Case 751A Case 948G	R _{θJA}	118 156 190	°C/W
Storage Temperature Range	T _{stg}	-65 to +150	°C
Operating Ambient Temperature Range LM224 LM324, LM324A, LM324E LM2902, LM2902E LM2902V, NCV2902 (Note 3)	T _A	-25 to +85 0 to +70 -40 to +105 -40 to +125	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Split Power Supplies.
2. All R_{θJA} measurements made on evaluation board with 1 oz. copper traces of minimum pad size. All device outputs were active.
3. NCV2902 is qualified for automotive use.

ESD RATINGS

Rating	HBM	MM	Unit
ESD Protection at any Pin (Human Body Model – HBM, Machine Model – MM)			
NCV2902 (Note 3)	2000	200	V
LM324E, LM2902E	2000	200	V
LM324DG/DR2G, LM2902DG/DR2G	200	100	V
All Other Devices	2000	200	V



ELECTRICAL CHARACTERISTICS ($V_{CC} = 5.0\text{ V}$, $V_{EE} = \text{GND}$, $T_A = 25^\circ\text{C}$, unless otherwise noted.)

Characteristics	Symbol	LM224			LM324A			LM324, LM324E			LM2902, LM2902E			LM2902V/NCV2902			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage $V_{CC} = 5.0\text{ V}$ to 30 V $V_{ICR} = 0\text{ V}$ to $V_{CC} - 1.7\text{ V}$, $V_O = 1.4\text{ V}$, $R_S = 0\ \Omega$ $T_A = 25^\circ\text{C}$ $T_A = T_{\text{high}}$ (Note 4) $T_A = T_{\text{low}}$ (Note 4)	V_{IO}	-	2.0	5.0	-	2.0	3.0	-	2.0	7.0	-	2.0	7.0	-	2.0	7.0	mV
Average Temperature Coefficient of Input Offset Voltage $T_A = T_{\text{high}}$ to T_{low} (Notes 4 and 6)	$\Delta V_{IO}/\Delta T$	-	7.0	-	-	7.0	30	-	7.0	-	-	7.0	-	-	7.0	-	$\mu\text{V}/^\circ\text{C}$
Input Offset Current $T_A = T_{\text{high}}$ to T_{low} (Note 4)	I_{IO}	-	3.0	30	-	5.0	30	-	5.0	50	-	5.0	50	-	5.0	50	nA
Average Temperature Coefficient of Input Offset Current $T_A = T_{\text{high}}$ to T_{low} (Notes 4 and 6)	$\Delta I_{IO}/\Delta T$	-	10	-	-	10	300	-	10	-	-	10	-	-	10	-	$\text{pA}/^\circ\text{C}$
Input Bias Current $T_A = T_{\text{high}}$ to T_{low} (Note 4)	I_{IB}	-	-90	-150	-	-45	-100	-	-90	-250	-	-90	-250	-	-90	-250	nA
Input Common Mode Voltage Range (Note 5) $V_{CC} = 30\text{ V}$ $T_A = +25^\circ\text{C}$ $T_A = T_{\text{high}}$ to T_{low} (Note 4)	V_{ICR}	0	-	28.3	0	-	28.3	0	-	28.3	0	-	28.3	0	-	28.3	V
Differential Input Voltage Range	V_{IDR}	-	-	V_{CC}	-	-	V_{CC}	-	-	V_{CC}	-	-	V_{CC}	-	-	V_{CC}	V
Large Signal Open Loop Voltage Gain $R_L = 2.0\text{ k}\Omega$, $V_{CC} = 15\text{ V}$, for Large V_O Swing $T_A = T_{\text{high}}$ to T_{low} (Note 4)	A_{VOL}	50	100	-	25	100	-	25	100	-	25	100	-	25	100	-	V/mV
Channel Separation $10\text{ kHz} \leq f \leq 20\text{ kHz}$, Input Referenced	CS	-	-120	-	-	-120	-	-	-120	-	-	-120	-	-	-120	-	dB
Common Mode Rejection, $R_S \leq 10\text{ k}\Omega$	CMR	70	85	-	65	70	-	65	70	-	50	70	-	50	70	-	dB
Power Supply Rejection	PSR	65	100	-	65	100	-	65	100	-	50	100	-	50	100	-	dB

