HEWLETT PACKARD

GaAs MMIC DC-50 GHz Voltage Variable Absorptive Attenuator

Technical Data

HMMC-1001

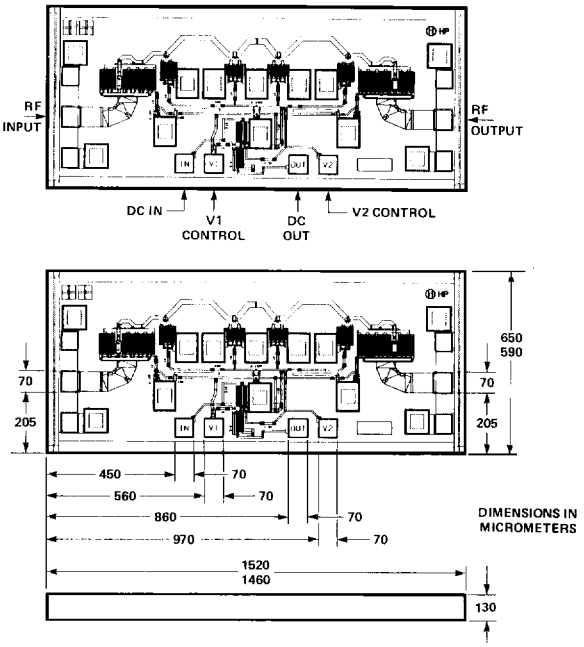
Features

- **Wide Attenuation Range >30 dB**
- **Exceptional Bandwidth DC – 50 GHz**
- **VSWR <2:1 Cascadable**
- **Very Low DC Power Dissipation <50 milliwatts**

Description

The HMMC-1001 GaAs MMIC attenuator is designed for wide dynamic attenuation range with excellent input/output match over the full DC to 50 GHz band. The circuit employs six MESFET devices as voltage variable resistors. A DC reference circuit, on chip, may be used for enhanced performance such as automatic impedance matching, linear attenuation, and temperature compensation. The chips have silicon nitride passivation and polyimide scratch protection.

Outline Drawing



Absolute Maximum Ratings* T_A = 25°C

Symbol	Parameters	Units	Min.	Max.
V_{RF}	DC Voltage to RF Ports	volts	-0.6	+5.0
V1,V2	Control Voltages	volts	-5.0	+0.5
V_{DC}	DC In/DC Out	volts	-0.6	+1.0
P_{IN}**	RF Input Power	dBm		+17
T_{CH}	Operating Channel Temperature	°C	-55	+140
T_{ST}	Storage Temperature	°C	-65	+165
T_{MAX}	Maximum Assembly Temperature (for 60 seconds maximum)	°C		+300

*Operation in excess of any one of these conditions may result in permanent damage to this device.

**Derate linearly to zero at maximum rated temperature.

Applications

The HMMC-1001 can be used as a voltage controlled attenuator in ECM, EW, radar, and telecommunication systems. The combination of wide attenuation range, low minimum attenuation, and flat frequency response, combined with excellent input/output match makes it useful in applications such as automatic gain control, amplitude and pulse modulation, and SPST switching.

Electrical Specifications

$T_A = 25°C$, $Z_0 = 50\ \Omega$

Parameters	Frequency (GHz)	Units	Min.	Typ.	Max.
Minimum Attenuation (S21) V1 = 0 V, V2 = -4	1.5	dB		1.0	2.4
	8.0			1.4	2.4
	20.0			1.7	2.4
	26.5			2.0	2.4
Input/Output Return Loss V1 = 0 V, V2 = -4 V	<26.5	dB	10	16	
Maximum Attenuation (S21) V1 = –4 V, V2 = 0 V	1.5	dB	27	31	
	8.0		27	34	
	20.0		27	38	
	26.5		27	40	
Input/Output Return Loss V1 = –4 V, V2 = 0 V	<26.5	dB	8	>11	
DC Power Dissipation (does not include input signals)		mW			50
Input Power at 1 dB Attenuation Change	<26.5	dBm		0	

