VMMK-3603

1 - 6 GHz Positive Gain Slope Low Noise Amplifier in SMT Package

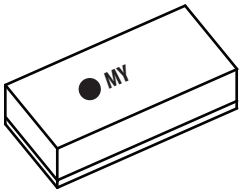
Data Sheet

Lead (Pb) Free
RoHS 6 fully
compliant

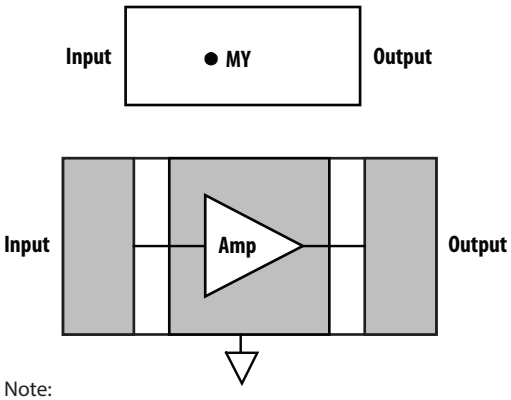
Description

The VMMK-3603 is a small and easy-to-use, broadband, positive gain slope low noise amplifier operating in various frequency bands from 1 to 6 GHz with typical noise figure of 1.4 dB. It is housed in the Avago Technologies' industry-leading and revolutionary sub-miniature chip scale package (GaAsCap wafer scale leadless package) which is small and ultra thin yet can be handled and placed with standard 0402 pick and place assembly equipment. The VMMK-3603 provides a typical gain of 17 dB with good linearity of +25 dBm typical OIP3 and input and output return losses. It can be operated from 3 V to 5 V power supply. It is fabricated using Avago Technologies unique 0.25 μm E-mode PHEMT technology which eliminates the need for negative gate biasing voltage.

WLP0402, 1 mm x 0.5 mm x 0.25 mm



Pin Connections (Top View)



Note:
"M" = Device Code
"Y" = Month Code

Features

- 1 x 0.5 mm surface mount package
- Ultrathin (0.25 mm)
- Wide frequency range: 1 to 6 GHz
- Low noise figure
- Positive gain slope
- Self-Biasing: 3 to 5 V

Specifications (5 GHz, Vdd = 5 V, Zin = Zout = 50 Ω)

- Small signal gain: 17 dB typ.
- Noise Figure = 1.5 dB typ.
- Output 3rd Order Intercept Point = 25 dBm

Applications

- 2.4, 3.5, and 5-6 GHz WLAN and WiMax
- 802.16 & 802.20 BWA systems
- Radar and ECM systems
- Generic IF amplifier

Attention: Observe precautions for handling electrostatic sensitive devices.
ESD Machine Model = 50 V
ESD Human Body Model = 300 V
Refer to Avago Application Note A004R:
Electrostatic Discharge, Damage and Control.

Electrical Specifications

Table 1. Absolute Maximum Rating [1]

Symbol	Parameters/Condition	Unit	Absolute Max
Vd	Supply Voltage (RF Output) [2]	V	8
Id	Supply Current [2]	mA	56
$P_{in, max}$	CW RF Input Power (RF Input) [3]	dBm	15
P_{diss}	Total Power Dissipation	mW	460
Tch	Max Channel Temperature	°C	+150
θjc	Thermal Resistance [4]	°C/W	95.3

Notes
1. Operation of this device above any one of these parameters may cause permanent damage
2. Bias is assumed DC quiescent conditions
3. With the DC (typical bias) and RF applied to the device at board temperature Tb = 25° C
4. Thermal resistance is measured from junction to board using IR method

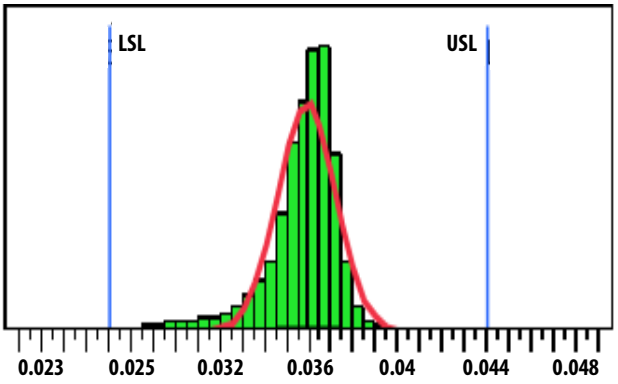
Table 2. DC and RF Specifications [1]

T_A = 25° C, Vd = 5 V, Freq = 5 GHz, $Z_{in} = Z_{out}$ = 50 Ω (unless otherwise specified)

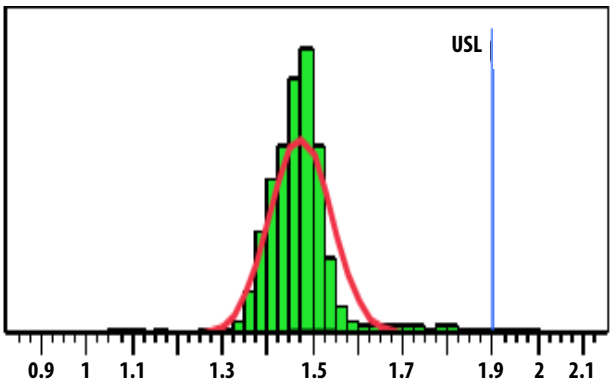
Symbol	Parameters/Condition	Unit	Minimum	Typical	Maximum
Id [2]	Supply Current	mA	27	36	44
NF [2,3]	Noise Figure	dB		1.5	1.9
Ga [2,3]	Associated Gain	dB	15.5	16.8	19.5
S11 [4]	Input Return Loss	dB		-11	
S22 [4]	Output Return Loss	dB		-11	
OIP3 [4,5]	Output 3rd Order Intercept Point	dBm		25	