4. LM224: $T_{\text{low}} = -25^\circ\text{C}$, $T_{\text{high}} = +85^\circ\text{C}$
 LM324/LM324A/LM324E: $T_{\text{low}} = 0^\circ\text{C}$, $T_{\text{high}} = +70^\circ\text{C}$
 LM2902/LM2902E: $T_{\text{low}} = -40^\circ\text{C}$, $T_{\text{high}} = +105^\circ\text{C}$
 LM2902V & NCV2902: $T_{\text{low}} = -40^\circ\text{C}$, $T_{\text{high}} = +125^\circ\text{C}$
 NCV2902 is qualified for automotive use.

5. The input common mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3 V . The upper end of the common mode voltage range is $V_{CC} - 1.7\text{ V}$, but either or both inputs can go to $+32\text{ V}$ without damage, independent of the magnitude of V_{CC} .
6. Guaranteed by design.



ELECTRICAL CHARACTERISTICS ($V_{CC} = 5.0\text{ V}$, $V_{EE} = \text{GND}$, $T_A = 25^\circ\text{C}$, unless otherwise noted.)

Characteristics	Symbol	LM224			LM324A			LM324, LM324E			LM2902, LM2902E			LM2902V/NCV2902			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Output Voltage – High Limit $V_{CC} = 5.0\text{ V}$, $R_L = 2.0\text{ k}\Omega$, $T_A = 25^\circ\text{C}$ $V_{CC} = 30\text{ V}$, $R_L = 2.0\text{ k}\Omega$, $(T_A = T_{\text{high}} \text{ to } T_{\text{low}})$ (Note 7) $V_{CC} = 30\text{ V}$, $R_L = 10\text{ k}\Omega$, $(T_A = T_{\text{high}} \text{ to } T_{\text{low}})$ (Note 7)	V_{OH}	3.3	3.5	–	3.3	3.5	–	3.3	3.5	–	3.3	3.5	–	3.3	3.5	–	V
Output Voltage – Low Limit, $V_{CC} = 5.0\text{ V}$, $R_L = 10\text{ k}\Omega$, $T_A = T_{\text{high}} \text{ to } T_{\text{low}}$ (Note 7)	V_{OL}	–	5.0	20	–	5.0	20	–	5.0	20	–	5.0	100	–	5.0	100	mV
Output Source Current ($V_{ID} = +1.0\text{ V}$, $V_{CC} = 15\text{ V}$) $T_A = 25^\circ\text{C}$ $T_A = T_{\text{high}} \text{ to } T_{\text{low}}$ (Note 7)	I_{O+}	20 10	40 20	– –	20 10	40 20	– –	20 10	40 20	– –	20 10	40 20	– –	20 10	40 20	– –	mA
Output Sink Current ($V_{ID} = -1.0\text{ V}$, $V_{CC} = 15\text{ V}$) $T_A = 25^\circ\text{C}$ $T_A = T_{\text{high}} \text{ to } T_{\text{low}}$ (Note 7) ($V_{ID} = -1.0\text{ V}$, $V_O = 200\text{ mV}$, $T_A = 25^\circ\text{C}$)	I_{O-}	10 5.0 12	20 8.0 50	– – –	10 5.0 12	20 8.0 50	– – –	10 5.0 12	20 8.0 50	– – –	10 5.0 –	20 8.0 –	– – –	10 5.0 –	20 8.0 –	– – –	mA μA
Output Short Circuit to Ground (Note 8)	I_{SC}	–	40	60	–	40	60	–	40	60	–	40	60	–	40	60	mA
Power Supply Current ($T_A = T_{\text{high}} \text{ to } T_{\text{low}}$) (Note 7) $V_{CC} = 30\text{ V}$, $V_O = 0\text{ V}$, $R_L = \infty$ $V_{CC} = 5.0\text{ V}$, $V_O = 0\text{ V}$, $R_L = \infty$	I_{CC}	– –	– –	3.0 1.2	– –	1.4 0.7	3.0 1.2	– –	– –	3.0 1.2	– –	– –	3.0 1.2	– –	– –	3.0 1.2	mA

7. LM224: $T_{\text{low}} = -25^\circ\text{C}$, $T_{\text{high}} = +85^\circ\text{C}$
 LM324/LM324A/LM324E: $T_{\text{low}} = 0^\circ\text{C}$, $T_{\text{high}} = +70^\circ\text{C}$
 LM2902/LM2902E: $T_{\text{low}} = -40^\circ\text{C}$, $T_{\text{high}} = +105^\circ\text{C}$
 LM2902V & NCV2902: $T_{\text{low}} = -40^\circ\text{C}$, $T_{\text{high}} = +125^\circ\text{C}$
 NCV2902 is qualified for automotive use.

