SiGe microwave cryogenic low noise amplifier design YSG1

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1. Introduction

YSG series 1 are 0.1 – 1.1 GHz low noise cryogenic amplifiers designed and built at the *Observatorio de Yebes* for the Purple Mountain Observatory SIS receivers. They are based on the wider band design YSG 0. A short description of YSG0 LNA is included in Appendix I.

2. Amplifier development

The main specifications of the amplifier were:

- Frequency band: 0.1 - 1.1 GHz
- Input/Output Reflection: < - 15 dB
- Average gain: > 35 dB
- Average noise temperature: Best effort

2.1 Prototype modification

The first stage of the new amplifier development was to modify the existing YSG0 design to meet the specifications, with especial attention to the lower end of the frequency band. These modifications, which included new components and changes in some component values changes, were modelled with ADS and tested in two existing YSG0 prototypes. One of these prototypes was further modified to have and independent bias voltage for each stage. This simplifies the interpretation of results and allows more flexibility in the optimization. The different modifications and test results are mentioned bellow.

Inter-stage coupling capacitor

Different capacitor values have been tested in order to improve the performance in the 0.1-1.1 GHz band. The noise and gain measurements are shown in Figure 2, where it can be seen that a higher capacitance improves the behaviour at low frequencies.

The value of the interstage capacitor finally used was 22 pF.

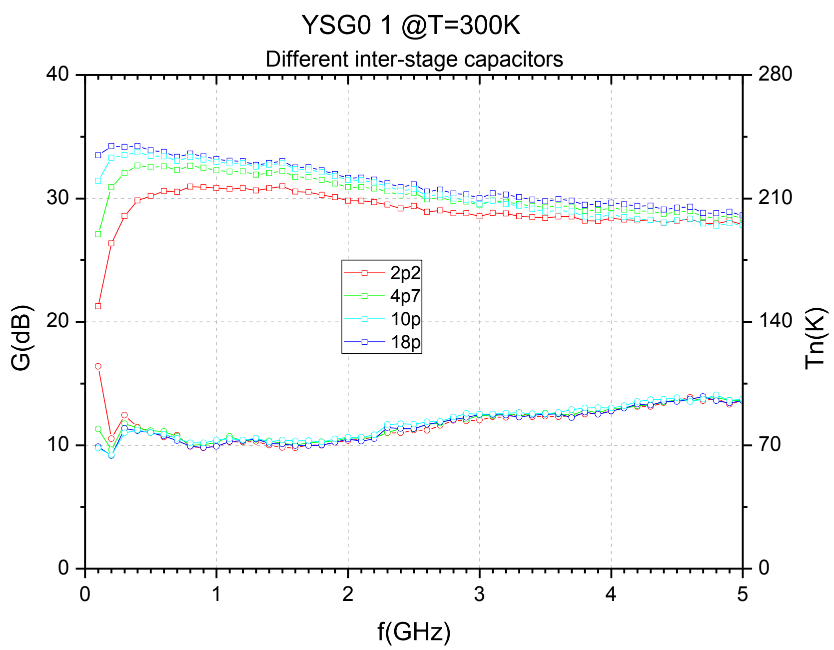


Figure 1: Noise Figure Meter measurements with different inter-stage capacitors

First stage collector inductor and output resistor

In order to improve the reflection in the band, some changes were performed. The combined results are shown in figure 2:

- The input reflection decreased changing the first stage collector SMD inductor of 3 nH by a 100 nH inductance made with AWG 36 gold plated wire (14 turns of 1 mm in diameter, 2 mm long). This inductance was changed later by a SMD inductor of 100 nH (0603), more repetitive and easier to mount.
- The output resistor of 51 Ω was also changed by a 10 Ω one, achieving a better output and also input reflection.

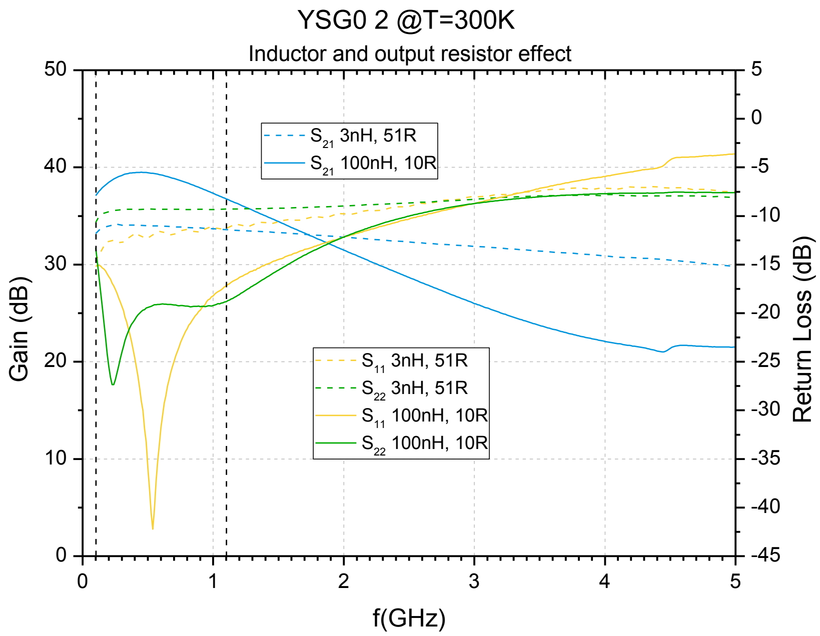


Figure 2: Inductor and output resistor effect

One side-effect of these changes was the non unconditional stability of the amplifier: the Rollet factor was lower than 1 at 8 GHz at cryogenic temperature.

RC circuit and ferrite toroid

In order to solve the stability problem an RC circuit from the second stage collector to ground was added. The values calculated with ADS, were 20 Ω for the resistor (the available value used was 22.6 Ω) and 1 pF for the capacitor.

Although a decrease of gain at high frequencies was achieved, the Rollet factor did not improve as expected at 8 GHz with the RC circuit (see figure 3).

An alternative solution to improve the stability was to mount a ferrite toroid around a wire between the first stage collector and the inter-stage capacitor. A reduction of both reflections and gain was achieved and therefore, an improvement of the Rollet factor. Several tests with different positions and orientations of the toroid, different toroid sizes and materials and different lengths, number of turns and types of wire were performed. It was found that the better option was a toroid as described in figure 4 crossed by 1 turn of enameled wire. The result of the improvement is shown in figure 5.

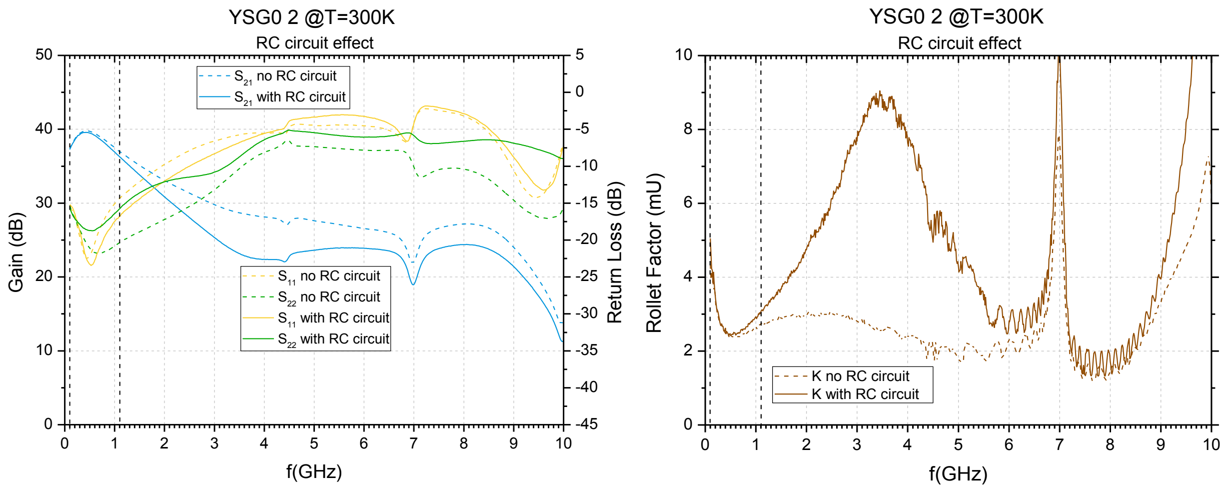


Figure 3: RC circuit at output effect. Note that despite the unconditional stability at room temperature, the Rollet factor always decreases upon cooling and it was lower than 1 at 8 GHz at cryogenic temperature.

Micrometals toroid	T-10-1
Inner diameter	1.12 mm
Outer diameter	2.46 mm
Height	0.76 mm
Nominal Inductance	3.2 nH/N^2

Figure 4: Photograph and characteristics of the mounted toroid

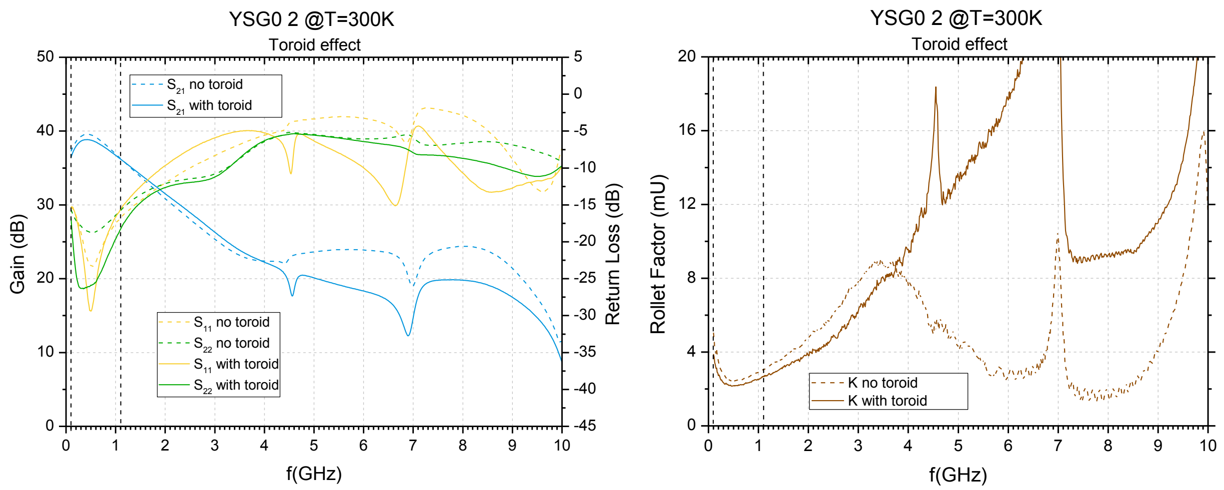


Figure 5: Toroid effect. Only results with the toroid and wire finally used are shown

Transistor

Different models of commercially available packaged NPN SiGe transistors with good noise performance were tested in the first stage of one prototype to compare their cryogenic noise temperature. The tested transistors were BFU725 from NXP and BFP720 and BFP840ESD from Infineon. Infineon transistors have lower power consumption than NXP. BFP840ESD has an ESD protection circuit. The results are shown in figure 6. BFP720 transistor was probably oscillating, as it had a positive input reflection coefficient at 11 GHz and the noise temperature was abnormally high. The best results were obtained with the transistor of the original design (NXP BFU725F/N1), which was chosen for the final version.

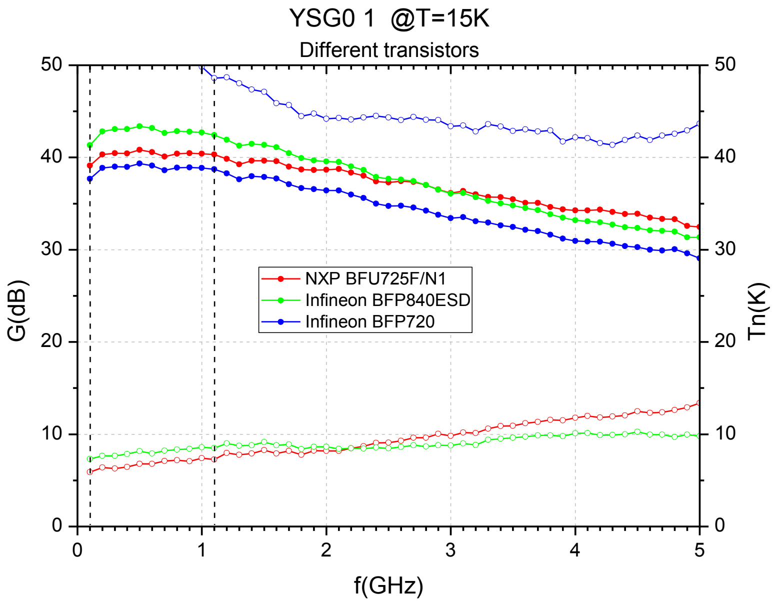


Figure 6: Transistor comparison

Other modifications

Other minor changes carried out with respect to YSG0 were:

- The base resistor of both stages was changed from 1.5 kΩ to 1kΩ in order to improve slightly the input and output reflection
- A slight improvement of the stability was achieved removing the 2.2 pF capacitor at the output

Figure 7 shows the final schematic of the amplifier.

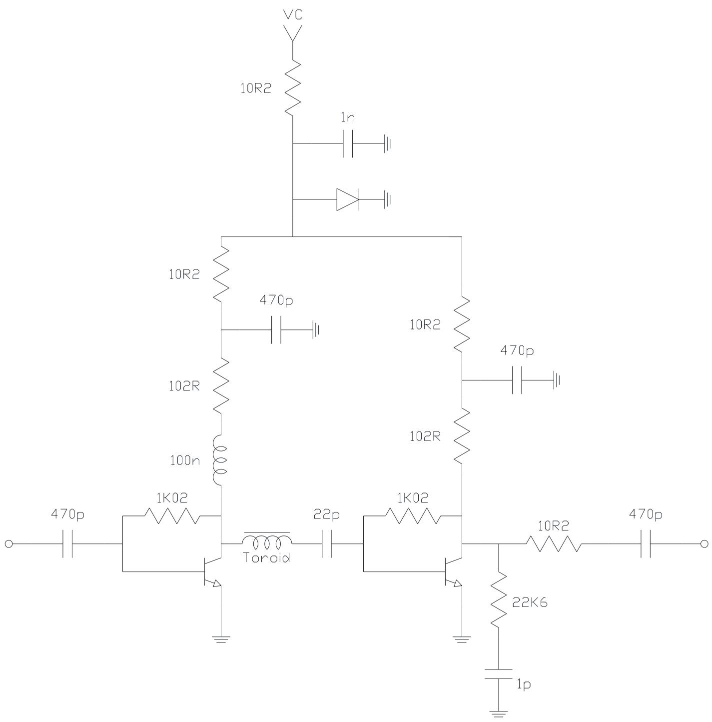


Figure 7: YSG1 amplifier final schematic

2.2 Chassis and substrate design

The design of the substrate has been made trying to keep it as compact as possible while observing the necessary restrictions for its assembly. It has been fabricated in a Rogers RT Duroid 6002 with a thickness of 5 mils.

The modifications with respect to YSG0 are listed below:

- Bigger coil in the first stage (from 0402 to 0603)
- Recess in the substrate to insert the ferrite toroid
- RC circuit at the second stage collector
- Transistors in orthogonal orientation

The amplifier chassis is made of gold plated aluminum.

The DC bias connector is a 2-pin PCB socket connector with 2 mm pitch from Preci-Dip (Ref. 830-80-002-40-001101). After some tests to optimize the bias of each stage independently in the prototype, and in view of the little improvement obtained, it was decided to maintain only one bias voltage for both stages.

Input and output RF ports are SMA female connectors from Radial (Ref. R125-460-000).

