

# RF LDMOS Wideband Integrated Power Amplifiers

The MW4IC2020 wideband integrated circuit is designed with on-chip matching that makes it usable from 1600 to 2400 MHz. This multi-stage structure is rated for 26 to 28 Volt operation and covers all typical cellular base station modulation formats.

## Final Application

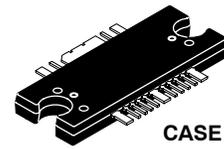
- Typical Two-Tone Performance:  $V_{DD} = 26$  Volts,  $I_{DQ1} = 80$  mA,  $I_{DQ2} = 200$  mA,  $I_{DQ3} = 300$  mA,  $P_{out} = 20$  Watts PEP, Full Frequency Band  
 Power Gain — 29 dB  
 IMD — -32 dBc  
 Drain Efficiency — 26% (at 1805 MHz) and 20% (at 1990 MHz)

## Driver Applications

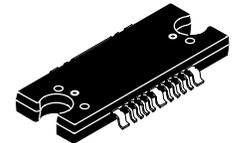
- Typical GSM EDGE Performance:  $V_{DD} = 26$  Volts,  $I_{DQ1} = 80$  mA,  $I_{DQ2} = 230$  mA,  $I_{DQ3} = 230$  mA,  $P_{out} = 5$  Watts Avg., Full Frequency Band  
 Power Gain — 29 dB  
 Spectral Regrowth @ 400 kHz Offset = -66 dBc  
 Spectral Regrowth @ 600 kHz Offset = -77 dBc  
 EVM — 1% rms
- Typical CDMA Performance:  $V_{DD} = 26$  Volts,  $I_{DQ1} = 80$  mA,  $I_{DQ2} = 240$  mA,  $I_{DQ3} = 250$  mA,  $P_{out} = 1$  Watt Avg., Full Frequency Band, IS-97 Pilot, Sync, Paging, Traffic Codes 8 through 13  
 Power Gain — 30 dB  
 ACPR @ 885 kHz Offset = -61 dBc @ 30 kHz Bandwidth  
 ALT1 @ 1.25 MHz Offset = -69 dBc @ 12.5 kHz Bandwidth  
 ALT2 @ 2.25 MHz Offset = -59 dBc @ 1 MHz Bandwidth
- Capable of Handling 3:1 VSWR, @ 26 Vdc, 1990 MHz, 8 Watts CW Output Power
- Stable into a 3:1 VSWR. All Spurs Below -60 dBc @ 100 mW to 8 W CW  $P_{out}$ .
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- On-Chip Matching (50 Ohm Input, DC Blocked, >5 Ohm Output)
- Integrated Temperature Compensation with Enable/Disable Function
- On-Chip Current Mirror  $g_m$  Reference FET for Self Biasing Application (1)
- Integrated ESD Protection
- N Suffix Indicates Lead-Free Terminations. RoHS Compliant.
- 200°C Capable Plastic Package
- In Tape and Reel. R1 Suffix = 500 Units per 44 mm, 13 inch Reel