8. The input common mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common mode voltage range is $V_{CC} - 1.7\text{ V}$, but either or both inputs can go to +32 V without damage, independent of the magnitude of V_{CC} .

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

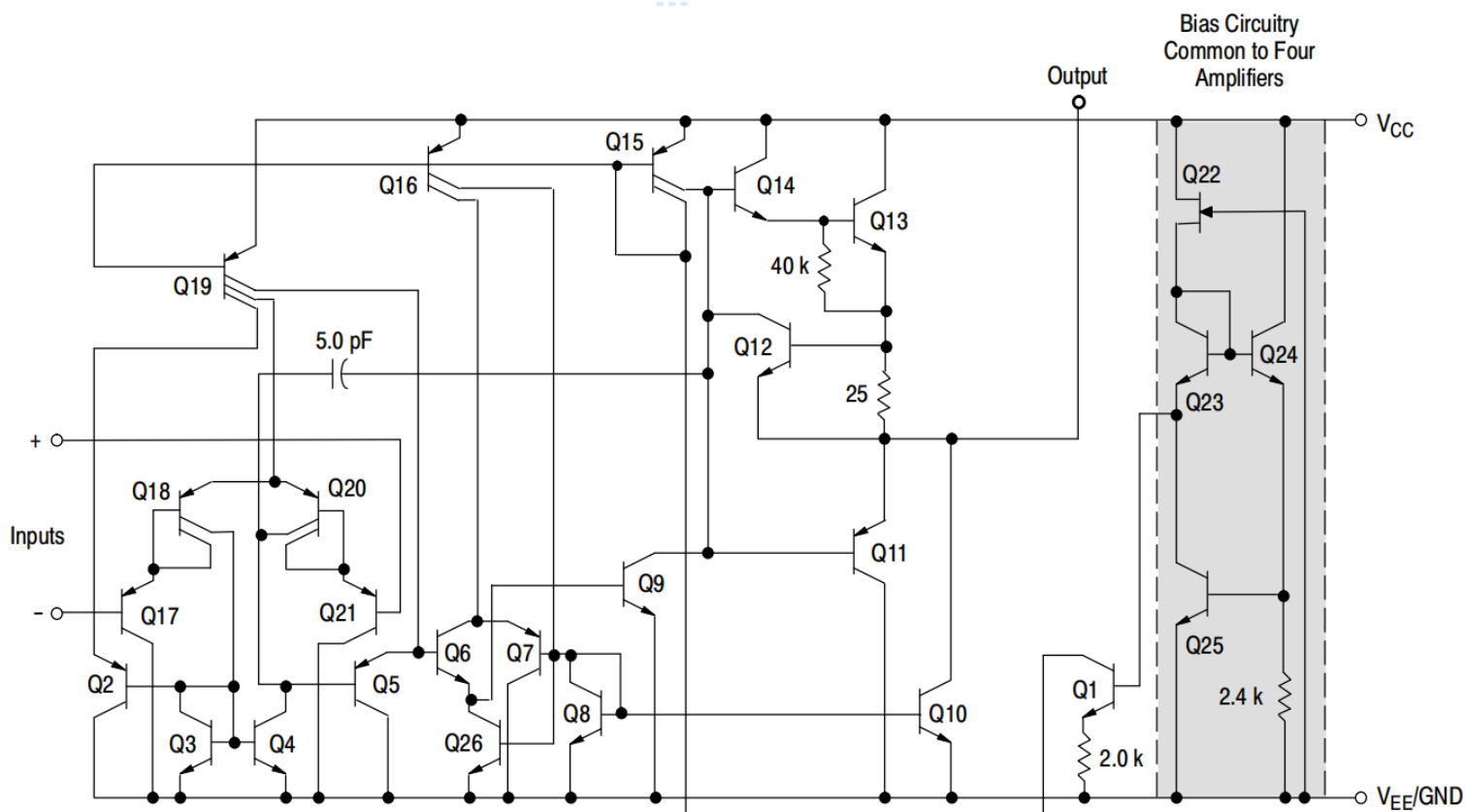


Figure 1. Representative Circuit Diagram
(One-Fourth of Circuit Shown)