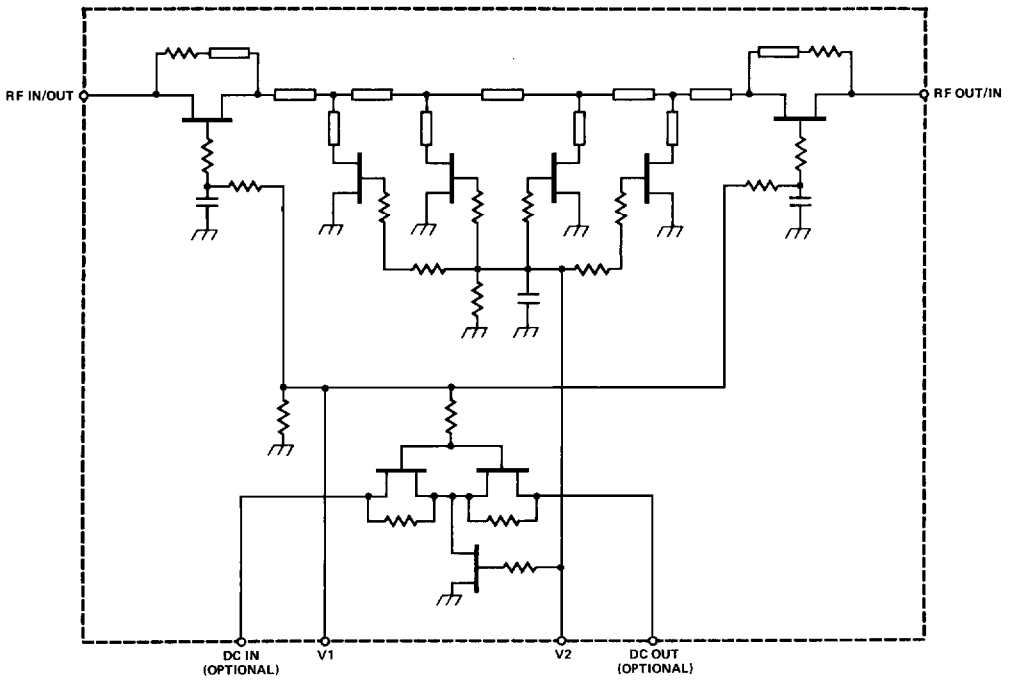


Figure 1. Schematic.

Operation

In the HMMC-1001 schematic (Figure 1) the six MESFETs in the RF signal path are in the configuration of a resistive TEE attenuator. The circuit is symmetrical, allowing either RF port to be the signal input or output. The attenuation level is set by the control voltages V1 (which controls the series resistors in the TEE) and V2 (which controls the shunt resistor in the TEE). Typical values for V1 and V2, chosen to provide optimum input and output VSWR, are shown in Figure 2. The DC_{IN} and DC_{OUT} terminals may be used with an external driver circuit (see below). If not used, these terminals may either be grounded or left open.

If operation from a single control voltage is desired, either one of two driver circuits may be used. The first is shown in Figure 3. An operation amplifier connected to the DC_{IN} and V1 terminals provides automatic input and output impedance matching by comparing the (nominal 500 Ω) resistance of the DC reference circuit to the value of R1. A second operational amplifier, connected to the DC_{OUT} and V2 terminals, provides linear attenuation settings from the single control voltage as shown in Figure 4. In this driver network, V_{REF} is typically set at –0.6 V and R1 is adjusted to achieve optimum return loss. The attenuation is then set at the desired level by varying V_{IN} between 0 and –2 V.

A simplified driver circuit is shown in Figure 5. Here, one of the operational amplifiers is eliminated and attenuation is set directly by varying the voltage at V2. The result is the attenuation vs. control voltage curve shown in Figure 6.

With either of these driver circuits, R1 and R2 are adjusted for best return loss. Nominal values for both are 420 Ω. For operation with either driver, the typical attenuation, return loss characteristics, and group delay are shown in Figures 7, 8 and 9 respectively.

Assembly Techniques

Solder die attach using an AuSn solder preform is recommended. Gold thermosonic wedge bonding is recommended for all wire bonds. The top and bottom metallization is gold. Other assembly methods may also be used. For more detailed information see HP Application Note #999 "GaAs MMIC Assembly and Handling Guidelines".

GaAs MMICs are ESD sensitive. Proper precautions should be used when handling these devices.

