MSF-86 Series
Silicon Bipolar MMIC
Frequency Converter

Features

- **Up or Down Frequency Conversion with up to 12 dB Conversion Gain**
- **RF Input from 0.1 to 2.0 GHz**
- **Low Phase Noise Self-Oscillating LO from 0.1 to 2.0 GHz Using External Tank Circuit**
- **Downconverted IF Output from DC to 0.5 GHz**
- **Uniform Performance**
- **Low Power Consumption per Function**
- **Low Cost per Function**
- **Low Bias Voltage**

Description

The MSF-86 Series is a family of silicon bipolar Monolithic Microwave Integrated Circuit (MMIC) Frequency Converters. These MMIC's are characterized as simple, 2-port active mixers with low power injected LO. They can also function as self-oscillating active mixers.

The MSF-86 Series is ideally suited for very low cost or size constrained designs where adequate conversion gain flatness, LO-RF and LO-IF isolation or spurious signal rejection can be achieved using simple external filters.

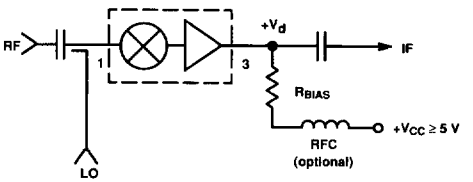
Typical applications include GPS navigation and INMARSAT receivers, mobile and cellular radio receivers, VHF/UHF converters, and communications and radar systems.

The MSF-86 Series is fabricated using a 10 GHz f_T silicon bipolar MMIC process that features sub-micrometer nitride self-alignment and ion-implantation to achieve excellent unit-to-unit uniformity. Biasing requires a fixed single polarity supply with an external current stabilizing resistor.

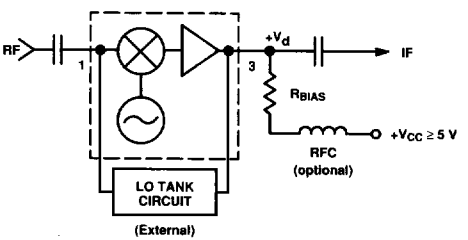
These MMIC's are offered in package styles suitable for industrial, military and commercial applications; model MSF-8635 is housed in a cost effective, glass sealed ceramic package, model MSF-8670 is in a high reliability, hermetically sealed gold-ceramic package, and model MSF-8685 is in a low cost, plastic package.

Functional Block Diagrams

2-Port Active Mixer



Self-Oscillating Mixer



Electrical Specifications, T_A = 25°C, I_d = 16 mA,[1] Z_O = 50 Ω
–20 dBm RF Input at 1.575 GHz and –8 dBm injected[2] LO at 1.4 GHz

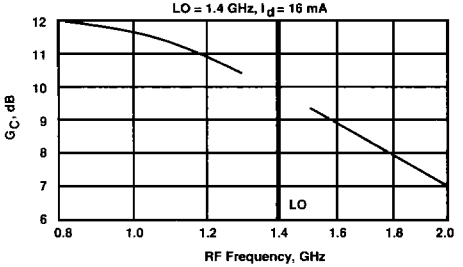
Symbol	Parameters/Test Conditions		Units	MSF-8635			MSF-8670			MSF-8685		
				Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.
G_C	Conversion Gain at 0.175 GHz IF	f = 1.575 GHz	dB	7.5	9.0		7.5	9.0		6.0	8.0	
$P_{1\ dB}$	Output Power at 1 dB Compression	f = 0.175 GHz	dBm		–2.5			–2.5			–2.5	
IP_3	3rd Order Output Intercept Point	f = 0.175 GHz	dBm		7.0			7.0			7.0	
NF	Single-Side-Band Noise Figure	f = 1.575 GHz	dB		15.0			15.0			16.0	
VSWR	Input VSWR	f = 0.1 to 1.5 GHz	–		1.4:1			1.9:1			1.5:1	
	Output VSWR	f = 0.1 to 1.5 GHz	–		1.3:1			1.8:1			1.4:1	
V_d	Device Voltage		V	3.2	3.5	3.8	3.2	3.5	3.8	3.2	3.5	3.8
dV/dT	Device Voltage Temp. Coefficient		mV/°C		–8.0			–8.0			–8.0	

Notes: 1. The recommended operating range for this device is 12 mA to 25 mA. Typical performance as a function of current is on the following page.
2. For the 2-port active mixer application, the LO power is specified at port 1 of the MMIC.