**MW4IC2020NBR1**  
**MW4IC2020GNBR1**  
**MW4IC2020MBR1**  
**MW4IC2020GMBR1**

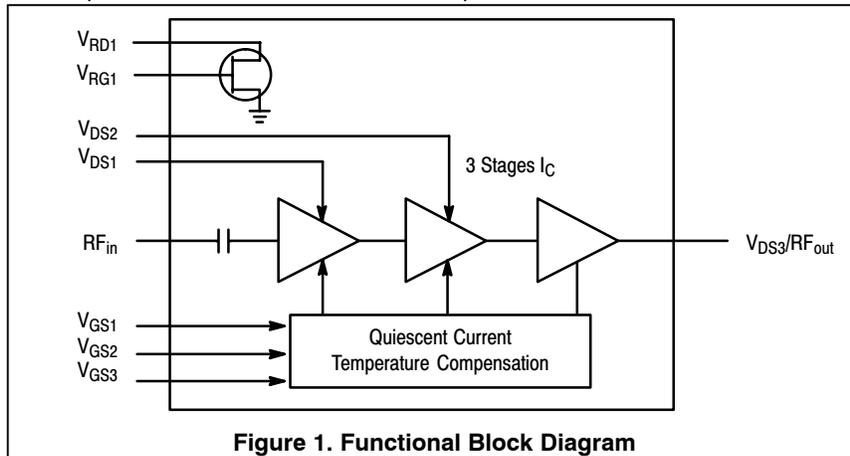
**1805-1990 MHz, 20 W, 26 V**  
**GSM/GSM EDGE, CDMA**  
**RF LDMOS WIDEBAND**  
**INTEGRATED POWER AMPLIFIERS**



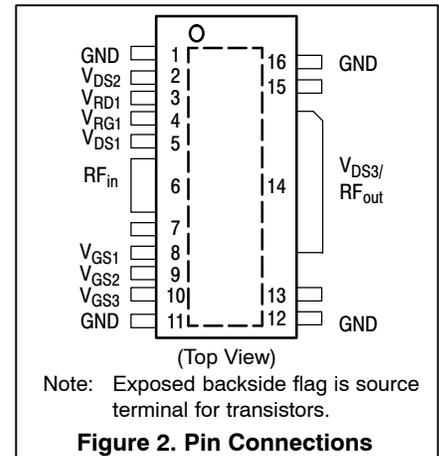
**CASE 1329-09**  
**TO-272 WB-16**  
**PLASTIC**  
**MW4IC2020NBR1(MBR1)**



**CASE 1329A-03**  
**TO-272 WB-16 GULL**  
**PLASTIC**  
**MW4IC2020GNBR1(GMBR1)**



**Figure 1. Functional Block Diagram**



(Top View)  
 Note: Exposed backside flag is source terminal for transistors.

**Figure 2. Pin Connections**

1. Refer to AN1987, *Quiescent Current Control for the RF Integrated Circuit Device Family*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1987.

**Table 1. Maximum Ratings**

Rating	Symbol	Value	Unit
Drain-Source Voltage	$V_{DSS}$	-0.5, +65	Vdc
Gate-Source Voltage	$V_{GS}$	-0.5, +15	Vdc
Storage Temperature Range	$T_{stg}$	-65 to +175	°C
Operating Junction Temperature	$T_J$	200	°C
Input Power	$P_{in}$	20	dBm

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (1)	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$		°C/W
Stage 1		10.5	
Stage 2		5.1	
Stage 3		2.3	

**Table 3. ESD Protection Characteristics**

Test Conditions	Class
Human Body Model	2 (Minimum)
Machine Model	M3 (Minimum)
Charge Device Model	C5 (Minimum)

**Table 4. Moisture Sensitivity Level**

Test Methodology	Rating	Package Peak Temperature	Unit
Per JESD 22-A113, IPC/JEDEC J-STD-020	3	260	°C

**Table 5. Electrical Characteristics** ( $T_C = 25^\circ\text{C}$  unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
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**Functional Tests** (In Freescale Wideband 1805-1990 MHz Test Fixture, 50 ohm system)  $V_{DD} = 26$  Vdc,  $I_{DQ1} = 80$  mA,  $I_{DQ2} = 200$  mA,  $I_{DQ3} = 300$  mA,  $P_{out} = 20$  W PEP,  $f_1 = 1990$  MHz,  $f_2 = 1990.1$  MHz and  $f_1 = 1805$  MHz,  $f_2 = 1805.1$  MHz, Two-Tone CW

Power Gain	$G_{ps}$	27	29	—	dB
Drain Efficiency	$\eta_D$	24	26	—	%
	$f_1 = 1805$ MHz, $f_2 = 1805.1$ MHz	18	20		
	$f_1 = 1990$ MHz, $f_2 = 1990.1$ MHz				
Input Return Loss	IRL	—	—	-10	dB
Intermodulation Distortion	IMD	—	-32	-27	dBc