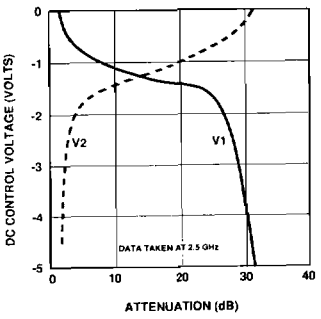


Figure 2. Typical DC Control Voltages.

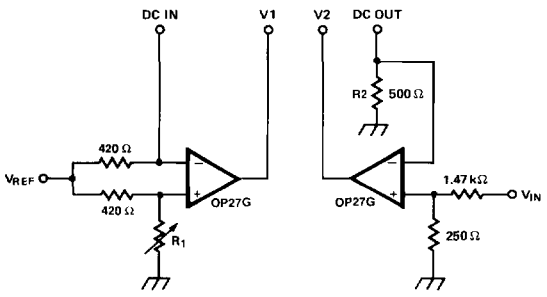


Figure 3. Linear Driver Circuit.

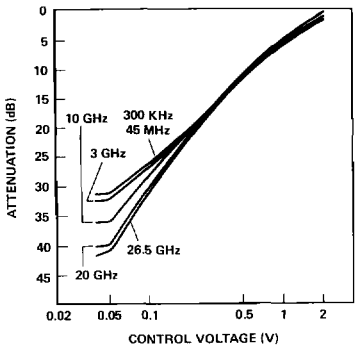


Figure 4. Typical Attenuation vs. Control Voltage (V_{IN}) for the Linear Driver Circuit.

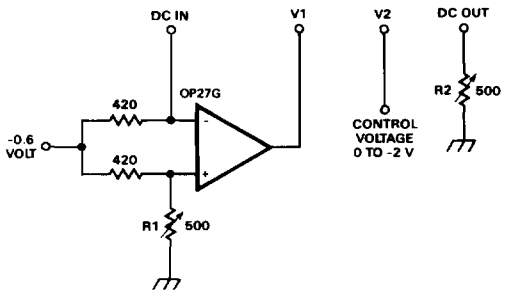


Figure 5. Simplified Driver Circuit.

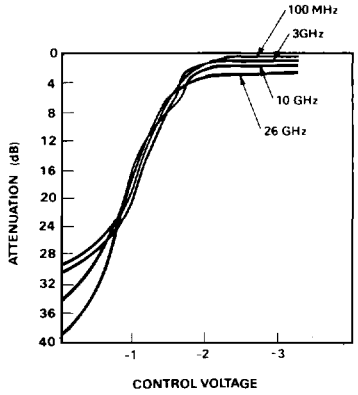


Figure 6. Typical Attenuation vs. Control Voltage (V_{IN}) Simplified Driver Circuit.

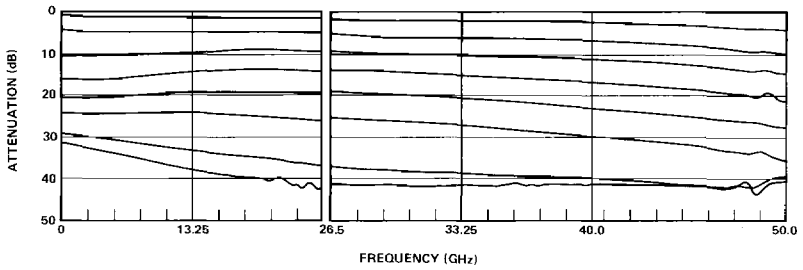


Figure 7. Typical Attenuation Characteristics.

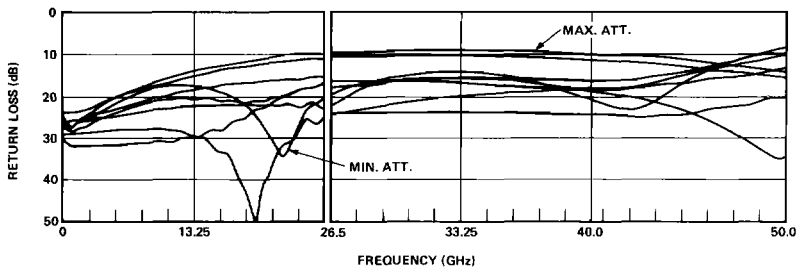


Figure 8. Typical Input and Output Return Loss.