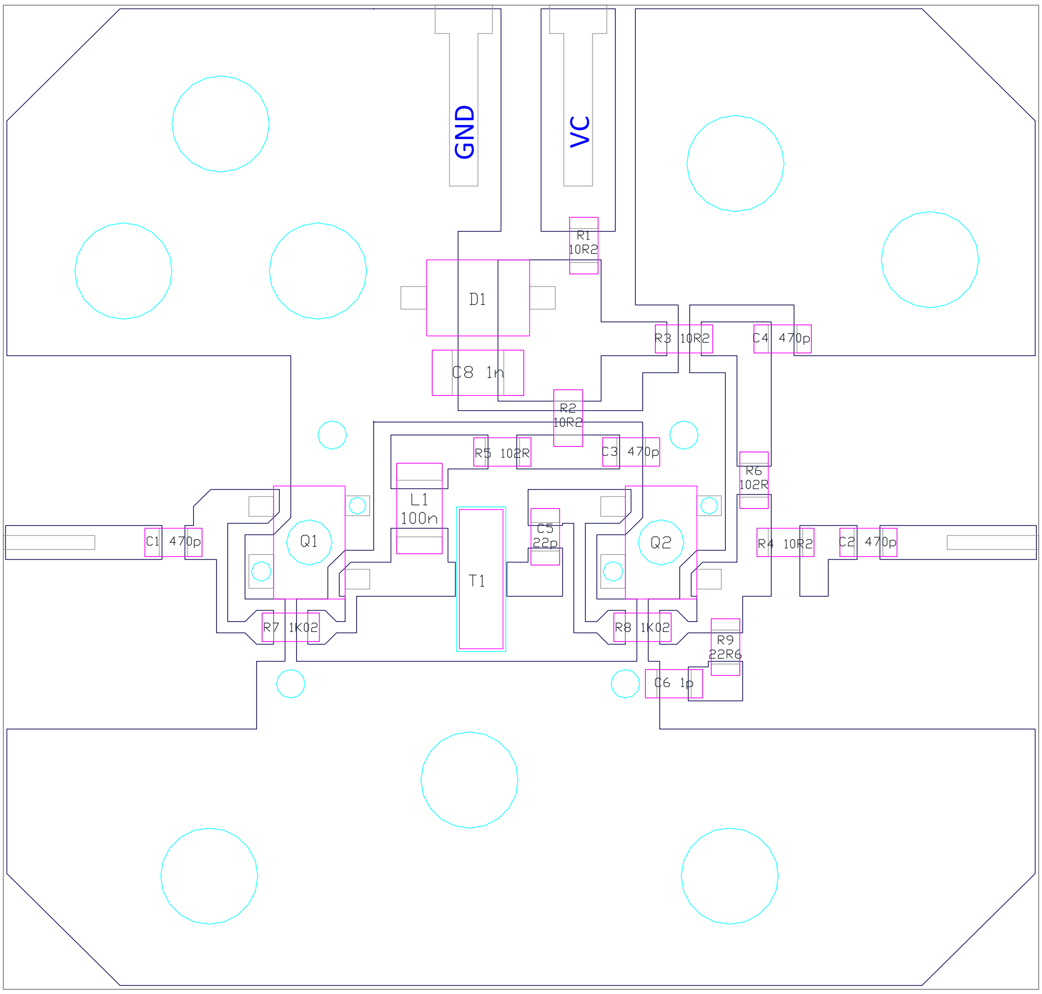
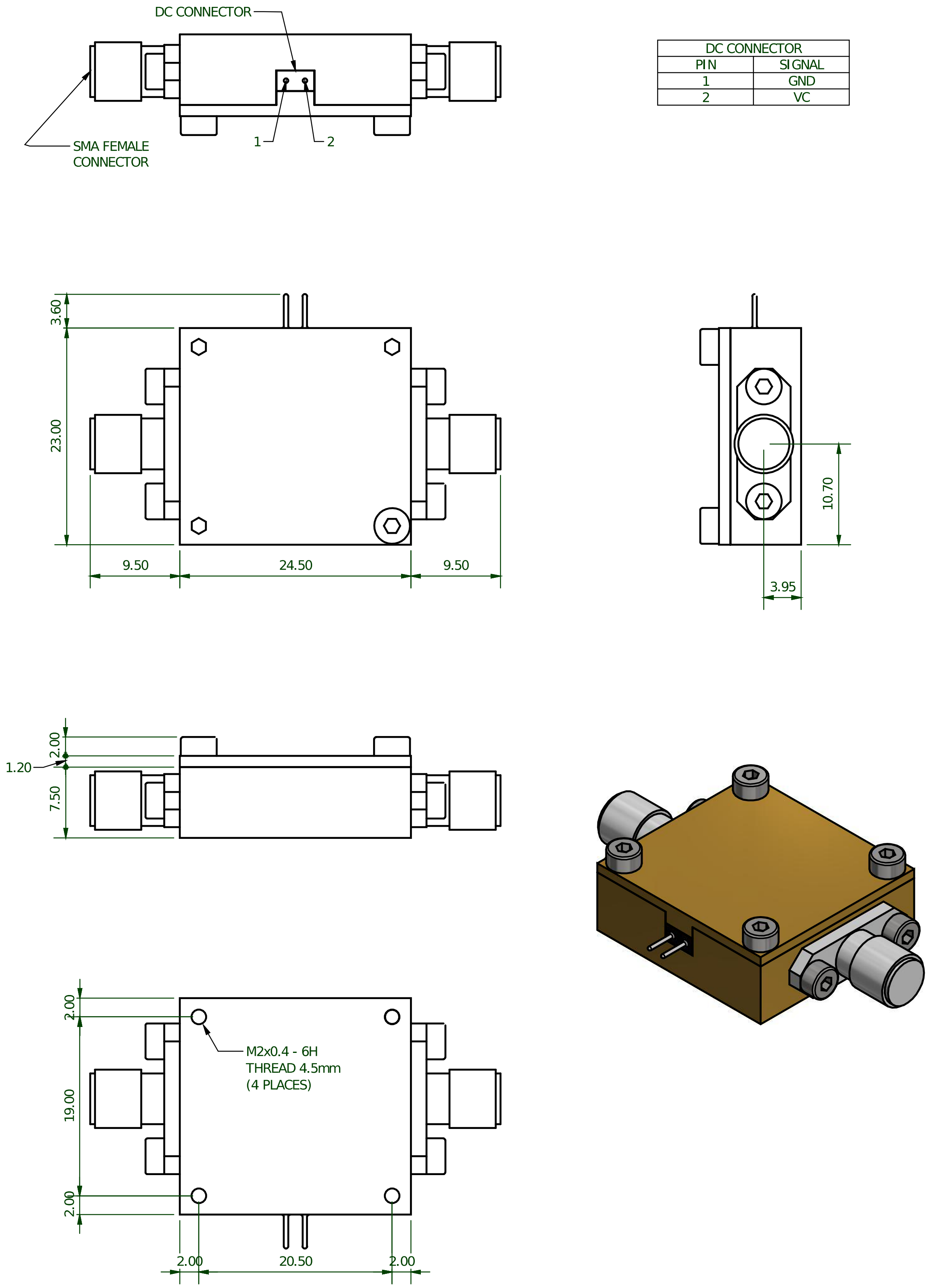


Figure 8: YSG1 amplifier substrate

COMPONENTES			
CODE	VALUE	MNFR	P/N
R1-R4	10.2	TE CONNECTIVITY	CPF0402B10R2E1
R5-R6	102	TE CONNECTIVITY	CPF0402B102RE1
R7-R8	1K02	TE CONNECTIVITY	CPF0402B1K02E1
R9	22.6	TE CONNECTIVITY	CPF0402B22R6E1
C1-C4	470p	AVX	04025A471JAT2A
C5	22p	AVX	04025A220JAT2A
C6	1p	AVX	04025U1R0BAT2A
C7	2p2	AVX	04023J2R2BBSTR
C8	1n	AVX	06035A102JAT2A
L1	100n	MURATA	LPW18ANR10J00D
Q1-Q2		NXP	BFU725F/N1 (2014)
D1		NEXPERIA	BZX384-C5V1
T1		MICROMETALS	T10-1

Figure 9: List of components of YSG1 amplifier



DC CONNECTOR	
PIN	SIGNAL
1	GND
2	VC

Figure 10: YSG1 mechanical and electrical interface, external dimensions and DC connector pin-out

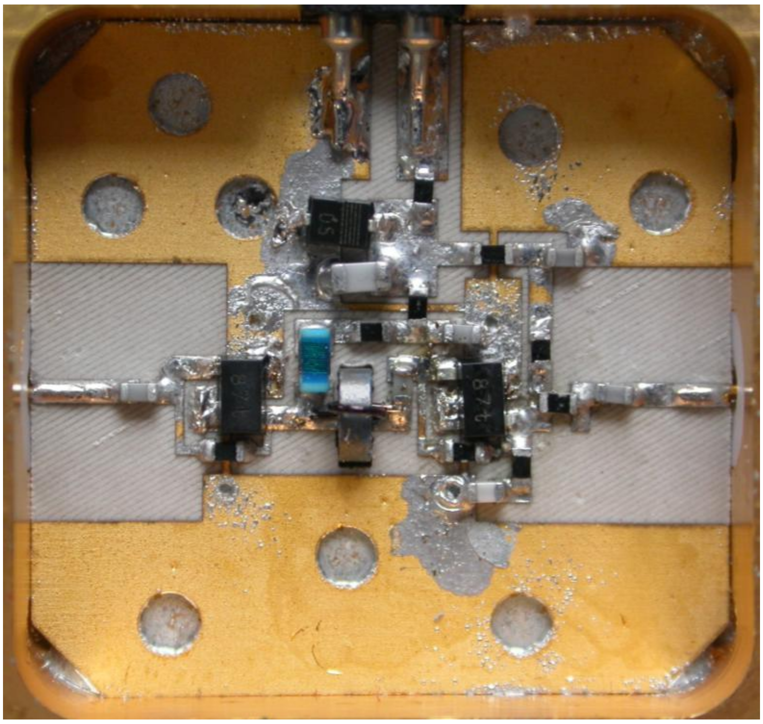


Figure 11: Internal view of YSG 1002 amplifier

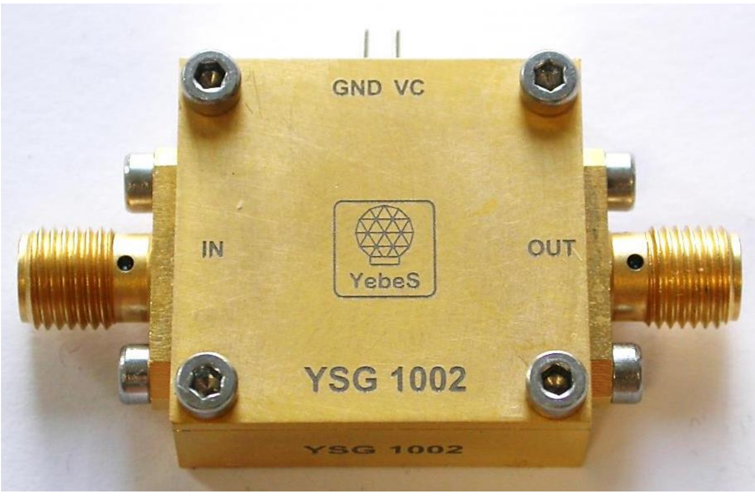


Figure 12: External view of YSG 1002 amplifier

3. Measurements

Noise temperature (and gain) was measured with a system based on a computer controlled Agilent N8975A Noise Figure Meter described in detail in [1], [2]. Room temperature data were obtained with an Agilent N4000A noise diode. The DUT is cooled in a Dewar with a CTI 1020 refrigerator. Cryogenic measurements were taken with the "cold attenuator" method, using an Agilent N4002A noise diode (at room temperature) plus a 15 dB attenuator and a Heat-Block device cooled at cryogenic temperature. Temperature is carefully monitored in the attenuator body using a Lake Shore sensor diode. An absolute accuracy (@ 2 σ) of 14 K at T_{amb}=297 K and 1.7 K at T_{amb}=14 K can be estimated with methods presented in [3]. Repeatability is better than these values by an order of magnitude.

S parameters were measured in the same Dewar with an Agilent E8364B Vector Network Analyzer from 0.1 to 20.1 GHz. A detailed description of the measurement procedure used at cryogenic temperature can be found in [1], [2]. The amplifier output is connected to one of the stainless steel Dewar transitions and its input to the other through a semi-flexible Cu cable. A full two port calibration is done at room temperature with the electronic calibration kit Agilent N4693-60001 inside the Dewar in place of the amplifier, with the same semi-flexible cable. The stainless steel lines are supposed to be invariant with temperature. The Cu cable is measured at cryogenic temperature independently and its loss is taken into account to correct S11 and S21. Time domain gating is used to correct for the residual reflection changes in the lines.

Additional measurements to ensure the absence of oscillations were performed at room and cryogenic temperatures.

4. Results

Four amplifiers were assembled and tested with similar results. The data of them is presented in figures 13, 14 and 15. Table 1 shows a summary of the measurements at cryogenic temperature. The datasheets of the three amplifiers sent to Purple Mountain Observatory are presented in [4].

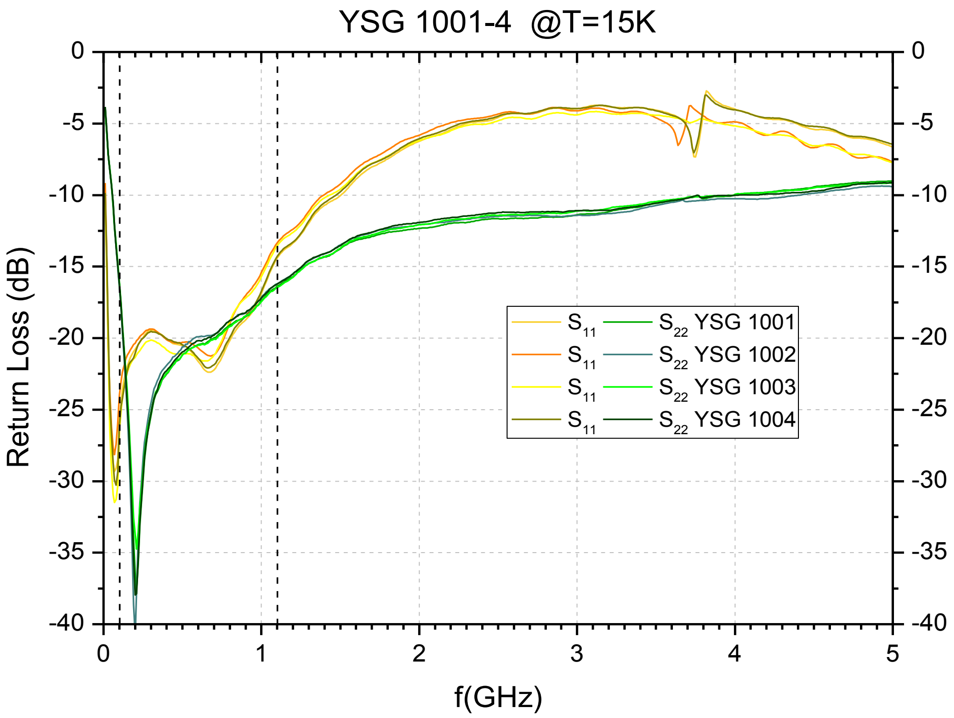


Figure 13: Measurement of return loss of YSG amplifiers at cryogenic temperature

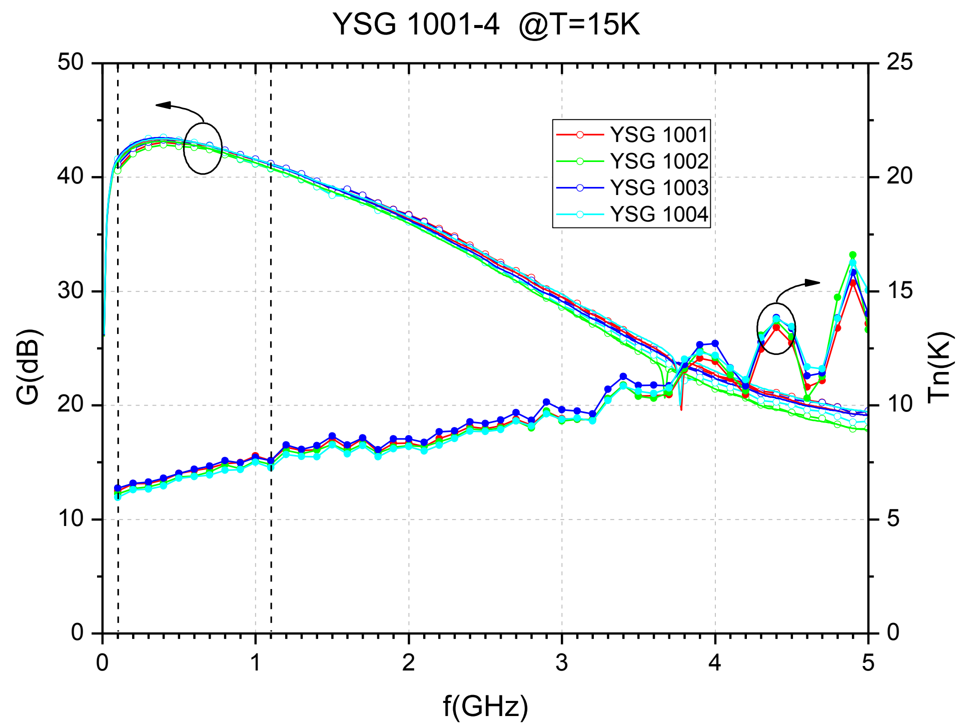


Figure 14: Measurement of gain and noise temperature of YSG amplifiers at cryogenic temperature

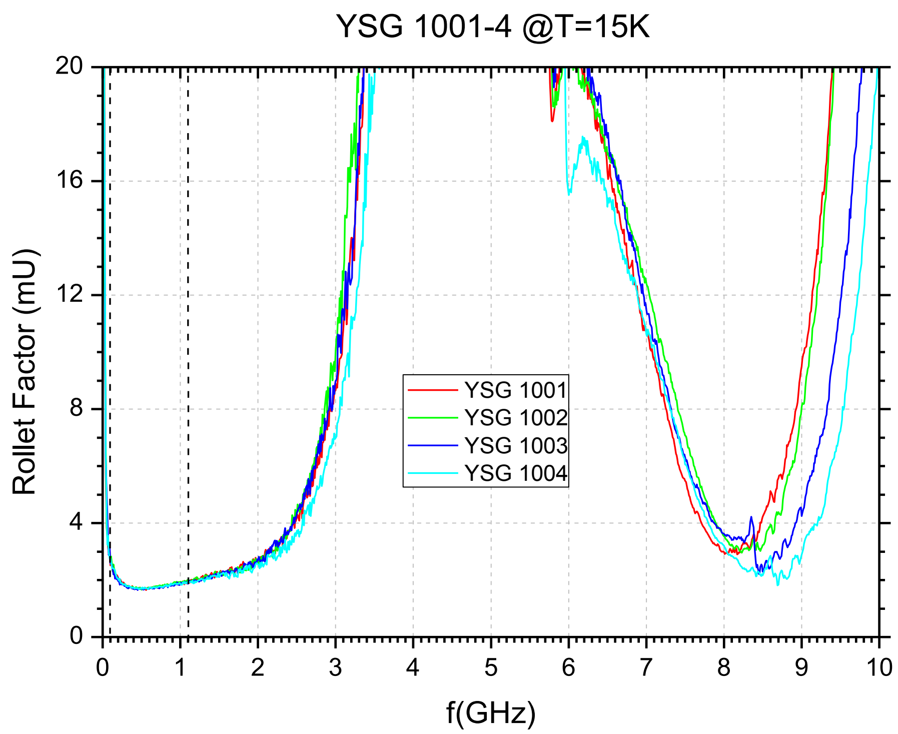


Figure 15: Measurement of Rollet factor of YSG amplifiers at cryogenic temperature

YSG1 0.1-1-1 GHz amplifiers @ 15 K						
Amplifier ID	$T_{n\ mean}$ (K)	$T_{n\ min}$ (K)	$G_{mean}/\Delta G$ (dB)	$S11_{max}$ (dB)	$S22_{max}$ (dB)	K_{min}
YSG 1001	7.1	6.2	42.6/2.23	-14.4	-16.2	1.65
YSG 1002	6.9	6.1	42.3/2.35	-13.4	-16.2	1.68
YSG 1003	7.1	6.4	42.6/2.38	-13.6	-16.1	1.65
YSG 1004	6.8	6	42.6/2.24	-14.3	-16.2	1.68

Table 1: Summary of measurements of YSG1 amplifiers at cryogenic temperature

Appendix I: YSG0 LNA design

This LNA is based on a Caltech design (S. Weinreb, 2008) [5]. It has two stages of SiGe HBT transistors (model NXP BFU725F/N1) that work in a common emitter configuration. Only one bias voltage is required to bias the amplifier, as seen in Figure 16.