**Typical Performances** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 26$  Vdc,  $I_{DQ1} = 80$  mA,  $I_{DQ2} = 200$  mA,  $I_{DQ3} = 300$  mA, 1805 MHz < Frequency < 1990 MHz, 1-Tone

Saturated Pulsed Output Power ( $f = 1$ kHz, Duty Cycle 10%)	$P_{sat}$	—	33	—	W
Quiescent Current Accuracy over Temperature (-10 to 85°C) (2)	$\Delta I_{QT}$	—	±5	—	%
Gain Flatness in 30 MHz Bandwidth @ $P_{out} = 1$ W CW	$G_F$	—	0.15	—	dB
Deviation from Linear Phase in 30 MHz Bandwidth @ $P_{out} = 1$ W CW	$\Phi$	—	±0.5	—	°
			±0.2		
Delay @ $P_{out} = 1$ W CW Including Output Matching	Delay	—	1.8	—	ns
Part-to-Part Phase Variation @ $P_{out} = 1$ W CW	$\Phi\Delta$	—	±10	—	°

1. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1955.

2. Refer to AN1977, *Quiescent Current Thermal Tracking Circuit in the RF Integrated Circuit Family*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1977.

(continued)

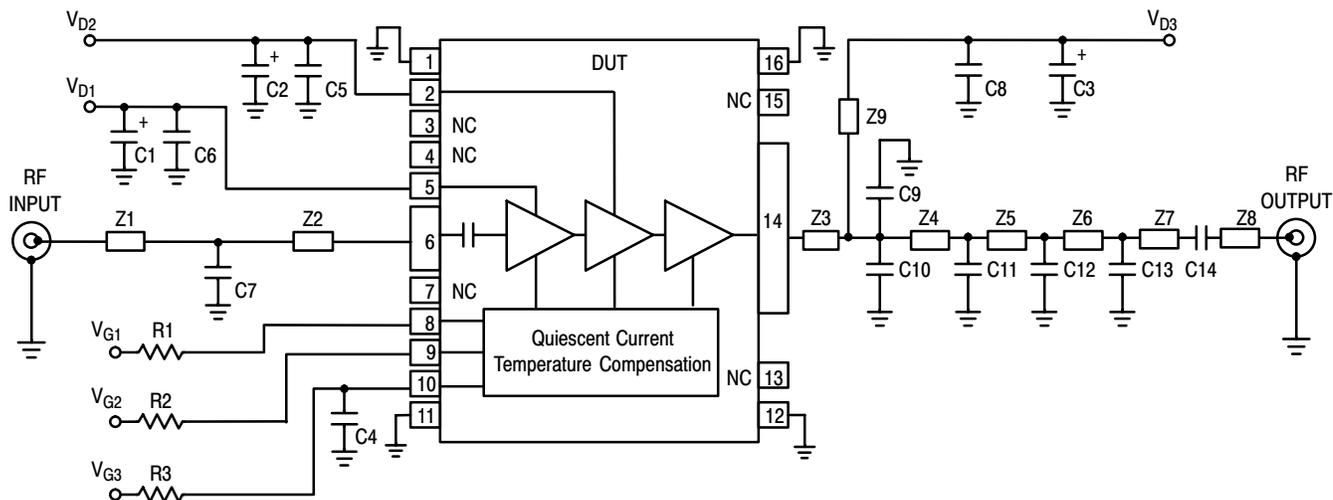
**Table 5. Electrical Characteristics** ( $T_C = 25^\circ\text{C}$  unless otherwise noted) **(continued)**