Notes
1. Losses of the test system have been de-embedded from final data
2. Measured data obtained from wafer-probing using a G-S, S-G pyramid probe
3. NF and Ga obtained from Noise Figure Meter
4. S-parameters and OIP3 data obtained using 300 µm G-S-G probing on PCB substrate
5. OIP3 test condition: Center frequency = 5 GHz, 2 tone offset = 10 MHz, Pin = -25 dBm

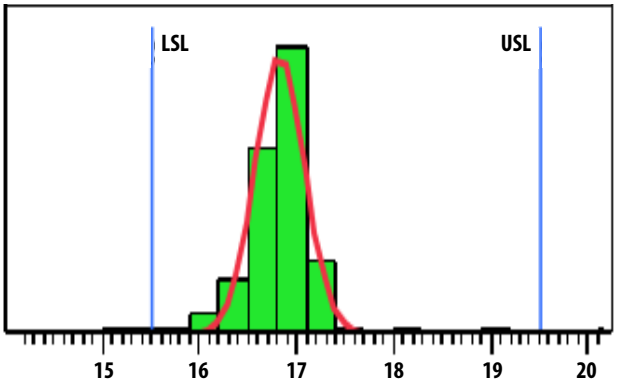
Product Consistency Distribution Charts at 5.0 GHz, Vd = 5 V



Id @ Vd = 5 V, Mean = 36 mA, LSL = 27 mA, USL = 44mA



NF @ 5 GHz, Mean = 1.5 dB, USL = 1.9 dB



Gain @ 5GHz, Mean = 16.8 dB, LSL = 15.5 dB, USL = 19.5 dB
(Data obtained using Noise Figure Analyzer)

Notes:
Distribution data based on 65 Kpcs part sample size from MPV lots.
Future wafers allocated to this product may have nominal values anywhere between the upper and lower limits.

VMMK-3603 Typical Performance

T_A = 25° C, Z_{in} = Z_{out} = 50 Ω; biasing by a broadband bias tee; S-param data obtained using 300 µm GSG probing on PCB substrate, NF, IP3, and P1dB obtained using eval board; losses calibrated out to the package reference plane.