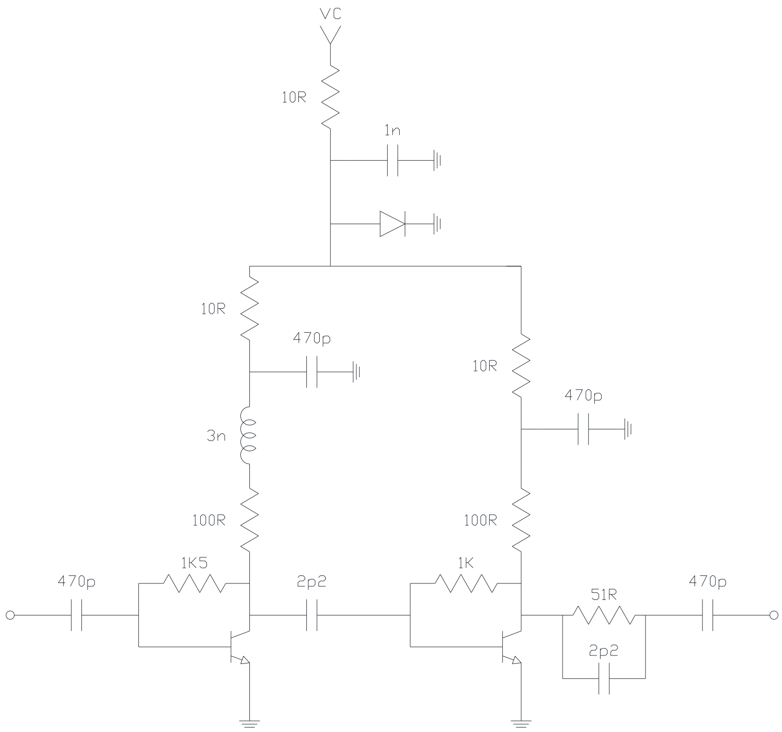


Figure 16: YSG0 amplifier schematic

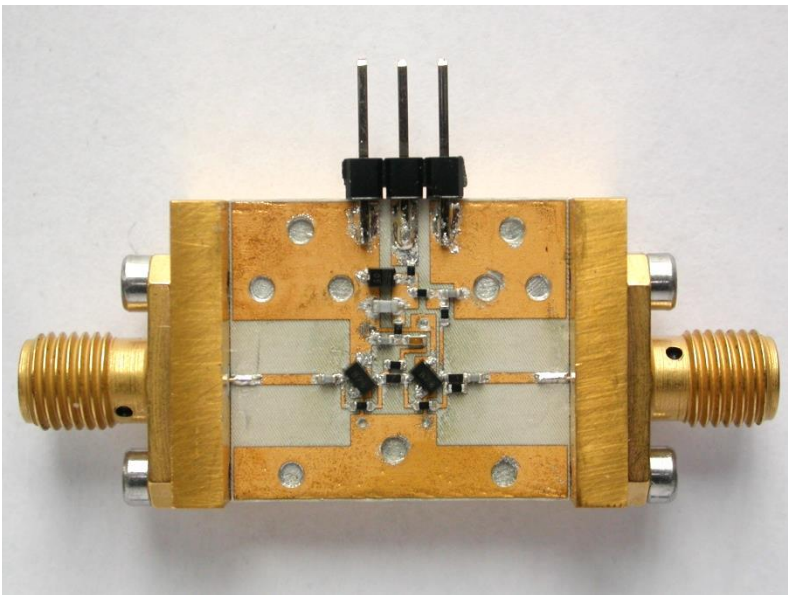


Figure 17: External view of an YSG0 LNA

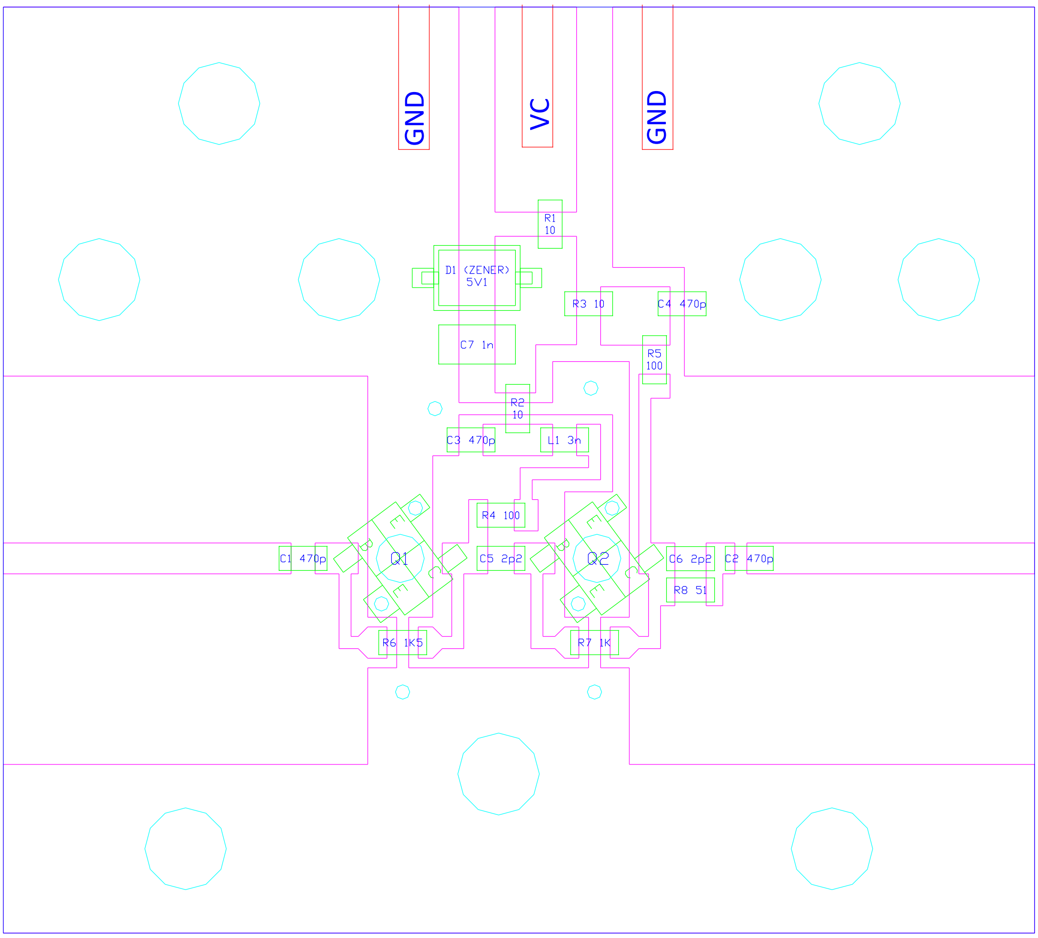


Figure 18: YSG0 amplifier substrate

COMPONENTES			
CODE	VALUE	MNFR	P/N
R1-R3	10	VISHAY	CRCW040210R0FKED
R4-R5	100	VISHAY	CRCW0402100RFKED
R6	1K5	VISHAY	CRCW04021K50FKED
R7	1K	VISHAY	CRCW04021K00FKED
R8	51	VISHAY	CRCW040251R0FKED
C1-C4	470p	AVX	04025A471JAT2A
C5-C6	2p2	AVX	04023J2R2BBSTR
C7	1n	AVX	06035A102JAT2A
L1	3n	MURATA	LQP15MN3N0W02D
Q1-Q2		NXP	BFU725F/N1 (2014)
D1		NEXPERIA	BZX384-C5V1

Figure 19: List of components of YSG0 amplifier

Noise and gain results of YSG0 design at cryogenic temperature for two different frequency bands are presented in Figure 20.

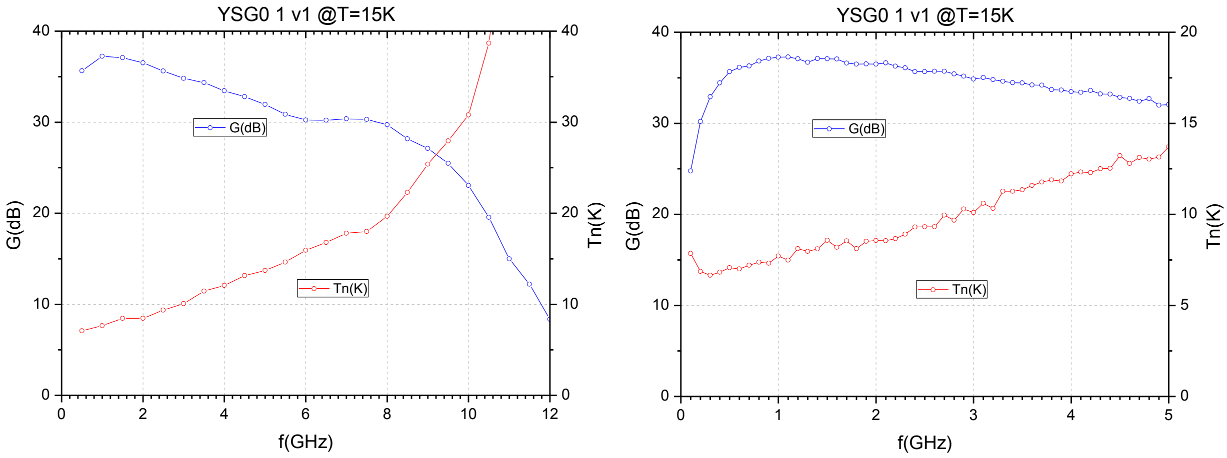


Figure 20: Noise and gain measurement of a YSG0 LNA at 15 K

Appendix II: Datasheets

Type CPF Series

Key Features

Thin film precision resistors with TC's to 15ppm and tolerances to 0.05%.

Wide range of case sizes from 0201 to 2512

Suitable for all applications where close accuracy and stability are essential

Terminal finish – electroplated 100% matte Sn

Applications

Communications

Industrial Controls

Instrumentation

Medical

The CPF series is a high stability precision chip resistor range offering various power dissipations relating to a wide range of chip sizes. The CPF series offers TCR's down to 15ppm/°C and resistance tolerances to 0.1%. Standard values are within the IEC 63 E96 and E24 value grids. The CPF has accurate and uniform physical dimensions to facilitate placement

Electrical Characteristics

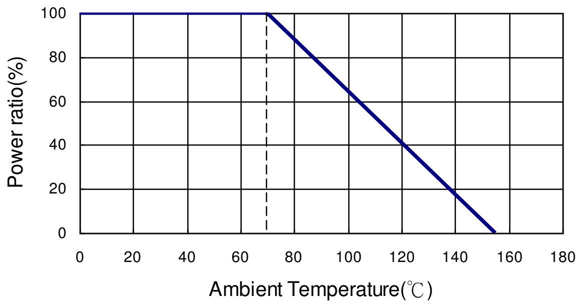
Chip Size		0201			
Rated Power @70°C		0.03125W			
Resistance Range Ω	Min.	49R9	49R9	49R9	49R9
	Max	4K99	33K	4K99	33K
Tolerance		0.5		1	
Code Letter		D		F	
Selection series		E24 & E96			
Temp. Coefficient (ppm/°C)		25	50	25	50
Code Letter		E	C	E	C
Operating Voltage (Max)		15V			
Max. Overload Voltage		30V			
Operating Temp. Range		-55 ~ +155°C			
Insulation Resistance dry min.		>1000MΩ			
Stability		0.5%			

Chip Size		0402											
Rated Power @70°C		0.063W											
Resistance Range Ω	Min.	49R9			49R9	10R		49R9	4R7		49R9	4R7	
	Max	20K			69K8	255K		69K8	511K		69K8	511K	
Tolerance (%)		0.05			0.1			0.5			1		
Code Letter		A			B			D			F		
Selection series		E24 & E96											
T.C.R. (ppm/°C)		15	25	50	15	25	50	15	25	50	15	25	50
Code Letter		D	E	C	D	E	C	D	E	C	D	E	C
Max Operating Volt.		25V											
Max. Overload Volt.		50V											
Op. Temp. Range		-55 ~ +155°C											
Insulation Resistance		>1000MΩ											
Stability		0.5%											

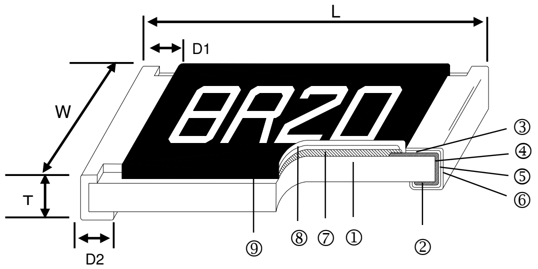
Chip Size		0603											
Rated Power @70°C		0.063W											
Resistance Range Ω	Min.	4R7			4R7	4R7		4R7	1R0		4R7	1R0	
	Max	332K			511K	1M0		511K	1M0		511K	1M0	
Tolerance (%)		0.05			0.1			0.5			1		
Code Letter		A			B			D			F		
Selection series		E24 & E96											
T.C.R. (ppm/°C)		15	25	50	15	25	50	15	25	50	15	25	50
Code Letter		D	E	C	D	E	C	D	E	C	D	E	C
Max Operating Volt.		50V											
Max. Overload Volt.		100V											
Op. Temp. Range		-55 ~ +155°C											
Insulation Resistance		>1000MΩ											
Stability		0.5%											

Chip Size		0805											
Rated Power @70°C		0.1W											
Resistance Range Ω	Min.	4R7			4R7	4R7		4R7	1R0		4R7	1R0	
	Max	1M0			1M0	2M0		1M0	2M0		1M0	2M0	
Tolerance (%)		0.05			0.1			0.5			1		
Code Letter		A			B			D			F		
Selection series		E24 & E96											
T.C.R. (ppm/°C)		15	25	50	15	25	50	15	25	50	15	25	50
Code Letter		D	E	C	D	E	C	D	E	C	D	E	C
Max Operating Volt.		100V											
Max. Overload Volt.		200V											
Op. Temp. Range		-55 ~ +155°C											
Insulation Resistance		>1000MΩ											
Stability		0.5%											

Derating Curve

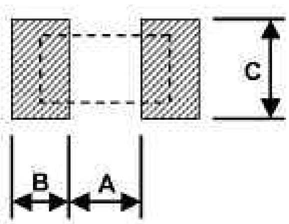


Construction and dimensions



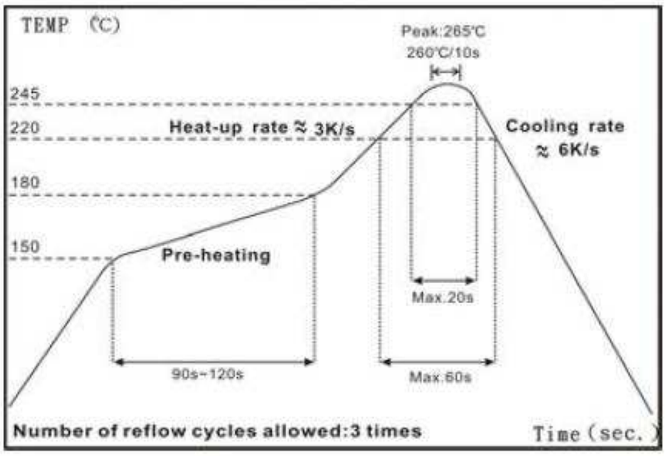
①	Alumina Substrate	④	Edge Electrode (NiCr)	⑦	Resistor Layer (NiCr)
②	Bottom Electrode (Ag)	⑤	Barrier Layer (Ni)	⑧	Overcoat (Epoxy)
③	Top Electrode (Ag)	⑥	External Electrode (Sn)	⑨	Marking