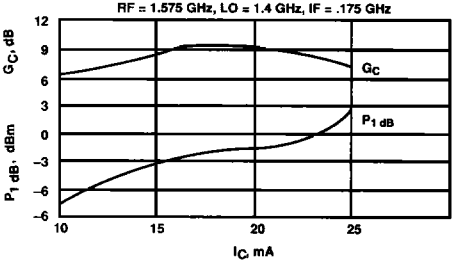
Typical Performance, T_A = 25°C

(unless otherwise noted)

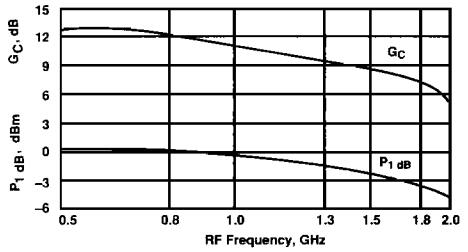
ACTIVE MIXER:
CONVERSION GAIN vs. RF FREQUENCY
LO = 1.4 GHz, I_d = 16 mA



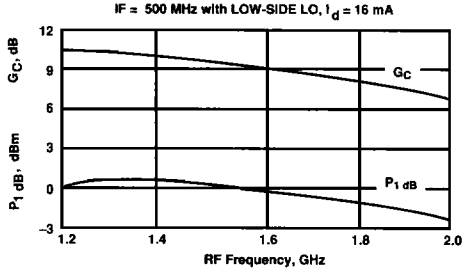
ACTIVE MIXER:
CONVERSION GAIN and OUTPUT POWER @ 1 dB
GAIN COMPRESSION vs. CURRENT
RF = 1.575 GHz, LO = 1.4 GHz, IF = .175 GHz



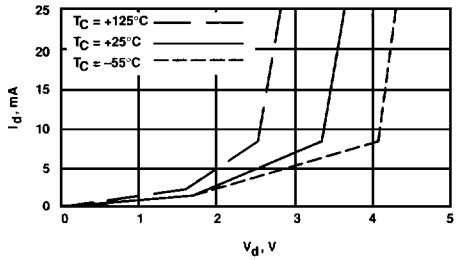
ACTIVE MIXER:
CONVERSION GAIN and IF OUTPUT POWER
@ 1 dB GAIN COMPRESSION vs. FREQUENCY
IF = 70 MHz with LOW-SIDE LO, I_d = 16 mA



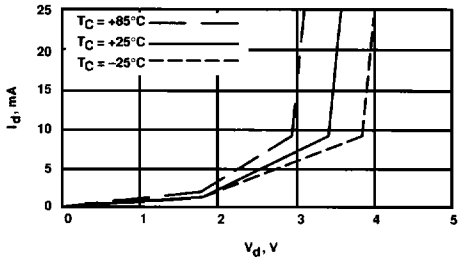
ACTIVE MIXER:
CONVERSION GAIN and IF OUTPUT POWER
@ 1 dB GAIN COMPRESSION vs. FREQUENCY
IF = 500 MHz with LOW-SIDE LO, I_d = 16 mA



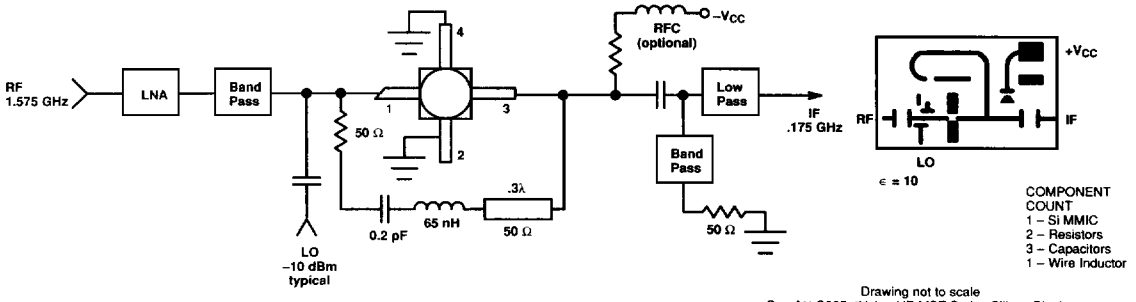
DEVICE CURRENT vs. VOLTAGE
MSF-8635, MSF-8670



DEVICE CURRENT vs. VOLTAGE
MSF-8685



EXAMPLE OF GPS DOWN CONVERTER USING MSF-86XX SERIES–CONVERSION GAIN = 8.5 dB AT 1.575 GHz WITH INJECTION-LOCKED SELF–OSCILLATING LO AT 1.4 GHz



COMPONENT
COUNT
1 – Si MMIC
2 – Resistors
3 – Capacitors
1 – Wire Inductor

Drawing not to scale
See AN-S005, "Using HP MSF Series Silicon Bipolar
MMIC Frequency Converters".