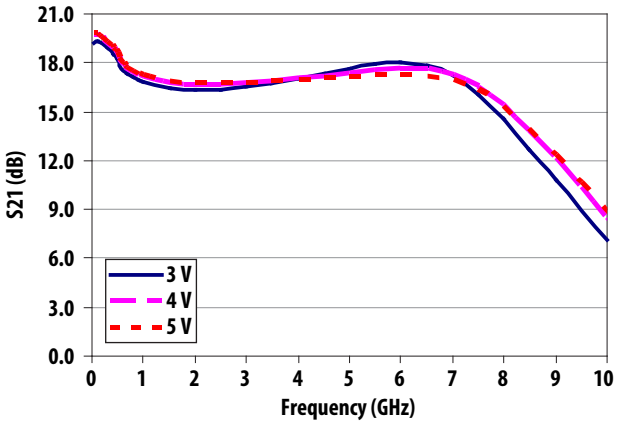


Figure 1. Small Signal Gain Over Bias

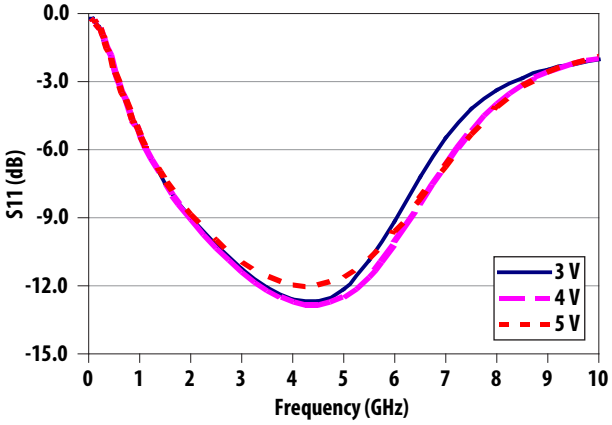


Figure 2. Input Return Loss Over Bias

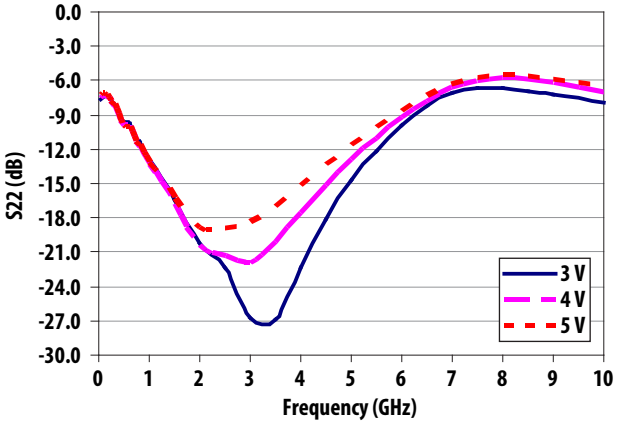


Figure 3. Output Return Loss Over Bias

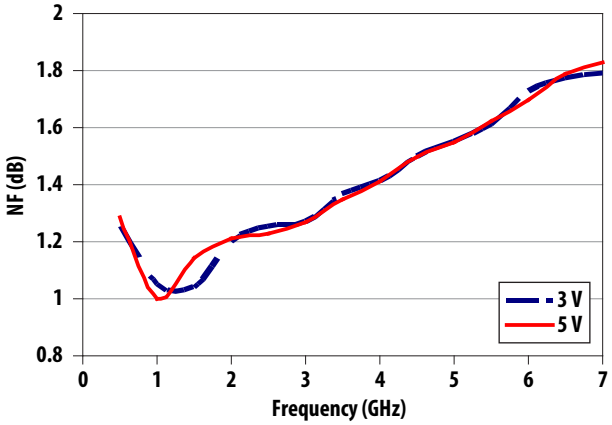


Figure 4. NF Over Bias

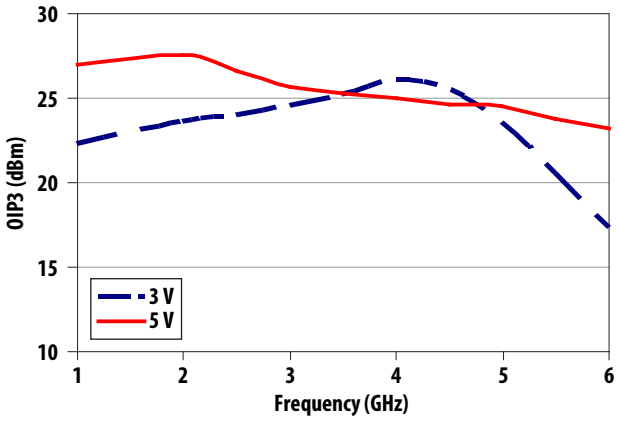


Figure 5. OIP3 Over Bias

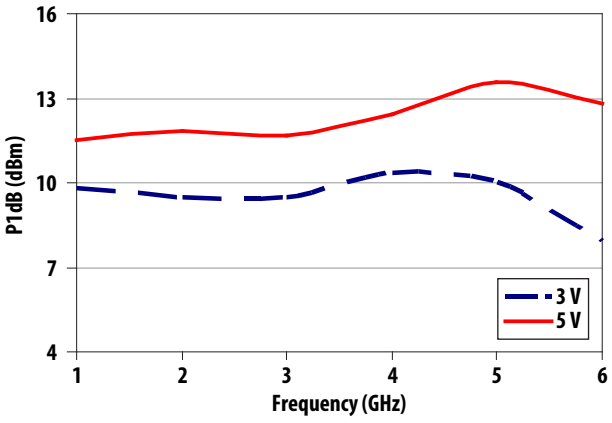


Figure 6. OP1dB Over Bias

VMMK-3603 Typical Performance

Vd = 5 V unless noted, $Z_{in} = Z_{out} = 50\ \Omega$, biasing by a broadband bias tee; over temp data obtained using eval board; losses calibrated out to the package reference plane.