Size	L (mm)	W (mm)	T (mm)	D1 (mm)	D2 (mm)	Weight (g) (1000 Pcs.)
0201	0.58±0.05	0.29±0.05	0.23±0.05	0.12±0.05	0.15±0.05	0.14
0402	1.00±0.05	0.50±0.05	0.30±0.05	0.20±0.10	0.20±0.10	0.54
0603	1.55±0.10	0.80±0.10	0.45±0.10	0.30±0.20	0.30±0.20	1.83
0805	2.00±0.15	1.25±0.15	0.55±0.10	0.30±0.20	0.40±0.20	4.71
1206	3.05±0.15	1.55±0.15	0.55±0.10	0.42±0.20	0.35±0.25	9.02
1210	3.10±0.15	2.40±0.15	0.55±0.10	0.40±0.20	0.55±0.25	10
2010	4.90±0.15	2.40±0.15	0.55±0.10	0.60±0.30	0.50±0.25	23.61
2512	6.30±0.15	3.10±0.15	0.55±0.10	0.60±0.30	0.50±0.25	38.06



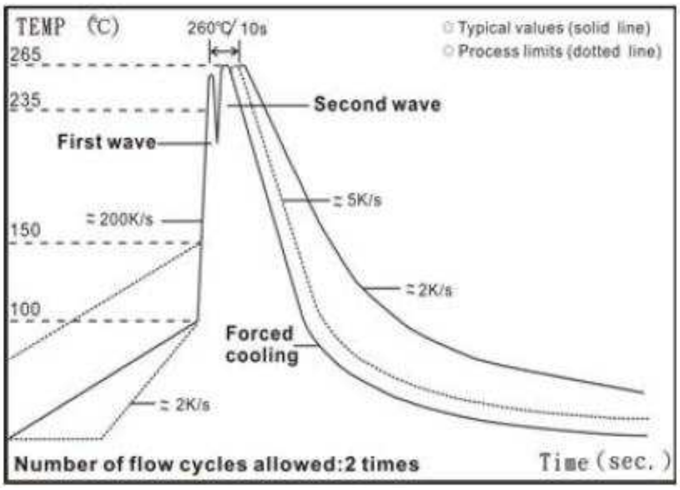
Recommended Land Pattern			
Size	A	B	C
0201	0.25	0.30	0.40±0.2
0402	0.50	0.50	0.60±0.2
0603	0.80	1.00	0.90±0.2
0805	1.00	1.00	1.35±0.2
1206	2.00	1.15	1.70±0.2
1210	2.00	1.15	2.50±0.2
2010	3.60	1.40	2.50±0.2
2512	4.90	1.60	3.10±0.2

Reflow Solder Profile



Time of Reflow soldering at maximum temperature point 260°C = 10s

Wave Solder Profile



Time of Wave soldering at maximum temperature point 260°C = 10s

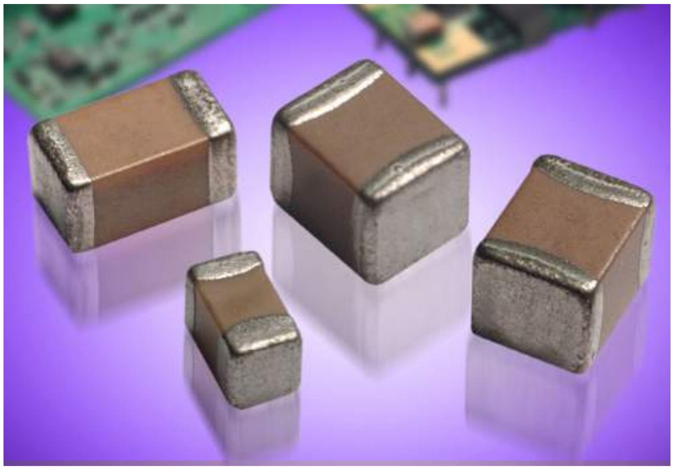
Time of Soldering Iron at maximum temperature point 410°C = 5s

How To Order

CPF	0603	B	100R	E	1
Common Part	**Package Size**	**Tolerance**	**Value**	**TCR**	**Packaging**
CPF - precision thin film chip resistor	0201 1206 0402 1210 0603 2010 0805 2512	B - ±0.1% D - ±0.5% F - ±1%	100R - 100Ω 1K0 - 1000Ω 10K – 10,000Ω	D – 15PPM E - 25PPM C - 50PPM	1 – 1K REEL Blank – standard reel 0201 0402 - 10K 0603 0805 1206 1210 – 5K 2010 2512 - 4K

C0G (NP0) Dielectric

General Specifications



C0G (NP0) is the most popular formulation of the "temperature-compensating," EIA Class I ceramic materials. Modern C0G (NP0) formulations contain neodymium, samarium and other rare earth oxides.

C0G (NP0) ceramics offer one of the most stable capacitor dielectrics available. Capacitance change with temperature is 0 ±30ppm/°C which is less than ±0.3% C from -55°C to +125°C. Capacitance drift or hysteresis for C0G (NP0) ceramics is negligible at less than ±0.05% versus up to ±2% for films. Typical capacitance change with life is less than ±0.1% for C0G (NP0), one-fifth that shown by most other dielectrics. C0G (NP0) formulations show no aging characteristics.

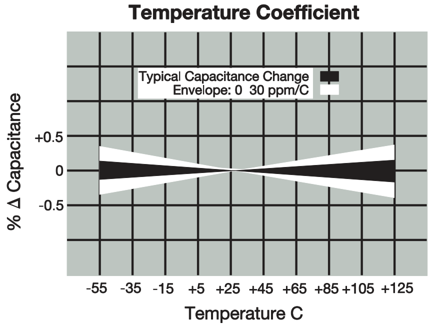
PART NUMBER (see page 2 for complete part number explanation)

RoHS COMPLIANT

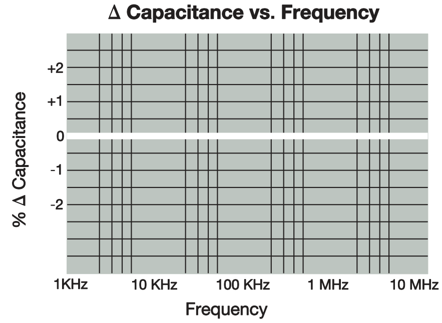
0805	5	A	101	J	A	T	2	A
Size (L" x W")	**Voltage** 6.3V = 6 10V = Z 16V = Y 25V = 3 50V = 5 100V = 1 200V = 2 500V = 7	**Dielectric** C0G (NP0) = A	**Capacitance Code (In pF)** 2 Sig. Digits + Number of Zeros	**Capacitance Tolerance** B = ±.10 pF (<10pF) C = ±.25 pF (<10pF) D = ±.50 pF (<10pF) F = ±1% (≥ 10 pF) G = ±2% (≥ 10 pF) J = ±5% K = ±10%	**Failure Rate** A = Not Applicable	**Terminations** T = Plated Ni and Sn **Contact Factory For 1 = Pd/Ag Term 7 = Gold Plated** **NOT RoHS COMPLIANT**	**Packaging** 2 = 7" Reel 4 = 13" Reel U = 4mm TR (01005) **Contact Factory For Multiples**	**Special Code** A = Std. Product

NOTE: Contact factory for availability of Termination and Tolerance Options for Specific Part Numbers. Contact factory for non-specified capacitance values.

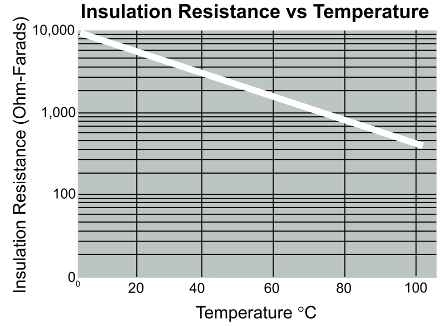
Temperature Coefficient



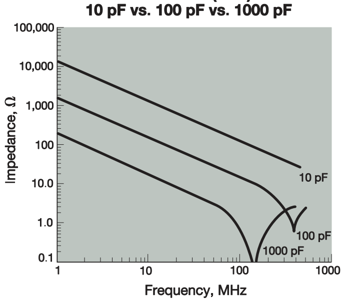
Δ Capacitance vs. Frequency



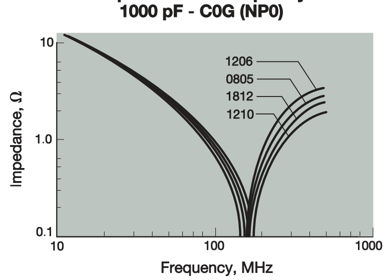
Insulation Resistance vs Temperature



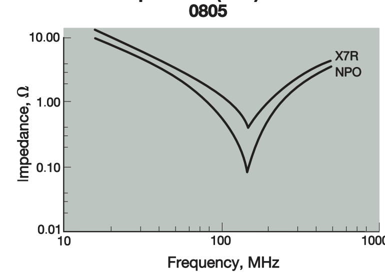
Variation of Impedance with Cap Value Impedance vs. Frequency 0805 - C0G (NP0) 10 pF vs. 100 pF vs. 1000 pF



Variation of Impedance with Chip Size Impedance vs. Frequency 1000 pF - C0G (NP0)

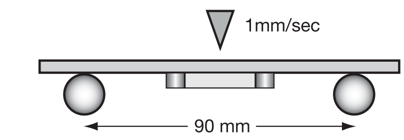


Variation of Impedance with Ceramic Formulation Impedance vs. Frequency 1000 pF - C0G (NP0) vs X7R 0805



C0G (NP0) Dielectric

Specifications and Test Methods

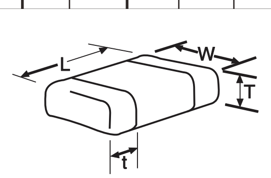
Parameter/Test		NP0 Specification Limits	Measuring Conditions
Operating Temperature Range		-55ºC to +125ºC	Temperature Cycle Chamber
Capacitance		Within specified tolerance	Freq.: 1.0 MHz ± 10% for cap ≤ 1000 pF 1.0 kHz ± 10% for cap > 1000 pF Voltage: 1.0Vrms ± .2V
Q		<30 pF: Q≥ 400+20 x Cap Value ≥30 pF: Q≥ 1000	
Insulation Resistance		100,000MΩ or 1000MΩ - µF, whichever is less	Charge device with rated voltage for 60 ± 5 secs @ room temp/humidity
Dielectric Strength		No breakdown or visual defects	Charge device with 250% of rated voltage for 1-5 seconds, w/charge and discharge current limited to 50 mA (max) Note: Charge device with 150% of rated voltage for 500V devices.
Resistance to Flexure Stresses	Appearance	No defects	Deflection: 2mm Test Time: 30 seconds 
	Capacitance Variation	±5% or ±.5 pF, whichever is greater	
	Q	Meets Initial Values (As Above)	
	Insulation Resistance	≥ Initial Value x 0.3	
Solderability		≥ 95% of each terminal should be covered with fresh solder	Dip device in eutectic solder at 230 ± 5ºC for 5.0 ± 0.5 seconds
Resistance to Solder Heat	Appearance	No defects, <25% leaching of either end terminal	Dip device in eutectic solder at 260ºC for 60seconds. Store at room temperature for 24 ± 2hours before measuring electrical properties.
	Capacitance Variation	≤ ±2.5% or ±.25 pF, whichever is greater	
	Q	Meets Initial Values (As Above)	
	Insulation Resistance	Meets Initial Values (As Above)	
	Dielectric Strength	Meets Initial Values (As Above)	
Thermal Shock	Appearance	No visual defects	Step 1: -55ºC ± 2º — 30 ± 3 minutes
	Capacitance Variation	≤ ±2.5% or ±.25 pF, whichever is greater	Step 2: Room Temp — ≤ 3 minutes
	Q	Meets Initial Values (As Above)	Step 3: +125ºC ± 2º — 30 ± 3 minutes
	Insulation Resistance	Meets Initial Values (As Above)	Step 4: Room Temp — ≤ 3 minutes
	Dielectric Strength	Meets Initial Values (As Above)	Repeat for 5 cycles and measure after 24 hours at room temperature
Load Life	Appearance	No visual defects	Charge device with twice rated voltage in test chamber set at 125ºC ± 2ºC for 1000 hours (+48, -0). Remove from test chamber and stabilize at room temperature for 24 hours before measuring.
	Capacitance Variation	≤ ±3.0% or ± .3 pF, whichever is greater	
	Q (C=Nominal Cap)	≥ 30 pF: Q≥ 350 ≥10 pF, <30 pF: Q≥ 275 +5C/2 <10 pF: Q≥ 200 +10C	
	Insulation Resistance	≥ Initial Value x 0.3 (See Above)	
	Dielectric Strength	Meets Initial Values (As Above)	
Load Humidity	Appearance	No visual defects	Store in a test chamber set at 85ºC ± 2ºC/ 85% ± 5% relative humidity for 1000 hours (+48, -0) with rated voltage applied. Remove from chamber and stabilize at room temperature for 24 ± 2 hours before measuring.
	Capacitance Variation	≤ ±5.0% or ± .5 pF, whichever is greater	
	Q	≥ 30 pF: Q≥ 350 ≥10 pF, <30 pF: Q≥ 275 +5C/2 <10 pF: Q≥ 200 +10C	
	Insulation Resistance	≥ Initial Value x 0.3 (See Above)	
	Dielectric Strength	Meets Initial Values (As Above)	

C0G (NP0) Dielectric

Capacitance Range

PREFERRED SIZES ARE SHADED

SIZE	0101*	0201		0402			0603					0805					1206					
Soldering	Reflow Only	Reflow Only		Reflow/Wave			Reflow/Wave					Reflow/Wave					Reflow/Wave					
Packaging	All Paper	All Paper		All Paper			All Paper					Paper/Embossed					Paper/Embossed					
(L) Length mm (in.)	0.40 ± 0.02 (0.016 ± 0.0008)	0.60 ± 0.09 (0.024 ± 0.004)		1.00 ± 0.10 (0.040 ± 0.004)			1.60 ± 0.15 (0.063 ± 0.006)					2.01 ± 0.20 (0.079 ± 0.008)					3.20 ± 0.20 (0.126 ± 0.008)					
(W) Width mm (in.)	0.20 ± 0.02 (0.008 ± 0.0008)	0.30 ± 0.09 (0.011 ± 0.004)		0.50 ± 0.10 (0.020 ± 0.004)			0.81 ± 0.15 (0.032 ± 0.006)					1.25 ± 0.20 (0.049 ± 0.008)					1.60 ± 0.20 (0.063 ± 0.008)					
(t) Terminal mm (in.)	0.10 ± 0.04 (0.004 ± 0.0016)	0.15 ± 0.05 (0.006 ± 0.002)		0.25 ± 0.15 (0.010 ± 0.006)			0.35 ± 0.15 (0.014 ± 0.006)					0.50 ± 0.25 (0.020 ± 0.010)					0.50 ± 0.25 (0.020 ± 0.010)					
WVDC	16	25	50	16	25	50	16	25	50	100	200	16	25	50	100	200	16	25	50	100	200	500
Cap (pF) 0.5		A	A	C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	J	J
1.0	B	A	A	C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	J	J
1.2	B	A	A	C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	J	J
1.5	B	A	A	C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	J	J
1.8	B	A	A	C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	J	J
2.2	B	A	A	C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	J	J
2.7	B	A	A	C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	J	J
3.3	B	A	A	C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	J	J
3.9	B	A	A	C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	J	J
4.7	B	A	A	C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	J	J
5.6	B	A	A	C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	J	J
6.8	B	A	A	C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	J	J
8.2	B	A	A	C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	J	J
10	B	A	A	C	C	C	G	G	G	G	G	J	J	J	J	J	J	J	J	J	J	J
12	B	A	A	C	C	C	G	G	G	G	G	J	J	J	J	J	J	J	J	J	J	J
15	B	A	A	C	C	C	G	G	G	G	G	J	J	J	J	J	J	J	J	J	J	J
18	B	A	A	C	C	C	G	G	G	G	G	J	J	J	J	J	J	J	J	J	J	J
22	B	A	A	C	C	C	G	G	G	G	G	J	J	J	J	J	J	J	J	J	J	J
27	B	A	A	C	C	C	G	G	G	G	G	J	J	J	J	J	J	J	J	J	J	J
33	B	A	A	C	C	C	G	G	G	G	G	J	J	J	J	J	J	J	J	J	J	J
39	B	A	A	C	C	C	G	G	G	G	G	J	J	J	J	J	J	J	J	J	J	J
47	B	A	A	C	C	C	G	G	G	G	G	J	J	J	J	J	J	J	J	J	J	J
56	B	A	A	C	C	C	G	G	G	G	G	J	J	J	J	J	J	J	J	J	J	J
68	B	A	A	C	C	C	G	G	G	G	G	J	J	J	J	J	J	J	J	J	J	J
82	B	A	A	C	C	C	G	G	G	G	G	J	J	J	J	J	J	J	J	J	J	J
100	B	A	A	C	C	C	G	G	G	G	G	J	J	J	J	J	J	J	J	J	J	J
120				C	C	C	G	G	G	G	G	J	J	J	J	J	J	J	J	J	J	J
150				C	C	C	G	G	G	G	G	J	J	J	J	J	J	J	J	J	J	J
180				C	C	C	G	G	G	G	G	J	J	J	J	J	J	J	J	J	J	J
220				C	C	C	G	G	G	G	G	J	J	J	J	J	J	J	J	J	J	M
270				C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	J	M
330				C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	J	M
390				C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	J	M
470				C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	J	M
560				C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	J	M
680				C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	J	P
820				C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	M	
1000				C	C	C	G	G	G	G		J	J	J	J	J	J	J	J	J	Q	
1200							G	G	G			J	J	J	J		J	J	J	J	Q	
1500							G	G	G			J	J	J	J		J	J	J	M	Q	
1800							G	G	G			J	J	J	N		J	J	M	M	Q	
2200							G	G	G			N	N	N	N		J	J	M	P	Q	
2700							G	G	G			N	N	N	N		J	J	M	P	Q	
3300							G	G	G			P	P	P	N		J	J	M	P	Q	
3900							G	G	G			P	P	P	N		J	J	M	P		
4700							G	G	G			P	P	P	N		J	J	M	P		
5600												P	P	P			J	J	M	P		
6800												P	P	P			M	M	M	P		
8200												P	P	P			M	M	M	P		
Cap (μF) 0.010												P	P	P			P	P	P	P		
0.012																						
0.015																						
0.018																						
0.022																						
0.027																						
0.033																						
0.039																						
0.047																						
0.068																						
0.082																						
0.1																						
WVDC	16	25	50	16	25	50	16	25	50	100	200	16	25	50	100	200	16	25	50	100	200	500
SIZE	0101*	0201		0402			0603					0805					1206					