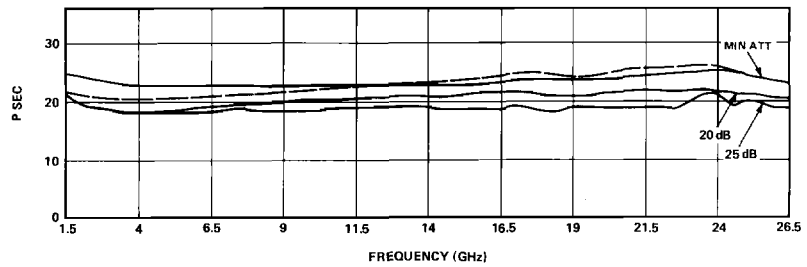


Figure 9. Typical Group Delay.

Typical S-Parameters at Various Attenuation Settings, T_A = 25°C

Minimum Attenuation Setting

Frequency (MHz)	S_{11}		S_{21}			S_{12}		S_{22}	
	Mag.	Ang.	dB	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.
45	0.065	-11.0	-0.59	0.934	-1.0	0.932	-1.2	0.065	-12.5
100	0.056	-18.0	-0.72	0.921	-1.9	0.920	-1.8	0.058	-18.9
500	0.044	-30.4	-0.88	0.904	-5.1	0.903	-5.0	0.043	-30.0
1000	0.043	-45.3	-0.94	0.897	-9.3	0.896	-9.2	0.043	-46.5
2000	0.052	-71.0	-1.00	0.891	-17.7	0.891	-17.6	0.054	-71.3
4000	0.080	-105.8	-1.08	0.883	-34.5	0.883	-34.4	0.081	-104.9
6000	0.105	-131.1	-1.15	0.876	-51.2	0.876	-51.2	0.107	-127.9
8000	0.129	-154.7	-1.22	0.869	-67.8	0.866	-68.0	0.127	-151.1
10000	0.143	-176.5	-1.32	0.859	-84.6	0.860	-84.6	0.142	-171.6
12000	0.151	162.7	-1.37	0.854	-101.1	0.856	-101.0	0.144	168.7
15000	0.137	130.8	-1.39	0.852	-126.2	0.852	-126.4	0.130	138.7
18000	0.100	101.1	-1.45	0.846	-151.9	0.847	-152.0	0.095	106.8
22000	0.012	-5.1	-1.56	0.835	172.3	0.831	172.8	0.011	34.2
26000	0.091	-140.5	-1.97	0.797	137.0	0.794	135.9	0.093	-142.0

5dB Setting

Frequency (MHz)	S_{11} Mag.	S_{11} Ang.	dB	S_{21} Mag.	S_{21} Ang.	S_{12} Mag.	S_{12} Ang.	S_{22} Mag.	S_{22} Ang.
100	0.081	-173.8	-5.08	0.557	-1.8	0.557	-1.8	0.083	-173.5
500	0.092	-175.0	-5.26	0.546	-5.3	0.545	-5.1	0.094	-175.2
1000	0.097	-176.9	-5.32	0.542	-9.4	0.541	-9.3	0.099	-175.9
2000	0.102	-178.0	-5.35	0.540	-17.9	0.539	-17.8	0.105	-176.3
4000	0.117	178.4	-5.43	0.535	-35.0	0.535	-34.9	0.120	-179.2
6000	0.134	170.1	-5.47	0.533	-52.0	0.532	-52.0	0.137	173.2
8000	0.153	158.0	-5.50	0.531	-69.1	0.530	-69.2	0.154	161.3
10000	0.166	143.5	-5.53	0.529	-86.4	0.530	-86.5	0.165	147.1
12000	0.172	126.9	-5.48	0.532	-103.8	0.531	-103.8	0.169	130.6
15000	0.162	98.7	-5.43	0.535	-130.9	0.534	-130.8	0.158	103.4
18000	0.128	66.6	-5.47	0.533	-159.3	0.532	-159.1	0.128	69.8
22000	0.055	-5.4	-5.80	0.513	161.4	0.514	161.3	0.055	-.7
26000	0.069	-131.1	-6.65	0.465	121.5	0.470	121.2	0.062	-132.2