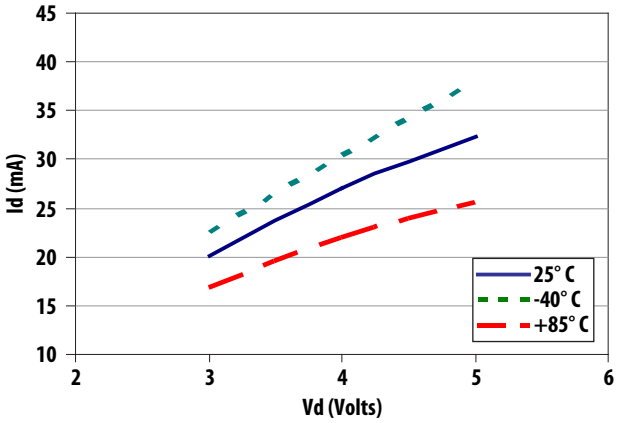


Figure 7. Id vs. Vd over Temp

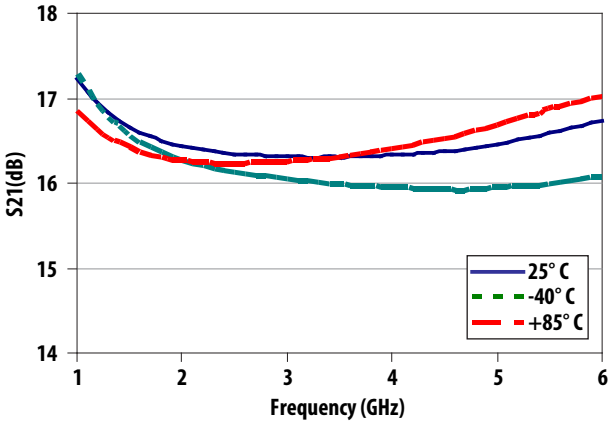


Figure 8. Gain over Temp

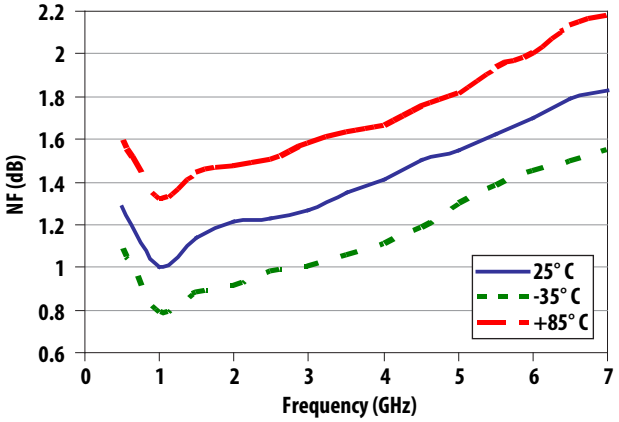


Figure 9. NF Over Temp

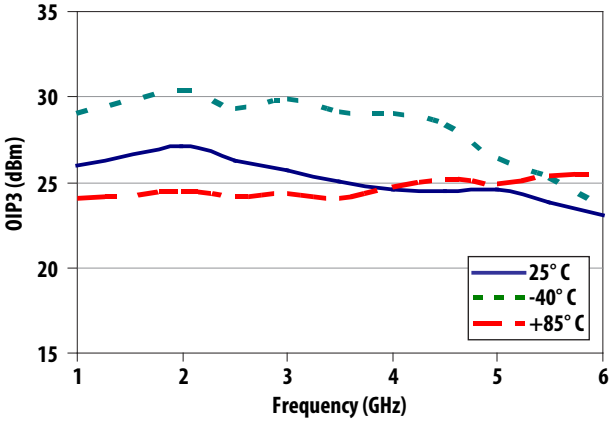


Figure10. OIP3 Over Temp

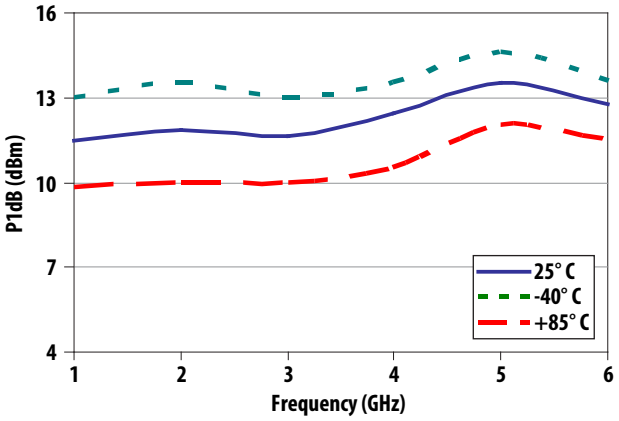


Figure 11. OP1dB Over Temp

Typical Scattering Parameters

T_A = 25° C, Vd = 3 V, $Z_{in} = Z_{out}$ = 50 Ω unless noted. Data obtained using 300 µm G-S-G PCB substrate & broadband bias tees, losses calibrated out to the package reference plane.