Letter	A	B	C	E	G	J	K	M	N	P	Q	X	Y	Z
Max. Thickness	0.33 (0.013)	0.22 (0.009)	0.56 (0.022)	0.71 (0.028)	0.90 (0.035)	0.94 (0.037)	1.02 (0.040)	1.27 (0.050)	1.40 (0.055)	1.52 (0.060)	1.78 (0.070)	2.29 (0.090)	2.54 (0.100)	2.79 (0.110)
	PAPER						EMBOSSED							

PAPER and EMBOSSED available for 01005

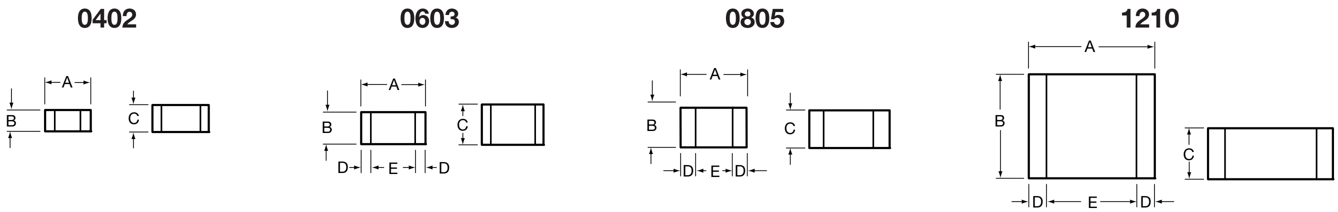
RF/Microwave C0G (NP0) Capacitors (RoHS)

Ultra Low ESR, "U" Series, C0G (NP0) Chip Capacitors

GENERAL INFORMATION

"U" Series capacitors are C0G (NP0) chip capacitors specially designed for "Ultra" low ESR for applications in the communications market. Max ESR and effective capacitance are met on each value producing lot to lot uniformity. Sizes available are EIA chip sizes 0402, 0603, 0805, and 1210.

DIMENSIONS: inches (millimeters)



inches (mm)

Size	A	B	C	D	E
0402	0.039±0.004 (1.00±0.1)	0.020±0.004 (0.50±0.1)	0.022 (0.55mm) max	N/A	N/A
0603	0.060±0.010 (1.52±0.25)	0.030±0.010 (0.76±0.25)	0.036 (0.91mm) max	0.010±0.005 (0.25±0.13)	0.030 (0.76) min
0805	0.079±0.008 (2.01±0.2)	0.049±0.008 (1.25±0.2)	0.040±0.005 (1.02±0.127)	0.020±0.010 (0.51±0.255)	0.020 (0.51) min
1210	0.126±0.008 (3.2±0.2)	0.098±0.008 (2.49±0.2)	0.050±0.005 (1.27±0.127)	0.025±0.015 (0.635±0.381)	0.040 (1.02) min

HOW TO ORDER

0805 1 U 100 J A T 2 A

Case Size
0402
0603
0805
1210

Voltage Code
3 = 25V
5 = 50V
1 = 100V
2 = 200V

Dielectric = Ultra Low ESR

Capacitance
EIA Capacitance Code in pF.
First two digits = significant figures or "R" for decimal place.
Third digit = number of zeros or after "R" significant figures.

Capacitance Tolerance Code
B = ±0.1pF
C = ±0.25pF
D = ±0.5pF
F = ±1%
G = ±2%
J = ±5%
K = ±10%
M = ±20%

Failure Rate Code
A = Not Applicable

Termination
T= Plated Ni and Sn

Packaging Code
2 = 7" Reel
4 = 13" Reel

Special Code
A = Standard

RoHS COMPLIANT

NOTE: Contact factory for availability of Termination and Tolerance Options for Specific Part Numbers.

ELECTRICAL CHARACTERISTICS

Capacitance Values and Tolerances:
Size 0402 - 0.2 pF to 30 pF @ 1 MHz
Size 0603 - 1.0 pF to 100 pF @ 1 MHz
Size 0805 - 1.6 pF to 160 pF @ 1 MHz
Size 1210 - 2.4 pF to 1000 pF @ 1 MHz

Temperature Coefficient of Capacitance (TC):
0±30 ppm/°C (-55° to +125°C)

Insulation Resistance (IR):
10^{12} Ω min. @ 25°C and rated WVDC
10^{11} Ω min. @ 125°C and rated WVDC

Working Voltage (WVDC):

Size		Working Voltage
0402	-	100, 50, 25 WVDC
0603	-	200, 100, 50 WVDC
0805	-	200, 100 WVDC
1210	-	200, 100 WVDC

Dielectric Working Voltage (DWV):
250% of rated WVDC

Equivalent Series Resistance Typical (ESR):
0402 - See Performance Curve, page 9
0603 - See Performance Curve, page 9
0805 - See Performance Curve, page 9
1210 - See Performance Curve, page 9

Marking: Laser marking EIA J marking standard (except 0603) (capacitance code and tolerance upon request).

MILITARY SPECIFICATIONS
Meets or exceeds the requirements of MIL-C-55681

RF/Microwave C0G (NP0) Capacitors (RoHS)

Ultra Low ESR, "U" Series, C0G (NP0) Chip Capacitors

CAPACITANCE RANGE

Cap (pF)	Available Tolerance	Size 0402	0603	0805	1210
0.2	B,C	100V	N/A	N/A	N/A
0.3					
0.4					
0.5	B,C				
0.6	B,C,D				
0.7					
0.8					
0.9	B,C,D	↓	↓	↓	↓

Cap (pF)	Available Tolerance	Size 0402	0603	0805	1210
1.0	B,C,D	100V	200V	200V	200V
1.1					
1.2					
1.3					
1.4					
1.5					
1.6					
1.7					
1.8					
1.9					
2.0					
2.1					
2.2					
2.4					
2.7					
3.0					
3.3					
3.6					
3.9					
4.3					
4.7					
5.1					
5.6					
6.2	B,C,D				
6.8	B,C,J,K,M	↓	↓	↓	↓

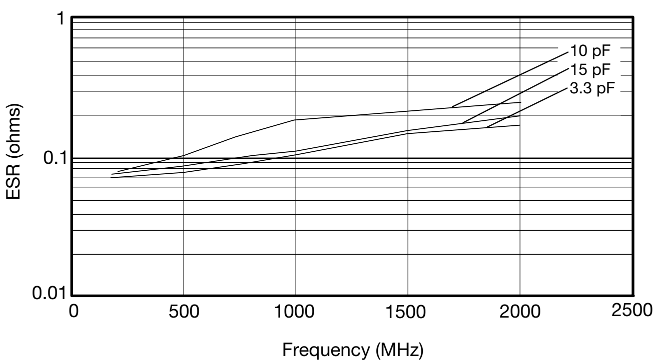
Cap (pF)	Available Tolerance	Size 0402	0603	0805	1210
7.5	B,C,J,K,M	100V	200V	200V	200V
8.2	↓				
9.1	B,C,J,K,M	↓			
10	F,G,J,K,M	100V			
11		50V			
12					
13					
15			↓		
18			200V		
20			100V		
22					
24					
27		↓			
30		50V			
33		N/A			
36					
39					
43					
47					
51					
56					
68					
75					
82					
91	↓	↓	↓	↓	↓

Cap (pF)	Available Tolerance	Size 0402	0603	0805	1210
100	F,G,J,K,M	N/A	100V	200V	200V
110			50V		
120			50V	↓	
130			N/A	200V	
140				100V	
150				↓	
160				100V	
180				N/A	
200					
220					
270					
300					
330					
360					
390					↓
430					200V
470					100V
510					
560					
620					
680					
750					
820					
910	↓				
1000	F,G,J,K,M	↓	↓	↓	↓

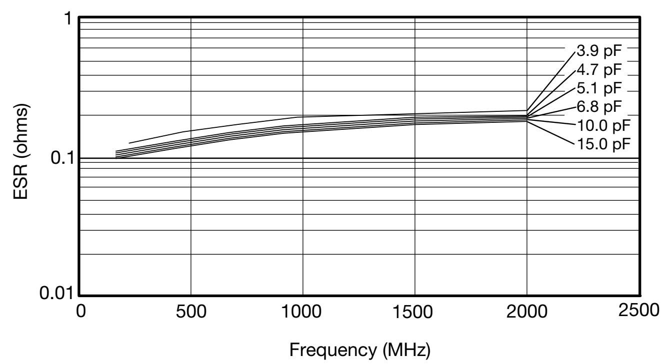
RoHS COMPLIANT

ULTRA LOW ESR, "U" SERIES

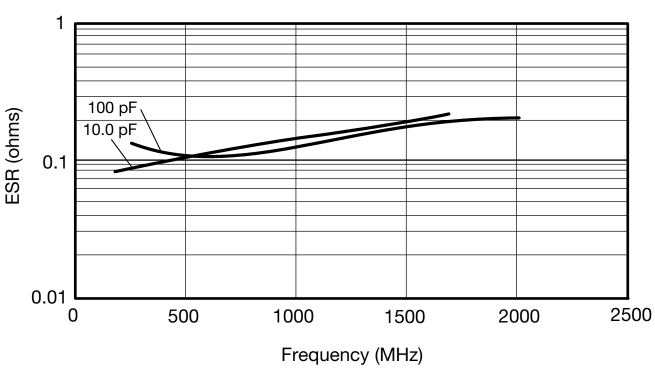
TYPICAL ESR vs. FREQUENCY
0402 "U" SERIES



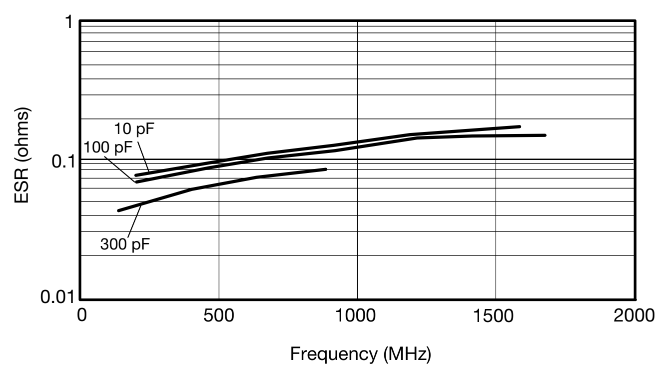
TYPICAL ESR vs. FREQUENCY
0603 "U" SERIES



TYPICAL ESR vs. FREQUENCY
0805 "U" SERIES



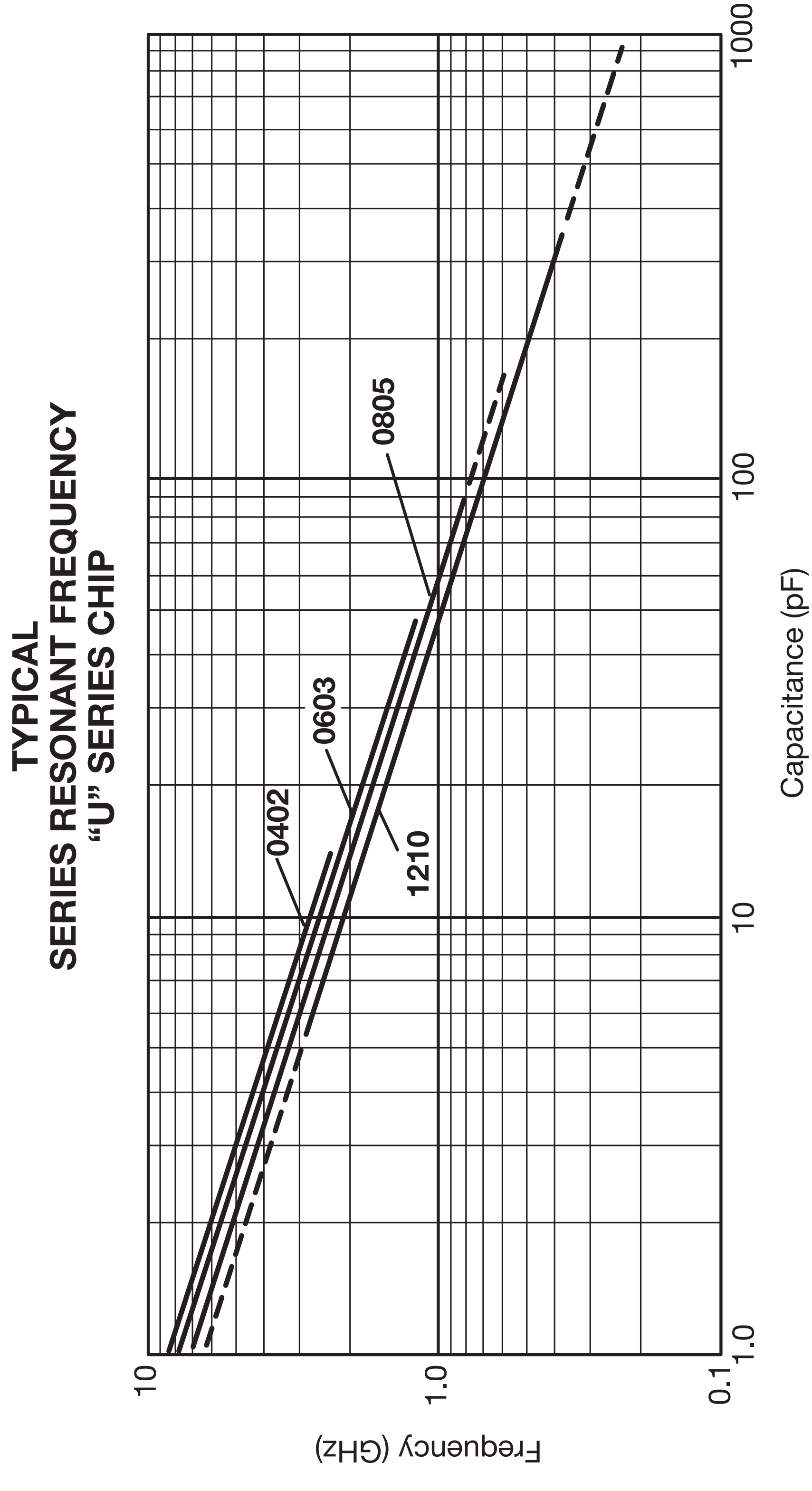
TYPICAL ESR vs. FREQUENCY
1210 "U" SERIES



ESR Measured on the Boonton 34A

RF/Microwave C0G (NP0) Capacitors

Ultra Low ESR, "U" Series, C0G (NP0) Chip Capacitors



Inductor Data Sheet

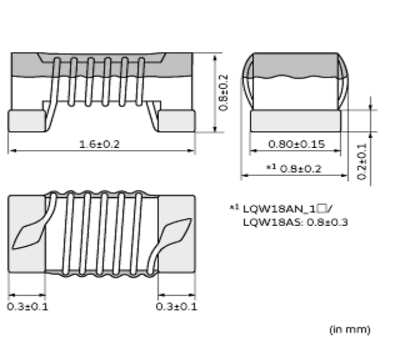
LQW18ANR10J00#

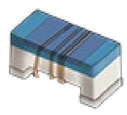
"#" indicates a package specification code.

