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MBC13720

The RF Building Block Series

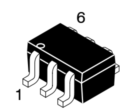
SiGe:C Low Noise Amplifier with Bypass Switch

SiGe:C LNA
WITH BYPASS SWITCH

SEMICONDUCTOR
TECHNICAL DATA

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

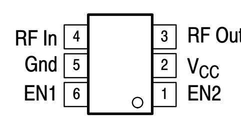
- Selectable Current, 5.0 mA or 11 mA
- Standby Mode to Turn Off Device Completely
- High Input IP3:
  - 10 dBm @ 1.9 GHz
  - 13 dBm @ 2.4 GHz
- Low Noise Figure:
  - 1.38 dB @ 1.9 GHz
  - 1.55 dB @ 2.4 GHz
- Gain @ 9.0 mA, 2.75 V:
  - 14.5 dB @ 1.9 GHz
  - 12 dB @ 2.4 GHz
- Suitable for use from 400 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



(Scale 4:1)

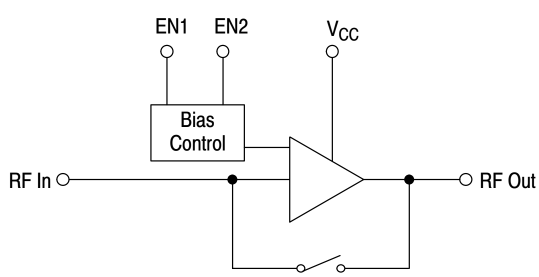
PLASTIC PACKAGE
CASE 419B
(SOT–363)

PIN CONNECTIONS



(Top View)

Simplified Block Diagram



ORDERING INFORMATION

Device	Device Marking	Package
MBC13720T1	20	SOT–363

MAXIMUM RATINGS

Rating	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

NOTES: 1. Maximum Ratings are those values beyond which damage to the device may occur. Functional operation should be restricted to the limits in the Recommended Operating Conditions and Electrical Characteristics tables.
2. ESD (electrostatic discharge) immunity meets Human Body Model (HBM) ≤550 V and Machine Model (MM) ≤50 V. Additional EST data available upon request.

RECOMMENDED OPERATING CONDITIONS

Characteristic	Symbol	Min	Typ	Max	Unit
Operating Voltage	V_{CC}	2.5	2.7	3.0	V
Frequency Range	f_{RF}	400	–	2400	MHz

ELECTRICAL CHARACTERISTICS (V_{CC} = 2.75 V, T_A = 25°C, unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Current Consumption	I_{CC}				
Low IP3		–	5.0	–	mA
High IP3		–	11	–	mA
Bypass		–	0	–	µA
Input/Output Return Loss	RL				dB
Low IP3		–	10	–	
High IP3		–	10	–	
Bypass		–	12	–	
RF Gain (900 MHz)	G				dB
Low IP3		–	20	–	
High IP3		–	21	–	
Bypass		–	–2.9	–	
RF Gain (1.9 GHz)	G				dB
Low IP3		–	13	–	
High IP3		–	14.5	–	
Bypass		–	–2.5	–	
RF Gain (2.4 GHz)	G				dB
Low IP3		–	11.5	–	
High IP3		–	12	–	
Bypass		–	–2.8	–	
Noise Figure	NF				dB
900 MHz		–	1.2	–	
1.9 GHz		–	1.38	–	
2.4 GHz		–	1.55	–	
Input IP3 (900 MHz)	IIP3				dBm
Low IP3		–	–3.5	–	
High IP3		–	10	–	
Bypass		–	27	–	
Input IP3 (1.9 GHz)	IIP3				dBm
Low IP3		–	4.0	–	
High IP3		–	10	–	
Bypass		–	29	–	
Input IP3 (2.4 GHz)	IIP3				dBm
Low IP3		–	6.0	–	
High IP3		–	13	–	
Bypass		–	25	–	

ELECTRICAL CHARACTERISTICS (V_{CC} = 2.75 V, T_A = 25°C, unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Output 1dB Compression (900 MHz)	P_{1dB}				dBm
Low IP3		–	12	–	
High IP3		–	11.5	–	
Bypass		–	5.0	–	
Output 1db Compression (1.9 GHz)	P_{1dB}				dBm
Low IP3		–	11	–	
High IP3		–	11.5	–	
Bypass		–	5.0	–	
Output 1dB Compression (2.4 GHz)	P_{1dB}				dBm
Low IP3		–	14	–	
High IP3		–	14	–	
Bypass		–	5.0	–	
Reverse Isolation	$\|S_{12}\|$				dB
Low IP3		–	25	–	
High IP3		–	20	–	

Table 1. Truth Table

EN1	EN2	State	Current Consumption
0	0	Standby	< 20 μA
0	1	Bypass	0 μA
1	0	High IP3	11 mA (approx.)
1	1	Low IP3	5.0 mA (approx.)