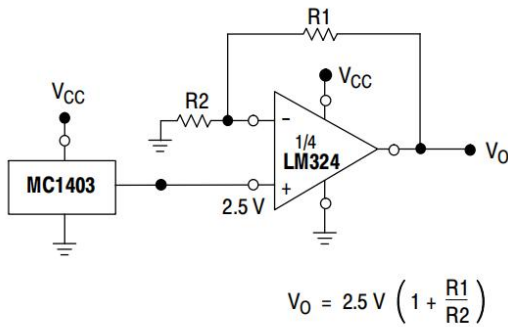


Figure 2. Voltage Reference

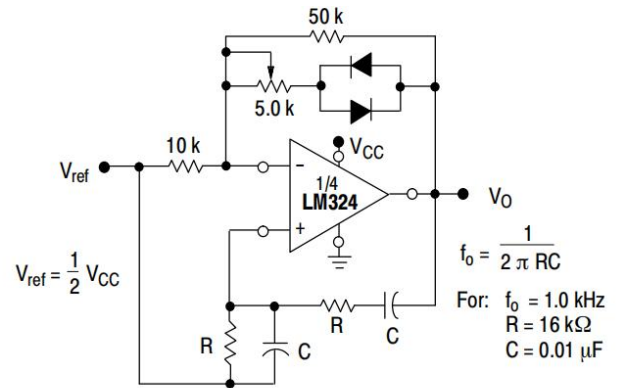


Figure 3. Wien Bridge Oscillator

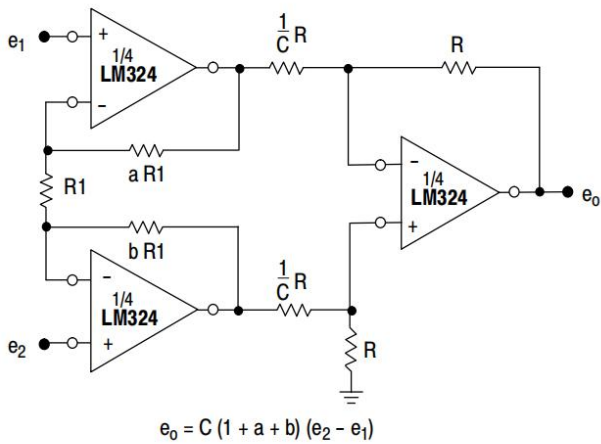


Figure 4. High Impedance Differential Amplifier