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Typical CDMA Performances</b> (In Modified CDMA Test Fixture, 50 ohm system) $V_{DD} = 26\text{ Vdc}$ , $I_{DQ1} = 80\text{ mA}$ , $I_{DQ2} = 240\text{ mA}$ , $I_{DQ3} = 250\text{ mA}$ , $P_{out} = 1\text{ W Avg.}$ , 11930 MHz<Frequency<1990 MHz, 1-Tone, 9 Channel Forward Model (Pilot, Paging, Sync, Traffic Codes 8 through 13). Peak/Avg. Ratio 9.8 dB @ 0.01% Probability on CCDF.					
Power Gain	$G_{ps}$	—	30	—	dB
Drain Efficiency	$\eta_D$	—	5	—	%
Adjacent Channel Power Ratio ( $\pm 885\text{ kHz @ } 30\text{ kHz Bandwidth}$ )	ACPR	—	-61	—	dBc
Alternate 1 Channel Power Ratio ( $\pm 1.25\text{ MHz @ } 12.5\text{ kHz Bandwidth}$ )	ALT1	—	-69	—	dBc
Alternate 2 Channel Power Ratio ( $\pm 2.25\text{ MHz @ } 1\text{ MHz Bandwidth}$ )	ALT2	—	-59	—	dBc

**Typical GSM EDGE Performances** (In Modified GSM EDGE Test Fixture, 50 ohm system)  $V_{DD} = 26\text{ Vdc}$ ,  $I_{DQ1} = 80\text{ mA}$ ,  $I_{DQ2} = 230\text{ mA}$ ,  $I_{DQ3} = 230\text{ mA}$ ,  $P_{out} = 5\text{ W Avg.}$ , 1805 MHz<Frequency<1990 MHz

Power Gain	$G_{ps}$	—	29	—	dB
Drain Efficiency	$\eta_D$	—	15	—	%
Error Vector Magnitude	EVM	—	1	—	% rms
Spectral Regrowth at 400 kHz Offset	SR1	—	-66	—	dBc
Spectral Regrowth at 600 kHz Offset	SR2	—	-77	—	dBc

NOTE - **CAUTION** - MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

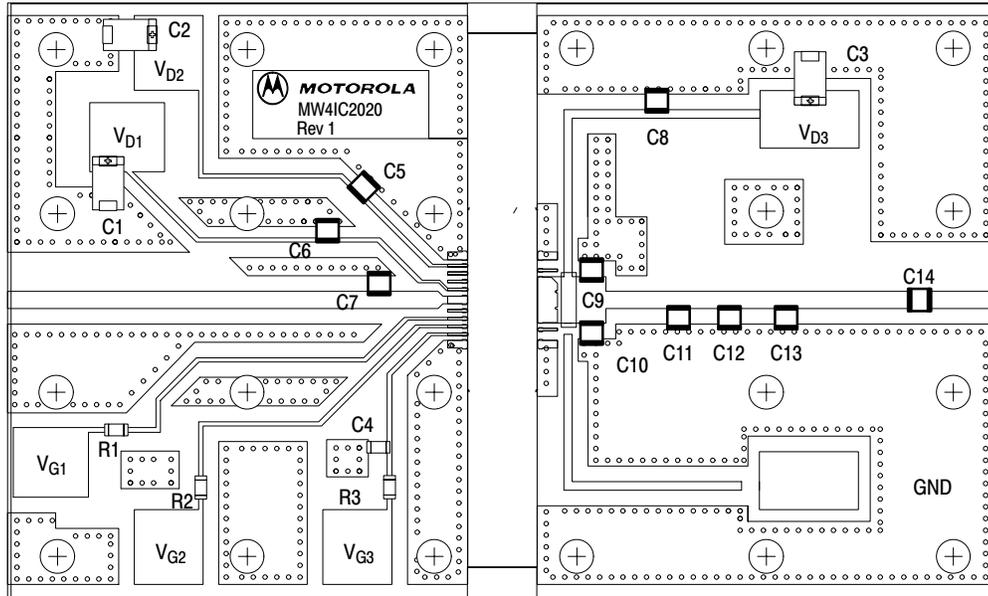


Z1	1.820" x 0.087" Microstrip	Z6	0.303" x 0.087" Microstrip
Z2	0.245" x 0.087" Microstrip	Z7	0.640" x 0.087" Microstrip
Z3	0.345" x 0.236" Microstrip	Z8	0.334" x 0.087" Microstrip
Z4	0.327" x 0.087" Microstrip	Z9	1.231" x 0.043" Microstrip
Z5	0.271" x 0.087" Microstrip	PCB	Taconic TLX8-0300, 0.030", $\epsilon_r = 2.55$

