Freescale Semiconductor
Technical Data

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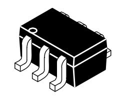
MBC13720



Package Information
Plastic Package
Case 419B
(SOT-363)

MBC13720

SiGe:C Low Noise Amplifier with Bypass Switch

Ordering Information

Device	Device Marking or Operating Temperature Range	Package
MBC13720T1[1]	20	SOT-363
MBC13720NT1[1]	20N	SOT-363

[1] Refer to Table 1.

Contents

1 Introduction

The MBC13720 is a high IP3, low noise amplifier designed for 400 MHz to 2.4 GHz multi-standard wireless applications. The input and output match is external to allow maximum design flexibility. The LNA has two selectable current settings as well as a standby mode. The LNA operates from a 2.5 to 3.0 V supply. The MBC13720 is fabricated using an advanced RF BiCMOS process with the SiGe:C option and is housed in an ultra small SOT-363 surface mount package.

1.1 Features

- Selectable current, 5.0 mA or 11 mA
- Standby mode to turn off device completely
- High Input IP3:
  10 dBm @ 1.9 GHz
  13 dBm @ 2.4 GHz
- Low Noise Figure:
  1.38 dB @ 1.9 GHz
  1.55 dB @ 2.4 GHz

- Gain @ 9.0 mA, 2.75 V:
  14.5 dB @ 1.9 GHz
  12 dB @ 2.4 GHz
- Suitable for use from 400 MHz to 2.4 GHz
- Bias stabilized for device and temperature variations
- Ultra small SOT-363 surface mount package
- Available only in tape and reel packaging
- Available only in a lead free version (device number MBC13720NT1) (Refer to Table 1.)

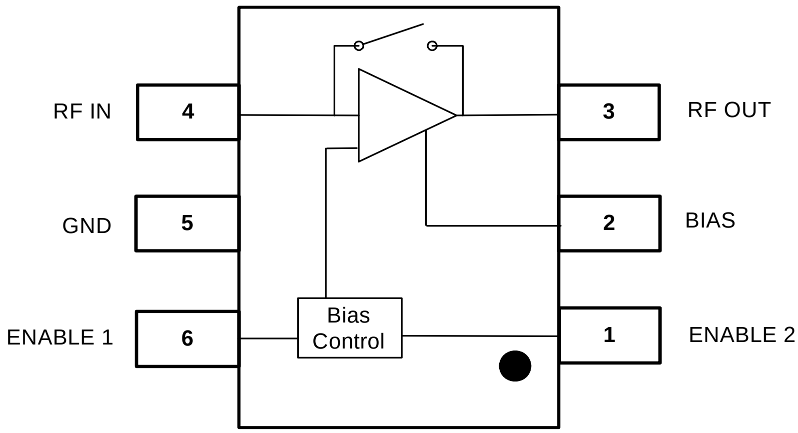


Figure 1. Pin Connections

2 Ordering Information

Table 1 provides additional details on MBC13720 orderable parts.

Table 1. Orderable Parts Details

Device	Operating Temp Range (TA.)	Package	Lead Frame	RoHS Compliant	PB-Free	MSL Level	Solder Temp
MBC13720T1	-30° to 85° C	Tape and Reel	Pb Plate	-	No	-	-
MBC13720NT1	-30° to 85° C	Tape and Reel	Pb Free	Yes	Yes	1	260° C

3 Electrical Specifications

Table 2. Maximum Ratings

Ratings	Symbol	Value	Unit
Supply Voltage	V_{CC}	3.3	V
Storage Temperature Range	T_{stg}	-65 to 150	°C
Operating Ambient Temperature Range	T_A	-30 to 85	°C
RF Input Power	Prf	10	dBm
Power Dissipation	Pdis	100	mW

Table 3. Recommended Operating Conditions

Characteristic	Symbol	Min	Typ	Max	Unit
RF Frequency Range	f_{RF}	400		2400	MHz
Supply Voltage	Vcc	2.3	2.7	3	V
Logic Voltage					
Input High Voltage, Enable 1 and Enable 2		1.5		Vcc	V
Input Low Voltage, Enable 1 and Enable 2		0		0.95	V

Table 4. Electrical Characteristics Measured in Frequency Specific Tuned Circuits