In Production | General | 125 ℃max. | Wound (Non mag) | Reflow OK | RoHS | REACH

< List of part numbers with package codes >
LQW18ANR10J00D , LQW18ANR10J00J , LQW18ANR10J00B

Shape





L size	1.6 ±0.2mm
W size	0.8 ±0.2mm
T size	0.8 ±0.2mm
Size code in inch (mm)	0603 (1608)

References

Packaging code	Specifications	Minimum quantity
D	φ180mm Paper taping	4000
J	φ330mm Paper taping	10000
B	Packing in bulk	500

Mass (Typ.)	
1 piece	0.003g

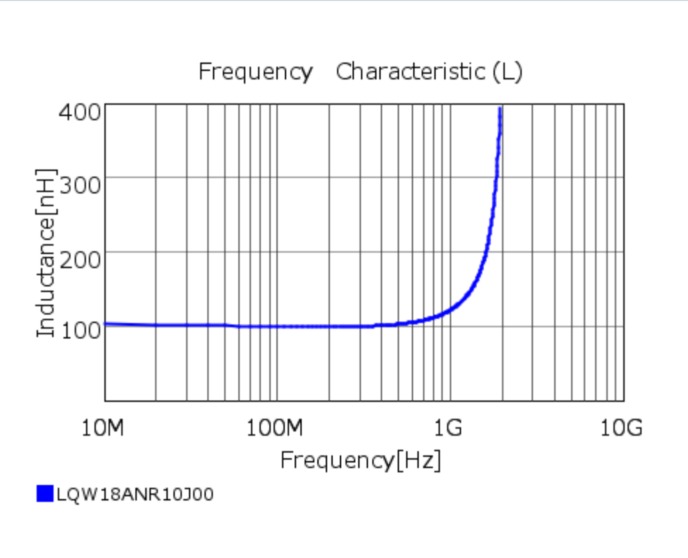
Specifications

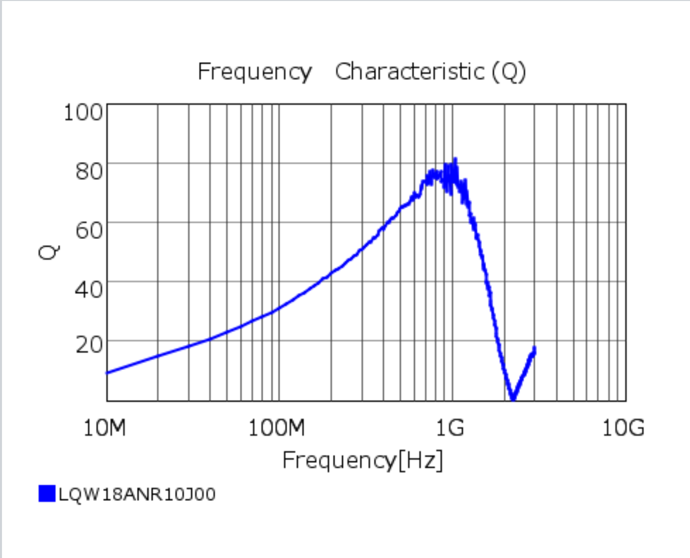
Inductance	100nH ±5%
Inductance test frequency	100MHz
Rated current (Itemp) (Based on Temperature rise)	220mA
Max. of DC resistance	0.68Ω
Q (min.)	34
Q test frequency	150MHz
Self resonance frequency (min.)	1800MHz
Operating temperature range (Self-temperature rise is not included)	-55～125℃
Series	LQW18AN_00

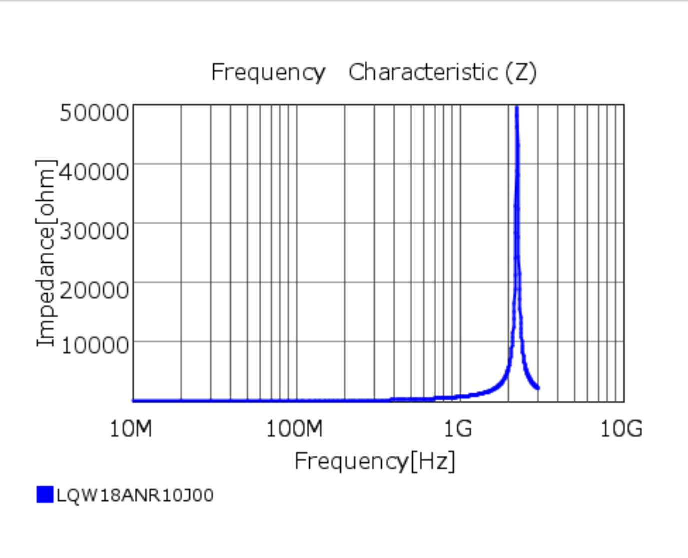
Murata Manufacturing Co., Ltd. URL : https://www.murata.com/

Last updated: 2018/05/30

Chart of characteristic data (The charts below may show another part number which shares its characteristics.)







BFU725F/N1

NPN wideband silicon germanium RF transistor

Rev. 2 — 3 November 2011 | Product data sheet

1. Product profile

1.1 General description

NPN silicon germanium microwave transistor for high speed, low noise applications in a plastic, 4-pin dual-emitter SOT343F package.

CAUTION

This device is sensitive to ElectroStatic Discharge (ESD). Observe precautions for handling electrostatic sensitive devices.

Such precautions are described in the *ANSI/ESD S20.20*, *IEC/ST 61340-5*, *JESD625-A* or equivalent standards.

1.2 Features and benefits

- Low noise high gain microwave transistor
- Noise figure (NF) = 0.7 dB at 5.8 GHz
- High maximum stable gain 27 dB at 1.8 GHz
- 110 GHz f_T silicon germanium technology

1.3 Applications

- 2nd LNA stage and mixer stage in DBS LNB’s
- Satellite radio
- Low noise amplifiers for microwave communications systems
- WLAN and CDMA applications
- Analog/digital cordless applications
- Ka band oscillators (DRO’s)

1.4 Quick reference data

Table 1. Quick reference data

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CBO}	collector-base voltage	open emitter	-	-	10	V
V_{CEO}	collector-emitter voltage	open base	-	-	2.8	V
V_{EBO}	emitter-base voltage	open collector	-	-	1.0	V
I_C	collector current		-	25	40	mA
P_{tot}	total power dissipation	$T_{sp} \leq 90$ °C [1]	-	-	136	mW
h_{FE}	DC current gain	$I_C = 10$ mA; $V_{CE} = 2$ V; $T_j = 25$ °C	160	280	400	

Table 1. Quick reference data *continued*

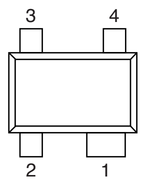
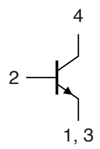
Symbol	Parameter	Conditions		Min	Typ	Max	Unit
C_{CBS}	collector-base capacitance	V_{CB} = 2 V; f = 1 MHz		-	70	-	fF
f_T	transition frequency	I_C = 25 mA; V_{CE} = 2 V; f = 2 GHz; T_{amb} = 25 °C		-	55	-	GHz
$G_{p(max)}$	maximum power gain	I_C = 25 mA; V_{CE} = 2 V; f = 5.8 GHz; T_{amb} = 25 °C	[2]	-	18	-	dB
NF	noise figure	I_C = 5 mA; V_{CE} = 2 V; f = 5.8 GHz; $\Gamma_S = \Gamma_{opt}$; T_{amb} = 25 °C		-	0.7	-	dB

[1] T_{sp} is the temperature at the solder point of the emitter lead.

[2] $G_{p(max)}$ is the maximum power gain, if K > 1. If K < 1 then $G_{p(max)}$ = Maximum Stable Gain (MSG).

2. Pinning information

Table 2. Discrete pinning

Pin	Description	Simplified outline	Graphic symbol
1	emitter		 mbb159
2	base		
3	emitter		
4	collector		

3. Ordering information

Table 3. Ordering information

Type number	Package		
	Name	Description	Version
BFU725F/N1	-	plastic surface-mounted flat pack package; reverse pinning; 4 leads	SOT343F

4. Marking

Table 4. Marking

Type number	Marking	Description
BFU725F/N1	B7*	* = p : made in Hong Kong
		* = t : made in Malaysia
		* = W : made in China

5. Limiting values

Table 5. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions		Min	Max	Unit
V_{CBO}	collector-base voltage	open emitter		-	10	V
V_{CEO}	collector-emitter voltage	open base		-	2.8	V
V_{EBO}	emitter-base voltage	open collector		-	1.0	V
I_C	collector current			-	40	mA
P_{tot}	total power dissipation	$T_{sp} \leq 90$ °C	[1]	-	136	mW
T_{stg}	storage temperature			−65	+150	°C
T_j	junction temperature			-	150	°C

[1] T_{sp} is the temperature at the solder point of the emitter lead.

6. Thermal characteristics

Table 6. Thermal characteristics

Symbol	Parameter	Conditions	Typ	Unit
$R_{th(j-sp)}$	thermal resistance from junction to solder point		440	K/W

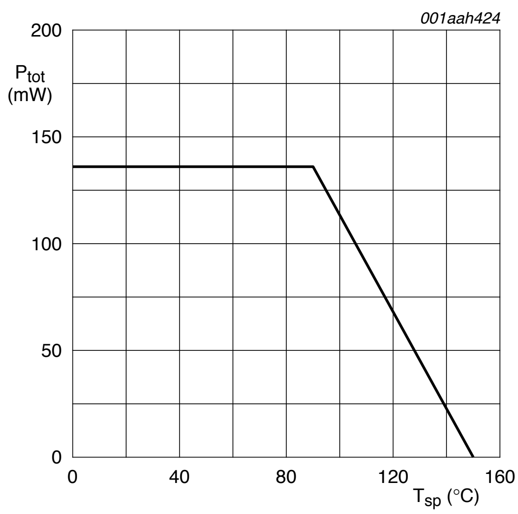


Fig 1. Power derating curve

7. Characteristics

Table 7. Characteristics

T_j = 25 °C unless otherwise specified.

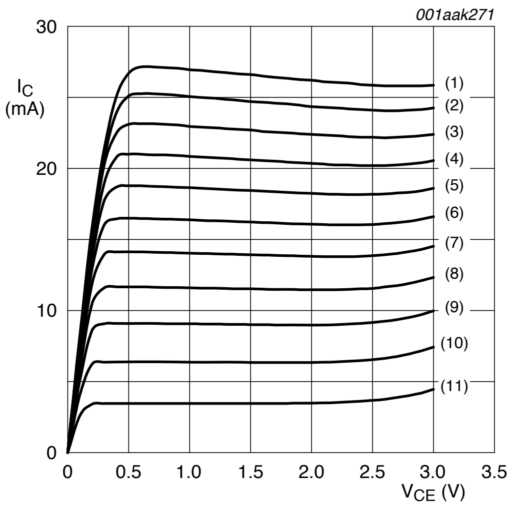
Symbol	Parameter	Conditions		Min	Typ	Max	Unit
$V_{(BR)CBO}$	collector-base breakdown voltage	I_C = 2.5 μA; I_E = 0 mA		10	-	-	V
$V_{(BR)CEO}$	collector-emitter breakdown voltage	I_C = 1 mA; I_B = 0 mA		2.8	-	-	V
I_C	collector current			-	25	40	mA
I_{CBO}	collector-base cut-off current	I_E = 0 mA; V_{CB} = 4.5 V		-	-	100	nA
h_{FE}	DC current gain	I_C = 10 mA; V_{CE} = 2 V		160	280	400	
C_{CES}	collector-emitter capacitance	V_{CB} = 2 V; f = 1 MHz		-	268	-	fF
C_{EBS}	emitter-base capacitance	V_{EB} = 0.5 V; f = 1 MHz		-	400	-	fF
C_{CBS}	collector-base capacitance	V_{CB} = 2 V; f = 1 MHz		-	70	-	fF
f_T	transition frequency	I_C = 25 mA; V_{CE} = 2 V; f = 2 GHz; T_{amb} = 25 °C		-	55	-	GHz
$G_{p(max)}$	maximum power gain	I_C = 25 mA; V_{CE} = 2 V; T_{amb} = 25 °C	[1]				
		f = 1.5 GHz		-	28	-	dB
		f = 1.8 GHz		-	27	-	dB
		f = 2.4 GHz		-	25.5	-	dB
		f = 5.8 GHz		-	18	-	dB
		f = 12 GHz		-	13	-	dB
$\|s_{21}\|^2$	insertion power gain	I_C = 25 mA; V_{CE} = 2 V; T_{amb} = 25 °C					
		f = 1.5 GHz		-	26.7	-	dB
		f = 1.8 GHz		-	25.4	-	dB
		f = 2.4 GHz		-	23	-	dB
		f = 5.8 GHz		-	16	-	dB
		f = 12 GHz		-	9.3	-	dB
NF	noise figure	I_C = 5 mA; V_{CE} = 2 V; $\Gamma_S = \Gamma_{opt}$; T_{amb} = 25 °C					
		f = 1.5 GHz		-	0.42	-	dB
		f = 1.8 GHz		-	0.43	-	dB
		f = 2.4 GHz		-	0.47	-	dB
		f = 5.8 GHz		-	0.7	-	dB
		f = 12 GHz		-	1.1	-	dB
G_{ass}	associated gain	I_C = 5 mA; V_{CE} = 2 V; $\Gamma_S = \Gamma_{opt}$; T_{amb} = 25 °C					
		f = 1.5 GHz		-	24	-	dB
		f = 1.8 GHz		-	22	-	dB
		f = 2.4 GHz		-	20	-	dB
		f = 5.8 GHz		-	13.5	-	dB
		f = 12 GHz		-	10	-	dB

Table 7. Characteristics *continued*

T_j = 25 °C unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$P_{L(1dB)}$	output power at 1 dB gain compression	I_C = 25 mA; V_{CE} = 2 V; Z_S = Z_L = 50 Ω; T_{amb} = 25 °C				
		f = 1.5 GHz	-	8.5	-	dBm
		f = 1.8 GHz	-	9	-	dBm
		f = 2.4 GHz	-	8.5	-	dBm
		f = 5.8 GHz	-	8	-	dBm
IP3	third-order intercept point	I_C = 25 mA; V_{CE} = 2 V; Z_S = Z_L = 50 Ω; T_{amb} = 25 °C; $f_2 = f_1$ + 1 MHz				
		f_1 = 1.5 GHz	-	17	-	dBm
		f_1 = 1.8 GHz	-	17	-	dBm
		f_1 = 2.4 GHz	-	17	-	dBm
		f_1 = 5.8 GHz	-	19	-	dBm

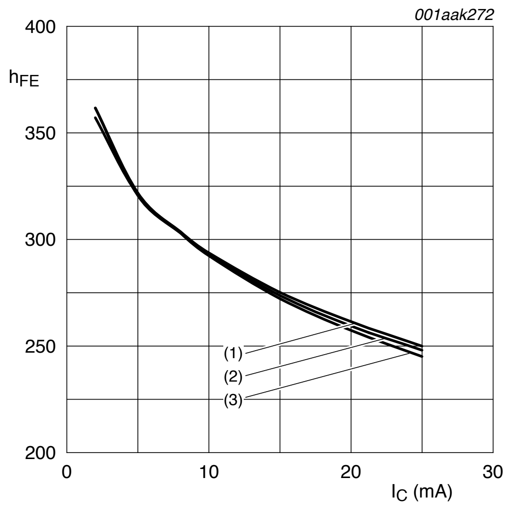
[1] $G_{p(max)}$ is the maximum power gain, if K > 1. If K < 1 then $G_{p(max)}$ = MSG.



T_{amb} = 25 °C.

(1) I_B = 110 μA
(2) I_B = 100 μA
(3) I_B = 90 μA
(4) I_B = 80 μA
(5) I_B = 70 μA
(6) I_B = 60 μA
(7) I_B = 50 μA
(8) I_B = 40 μA
(9) I_B = 30 μA
(10) I_B = 20 μA
(11) I_B = 10 μA

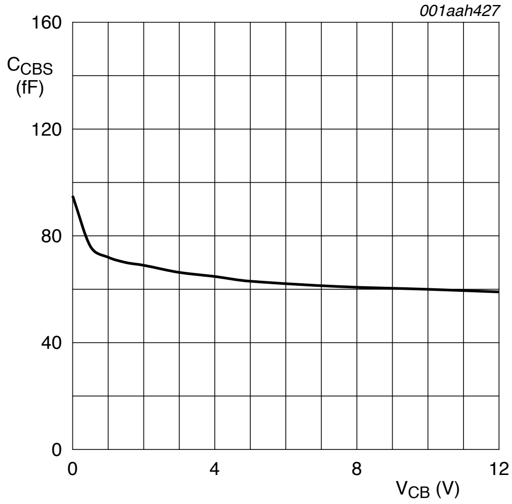
Fig 2. Collector current as a function of collector-emitter voltage; typical values



T_{amb} = 25 °C.