10 dB Setting

Frequency (MHz)	S_{11} Mag.	S_{11} Ang.	dB	S_{21} Mag.	S_{21} Ang.	S_{12} Mag.	S_{12} Ang.	S_{22} Mag.	S_{22} Ang.
45	0.067	-2.8	-10.1	0.314	-0.6	0.313	-0.8	0.061	-3.7
100	0.064	-6.5	-10.1	0.311	-1.7	0.310	-1.7	0.058	-8.3
500	0.056	-12.8	-10.4	0.303	-4.6	0.303	-4.4	0.050	-14.3
1000	0.053	-18.8	-10.4	0.301	-7.9	0.301	-7.8	0.048	-22.8
2000	0.053	-33.9	-10.4	0.301	-14.8	0.300	-14.8	0.049	-40.7
4000	0.056	-64.5	-10.4	0.302	-28.9	0.303	-28.9	0.056	-73.5
6000	0.059	-94.1	-10.3	0.307	-43.1	0.308	-43.1	0.064	-101.1
8000	0.062	-123.4	-10.0	0.316	-57.6	0.316	-57.8	0.070	-127.3
10000	0.063	-153.0	-9.71	0.327	-72.9	0.328	-72.9	0.072	-152.7
12000	0.062	177.8	-9.27	0.344	-89.0	0.343	-88.9	0.070	-178.0
15000	0.052	128.8	-8.66	0.369	-115.3	0.367	-115.2	0.054	140.4
18000	0.033	49.7	-8.25	0.387	-144.2	0.386	-144.5	0.029	64.2
22000	0.073	-77.1	-8.38	0.381	174.7	0.383	174.7	0.067	-75.2
26000	0.137	-127.7	-9.12	0.350	134.9	0.350	134.0	0.127	-129.8

15 dB Setting

Frequency (MHz)	S_{11} Mag.	S_{11} Ang.	dB	S_{21} Mag.	S_{21} Ang.	S_{12} Mag.	S_{12} Ang.	S_{22} Mag.	S_{22} Ang.
45	0.093	-1.3	-15.0	0.178	-0.4	0.178	-0.7	0.086	-2.2
100	0.093	-3.7	-15.1	0.176	-1.6	0.176	-1.6	0.085	-4.5
500	0.086	-8.3	-15.2	0.173	-3.7	0.172	-3.5	0.078	-9.2
1000	0.085	-13.6	-15.3	0.172	-6.1	0.171	-6.0	0.077	-15.7
2000	0.085	-25.8	-15.2	0.173	-11.5	0.172	-11.4	0.078	-29.5
4000	0.086	-51.2	-15.0	0.177	-22.5	0.177	-22.5	0.082	-57.0
6000	0.087	-76.5	-14.6	0.187	-34.4	0.188	-34.4	0.088	-82.0
8000	0.087	-101.6	-14.0	0.200	-47.6	0.200	-47.7	0.092	-105.9
10000	0.085	-126.9	-13.3	0.216	-62.5	0.217	-62.6	0.093	-128.4
12000	0.080	151.6	-12.7	0.233	-78.9	0.234	-78.8	0.089	-150.3
15000	0.063	175.0	-11.8	0.256	-106.2	0.256	-106.3	0.072	-179.4
18000	0.034	159.6	-11.4	0.269	-136.0	0.268	-136.1	0.042	164.8
22000	0.047	-135.5	-11.6	0.262	-176.7	0.264	-176.7	0.044	-144.1
26000	0.099	-151.7	-12.4	0.241	144.0	0.241	142.6	0.090	-159.5