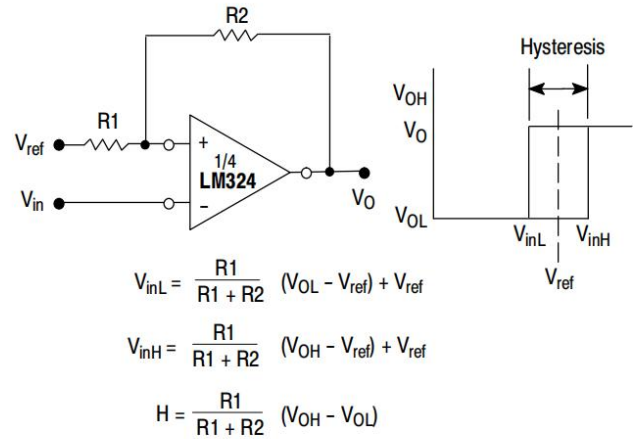


Figure 5. Comparator with Hysteresis

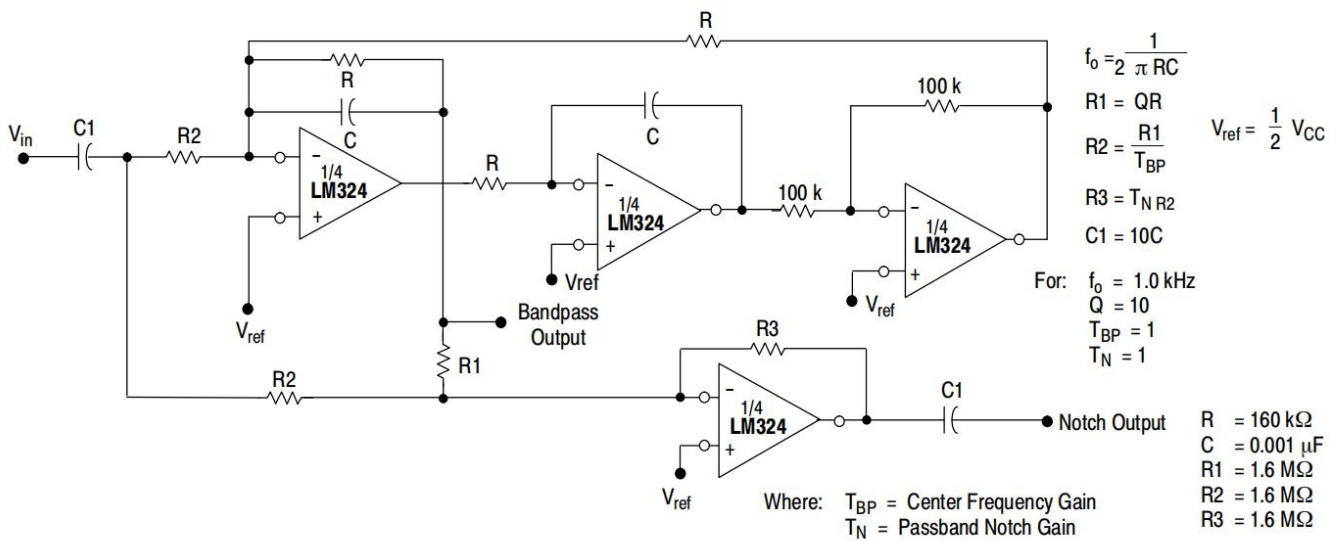


Figure 6. Bi-Quad Filter

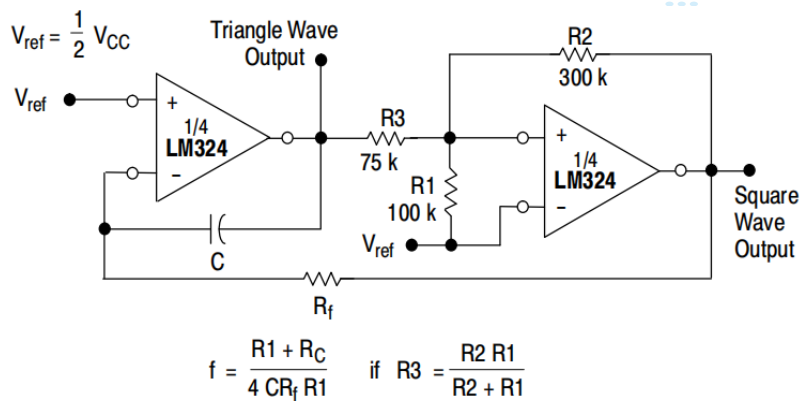


Figure 7. Function Generator