(V_{CC} = 2.75, T_A = 25° C)

Characteristic	Symbol	Min	Typ	Max	Unit
Current Consumption Low IP3 High IP3 Bypass	I_{CC}	 - - -	 5.0 11 0	 - - -	 mA mA µA
Input/Output Return Loss Low IP3 High IP3 Bypass	RL	 - - -	 10 10 12	 - - -	dB
RF Gain (900 MHz) Low IP3 High IP3 Bypass	G	 - - -	 19 20 -2.9	 - - -	dB
RF Gain (1.9 GHz) Low IP3 High IP3 Bypass	G	 - - -	 13 14 -2.5	 - - -	dB
RF Gain (2.4 GHz) Low IP3 High IP3 Bypass	G	 - - -	 11 12 -2.8	 - - -	dB

Table 4. Electrical Characteristics Measured in Frequency Specific Tuned Circuits (continued)
(V_{CC} = 2.75, T_A = 25° C)

Characteristic	Symbol	Min	Typ	Max	Unit
Noise Figure 900 MHz 1.9 GHz 2.4 GHz	NF	 - - -	 1.2 1.38 1.55	 - - -	dB
Input IP3 (900 MHz) Low IP3 High IP3 Bypass	IIP3	 - - -	 -3 2 27	 - - -	dBm
Input IP3 (1.9 GHz) Low IP3 High IP3 Bypass	IIP3	 - - -	 4.0 10 29	 - - -	dBm
Input IP3 (2.4 GHz) Low IP3 High IP3 Bypass	IIP3	 - - -	 6.0 13 25	 - - -	dBm
Output 1 dB Compression (900 MHz) Low IP3 High IP3 Bypass	P_{1dB}	 - - -	 12 11.5 5.0	 - - -	dBm
Output 1 db Compression (1.9 GHz) Low IP3 High IP3 Bypass	P_{1dB}	 - - -	 11 11.5 5.0	 - - -	dBm
Output 1 dB Compression (2.4 GHz) Low IP3 High IP3 Bypass	P_{1dB}	 - - -	 14 14 5.0	 - - -	dBm
Reverse Isolation Low IP3 High IP3	$\lvert S_{12} \rvert$	 - -	 25 20	 - -	dB

Table 5. Truth Table

EN1	EN2	State	Current Consumption
Low	Low	Standby	< 20 µA
Low	High	Bypass	0 µA
High	Low	High IP3	11 mA (approx.)
High	High	Low IP3	5.0 mA (approx.)

Note: Logic state of “high” equals V_{CC} voltage. Logic state of “low” equals ground potential.

4 Parameters

Table 6. High IP3 Mode Scattering Parameters
(V_{CC} = 2.7 V, EN1 = High, EN2 = Low)

f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{11}\rvert$	∠ φ
100	0.661	-8	21.189	161	0.010	36	0.829	-6
200	0.629	-14	18.913	146	0.014	54	0.801	-10
300	0.583	-20	16.730	134	0.019	61	0.764	-14
400	0.544	-21	14.168	123	0.024	67	0.726	-15
500	0.526	-23	12.141	116	0.029	71	0.709	-16
600	0.502	-25	10.757	111	0.034	73	0.690	-17
700	0.486	-26	9.523	106	0.039	75	0.676	-18
800	0.473	-27	8.531	101	0.044	76	0.665	-19
900	0.464	-28	7.725	98	0.050	77	0.656	-20
1000	0.457	-29	7.028	94	0.056	78	0.650	-21
1100	0.450	-30	6.461	92	0.061	79	0.643	-22
1200	0.446	-31	5.990	89	0.067	79	0.639	-23
1300	0.445	-32	5.551	86	0.073	80	0.634	-24
1400	0.443	-33	5.226	84	0.079	80	0.632	-25
1500	0.440	-35	4.903	82	0.085	80	0.628	-26
1600	0.437	-35	4.611	80	0.091	80	0.626	-27
1700	0.439	-37	4.370	78	0.097	80	0.623	-28
1800	0.439	-38	4.160	76	0.103	81	0.622	-29
1900	0.437	-40	3.981	74	0.111	81	0.618	-31
2000	0.440	-41	3.822	73	0.117	81	0.617	-32
2100	0.439	-42	3.675	71	0.124	81	0.613	-34
2200	0.443	-44	3.530	69	0.132	81	0.612	-35
2300	0.444	-45	3.416	68	0.140	82	0.611	-37
2400	0.448	-48	3.322	66	0.149	82	0.608	-38
2500	0.452	-50	3.236	64	0.159	81	0.605	-41
2600	0.456	-52	3.151	63	0.169	82	0.600	-43
2800	0.460	-57	3.032	59	0.193	81	0.589	-48
3000	0.472	-65	2.943	55	0.223	80	0.573	-54