Freq	S11			S21			S12			S22		
GHz	dB	mag	Phase	dB	mag	phase	dB	mag	phase	dB	mag	Phase
0.05	-0.2	0.977	-4.8864	19.2	9.153	-179.6516	-38.2	0.0123	91.3266	-7.7	0.4127	0.6165
0.1	-0.3	0.9706	-9.9273	19.3	9.2677	176.9829	-35.4	0.0169	75.7197	-7.3	0.431	-6.0822
0.2	-0.6	0.931	-19.6121	19.2	9.1431	170.3651	-30.1	0.0312	66.652	-7.4	0.4254	-17.5835
0.3	-1.2	0.8726	-28.1505	18.9	8.8217	165.3938	-27.3	0.0432	57.1804	-8.0	0.3971	-27.3636
0.4	-1.8	0.8098	-35.3755	18.5	8.4556	161.4364	-25.5	0.0533	48.1187	-8.8	0.3638	-35.3407
0.5	-2.5	0.7468	-41.2905	18.2	8.1299	158.4159	-24.3	0.061	40.9588	-9.6	0.3308	-41.8528
0.6	-3.1	0.701	-41.9333	17.6	7.5629	156.9294	-23.8	0.0645	35.7729	-9.8	0.3233	-37.1208
0.7	-3.7	0.6527	-45.824	17.3	7.3442	154.9164	-23.3	0.0687	30.5102	-10.6	0.2959	-40.3919
0.8	-4.3	0.6098	-49.2059	17.1	7.1755	153.0505	-22.8	0.0723	25.8161	-11.4	0.2699	-42.9121
0.9	-4.9	0.5718	-52.08	16.9	7.0187	151.3266	-22.5	0.0746	21.5702	-12.1	0.2487	-44.9453
1	-5.4	0.5385	-54.7877	16.8	6.9197	149.6624	-22.3	0.0767	18.0463	-12.9	0.2273	-46.2074
1.5	-7.5	0.4229	-65.4212	16.4	6.6173	141.4379	-21.8	0.0816	4.0387	-16.4	0.1522	-49.2137
2	-9.0	0.3552	-75.7226	16.3	6.5474	132.6275	-21.6	0.0831	-6.4352	-20.2	0.0975	-47.4521
2.5	-10.2	0.308	-81.3963	16.4	6.5943	123.4518	-21.6	0.0828	-14.7788	-22.4	0.0759	-43.3979
3	-11.3	0.2738	-91.3794	16.5	6.7138	113.3991	-21.8	0.0817	-22.0721	-26.7	0.0461	-22.5111
3.5	-12.1	0.2493	-103.0569	16.8	6.8955	102.6078	-21.9	0.0804	-29.1338	-26.9	0.045	26.9498
4	-12.6	0.2339	-115.7385	17.0	7.1158	90.9712	-22.0	0.0794	-35.6715	-22.3	0.0767	53.6397
4.5	-12.7	0.2322	-129.9118	17.4	7.3808	78.2102	-22.2	0.0778	-42.3765	-18.1	0.1244	59.6162
5	-12.2	0.2468	-145.5479	17.7	7.64	64.0695	-22.3	0.0765	-49.1329	-14.7	0.1836	56.8991
5.5	-10.9	0.2852	-160.1544	17.9	7.8875	48.8364	-22.6	0.0744	-55.7584	-12.1	0.2475	49.0542
6	-9.1	0.3497	-178.3697	18.1	7.9936	31.1873	-22.8	0.0726	-63.9077	-9.9	0.3195	39.2463
7	-5.5	0.5303	142.0171	17.2	7.2517	-8.7294	-23.8	0.0648	-82.9034	-7.1	0.4402	12.7602
8	-3.4	0.6782	104.6622	14.5	5.3295	-45.6505	-26.1	0.0494	-101.8767	-6.7	0.4647	-14.159
9	-2.5	0.7529	74.4856	10.8	3.4774	-73.6841	-29.1	0.035	-114.8967	-7.3	0.4338	-32.6621
10	-2.0	0.7925	51.7086	7.1	2.2691	-94.1122	-32.3	0.0242	-124.2559	-7.9	0.4012	-46.0125
11	-1.7	0.8225	33.4831	3.7	1.5278	-109.423	-36.0	0.0158	-131.9905	-8.5	0.3765	-55.8495
12	-1.5	0.8456	17.4077	0.6	1.069	-121.8166	-40.8	0.0091	-139.6964	-8.7	0.3655	-63.6328
13	-1.2	0.8722	4.7204	-2.5	0.7536	-131.9503	-53.2	0.0022	-142.2453	-8.7	0.3686	-70.3725
14	-1.1	0.8802	-7.1979	-5.1	0.5578	-140.5919	-54.0	0.002	0.5436	-8.6	0.3709	-77.0036
15	-1.0	0.8961	-17.3162	-7.5	0.4238	-148.3565	-50.2	0.0031	6.8353	-8.5	0.3737	-84.129
16	-0.8	0.9118	-27.6757	-9.7	0.3259	-155.8471	-42.0	0.0079	19.5505	-8.3	0.3841	-91.3885
17	-0.7	0.9244	-37.4873	-11.9	0.2546	-163.0428	-39.9	0.0101	15.9588	-8.1	0.3922	-97.2096
18	-0.6	0.9282	-46.3774	-14.0	0.199	-169.2785	-36.9	0.0143	2.392	-7.9	0.402	-103.6084
19	-0.6	0.9369	-55.4445	-15.9	0.1606	-174.9897	-37.6	0.0132	-10.438	-7.7	0.4107	-108.8462
20	-0.6	0.9385	-63.2833	-17.8	0.1288	178.771	-37.1	0.0139	-8.8364	-7.6	0.4181	-113.2307
21	-0.5	0.9455	-71.189	-19.9	0.1012	173.6276	-34.7	0.0185	-18.2437	-7.4	0.425	-117.8475
22	-0.5	0.9461	-77.8723	-21.3	0.0861	169.4539	-36.6	0.0148	-34.0351	-7.3	0.4314	-122.2301
23	-0.4	0.9518	-84.7844	-22.9	0.0718	162.3099	-37.7	0.013	-25.5129	-7.2	0.4363	-125.4319
24	-0.4	0.9516	-91.3249	-25.1	0.0555	157.727	-35.3	0.0171	-31.2849	-7.2	0.4362	-128.9087
25	-0.4	0.9543	-97.0884	-26.0	0.0504	150.9037	-38.6	0.0117	-36.8647	-7.2	0.4361	-132.6289

Typical Scattering Parameters

T_A = 25° C, Vd = 5 V, Z_{in} = Z_{out} = 50 Ω unless noted. Data obtained using 250 µm G-S-G PCB substrate & broadband bias tees, losses calibrated out to the package reference plane.