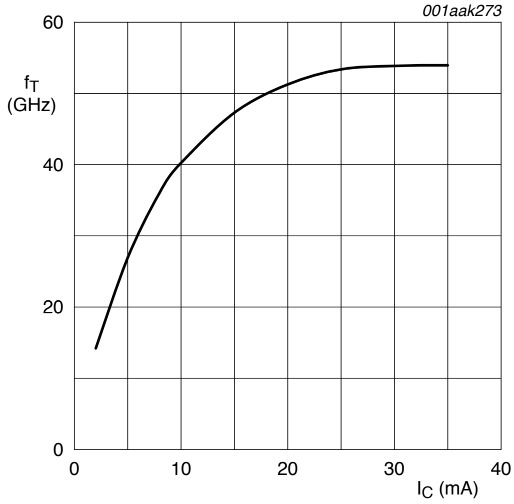
(1) V_{CE} = 1 V
(2) V_{CE} = 1.5 V
(3) V_{CE} = 2 V

Fig 3. DC current gain a function of collector current; typical values



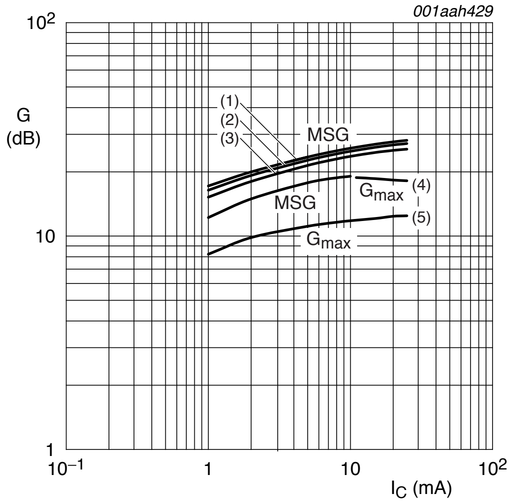
f = 1 MHz, T_{amb} = 25 °C.

Fig 4. Collector-base capacitance as a function of collector-base voltage; typical values



V_{CE} = 2 V; f = 2 GHz; T_{amb} = 25 °C.

Fig 5. Transition frequency as a function of collector current; typical values



V_{CE} = 2 V; T_{amb} = 25 °C.

(1) f = 1.5 GHz

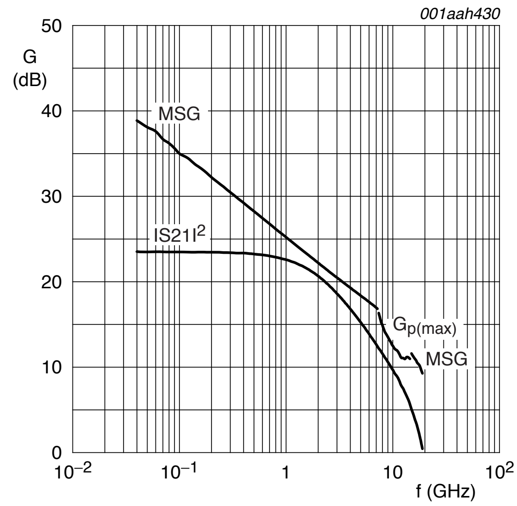
(2) f = 1.8 GHz

(3) f = 2.4 GHz

(4) f = 5.8 GHz

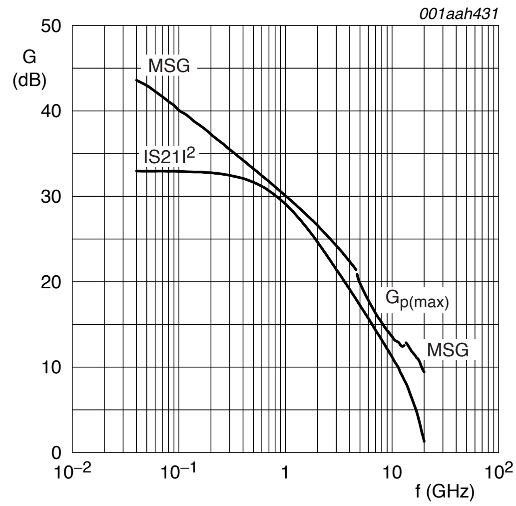
(5) f = 12 GHz

Fig 6. Gain as a function of collector current; typical value



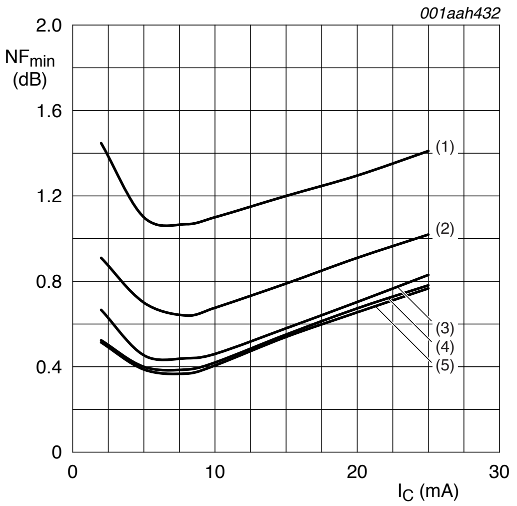
V_{CE} = 2 V; I_C = 5 mA; T_{amb} = 25 °C.

Fig 7. Gain as a function of frequency; typical values



V_{CE} = 2 V; I_C = 25 mA; T_{amb} = 25 °C.

Fig 8. Gain as a function of frequency; typical values



V_{CE} = 2 V; T_{amb} = 25 °C.

(1) f = 12 GHz

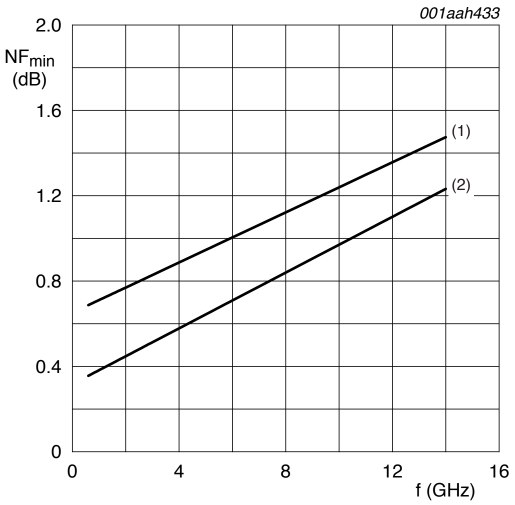
(2) f = 5.8 GHz

(3) f = 2.4 GHz

(4) f = 1.8 GHz

(5) f = 1.5 GHz

Fig 9. Minimum noise figure as a function of collector current; typical values



V_{CE} = 2 V; T_{amb} = 25 °C.

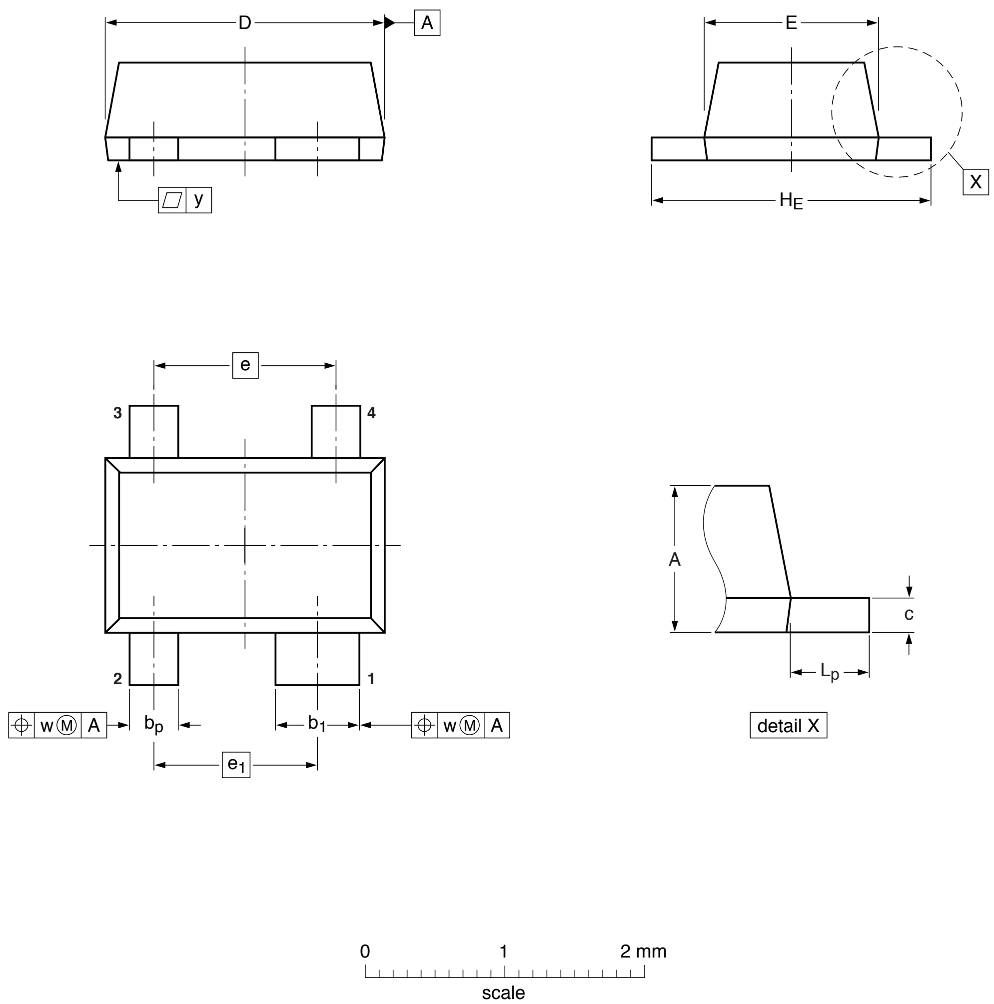
(1) I_C = 25 mA

(2) I_C = 5 mA

Fig 10. Minimum noise figure as a function of frequency; typical values

8. Package outline

Plastic surface-mounted flat pack package; reverse pinning; 4 leads **SOT343F**



DIMENSIONS (mm are the original dimensions)

UNIT	A max	b_p	b_1	c	D	E	e	e_1	H_E	L_p	w	y
mm	0.75 0.65	0.4 0.3	0.7 0.5	0.25 0.10	2.2 1.8	1.35 1.15	1.3	1.15	2.2 2.0	0.48 0.38	0.2	0.1

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT343F						~~05-07-12~~ 06-03-16

Fig 11. Package outline SOT343F

BZX384 series

Voltage regulator diodes

Rev. 3 — 11 October 2016 **Product data sheet**

1. Product profile

1.1 General description

Low-power voltage regulator diodes in a small SOD323 (SC-76) Surface-Mounted Device (SMD) plastic package.

The diodes are available in the normalized E24 ±2 % (BZX384-B) and approximately ±5 % (BZX384-C) tolerance range. The series includes 37 breakdown voltages with nominal working voltages from 2.4 V to 75 V.

1.2 Features and benefits

- Total power dissipation: ≤ 300 mW
- Two tolerance series: ±2 % and approximately ±5 %
- AEC-Q101 qualified
- Working voltage range: nominal 2.4 V to 75 V (E24 range)
- Non-repetitive peak reverse power dissipation: ≤ 40 W

1.3 Applications

- General regulation functions

1.4 Quick reference data

Table 1. Quick reference data

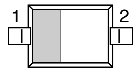
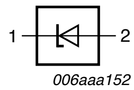
Symbol	Parameter	Conditions		Min	Typ	Max	Unit
V_F	forward voltage	I_F = 10 mA	[1]	-	-	0.9	V
P_{tot}	total power dissipation	$T_{amb} \leq 25$ °C	[2]	-	-	300	mW

[1] Pulse test: $t_p \leq 100$ µs; $\delta \leq 0.02$

[2] Device mounted on a FR4 Printed-Circuit Board (PCB), single-sided copper, tin-plated and standard footprint.

2. Pinning information

Table 2. Pinning

Pin	Symbol	Description	Simplified outline	Graphic symbol
1	K	cathode [1]		
2	A	anode		

[1] The marking bar indicates the cathode.

3. Ordering information

Table 3. Ordering information

Type number	Package		
	Name	Description	Version
BZX384 series[1]	SC-76	plastic surface-mounted package; 2 leads	SOD323

[1] The series includes 37 breakdown voltages with nominal working voltages from 2.4 V to 75 V and ±2 % and ±5 % tolerances.

4. Marking

Table 4. Marking codes

Type number	Marking code	Type number	Marking code	Type number	Marking code	Type number	Marking code
BZX384-B2V4	K1	BZX384-B15	M2	BZX384-C2V4	T3	BZX384-C15	DD
BZX384-B2V7	K2	BZX384-B16	M3	BZX384-C2V7	T4	BZX384-C16	DE
BZX384-B3V0	K3	BZX384-B18	M4	BZX384-C3V0	T5	BZX384-C18	DF
BZX384-B3V3	K4	BZX384-B20	M5	BZX384-C3V3	T6	BZX384-C20	DG
BZX384-B3V6	K5	BZX384-B22	M6	BZX384-C3V6	T7	BZX384-C22	DH
BZX384-B3V9	K6	BZX384-B24	M7	BZX384-C3V9	T8	BZX384-C24	DJ
BZX384-B4V3	K7	BZX384-B27	M8	BZX384-C4V3	T9	BZX384-C27	DK
BZX384-B4V7	K8	BZX384-B30	M9	BZX384-C4V7	T0	BZX384-C30	DL
BZX384-B5V1	K9	BZX384-B33	N0	BZX384-C5V1	D5	BZX384-C33	DM
BZX384-B5V6	L1	BZX384-B36	N1	BZX384-C5V6	D6	BZX384-C36	DN
BZX384-B6V2	L2	BZX384-B39	N2	BZX384-C6V2	T1	BZX384-C39	DP
BZX384-B6V8	L3	BZX384-B43	N3	BZX384-C6V8	D7	BZX384-C43	DR
BZX384-B7V5	L4	BZX384-B47	N4	BZX384-C7V5	D8	BZX384-C47	DS
BZX384-B8V2	L5	BZX384-B51	N5	BZX384-C8V2	D9	BZX384-C51	DT
BZX384-B9V1	L6	BZX384-B56	N6	BZX384-C9V1	D0	BZX384-C56	DU
BZX384-B10	L7	BZX384-B62	N7	BZX384-C10	T2	BZX384-C62	DV
BZX384-B11	L8	BZX384-B68	N8	BZX384-C11	DA	BZX384-C68	DW
BZX384-B12	L9	BZX384-B75	N9	BZX384-C12	DB	BZX384-C75	DX
BZX384-B13	M1	-	-	BZX384-C13	DC	-	-

5. Limiting values

Table 5. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions		Min	Max	Unit
I_F	forward current			-	250	mA
I_{ZSM}	non-repetitive peak reverse current		[1]	-	see Table 8 and 9	
P_{ZSM}	non-repetitive peak reverse power dissipation		[1]	-	40	W
P_{tot}	total power dissipation	$T_{amb} \leq 25$ °C	[2]	-	300	mW
T_j	junction temperature			–65	+150	°C
T_{amb}	ambient temperature			–65	+150	°C
T_{stg}	storage temperature			–65	+150	°C

[1] $t_p = 100$ µs; square wave; $T_j = 25$ °C before surge

[2] Device mounted on a FR4 PCB, single-sided copper, tin-plated and standard footprint.

6. Thermal characteristics

Table 6. Thermal characteristics

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
$R_{th(j-a)}$	thermal resistance from junction to ambient	in free air	[1]	-	-	415	K/W
$R_{th(j-sp)}$	thermal resistance from junction to solder point		[2]	-	-	110	K/W

[1] Device mounted on a FR4 PCB, single-sided copper, tin-plated and standard footprint.

[2] Soldering point of cathode tab.

7. Characteristics

Table 7. Characteristics

$T_j = 25$ °C unless otherwise specified.

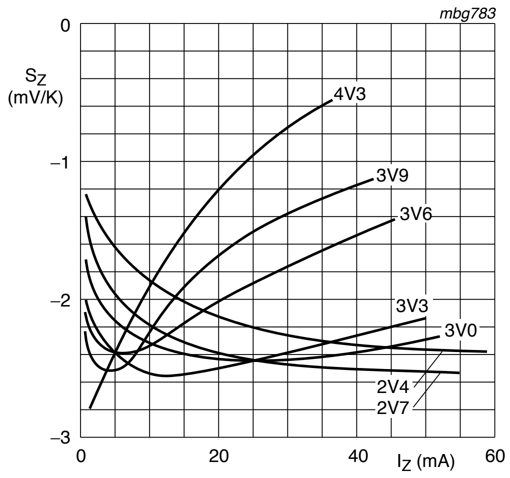
Symbol	Parameter	Conditions		Min	Typ	Max	Unit
V_F	forward voltage	$I_F = 10$ mA	[1]	-	-	0.9	V
		$I_F = 100$ mA	[1]	-	-	1.1	V

[1] Pulse test: $t_p \leq 100$ µs; $\delta \leq 0.02$

Table 8. Characteristics per type; BZX384-B2V4 to BZX384-C24

T_j = 25 °C unless otherwise specified.