Table 7. Bypass Mode Scattering Parameters
(V_{CC} = 2.7 V, EN1 = Low, EN2 = High)

f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	$\|S_{11}\|$	$\angle \phi$	$\|S_{11}\|$	$\angle \phi$	$\|S_{11}\|$	$\angle \phi$	$\|S_{11}\|$	$\angle \phi$
100	0.958	-11	0.115	79	0.116	80	0.950	-8
200	0.921	-21	0.222	70	0.224	70	0.925	-16
300	0.881	-30	0.318	61	0.319	61	0.889	-23
400	0.832	-38	0.399	53	0.396	53	0.849	-29
500	0.786	-45	0.457	45	0.462	46	0.806	-35
600	0.737	-52	0.515	39	0.513	39	0.764	-41
700	0.693	-57	0.552	33	0.553	33	0.724	-45
800	0.654	-63	0.585	28	0.584	28	0.689	-49
900	0.618	-67	0.610	23	0.609	23	0.655	-53
1000	0.587	-72	0.626	19	0.627	19	0.626	-57
1100	0.561	-76	0.642	16	0.643	15	0.598	-61
1200	0.533	-80	0.655	12	0.654	12	0.573	-64
1300	0.514	-83	0.660	9.0	0.663	8	0.549	-67
1400	0.493	-87	0.673	6.0	0.669	5	0.527	-71
1500	0.478	-90	0.672	2.0	0.673	2	0.506	-74
1600	0.461	-93	0.674	-1.0	0.676	-1	0.486	-78
1700	0.449	-96	0.675	-4.0	0.677	-4	0.468	-82
1800	0.435	-99	0.673	-7.0	0.675	-6	0.448	-85
1900	0.427	-102	0.671	-9.0	0.673	-9	0.431	-89
2000	0.421	-104	0.668	-11	0.670	-11	0.413	-93
2100	0.412	-107	0.663	-14	0.664	-14	0.397	-98
2200	0.407	-110	0.655	-16	0.658	-16	0.380	-103
2300	0.401	-114	0.647	-19	0.648	-19	0.364	-109
2400	0.396	-117	0.634	-21	0.638	-21	0.347	-115
2500	0.396	-121	0.622	-23	0.623	-23	0.335	-122
2600	0.396	-124	0.608	-25	0.609	-26	0.319	-130
2800	0.393	-132	0.569	-29	0.571	-29	0.294	-147
3000	0.397	-142	0.527	-32	0.528	-32	0.276	-167

Table 8. Standby Mode Scattering Parameters
(V_{CC} = 2.7 V, EN1 = Low, EN2 = Low)