Freq	S11			S21			S12			S22		
GHz	dB	mag	Phase	dB	mag	phase	dB	mag	phase	dB	mag	Phase
0.05	-0.2	0.9765	-5.3473	19.8	9.7378	179.865	-41.0	0.0089	101.6421	-7.2	0.4351	-3.1298
0.1	-0.3	0.969	-10.4315	19.8	9.7954	176.3417	-35.4	0.0169	76.4418	-7.1	0.4395	-7.9442
0.2	-0.7	0.9274	-20.7156	19.6	9.6011	169.8445	-30.3	0.0305	65.854	-7.5	0.424	-18.0476
0.3	-1.2	0.8665	-29.613	19.3	9.2449	164.9479	-27.5	0.0423	55.4655	-8.1	0.3922	-26.6857
0.4	-1.9	0.8011	-37.1751	18.9	8.8561	161.1065	-25.8	0.0514	46.9769	-9.0	0.356	-33.6356
0.5	-2.6	0.7382	-43.3115	18.6	8.5166	158.0882	-24.7	0.0585	39.3595	-9.9	0.32	-39.0593
0.6	-3.2	0.692	-44.0449	18.0	7.9383	156.6006	-24.3	0.0613	33.9254	-10.0	0.3153	-33.3994
0.7	-3.8	0.6439	-48.1284	17.8	7.7203	154.5257	-23.8	0.0649	28.7538	-10.8	0.2874	-35.3222
0.8	-4.4	0.602	-51.7328	17.6	7.5547	152.582	-23.3	0.0682	24.1196	-11.6	0.2621	-36.6951
0.9	-5.0	0.565	-54.8713	17.4	7.3962	150.7578	-23.0	0.0706	19.7084	-12.4	0.2411	-37.3403
1	-5.5	0.5331	-57.8302	17.3	7.2968	148.9784	-22.8	0.0722	16.1648	-13.1	0.2204	-37.2186
1.5	-7.4	0.4246	-70.3244	16.9	6.9736	140.009	-22.3	0.0763	1.6183	-16.3	0.1525	-31.3163
2	-8.8	0.3619	-83.2252	16.7	6.854	130.4826	-22.2	0.0772	-9.1633	-18.8	0.1143	-16.0481
2.5	-10.0	0.3174	-92.634	16.7	6.8325	120.5905	-22.3	0.0768	-18.3171	-18.9	0.1135	-5.6824
3	-10.9	0.2844	-106.7897	16.7	6.8564	110.0668	-22.5	0.0749	-26.6003	-18.5	0.1195	10.6561
3.5	-11.6	0.263	-123.054	16.8	6.9151	99.0187	-22.7	0.0732	-33.7451	-17.0	0.142	21.9712
4	-12.0	0.2502	-140.3754	16.9	6.9917	87.4663	-23.0	0.071	-40.969	-15.1	0.1751	27.5352
4.5	-12.0	0.2507	-158.2552	17.0	7.0797	75.2214	-23.3	0.0685	-48.1875	-13.3	0.2151	28.9598
5	-11.6	0.2633	-176.0757	17.1	7.1631	62.193	-23.6	0.0658	-55.6692	-11.6	0.2629	27.4716
5.5	-10.8	0.2877	169.4924	17.2	7.2488	48.8057	-24.1	0.0622	-62.7037	-10.0	0.3145	22.774
6	-9.6	0.3314	154.7483	17.2	7.2799	33.8787	-24.6	0.0589	-70.5383	-8.6	0.3699	16.8808
7	-6.7	0.4614	127.6033	16.9	6.9966	0.4678	-25.9	0.0507	-87.777	-6.4	0.4766	-0.4897
8	-4.1	0.6221	100.0949	15.4	5.8749	-35.6531	-28.3	0.0383	-108.0513	-5.5	0.5292	-22.568
9	-2.6	0.7394	72.7048	12.4	4.1718	-68.1977	-31.9	0.0255	-123.9911	-5.9	0.5066	-40.9205
10	-1.9	0.7993	50.3166	8.9	2.7894	-93.3719	-36.4	0.0151	-135.8243	-6.7	0.4642	-54.412
11	-1.6	0.8348	32.1122	5.4	1.8683	-112.2912	-42.3	0.0077	-149.8587	-7.4	0.4279	-63.6579
12	-1.3	0.8576	16.1694	2.2	1.2907	-127.1685	-52.8	0.0023	174.2257	-7.8	0.4092	-70.3075
13	-1.1	0.8829	3.6129	-0.9	0.8968	-139.2016	-46.6	0.0047	47.2364	-7.8	0.4073	-75.9325
14	-1.0	0.8885	-8.2264	-3.7	0.6537	-149.3954	-42.9	0.0072	28.2504	-7.8	0.4067	-81.6577
15	-0.9	0.9029	-18.1508	-6.2	0.4898	-158.4144	-41.6	0.0083	19.5155	-7.8	0.4089	-87.9
16	-0.7	0.9173	-28.4392	-8.6	0.3727	-167.162	-38.0	0.0126	19.2396	-7.6	0.4188	-94.5239
17	-0.6	0.9284	-38.1504	-10.8	0.2876	-175.4717	-36.5	0.015	15.2695	-7.4	0.4264	-99.7235
18	-0.6	0.9313	-46.9227	-13.0	0.2227	176.9209	-34.8	0.0183	4.0748	-7.2	0.4356	-105.7808
19	-0.5	0.9389	-55.9194	-15.0	0.1778	170.0955	-35.3	0.0171	-7.7662	-7.1	0.4435	-110.7482
20	-0.5	0.9399	-63.6621	-17.0	0.1416	162.632	-35.3	0.0171	-8.2348	-6.9	0.4507	-114.8575
21	-0.5	0.946	-71.499	-19.2	0.1101	155.5804	-33.6	0.021	-16.9273	-6.8	0.4566	-119.3594
22	-0.5	0.9467	-78.2123	-20.7	0.092	150.8211	-35.3	0.0171	-30.2145	-6.7	0.4632	-123.5707
23	-0.4	0.9515	-85.0468	-22.3	0.0767	142.117	-36.1	0.0156	-25.443	-6.6	0.4678	-126.9413
24	-0.4	0.9513	-91.568	-24.6	0.0589	134.4502	-34.3	0.0193	-32.1079	-6.6	0.4674	-130.3008
25	-0.4	0.9531	-97.3009	-25.5	0.0531	127.8596	-37.2	0.0138	-33.6267	-6.6	0.4662	-134.0917