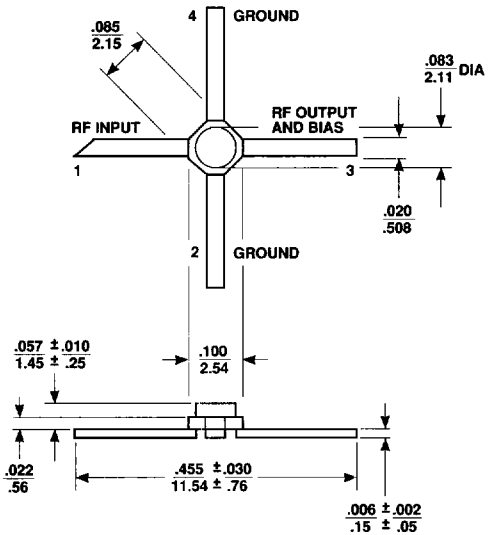
Absolute Maximum Ratings

Parameter	Absolute Maximum[1]		
	MSF-8635	MSF-8670	MSF-8685
Device Current	50 mA	50 mA	50 mA
Power Dissipation[2,4]	200 mW	200 mW	200 mW
RF Input Power	+20 dBm	+20 dBm	+20 dBm
Junction Temperature	200 °C	200 °C	150 °C
Storage Temperature	200 °C[3]	200 °C	150 °C
Thermal Resistance[4]	155 °C/W	130 °C/W	110 °C/W

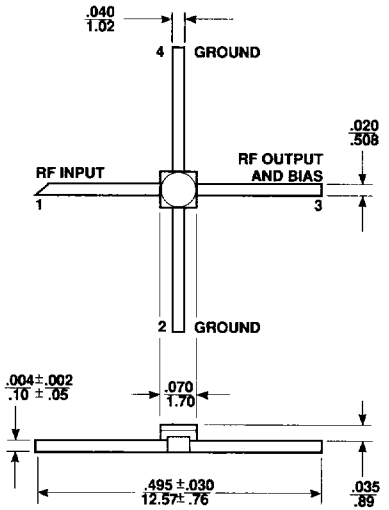
Notes:

1. Permanent damage may occur if any of these limits are exceeded.
2. Derate at 6.5 mW/°C for T_C > 169°C (MSF-8635); 7.7 mW/°C for T_C > 174°C (MSF-8870); 9.1 mW/°C for T_C > 128°C (MSF-8685).
3. Storage above +150°C may tarnish the leads of this package making it difficult to solder into a circuit.
4. T_{CASE} = 25°C.

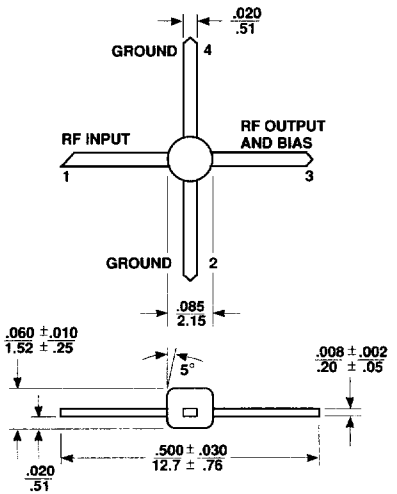
MSF-8635 micro-X package



MSF-8670 70 mil package



MSF-8685 85 mil plastic package



Notes:

1. Dimensions are in $\frac{\text{in}}{\text{mm}}$

2. Tolerances (unless otherwise specified)
   in: .xxx = ±.005
   mm: .xx = ±.13

Typical Scattering Parameters: MSF-8635

T_A = 25°C, I_d = 16 mA

Freq.	S_{11}		S_{21}			S_{12}			S_{22}		
GHz	Mag	Ang	dB	Mag	Ang	dB	Mag	Ang	Mag	Ang	k
0.1	.03	–178	20.5	10.59	171	–23.4	.068	5	.04	–44	1.05
0.2	.02	–177	20.3	10.31	161	–22.9	.071	8	.05	–68	1.04
0.3	.02	–164	20.0	9.96	152	–22.4	.076	14	.06	–87	1.04
0.4	.02	–116	19.6	9.55	144	–22.0	.079	19	.07	–104	1.03
0.5	.02	–100	19.2	9.08	136	–21.8	.081	21	.09	–114	1.04
0.6	.04	–89	18.7	8.59	128	–21.3	.086	24	.09	–123	1.04
0.8	.07	–96	17.7	7.66	115	–20.2	.098	29	.10	–140	1.03
1.0	.10	–108	16.6	6.79	103	–19.4	.107	31	.11	–156	1.02
1.5	.17	–134	14.2	5.13	79	–17.2	.138	30	.12	172	1.03
2.0	.24	–160	12.1	4.01	60	–15.8	.163	26	.12	148	1.04
2.5	.31	–178	10.3	3.26	48	–15.1	.175	27	.12	140	1.08
3.0	.37	166	8.7	2.72	34	–14.4	.190	24	.11	135	1.10
3.5	.42	151	7.4	2.33	21	–13.9	.203	19	.10	144	1.11
4.0	.46	139	6.2	2.04	9	–13.3	.216	16	.08	167	1.11
4.5	.48	126	5.1	1.81	–3	–12.8	.229	12	.08	–173	1.11
5.0	.52	110	4.2	1.62	–15	–12.2	.245	8	.09	–173	1.09