NOTE: Logic state of ″1″ equals V_{CC} voltage. Logic state of ″0″ equals ground potential.

Table 2. Low IP3 Mode Scattering Parameters
(V_{CC} = 2.7 V, EN1 = High, EN2= High)

f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
100	0.811	–7	11.939	168	0.010	39	0.890	–5
200	0.787	–14	11.375	157	0.015	55	0.875	–9
300	0.756	–20	10.789	148	0.021	61	0.853	–12
400	0.706	–24	9.892	138	0.026	65	0.819	–15
500	0.673	–28	8.949	131	0.031	68	0.796	–17
600	0.636	–31	8.293	125	0.036	69	0.772	–19
700	0.602	–34	7.590	119	0.040	70	0.750	–21
800	0.575	–36	6.987	114	0.045	72	0.732	–22
900	0.553	–38	6.457	109	0.050	73	0.716	–24
1000	0.531	–39	5.972	105	0.055	74	0.702	–25
1100	0.514	–40	5.566	101	0.060	75	0.690	–26
1200	0.500	–42	5.218	98	0.065	76	0.680	–27
1300	0.488	–43	4.884	95	0.070	77	0.671	–28
1400	0.477	–44	4.629	92	0.075	77	0.664	–29
1500	0.469	–45	4.373	89	0.081	78	0.657	–30
1600	0.458	–46	4.136	87	0.087	79	0.651	–31
1700	0.455	–47	3.938	84	0.093	79	0.645	–32
1800	0.450	–48	3.762	82	0.099	80	0.641	–33
1900	0.445	–49	3.614	80	0.105	80	0.636	–34
2000	0.442	–50	3.479	78	0.112	81	0.631	–35
2100	0.440	–51	3.352	76	0.119	81	0.625	–37
2200	0.438	–52	3.223	74	0.126	82	0.621	–38
2300	0.440	–53	3.127	72	0.135	82	0.619	–39
2400	0.440	–55	3.044	70	0.144	82	0.615	–41
2500	0.443	–57	2.966	68	0.154	82	0.610	–43
2600	0.446	–59	2.886	66	0.165	83	0.603	–45
2800	0.447	–64	2.778	62	0.189	83	0.589	–50
3000	0.458	–71	2.691	58	0.221	82	0.570	–56

Table 3. High IP3 Mode Scattering Parameters
(V_{CC} = 2.7 V, EN1 = High, EN2= Low)

f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	$\|S_{11}\|$	$\angle \phi$	$\|S_{21}\|$	$\angle \phi$	$\|S_{12}\|$	$\angle \phi$	$\|S_{22}\|$	$\angle \phi$
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 4. Bypass Mode Scattering Parameters
(V_{CC} = 2.7 V, EN1 = Low, EN2= High)

f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
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 5. Standby Mode Scattering Parameters
(V_{CC} = 2.7 V, EN1 = Low, EN2= Low)

f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	$\|S_{11}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{22}\|$	$\angle\phi$
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

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 2 pins. In Low IP3 mode, the 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 matching network in both bypass and amplifier modes. The bypass switch is designed such that the changes of input and output return losses between bypass mode and amplifier mode is minimized. As a result, the mismatch at the LNA input and output is minimized and therefore, the matching network design is simplified as well.