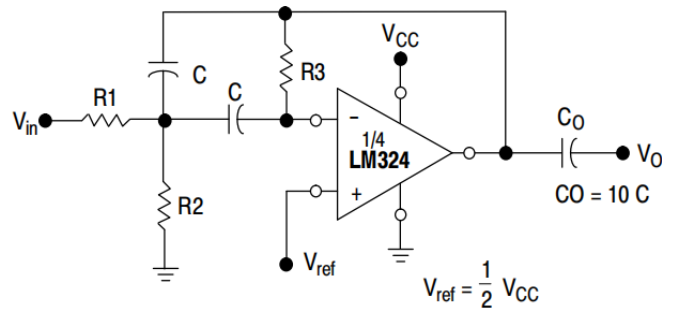


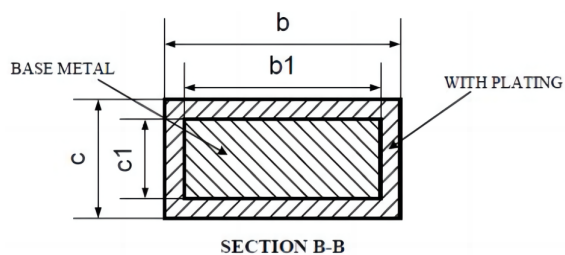
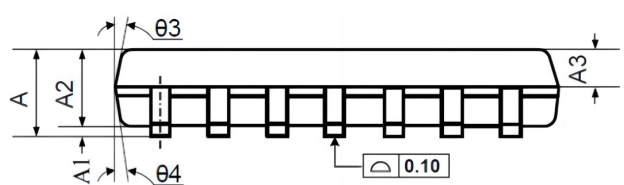
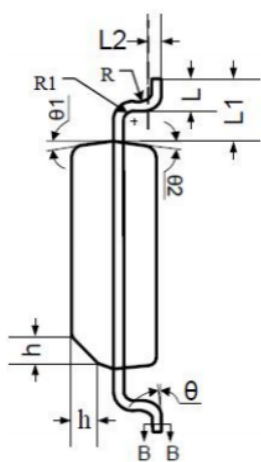
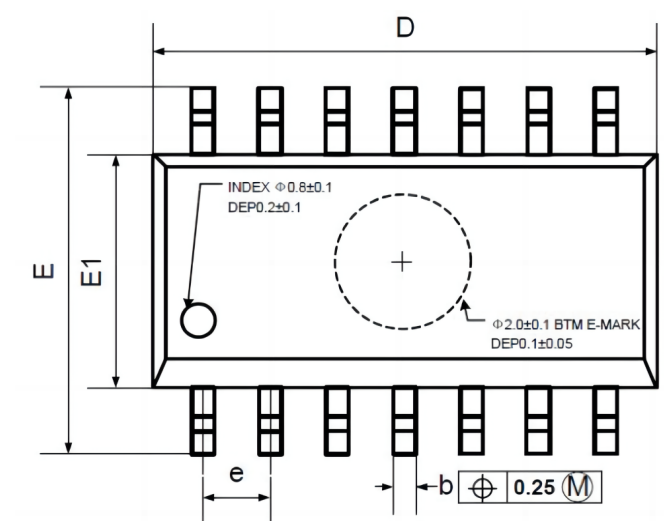
Figure 8. Multiple Feedback Bandpass Filter