f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	$\lvert S_{11}\rvert$	$\angle\phi$	$\lvert S_{11}\rvert$	$\angle\phi$	$\lvert S_{11}\rvert$	$\angle\phi$	$\lvert S_{11}\rvert$	$\angle\phi$
100	0.963	-4	0.010	35	0.010	43	0.951	-3
200	0.953	-7	0.014	61	0.016	61	0.948	-4
300	0.949	-10	0.022	71	0.022	68	0.947	-6
400	0.945	-13	0.029	76	0.029	72	0.945	-8
500	0.943	-16	0.036	75	0.036	74	0.944	-10
600	0.937	-19	0.043	70	0.043	74	0.941	-12
700	0.932	-21	0.050	76	0.049	74	0.938	-15
800	0.926	-24	0.054	74	0.056	74	0.935	-16
900	0.920	-27	0.062	75	0.063	73	0.932	-19
1000	0.914	-30	0.069	72	0.069	73	0.928	-21
1100	0.911	-33	0.075	72	0.075	72	0.923	-23
1200	0.903	-36	0.082	71	0.081	71	0.919	-25
1300	0.897	-38	0.086	72	0.087	70	0.913	-27
1400	0.892	-41	0.094	69	0.092	70	0.908	-29
1500	0.885	-44	0.097	69	0.097	69	0.902	-31
1600	0.877	-47	0.101	68	0.102	69	0.894	-33
1700	0.874	-50	0.104	68	0.106	69	0.887	-35
1800	0.861	-52	0.109	69	0.110	69	0.878	-37
1900	0.855	-55	0.115	69	0.115	69	0.868	-39
2000	0.850	-58	0.120	69	0.118	69	0.857	-42
2100	0.841	-61	0.120	70	0.122	70	0.845	-44
2200	0.831	-64	0.127	71	0.126	71	0.832	-46
2300	0.821	-67	0.132	72	0.132	73	0.816	-49
2400	0.808	-70	0.138	74	0.138	74	0.798	-52
2500	0.797	-73	0.146	75	0.146	76	0.776	-55
2600	0.784	-76	0.155	79	0.156	78	0.751	-58
2800	0.751	-82	0.183	80	0.184	81	0.688	-64
3000	0.720	-89	0.222	82	0.225	81	0.609	-70

Table 9. Low IP3 Noise Parameters
(V_{CC} = 2.7 V, EN1 = High, EN2 = High)

f (MHz)	Fmin (dB)	Mag	Ang	Rn	Ga (dB)
400	0.57	0.26	15.5	0.19	25.3
410	0.57	0.26	15.7	0.19	24.93
420	0.58	0.26	16	0.19	24.8
430	0.58	0.26	16.2	0.19	24.68
440	0.59	0.26	16.5	0.19	24.56
450	0.59	0.26	16.7	0.19	24.44
460	0.59	0.26	16.9	0.19	24.32
470	0.6	0.26	17.2	0.19	24.2
480	0.6	0.26	17.4	0.19	24.09
490	0.6	0.26	17.7	0.19	23.97
500	0.61	0.26	17.9	0.19	23.85
550	0.63	0.26	19.1	0.19	23.01
600	0.64	0.26	20.3	0.19	22.59
650	0.66	0.25	21.5	0.19	22.16
700	0.67	0.25	22.7	0.19	21.74
750	0.69	0.25	23.9	0.19	21.32
800	0.7	0.25	25.1	0.19	20.89
850	0.72	0.24	26.4	0.19	20.47
900	0.73	0.24	27.6	0.19	20.05
1000	0.76	0.24	30	0.19	19.2

Table 10. High IP3 Noise Parameters
(V_{CC} = 2.7 V, EN1 = High, EN2 = Low)

f (MHz)	Fmin (dB)	Mag	Ang	Rn	Ga (dB)
400	0.65	0.2	5.5	0.22	26.21
410	0.65	0.2	6.1	0.22	26.06
420	0.65	0.2	6.7	0.22	25.91
430	0.66	0.19	7.3	0.21	25.76
440	0.66	0.19	7.9	0.21	25.61
450	0.66	0.19	8.5	0.21	25.46
460	0.66	0.19	9.1	0.21	25.31
470	0.66	0.19	9.7	0.21	25.16

Table 10. High IP3 Noise Parameters (continued)
(V_{CC} = 2.7 V, EN1 = High, EN2 = Low)

f (MHz)	Fmin (dB)	Mag	Ang	Rn	Ga (dB)
480	0.67	0.18	10.3	0.2	25.01
490	0.67	0.18	10.9	0.2	24.87
500	0.67	0.18	11.5	0.2	24.54
550	0.68	0.17	14.5	0.19	24.06
600	0.69	0.16	17.5	0.19	23.59
650	0.7	0.15	20.5	0.18	23.12
700	0.71	0.14	23.5	0.18	22.65
750	0.72	0.13	26.5	0.17	22.17
800	0.73	0.12	29.4	0.17	21.7
850	0.74	0.11	32.4	0.16	21.23
900	0.75	0.1	35.4	0.16	20.76
1000	0.77	0.09	41.4	0.15	19.81

5 Application Information

The MBC13720 SiGe:C LNA is designed for applications in the 400 MHz to 2.4 GHz range. It has four different modes: Low IP3, High IP3, Bypass, and Standby. The IC is programmable through the Enable 1 and Enable 2 pins. In Low IP3 mode, current consumption is optimized. Current consumption is higher in High IP3 mode to boost the intercept point performance. The gain difference between Low IP3 and High IP3 modes is typically 1.0 dB; and typically the Low IP3 mode has a slightly better noise figure performance.