Typical Scattering Parameters: MSF-8670

T_A = 25°C, I_d = 16 mA

Freq.	S_{11}		S_{21}			S_{12}			S_{22}		
GHz	Mag	Ang	dB	Mag	Ang	dB	Mag	Ang	Mag	Ang	k
0.1	.05	–147	20.5	10.62	172	–23.3	.068	4	.05	–69	1.05
0.2	.07	–134	20.4	10.41	164	–23.0	.070	8	.09	–92	1.04
0.3	.09	–126	20.1	10.16	156	–22.6	.074	12	.13	–104	1.02
0.4	.11	–123	19.9	9.85	148	–22.4	.076	14	.16	–113	1.00
0.5	.13	–123	19.6	9.50	141	–22.0	.079	16	.20	–121	0.99
0.6	.15	–123	19.2	9.09	135	–21.8	.082	18	.22	–128	0.97
0.8	.19	–126	18.4	8.28	122	–20.7	.093	22	.25	–141	0.94
1.0	.24	–129	17.5	7.46	110	–19.8	.103	22	.27	–154	0.92
1.5	.31	–141	15.2	5.76	87	–18.2	.124	23	.27	–176	0.91
2.0	.38	–157	13.0	4.47	68	–17.2	.138	19	.24	166	0.94
2.5	.42	–167	11.1	3.59	57	–16.7	.146	20	.21	158	1.01
3.0	.46	178	9.5	2.97	45	–16.4	.152	16	.17	156	1.07
3.5	.48	173	7.9	2.49	33	–16.2	.155	11	.14	163	1.15
4.0	.48	164	6.6	2.13	22	–16.1	.156	9	.11	–175	1.27
4.5	.48	155	5.5	1.87	13	–15.9	.161	5	.11	–154	1.35
5.0	.48	143	4.5	1.67	3	–15.8	.163	3	.14	–141	1.46

Typical Scattering Parameters: MSF-8685

T_A = 25°C, I_d = 16 mA

Freq.	S_{11}		S_{21}			S_{12}			S_{22}		
GHz	Mag	Ang	dB	Mag	Ang	dB	Mag	Ang	Mag	Ang	k
0.1	.04	171	20.1	10.09	171	–22.5	.075	5	.04	–30	1.04
0.2	.02	–180	19.8	9.75	161	–22.4	.076	10	.05	–56	1.04
0.3	.02	–143	19.4	9.38	153	–22.2	.077	15	.07	–76	1.05
0.4	.03	–113	19.1	8.99	145	–21.8	.081	17	.08	–91	1.04
0.5	.05	–105	18.7	8.57	138	–21.3	.086	21	.10	–104	1.04
0.6	.07	–101	18.2	8.14	131	–20.7	.092	25	.11	–116	1.03
0.8	.10	–111	17.3	7.32	119	–19.7	.103	28	.13	–134	1.01
1.0	.13	–118	16.4	6.57	107	–18.8	.115	28	.14	–150	0.99
1.5	.21	–140	14.1	5.06	84	–17.1	.140	28	.15	180	1.00
2.0	.29	–163	12.0	3.98	65	–15.8	.163	26	.16	157	1.02
2.5	.34	–176	10.3	3.26	55	–15.2	.174	28	.16	150	1.06
3.0	.41	169	8.7	2.71	42	–14.8	.181	25	.15	143	1.10
3.5	.46	157	7.2	2.31	30	–14.2	.194	22	.13	144	1.11
4.0	.49	146	6.1	2.01	18	–13.8	.203	20	.10	156	1.13
4.5	.52	135	5.0	1.77	7	–13.4	.215	17	.09	173	1.14
5.0	.54	123	4.1	1.60	–3	–12.9	.226	15	.09	–178	1.14