ORDERING INFORMATION

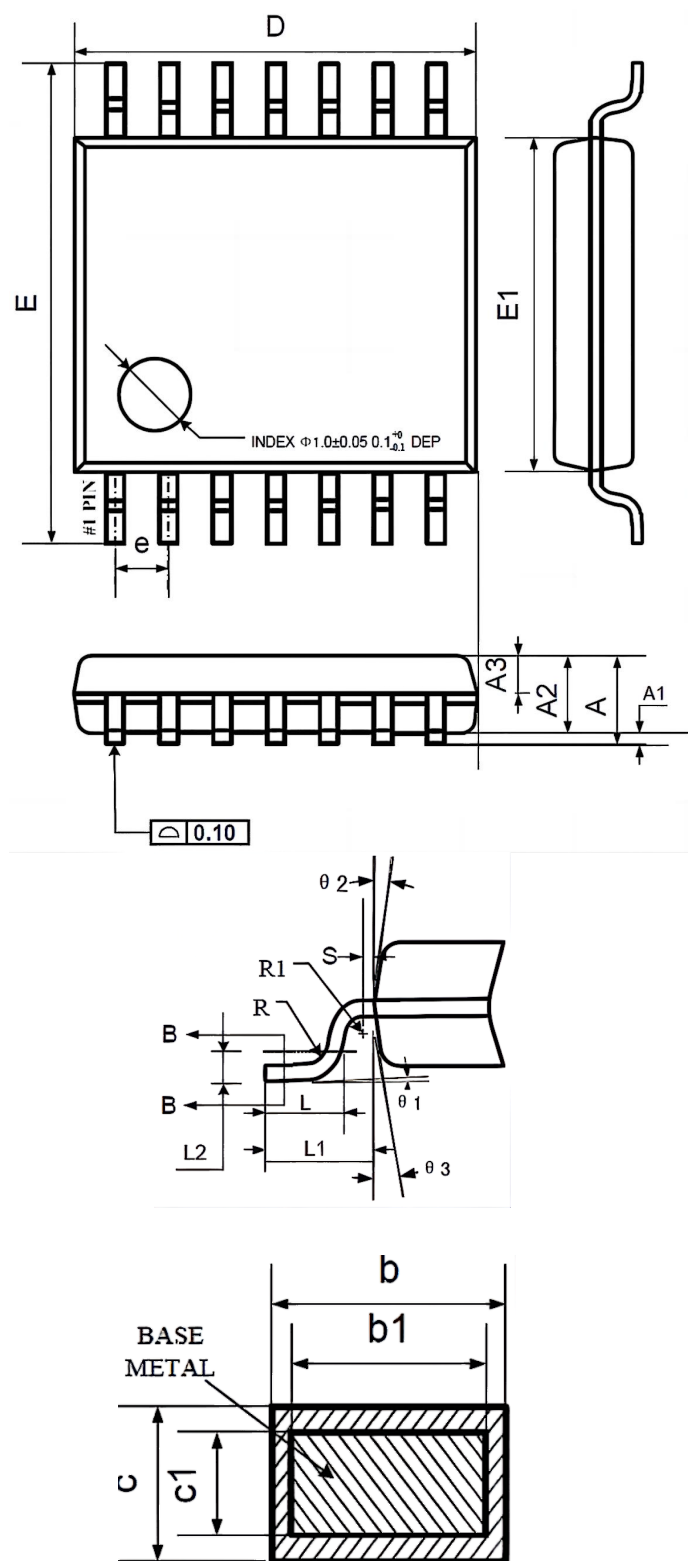
Order Number	Package	Package Quantity	Marking On The park
LM224DR2G-TUDI	SOP14	Tape,Reel,2500	LM224DG
LM224DTBR2G-TUDI	TSSOP14	Tape,Reel,2500	224
LM224NG-TUDI	DIP14	Tube,25,A box of 1000	LM224N
LM324DR2G-TUDI	SOP14	Tape,Reel,2500	LM324DG
LM324EDR2G-TUDI	SOP14	Tape,Reel,2500	LM324EDG
LM324DTBR2G-TUDI	TSSOP14	Tape,Reel,2500	324
LM324NG-TUDI	DIP14	Tube,25,A box of 1000	LM324N
LM324ADR2G-TUDI	SOP14	Tape,Reel,2500	LM324ADG
LM324ADTBR2G-TUDI	TSSOP14	Tape,Reel,2500	324A
LM324ANG-TUDI	DIP14	Tube,25,A box of 1000	LM324AN
LM2902DR2G-TUDI	SOP14	Tape,Reel,2500	LM2902DG
LM2902EDR2G-TUDI	SOP14	Tape,Reel,2500	LM2902EDG
LM2902DTBR2G-TUDI	TSSOP14	Tape,Reel,2500	2902
LM2902NG-TUDI	DIP14	Tube,25,A box of 1000	LM2902N
LM2902VDR2G-TUDI	SOP14	Tape,Reel,2500	LM2902VDG
LM2902VDTBR2G-TUDI	TSSOP14	Tape,Reel,2500	2902V
LM2902VNG-TUDI	DIP14	Tube,25,A box of 1000	LM2902VN
NCV2902DR2G-TUDI	SOP14	Tape,Reel,2500	NCV2902DG
NCV2902DTBR2G-TUDI	TSSOP14	Tape,Reel,2500	2902V

Package SOP14



Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	1.35	1.60	1.75
A1	0.10	0.15	0.25
A2	1.25	1.45	1.65
A3	0.55	0.65	0.75
b	0.36		0.49
b1	0.35	0.40	0.45
C	0.16		0.25
c1	0.15	0.20	0.25
D	8.53	8.63	8.73
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.27 BSC		
L	0.45	0.60	0.80
L1	1.04 REF		
L2	0.25 BSC		
R	0.07		
R1	0.07		
h	0.30	0.40	0.50
θ	0°		8°
θ1	6°	8°	10°
θ2	6°	8°	10°
θ3	5°	7°	9°
θ4	5°	7°	9°