The internal bypass switch is designed for broadband applications. One of the advantages of the MBC13720 is the simplification of the matching network in both bypass and amplifier modes. The bypass switch is designed so that changes of input and output return losses between bypass mode and amplifier mode are minimized. As a result, the mismatch at the LNA input and output is minimized and the matching network design is simplified.

In the design of the external matching network, conjugate matching does not necessarily provide the best noise figure performance. Balancing between noise figure, gain, and intercept point is the major design consideration. Typical circuits are provided in Figure 2 and Figure 3 for 1.9 GHz, 2.4 GHz and 900 MHz applications.

Figure 2 shows the typical application circuit at 1.9 and 2.4 GHz. The noise figure, input intercept point, gain, and return losses are optimized. L1 and C2 act as a low frequency trap to improve the input intercept point.

In Figure 3, the typical application circuit for 900 MHz is shown. The input low frequency trap again is used to maximize the input intercept point. It has moderate IP3 performance and high gain. Figure 4 shows the 900 MHz application circuit with feedback network for higher IP3. Capacitive feedback is used to increase the 3rd order input intercept point while decreasing gain and provides unconditional stability.

The corresponding PCBs are shown in Figure 5 through Figure 7. Table 11 lists the bill of materials for the 1900 MHz, 900 MHz, and High IP3 900 MHz application circuits. Typical characteristics of the application boards are shown in Table 12.