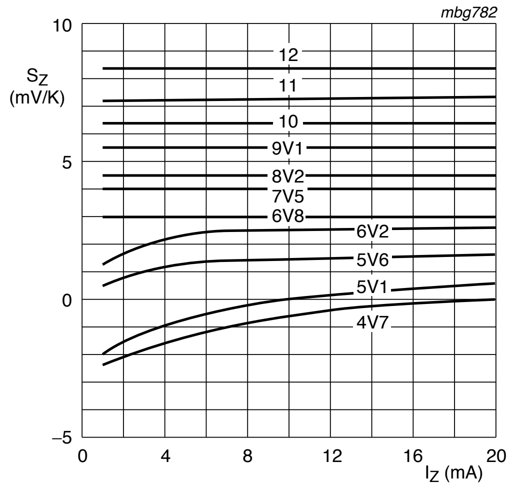
BZX384 -xxx	Sel	Working voltage V_Z (V)		Differential resistance r_{dif} (Ω)				Reverse current I_R (μA)		Temperature coefficient S_Z (mV/K)			Diode capacitance C_d (pF)[1]	Non-repetitive peak reverse current I_{ZSM} (A)[2]
		I_Z = 5 mA		I_Z = 1 mA		I_Z = 5 mA				I_Z = 5 mA				
		Min	Max	Typ	Max	Typ	Max	Max	V_R (V)	Min	Typ	Max	Max	Max
2V4	B	2.35	2.45	275	600	70	100	50	1	−3.5	−1.6	0	450	6.0
	C	2.2	2.6											
2V7	B	2.65	2.75	300	600	75	100	20	1	−3.5	−2.0	0	450	6.0
	C	2.5	2.9											
3V0	B	2.94	3.06	325	600	80	95	10	1	−3.5	−2.1	0	450	6.0
	C	2.8	3.2											
3V3	B	3.23	3.37	350	600	85	95	5	1	−3.5	−2.4	0	450	6.0
	C	3.1	3.5											
3V6	B	3.53	3.67	375	600	85	90	5	1	−3.5	−2.4	0	450	6.0
	C	3.4	3.8											
3V9	B	3.82	3.98	400	600	85	90	3	1	−3.5	−2.5	0	450	6.0
	C	3.7	4.1											
4V3	B	4.21	4.39	410	600	80	90	3	1	−3.5	−2.5	0	450	6.0
	C	4.0	4.6											
4V7	B	4.61	4.79	425	500	50	80	3	2	−3.5	−1.4	0.2	300	6.0
	C	4.4	5.0											
5V1	B	5.0	5.2	400	480	40	60	2	2	−2.7	−0.8	1.2	300	6.0
	C	4.8	5.4											
5V6	B	5.49	5.71	80	400	15	40	1	2	−2.0	1.2	2.5	300	6.0
	C	5.2	6.0											
6V2	B	6.08	6.32	40	150	6	10	3	4	0.4	2.3	3.7	200	6.0
	C	5.8	6.6											
6V8	B	6.66	6.94	30	80	6	15	2	4	1.2	3.0	4.5	200	6.0
	C	6.4	7.2											
7V5	B	7.35	7.65	30	80	6	15	1	5	2.5	4.0	5.3	150	4.0
	C	7.0	7.9											
8V2	B	8.04	8.36	40	80	6	15	0.7	5	3.2	4.6	6.2	150	4.0
	C	7.7	8.7											
9V1	B	8.92	9.28	40	100	6	15	0.5	6	3.8	5.5	7.0	150	3.0
	C	8.5	9.6											
10	B	9.8	10.2	50	150	8	20	0.2	7	4.5	6.4	8.0	90	3.0
	C	9.4	10.6											
11	B	10.8	11.2	50	150	10	20	0.1	8	5.4	7.4	9.0	85	2.5
	C	10.4	11.6											
12	B	11.8	12.2	50	150	10	25	0.1	8	6.0	8.4	10.0	85	2.5
	C	11.4	12.7											



BZX384-B/C2V4 to BZX384-B/C4V3

T_j = 25 °C to 150 °C

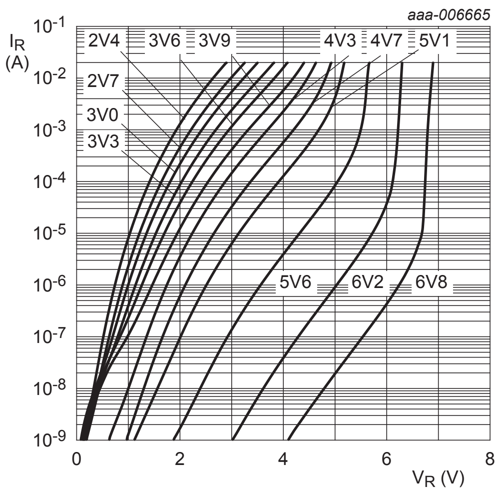
Fig 3. Temperature coefficient as a function of working current; typical values



BZX384-B/C4V7 to BZX384-B/C12

T_j = 25 °C to 150 °C

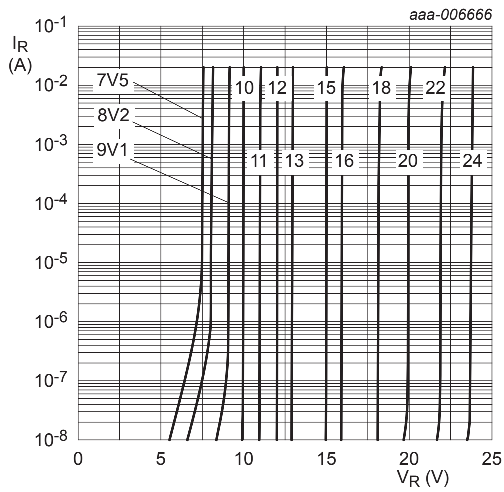
Fig 4. Temperature coefficient as a function of working current; typical values



BZX384-B/C2V4 to BZX384-B/C6V8

T_{amb} = 25 °C

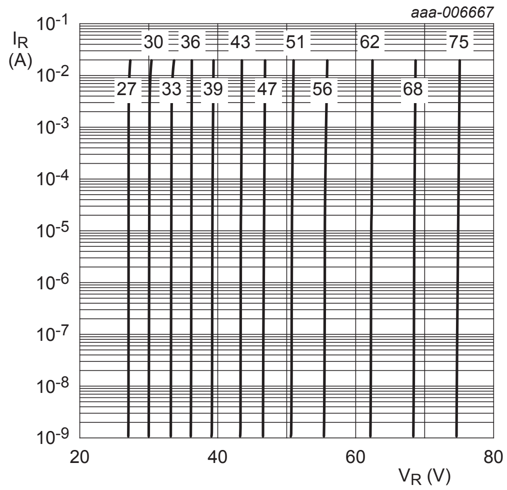
Fig 5. Reverse current as a function of reverse voltage; typical values



BZX384-B/C7V5 to BZX384-B/C24

T_{amb} = 25 °C

Fig 6. Reverse current as a function of reverse voltage; typical values



BZX384-B/C27 to BZX384-B/C75

T_{amb} = 25 °C

Fig 7. Reverse current as a function of reverse voltage; typical values

8. Test information

8.1 Quality information

This product has been qualified in accordance with the Automotive Electronics Council (AEC) standard *Q101 - Stress test qualification for discrete semiconductors*, and is suitable for use in automotive applications.

9. Package outline

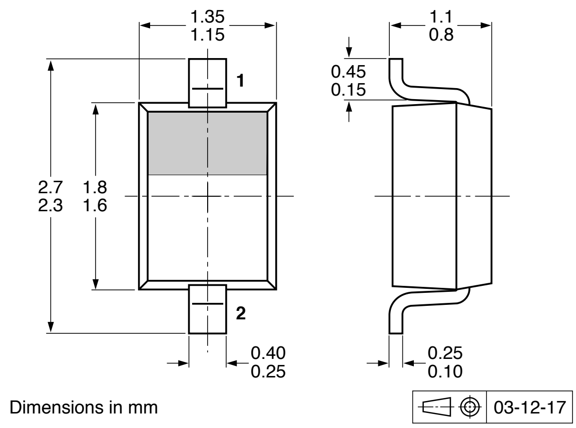


Fig 8. Package outline SOD323 (SC-76)

10. Soldering

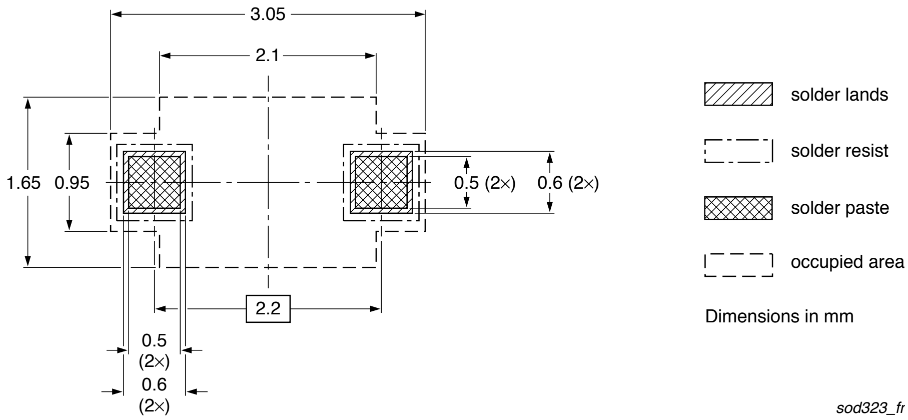


Fig 9. Reflow soldering footprint SOD323 (SC-76)

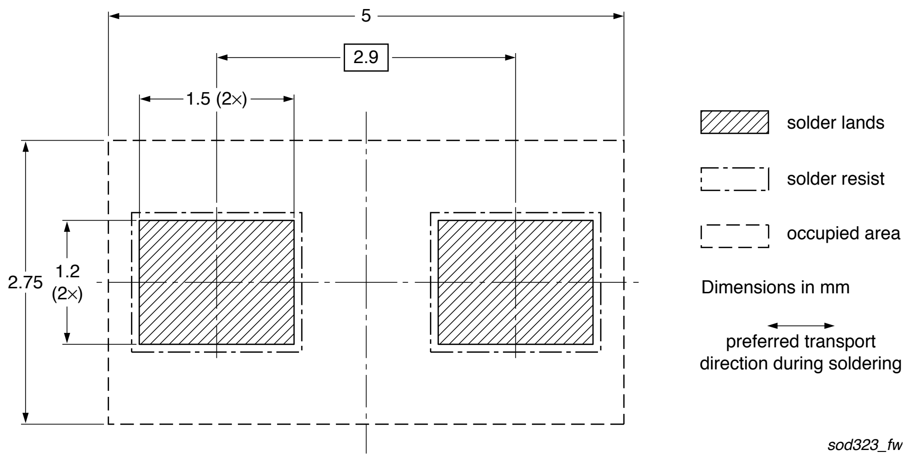
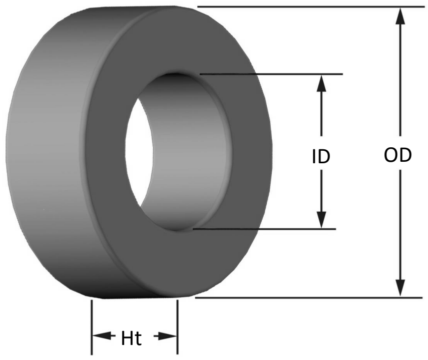


Fig 10. Wave soldering footprint SOD323 (SC-76)

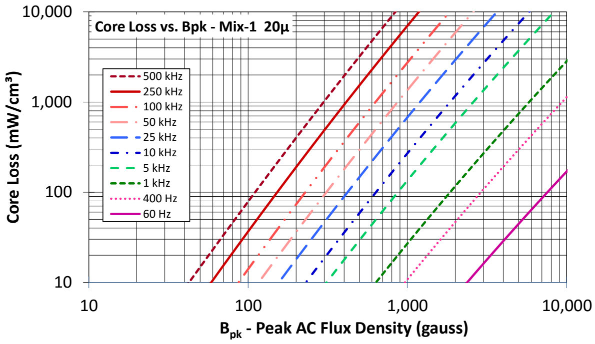
MICROMETALS
POWDER CORE SOLUTIONS

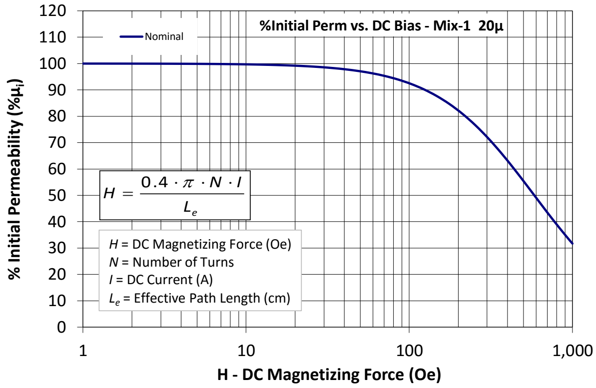
Part Number:	T10-1

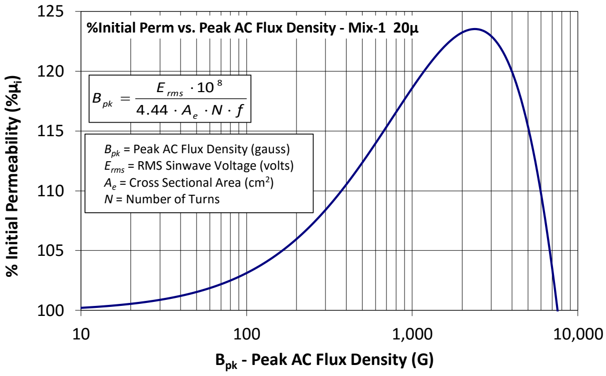
Revision 20160713 - Generated 2016-Aug-15

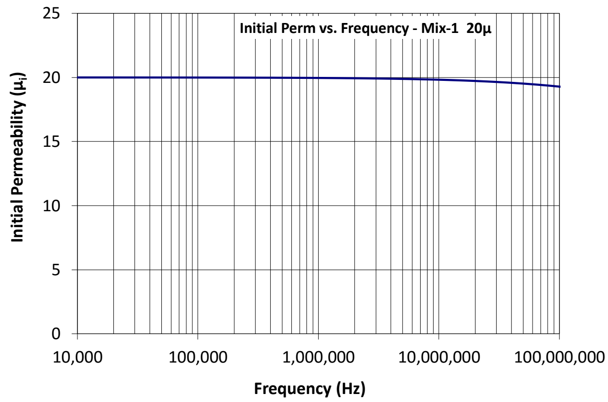


OD	(nom. - bare core)	2.46 mm	0.097 in
	(max. - after coating)	2.59 mm	0.102 in
ID	(nom. - bare core)	1.12 mm	0.044 in
	(min. - after coating)	0.99 mm	0.039 in
Ht	(nom. - bare core)	0.76 mm	0.030 in
	(max. - after coating)	0.89 mm	0.035 in
Mass	(approximate)	0.02 grams	
Magnetic Dimensions	A_e - Eff. Mag. Cross Section	0.00450 cm²	
	L_e - Eff. Mag. Path Length	0.560 cm	
	V_e - Eff. Core Volume	0.00250	
	WA - Min. Eff. Window Area	0.00770 cm²	
	sa - Surface Area	0.219 cm²	
	mlt - mean length per turn	0.387 cm	
Inductance	μ_i(reference)	20	
	A_L value (nominal)	3.2 nH/N²	
	Test Winding	N=25, #40 AWG	
	Frequency	1 MHz	
	Voltage on Agilent 4284A	0.050 V	
	A_L tolerance	±10%	
Core Loss	Core Loss(mW/cm³)= $\dfrac{f}{\dfrac{a}{Bpk^3}+\dfrac{b}{Bpk^{2.3}}+\dfrac{c}{Bpk^{1.65}}} + d \cdot Bpk^2 \cdot f^2$		
	where B_{pk} expressed in gauss, f expressed in hertz, and: *a=1.90E+09, b=2.00E+08, c=9.00E+05, d=4.30E-15*		
	Bpk	140 G	
	frequency	100 kHz	
	Core Loss (nominal)	31 mW/cm³	
	Core Loss (maximum)	36 mW/cm³	
DC Saturation	$\%\mu_i = \dfrac{1}{a + b \cdot H^c} + d$		
	where H expressed in oersteds, and: *a=1.00E-02, b=1.14E-06, c=1.43, d=0.00*		
	H_{DC}	200 Oe	
	Percent Initial Perm(nom.)	82.2%	
	Percent Initial Perm(min.)	78.0%	
Coating/Pkg	Coating Type:	Parylene C	
	Voltage Breakdown (min.)	500 Vrms, 60Hz	
	Limit	0.1 mA, 5 s	
	Package Quantity	250,000 Pcs/Box	









Winding Table													
Wire Size	AWG	34	36	38	40	42	44	#N/A	#N/A	#N/A	#N/A	#N/A
	mm	0.160	0.125	0.100	0.080	0.063	0.050	#N/A	#N/A	#N/A	#N/A	#N/A
Single Layer	Turns	12	15	19	25	32	40	#N/A	#N/A	#N/A	#N/A	#N/A
	Rdc(Ω)	39.8 m	79.1 m	159.4 m	333.5 m	679.0 m	1.3	#N/A	#N/A	#N/A	#N/A	#N/A
Full Winding	Turns	12	18	28	44	68	105	#N/A	#N/A	#N/A	#N/A	#N/A
	Rdc(Ω)	39.8 m	94.9 m	234.9 m	587.0 m	1.4	3.5	#N/A	#N/A	#N/A	#N/A	#N/A

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www.Micrometals.com

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