20 dB Setting

Frequency (MHz)	S_{11}		S_{21}			S_{12}		S_{22}	
	Mag.	Ang.	dB	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.
45	0.070	-1.5	-20.0	0.100	-0.4	0.100	-0.5	0.063	-2.0
100	0.070	-4.0	-20.1	0.099	-1.4	0.099	-1.6	0.063	-5.1
500	0.065	-10.1	-20.2	0.097	-3.4	0.097	-3.1	0.057	-11.4
1000	0.065	-17.7	-20.2	0.097	-5.6	0.096	-5.4	0.058	-20.6
2000	0.067	-33.8	-20.2	0.097	-10.5	0.097	-10.6	0.061	-38.6
4000	0.075	-64.6	-19.9	0.101	-20.8	0.100	-20.8	0.073	-70.7
6000	0.085	-92.2	-19.5	0.106	-32.3	0.107	-32.3	0.088	-96.3
8000	0.095	-116.6	-18.9	0.114	-45.5	0.114	-45.7	0.101	-118.6
10000	0.105	-138.7	-18.3	0.122	-60.5	0.122	-60.7	0.111	-138.1
12000	0.112	-158.3	-17.8	0.129	-76.9	0.129	-76.8	0.119	-156.2
15000	0.116	176.9	-17.3	0.136	-103.3	0.136	-103.1	0.122	-178.9
18000	0.113	158.7	-17.2	0.138	-130.5	0.136	-130.5	0.119	161.6
22000	0.109	145.8	-17.7	0.131	-166.8	0.132	-167.9	0.112	145.1
26000	0.111	133.6	-18.6	0.117	155.6	0.117	155.2	0.117	131.6

25 dB Setting

Frequency (MHz)	S_{11}		S_{21}			S_{12}		S_{22}	
	Mag.	Ang.	dB	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.
45	0.047	-2.1	-25.0	0.056	-0.5	0.056	-0.5	0.039	-3.1
100	0.047	-5.1	-25.2	0.055	-1.9	0.055	-1.6	0.040	-7.1
500	0.042	-15.3	-25.4	0.054	-4.0	0.054	-3.7	0.035	-18.2
1000	0.044	-27.1	-25.4	0.054	-7.0	0.054	-6.8	0.038	-32.1
2000	0.051	-49.1	-25.5	0.053	-13.2	0.053	-13.2	0.047	-56.1
4000	0.072	-82.8	-25.5	0.053	-25.5	0.053	-25.7	0.072	-88.0
6000	0.096	-106.9	-25.5	0.053	-38.7	0.054	-38.5	0.099	-109.4
8000	0.121	-126.4	-25.5	0.053	-51.8	0.054	-51.9	0.124	-127.5
10000	0.145	-144.3	-25.4	0.054	-66.1	0.054	-66.2	0.148	-143.6
12000	0.168	-160.4	-25.4	0.054	-80.9	0.054	-81.0	0.170	-158.7
15000	0.197	178.0	-25.7	0.052	-102.2	0.052	-103.3	0.196	-179.5
18000	0.219	158.6	-26.0	0.050	-123.4	0.049	-124.1	0.215	160.3
22000	0.243	136.4	-26.9	0.045	-153.2	0.045	-154.1	0.235	136.6
26000	0.259	112.6	-27.5	0.042	173.6	0.039	175.0	0.246	112.8

Maximum Attenuation Setting

Frequency (MHz)	S_{11}		S_{21}			S_{12}		S_{22}	
	Mag.	Ang.	dB	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.
45	0.048	-2.0	-30.2	0.031	-0.6	0.031	-0.9	0.045	-2.7
100	0.048	-5.0	-30.2	0.031	-1.7	0.031	-2.2	0.044	-6.3
500	0.045	-15.6	-30.5	0.030	-5.7	0.030	-5.4	0.041	-17.1
1000	0.047	-27.9	-30.8	0.029	-10.4	0.029	-10.2	0.045	-31.0
2000	0.056	-50.0	-31.1	0.028	-19.3	0.028	-19.4	0.055	-53.8
4000	0.083	-82.0	-31.7	0.026	-35.4	0.026	-35.6	0.085	-84.4
6000	0.115	-104.8	-32.8	0.023	-49.2	0.024	-49.2	0.119	-105.3
8000	0.149	-123.3	-33.6	0.021	-61.4	0.021	-62.0	0.152	-123.1
10000	0.183	-139.9	-34.0	0.020	-73.3	0.020	-73.4	0.185	-138.9
12000	0.216	-155.4	-34.9	0.018	-84.0	0.018	-82.6	0.217	-153.8
15000	0.261	-176.7	-35.9	0.016	-97.3	0.016	-99.3	0.257	-174.9
18000	0.299	163.7	-36.5	0.015	-110.8	0.015	-112.3	0.292	165.2
22000	0.346	140.0	-38.4	0.012	-130.3	0.013	-134.5	0.331	140.4
26000	0.394	114.5	-38.4	0.012	-150.4	0.011	-147.2	0.359	114.7