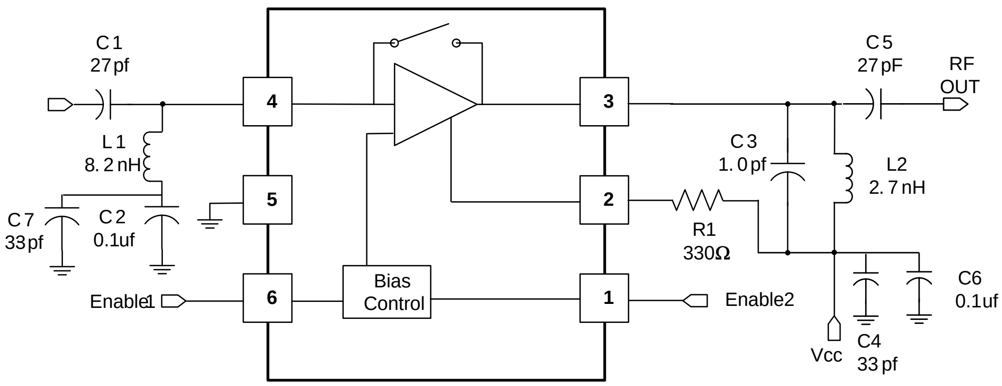


Figure 2. Typical 1.9 and 2.4 GHz LNA Application Schematic

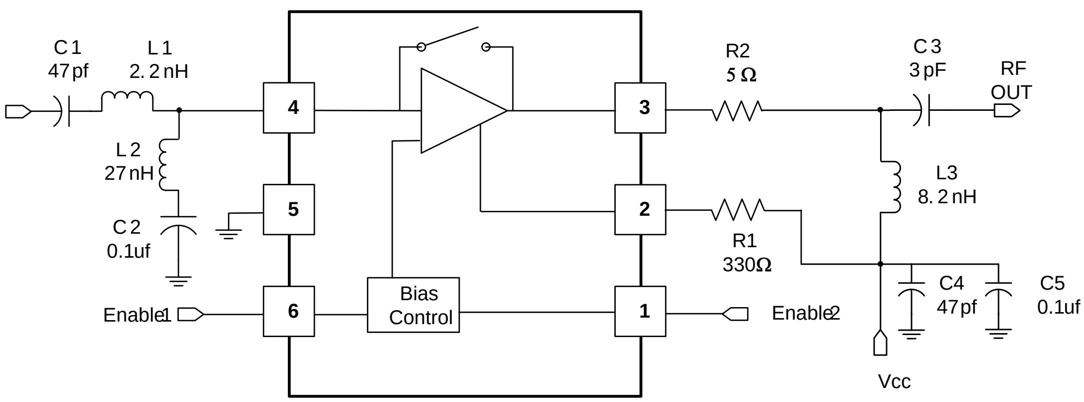


Figure 3. Typical 900 MHz LNA Application Schematic

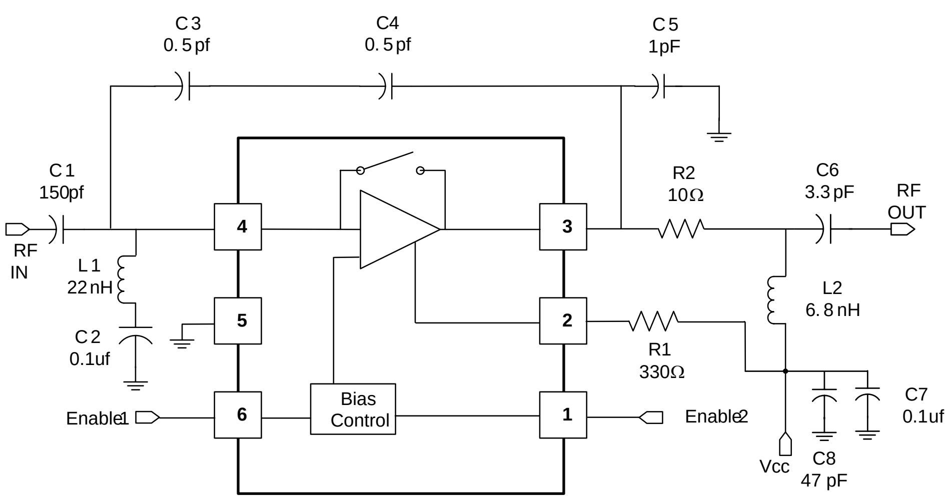


Figure 4. High IP3 900 MHz LNA Application Schematic

Table 11. Bill of Materials for the Application Circuits[1]

Component	Value	Case	Manufacturer	Comments
1900 MHz Figure 2 Application Circuit				
C1	27 pF	0402	Murata	DC Block, Input match
C2	0.1 uF	0603	Murata	Low freq bypass
C3	1.0 pF	0402	Murata	Output match
C4	33 pF	0402	Murata	Low freq bypass
C5	27 pF	0402	Murata	DC Block, Output match
C6	0.1 uF	0603	Murata	Low freq bypass
C7	33 pF	0402	Murata	RF bypass
L1	8.2 nH	0402	Toko	Low freq bypass
L2	2.7 nH	0402	Toko	DC feed, Output match
R1	330 ohm	0402	KOA	Bias
Q1	MBC13720	SOT363	Freescale	Freescale SiGe LNA
900 MHz Figure 3 Application Circuit				
C1	47 pF	0402	Murata	DC Block, Input match
C2	0.1 uF	0603	Murata	Low freq bypass
C3	3.0 pF	0402	Murata	DC block, Output match
C4	47 pF	0402	Murata	900 MHz short
C5	0.1 uF	0603	Murata	Low freq bypass
L1	2.2 nH	0402	Toko	Input match
L2	27 nH	0402	Toko	Input match
L3	8.2 nH	0402	Toko	Output match, bias decouple
R1	330 ohm	0402	KOA	Bias
R2	5 ohm	0402	KOA	Stability
Q1	MBC13720	SOT363	Freescale	Freescale SiGe LNA
High IP3 900 MHz Figure 4 Application Circuit				
C1	150 pF	402	Murata	DC Block, Input match
C2	0.1 uF	0603	Murata	Low freq bypass
C3	0.5 pF	402	Murata	IP3 improvement
C4	0.5 pF	402	Murata	IP3 improvement
C5	1.0 pF	402	Murata	RF bypass
C6	3.3 pF	402	Murata	Output match
C7	0.1 uF	0603	Murata	Low freq bypass
C8	47 pF	0402	Murata	RF Bypass

Table 11. Bill of Materials for the Application Circuits[1] (continued)

Component	Value	Case	Manufacturer	Comments
L1	22 nH	402	Toko	Input match
L2	6.8 nH	402	Toko	DC feed, output match
R1	330 ohm	402	KOA	Bias
R2	10 ohm	402	KOA	Stability
Q1	MBC13720	SOT363	Freescale	Freescale SiGe LNA

[1] All components are RoHS compliant.