VMMK-3603 Applications and Usage Information

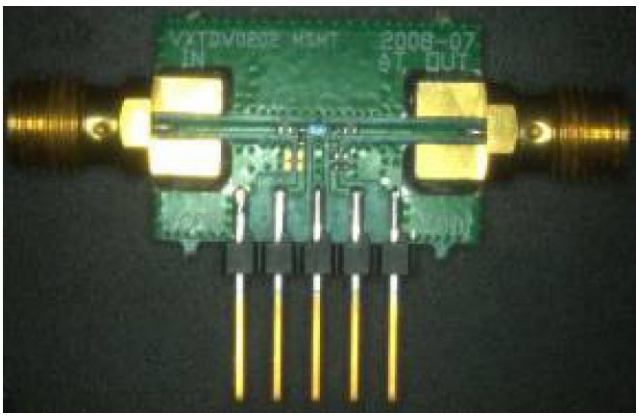


Figure 12. Evaluation/Test Board (available to qualified customers upon request)

Table 3. VMMK-3603 Demo Board BOM

Component	Value
DUT	VMMK-3603
C1	100 pF
C2	8.2 pF
C5	0.1 µF
C6	100 pF
R1	820 Ohms
R2	10 Ohms
L1	10 nH

Biasing and Operation

The VMMK-3603 is biased with a positive supply connected to the output pin Vd through an external user supplied bias decoupling network. Nominal current draw is 22 mA. A typical biasing scheme is shown in Figure 12.

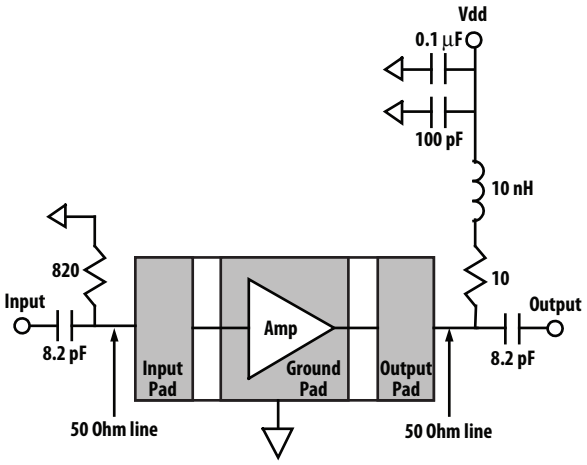


Figure 13. Example demonstration circuit of VMMK-3603 for broadband operation (1 GHz to 6 GHz).

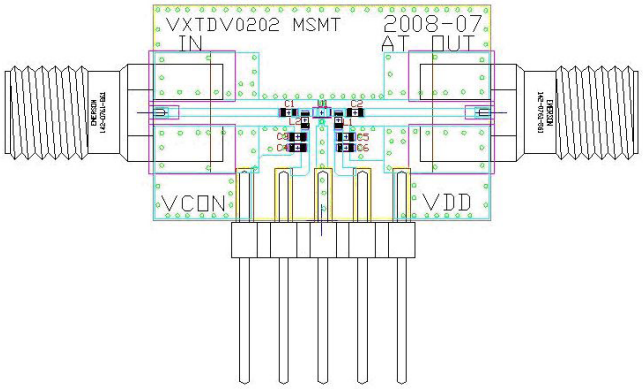


Figure 14. Biasing the VMMK-3603

A layout of a typical demo board is shown in Figure 14. The output bias decoupling network can be easily constructed using small surface mount components. The value of the output inductor can have a major effect on both low and high frequency operation. The demo board uses a 10 nH inductor that has a self resonant frequency higher than the maximum desired frequency of operation.

If the self-resonant frequency of the inductor is too close to the operating band, the value of the inductor will need to be adjusted so that the self-resonant frequency is significantly higher than the highest frequency of operation. A 10 ohm resistor is placed in series with the inductor to help provide greater bandwidth and to help with low frequency stability. To help with low frequency stability an 820 ohm resistor is used to shunt the input line to ground. 8.2 pF capacitors are used as dc blocks on the RF input and RF output lines.

Typically a passive component company like Murata does not specify S parameters at frequencies higher than 5 or 6 GHz for larger values of inductance making it difficult to properly simulate amplifier performance at higher frequencies. It has been observed that the Murata LQW15AN series of 0402 inductors actually works quite well above their normally specified frequency.

The parallel combination of the 100 pF and 0.1 µF capacitors provide a low impedance in the band of operation and at lower frequencies and should be placed as close as possible to the inductor. The low frequency bypass provides good rejection of power supply noise and also provides a low impedance termination for third order low frequency mixing products that will be generated when multiple in-band signals are injected into any amplifier.

S Parameter Measurements

The S-parameters are measured on a 0.016 inch thick RO4003 printed circuit test board, using G-S-G (ground signal ground) probes. Coplanar aveguide is used to provide a smooth transition form the probes to the device under test. The presence of the ground plane on top of the test board results in excellent grounding at the device under test. A combination of SOLT (Short – Open – Load – Thru) and TRL (Thru – Reflect – Line) calibration techniques are used to correct for the effects of the test board, resulting in accurate device S parameters.

Package and Assembly Note

For detailed description of the device package, handling and assembly, please refer to Application Note 5378.

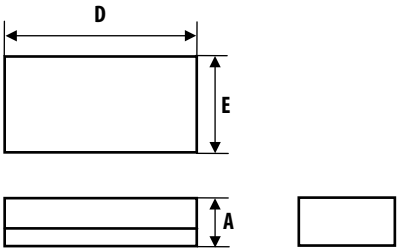
ESD Precautions

Note: These devices are ESD sensitive. The following precautions are strongly recommended. Ensure that an ESD approved carrier is used when die are transported from one destination to another. Personal grounding is to be worn at all times when handling these devices. For more detail, refer to Avago Application Note A004R: Electrostatic Discharge Damage and Control.