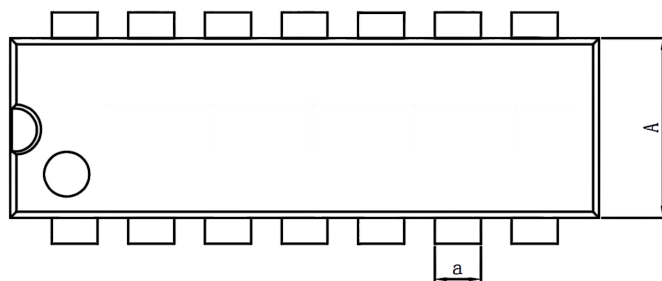
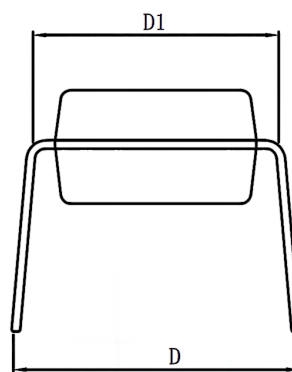
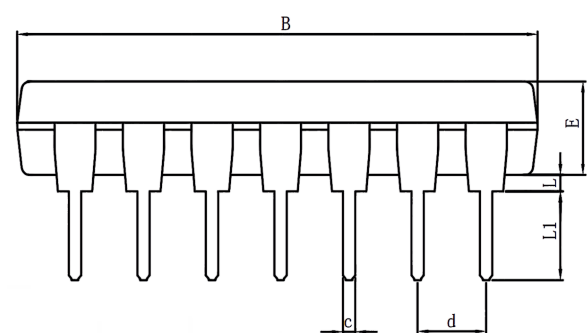
Package TSSOP14



Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	—	—	1.20
A1	0.05	—	0.15
A2	0.90	1.00	1.05
A3	0.34	0.44	0.54
b	0.20	—	0.28
b1	0.20	0.22	0.24
C	0.10	—	0.19
c1	0.10	0.13	0.15
D	4.86	4.96	5.06
E	6.20	6.40	6.60
E1	4.30	4.40	4.50
e	0.65 BSC		
L	0.45	0.60	0.75
L1	1.00 REF		
L2	0.25 BSC		
R	0.09	—	—
R1	0.09	—	—
S	0.20	—	—
$\theta 1$	0°	—	8°
$\theta 2$	10°	12°	14°
$\theta 3$	10°	12°	14°



Package DIP14



DIM.	MIN	TYP	MAX	DIM.	MIN	TYP	MAX
A	6.100	6.300	6.680	a	1.504	1.524	1.544
B	18.940	19.200	19.560	C	0.437	0.457	0.477
D	8.200	8.700	9.200	d	2.530	2.540	2.550
D1	7.42	7.62	7.82	L	0.500	—	0.800
E	3.100	3.300	3.550	L1	3.000	3.200	3.600



Important statement:

- TUDI Semiconductor reserves the right to modify the product manual without prior notice! Before placing an order, customers need to confirm whether the obtained information is the latest version and verify the completeness of the relevant information.
- Any semi-guide product is subject to failure or malfunction under specified conditions. It is the buyer's responsibility to comply with safety standards when using TUDI Semiconductor products for system design and whole machine manufacturing. And take the appropriate safety measures to avoid the potential in the risk of loss of personal injury or loss of property situation!
- TUDI Semiconductor products have not been licensed for life support, military, and aerospace applications, and therefore TUDI Semiconductor is not responsible for any consequences arising from the use of this product in these areas.
- If any or all TUDI Semiconductor products (including technical data, services) described or contained in this document are subject to any applicable local export control laws and regulations, they may not be exported without an export license from the relevant authorities in accordance with such laws.
- The specifications of any and all TUDI Semiconductor products described or contained in this document specify the performance, characteristics, and functionality of said products in their standalone state, but do not guarantee the performance, characteristics, and functionality of said products installed in Customer's products or equipment. In order to verify symptoms and conditions that cannot be evaluated in a standalone device, the Customer should ultimately evaluate and test the device installed in the Customer's product device.
- TUDI Semiconductor documentation is only allowed to be copied without any alteration of the content and with the relevant authorization. TUDI Semiconductor assumes no responsibility or liability for altered documents.
- TUDI Semiconductor is committed to becoming the preferred semiconductor brand for customers, and TUDI Semiconductor will strive to provide customers with better performance and better quality products.