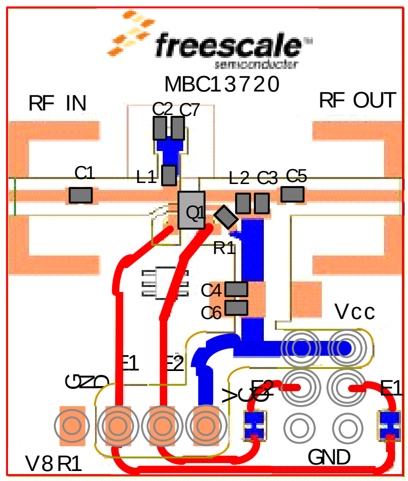


Figure 5. 1.9/2.4 GHz Assembly Diagram

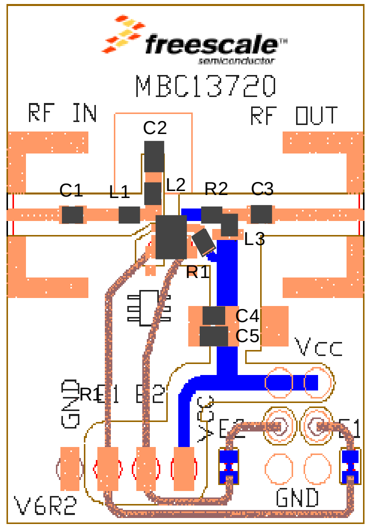


Figure 6. 900 MHz Assembly

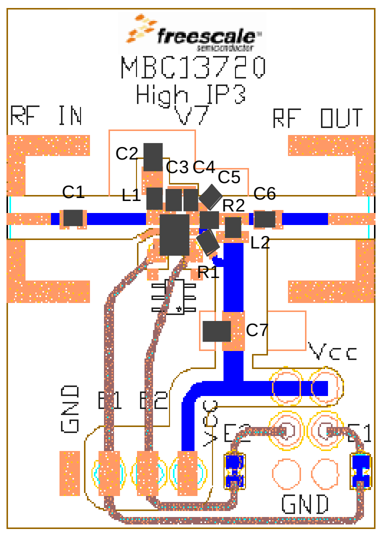


Figure 7. 900 MHz Capacitive Feedback Assembly Diagram

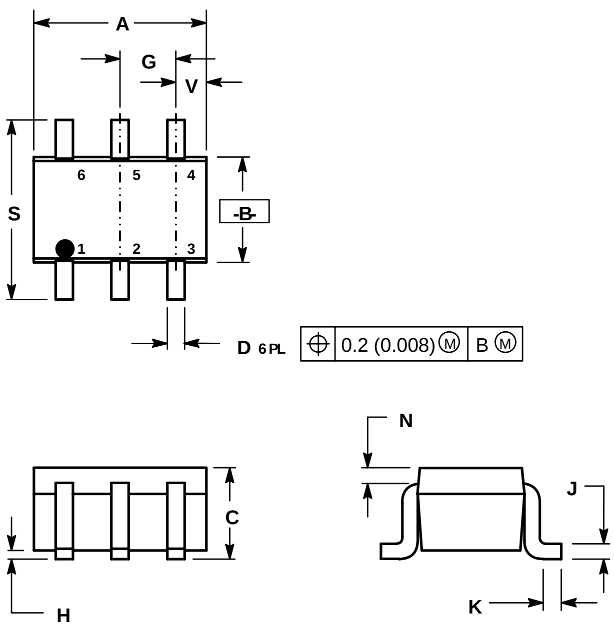
Table 12. Typical Electrical Characteristics of the Application Circuits