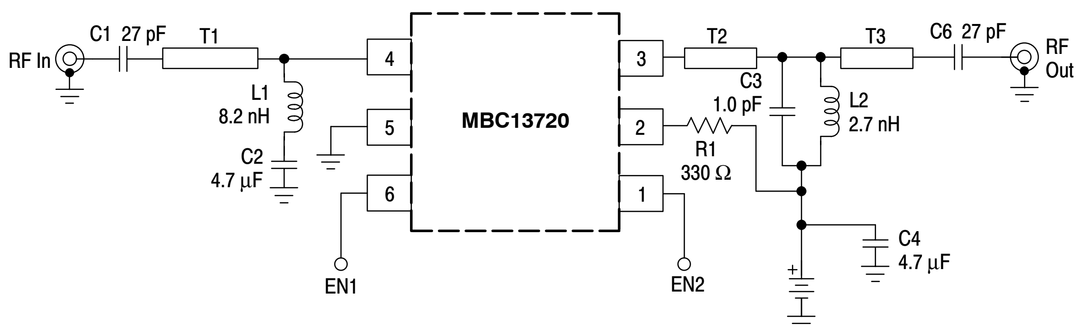
In the design of the external matching network, conjugate match condition does not necessarily provide the best noise figure performance. Balancing between noise figure, gain, and intercept point is the major design consideration. Typical circuits are provided in Figures 1 and 2 for 1.9 GHz, 2.4 GHz and 900 MHz applications.

In Figure 1, it shows the typical application circuit at 1.9 and 2.4 GHz. The noise figure, input intercept point, gain, and return losses are optimized. L2 and C2 act as a low frequency trap to improve the input intercept point. The noise figure measured on this board is 1.4 dB (in Low IP3 mode) at 1.9 GHz, including the external components, connectors, and PC board. The input third order intercept point is 10 dBm (in High IP3 mode).

In Figure 2, the typical application circuit at 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. For higher IP3, Figure 3 shows the application circuit with feedback network. Capacitive feedback method is used to reduce the gain and therefore increase the 3rd order input intercept point. The feedback circuit is designed to provide unconditional stability.

The corresponding PCBs are shown in Figures 4 through 9. Typical characteristics of the application boards are shown in Table 6.