Ordering Information

Part Number	Devices Per Container	Container
VMMK-3603-BLKG	100	Antistatic Bag
VMMK-3603-TR1G	5000	7" Reel

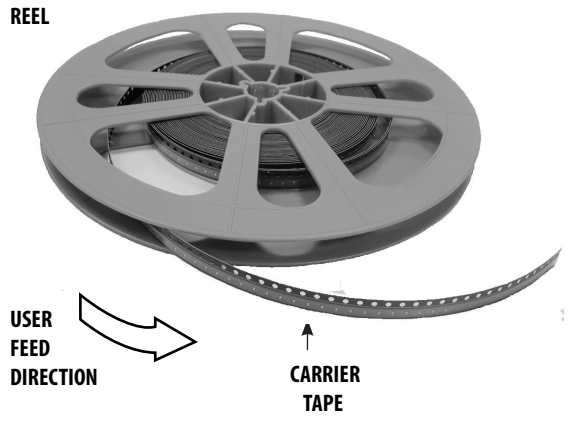
Package Dimension Outline



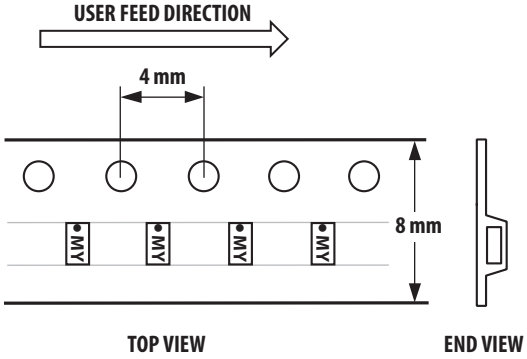
Dimensions Symbol	Min (mm)	Max (mm)
E	0.500	0.585
D	1.004	1.085
A	0.225	0.275

Note:
All dimensions are in mm

Reel Orientation

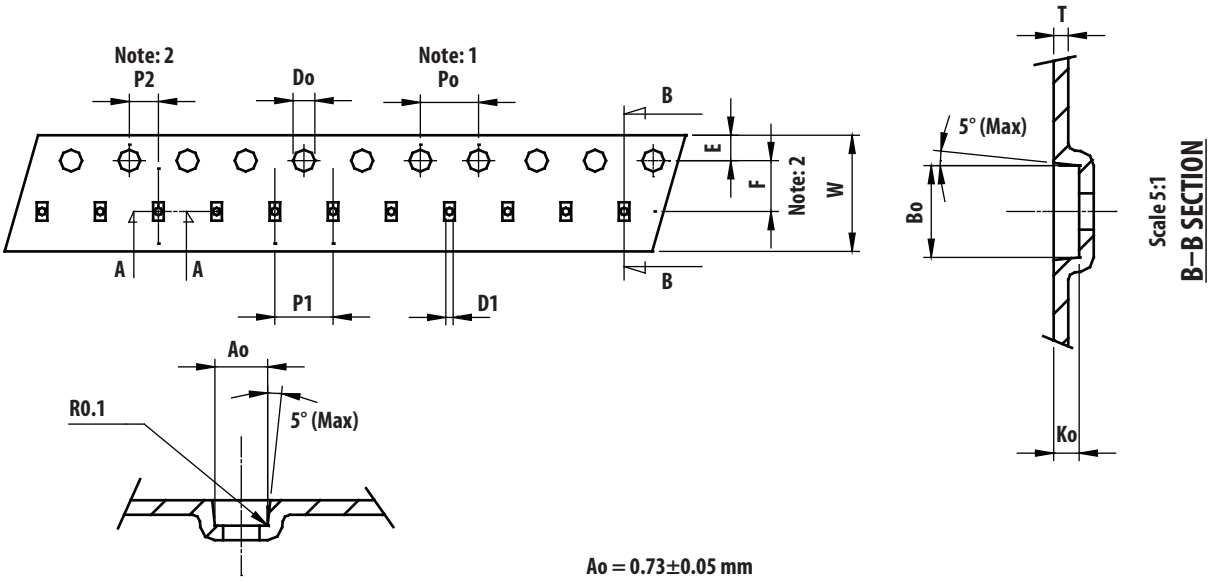


Device Orientation



Notes:
"M" = Device Code
"Y" = Month Code

Tape Dimensions



Scale 5:1

A–A SECTION

Ao = 0.73±0.05 mm

Bo = 1.26±0.05 mm

Ko = 0.35 $^{+0.05}_{+0}$ mm

Unit: mm

Symbol	Spec.
K1	–
Po	4.0±0.10
P1	4.0±0.10
P2	2.0±0.05
Do	1.55±0.05
D1	0.5±0.05
E	1.75±0.10
F	3.50±0.05
10Po	40.0±0.10
W	8.0±0.20
T	0.20±0.02

Notice:

1. 10 Sprocket hole pitch cumulative tolerance is ±0.1 mm.
2. Pocket position relative to sprocket hole measured as true position of pocket not pocket hole.
3. Ao & Bo measured on a place 0.3 mm above the bottom of the pocket to top surface of the carrier.
4. Ko measured from a plane on the inside bottom of the pocket to the top surface of the carrier.
5. Carrier camber shall be not than 1 m per 100 mm through a length of 250 mm.

For product information and a complete list of distributors, please go to our web site: **www.avagotech.com**

AV02-2919EN - December 26, 2012