Mode	Symbol	High IP3	Low IP3	Bypass	Standby	Unit
900 MHz TYPICAL (See Figure 3)						
Gain	G	20	19	-2.9	-22	dB
Noise Figure	NF	1.3	1.2	2.9	-	dB
Input Intermodulation Intercept Point	IIP3	2.0	-3.0	29	-	dBm

Table 12. Typical Electrical Characteristics of the Application Circuits (continued)

Mode	Symbol	High IP3	Low IP3	Bypass	Standby	Unit
Output Intermodulation Intercept Point	OIP3	23	17	26	-	dBm
Output 1dB Compression Point	P_{1dB}	11.5	10.5	5.0	-	dBm
Input Return Loss	$\lvert S_{11}\rvert^2$	11	10	12	-	dB
Output Return Loss	$\lvert S_{22}\rvert^2$	11	10	15	-	dB
Reverse Isolation	$\lvert S_{12}\rvert^2$	25	24	2.9	22	dB
900 MHz HIGH IP3 (See Figure 4)						
Gain	G	16	15	-4.0	-14.5	dB
Noise Figure	NF	1.4	1.3	4.0	-	dB
Input Intermodulation Intercept Point	IIP3	10	2.0	27	-	dBm
Output Intermodulation Intercept Point	OIP3	26	18.5	23	-	dBm
Output 1 dB Compression Point	P_{1dB}	11.5	12	5.0	-	dBm
Input Return Loss	$\lvert S_{11}\rvert^2$	12	11	8.0	-	dB
Output Return Loss	$\lvert S_{22}\rvert^2$	12	12	14	-	dB
Reverse Isolation	$\lvert S_{12}\rvert^2$	22	20	4.0	14.5	dB
1.9 GHz (See Figure 2)						
Gain	G	14	13	-2.5	-16	dB
Noise Figure	NF	1.5	1.4	2.5	-	dB
Input Intermodulation Intercept Point	IIP3	10	4.0	29	-	dBm
Output Intermodulation Intercept Point	OIP3	24.4	17	26.5	-	dBm
Output 1dB Compression Point	P_{1dB}	11.5	11	5.0	-	dBm
Input Return Loss	$\lvert S_{11}\rvert^2$	10	8.0	20	-	dB
Output Return Loss	$\lvert S_{22}\rvert^2$	8.0	7.0	30	-	dB
Reverse Isolation	$\lvert S_{12}\rvert^2$	19	19	2.5	16	dB
2.4 GHz (See Figure 2)						
Gain	G	12	11	-2.8	-15	dB
Noise Figure	NF	1.7	1.55	2.8	-	dB
Input Intermodulation Intercept Point	IIP3	13	6.0	25	-	dBm
Output Intermodulation Intercept Point	OIP3	25	17.5	22	-	dBm
Output 1dB Compression Point	P_{1dB}	14	14	5.0	-	dBm
Input Return Loss	$\lvert S_{11}\rvert^2$	12	10	12	-	dB
Output Return Loss	$\lvert S_{22}\rvert^2$	8.0	7.0	14	-	dB
Reverse Isolation	$\lvert S_{12}\rvert^2$	17	17	2.8	15	dB

6 Packaging



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.071	0.087	1.80	2.20
B	0.045	0.053	1.15	1.35
C	0.031	0.043	0.80	1.10
D	0.004	0.012	0.10	0.30
G	0.026 BSC		0.65 BSC	
H	---	0.004	---	0.10
J	0.004	0.010	0.10	0.25
K	0.004	0.012	0.10	0.30
N	0.008 REF		0.20 REF	
S	0.079	0.087	2.00	2.20
V	0.012	0.016	0.30	0.40

Figure 8. Outline Dimensions for SOT-363 (Case Outline 419B-01, Issue G)

7 Product Documentation

This data sheet is labeled as a particular type: Product Preview, Advance Information, or Technical Data. Definitions of these types are available at: http://www.freescale.com on the documentation page.

Table 13 summarizes revisions to this document since the previous release (Rev. 3.3).

Table 13. Revision History

Location	Revision
Table 4 Electrical Characteristics Measured in Frequency Specific Tuned Circuits	Updated RF Gain.
Table 12 Typical Electrical Characteristics of the Application Circuits	Updated Gain under 900 MHz TYPICAL.

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