Figure 1. Typical 1.9 and 2.4 GHz LNA Application Schematic



T1, T2, T3 = 50 Ω Microstrip Line @ 150 mils

Figure 2. Typical 900 MHz LNA Application Schematic

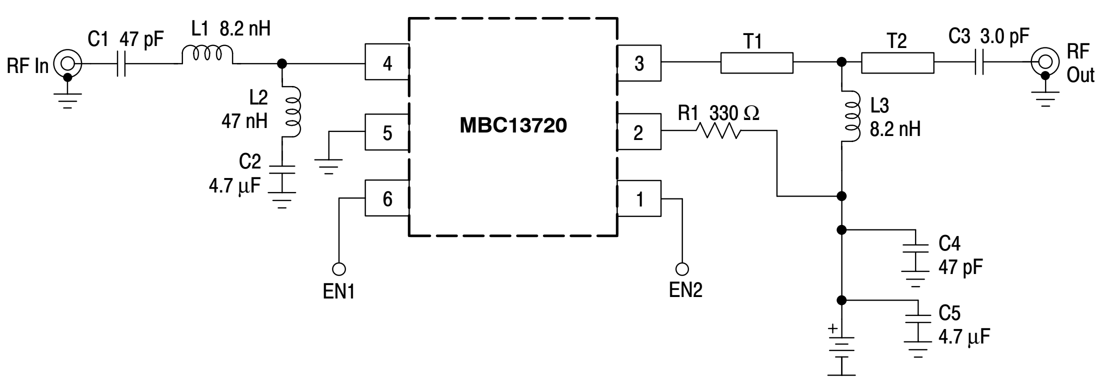


Figure 3. High IP3 900 MHz LNA Application Schematic

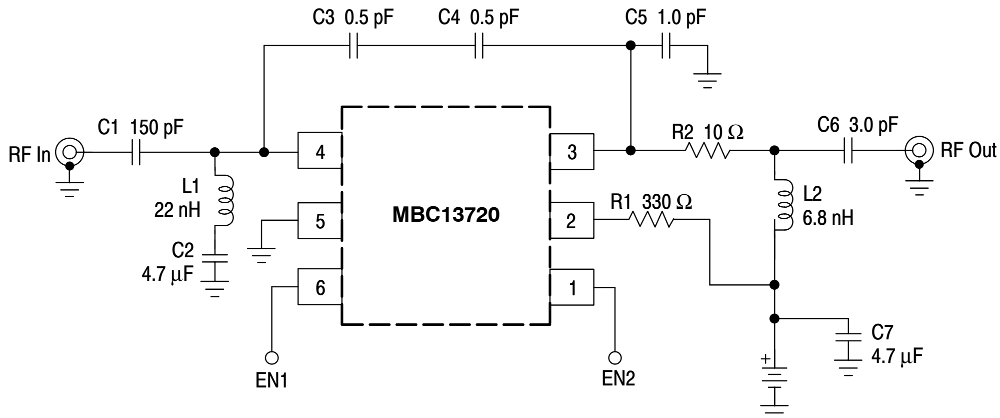


Figure 4. 1.9/2.4 GHz PCB

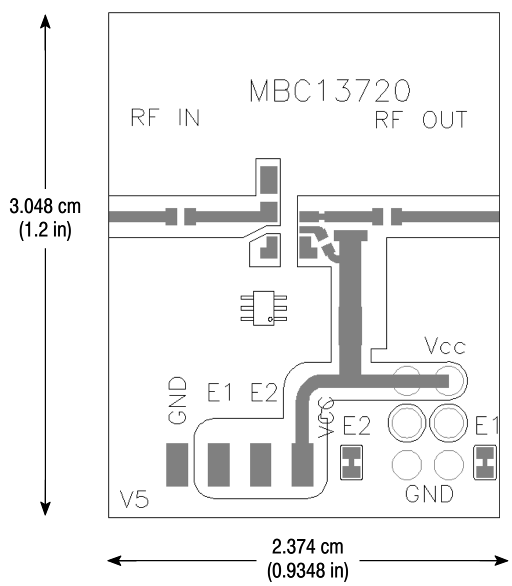


Figure 5. 1.9/2.4 GHz Assembly Diagram

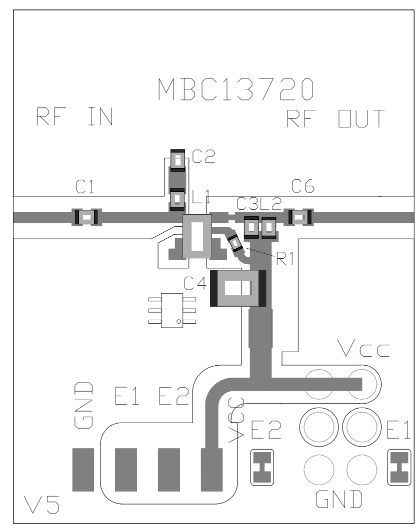


Figure 6. 900 MHz PCB

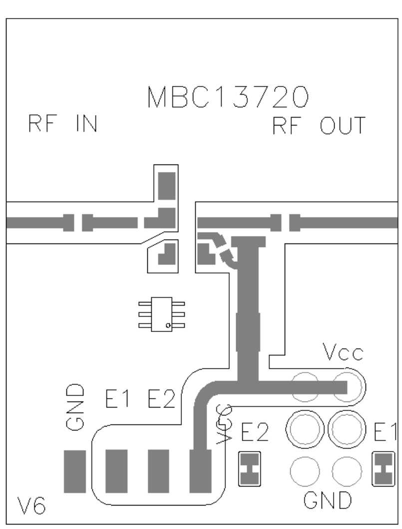
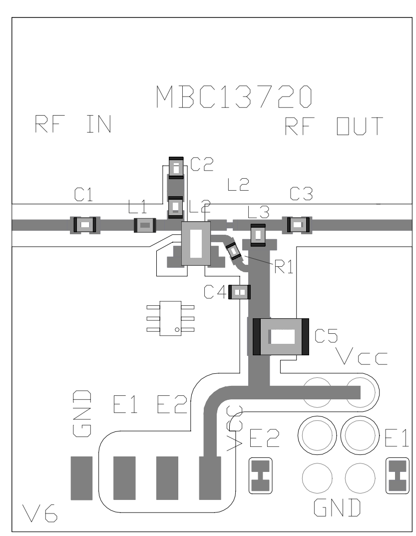


Figure 7. 900 MHz Assembly Diagram



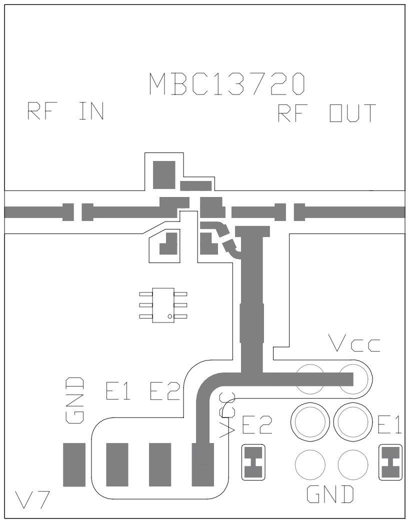


Figure 8. 900 MHz Capacitive Feedback PCB

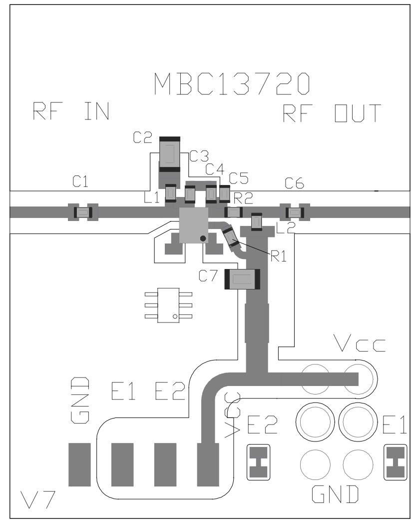


Figure 9. 900 MHz Capacitive Feedback Assembly Diagram

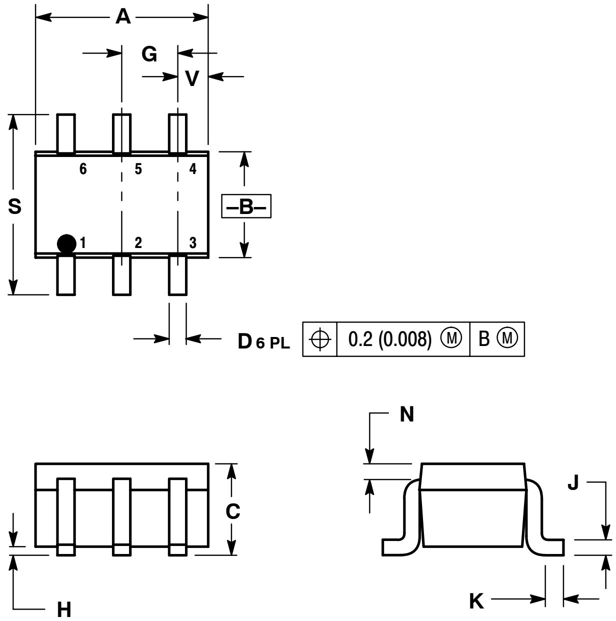
Table 6. Typical Electrical Characteristics of the Application Boards

Mode	Symbol	High IP3	Low IP3	Bypass	Standby	Unit
900 MHz TYPICAL (See Figure 2)						
Gain	G	21	20	–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
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	$\|S11\|^2$	11	10	12	–	dB
Output Return Loss	$\|S22\|^2$	11	10	15	–	dB
Reverse Isolation	$\|S12\|^2$	25	24	2.9	22	dB
900 MHz HIGH IP3 (See Figure 3)						
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	3.5	27	–	dBm
Output Intermodulation Intercept Point	OIP3	26	18.5	23	–	dBm
Output 1dB Compression Point	P_{1dB}	11.5	12	7.0	–	dBm
Input Return Loss	$\|S11\|^2$	12	11	8.0	–	dB
Output Return Loss	$\|S22\|^2$	12	12	14	–	dB
Reverse Isolation	$\|S12\|^2$	22	20	4.0	14.5	dB
1.9 GHz (See Figure 1)						
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	$\|S11\|^2$	10	8.0	20	–	dB
Output Return Loss	$\|S22\|^2$	8.0	7.0	30	–	dB
Reverse Isolation	$\|S12\|^2$	19	19	2.5	16	dB
2.4 GHz (See Figure 1)						
Gain	G	12	11	–2.8	–15	dB
Noise Figure	NF	1.7	1.65	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	$\|S11\|^2$	12	10	12	–	dB
Output Return Loss	$\|S22\|^2$	8.0	7.0	14	–	dB
Reverse Isolation	$\|S12\|^2$	17	17	2.8	15	dB

NOTE: PCB trace losses and connector losses are included in the measurement results.

OUTLINE DIMENSIONS

PLASTIC PACKAGE
CASE 419B–01
(SOT–363)
ISSUE G



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

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