**Figure 3. MW4IC2020NBR1(MBR1)(GNBR1)(GMBR1) Test Circuit Schematic**

**Table 6. MW4IC2020NBR1(MBR1)(GNBR1)(GMBR1) Test Circuit Component Designations and Values**

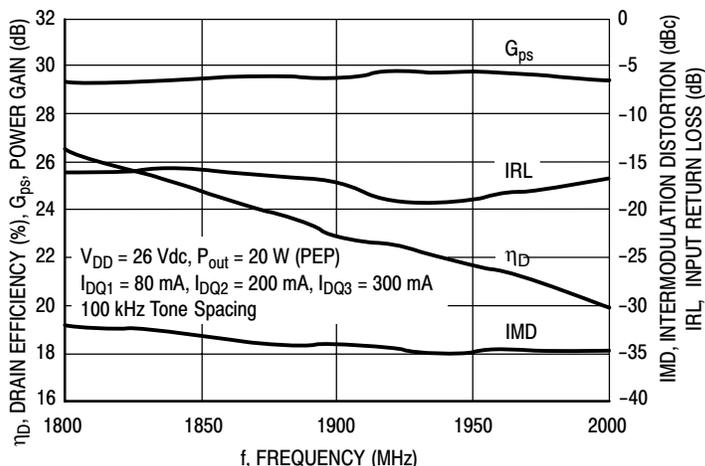
Part	Description	Part Number	Manufacturer
C1, C2, C3	10 $\mu$ F, 35 V Tantalum Capacitors	TAJE226M035	AVX
C4	220 nF Chip Capacitor (1206)	12065C224K28	AVX
C5, C6, C8	6.8 pF 100B Chip Capacitors	100B6R8CW	ATC
C7	0.5 pF 100B Chip Capacitor	100B0R5BW	ATC
C9, C11	1.8 pF 100B Chip Capacitors	100B1R8BW	ATC
C10	2.2 pF 100B Chip Capacitor	100B2R2BW	ATC
C12	1 pF 100B Chip Capacitor	100B1R0BW	ATC
C13	0.3 pF 100B Chip Capacitor	100B0R3BW	ATC
C14	10 pF 100B Chip Capacitor	100B100GW	ATC
R1, R2, R3	1.8 k $\Omega$ Chip Resistors (1206)		



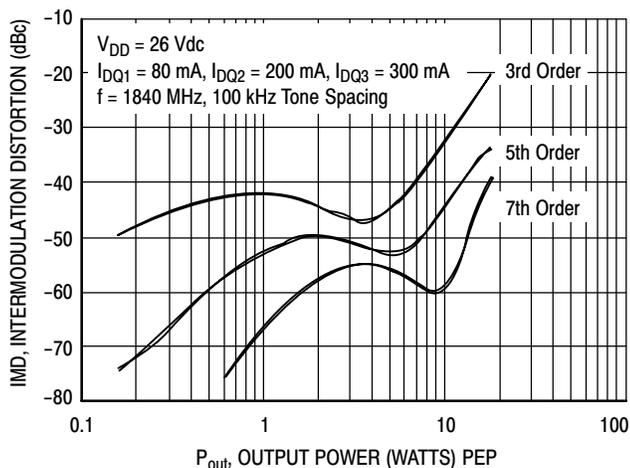
Freescale has begun the transition of marking Printed Circuit Boards (PCBs) with the Freescale Semiconductor signature/logo. PCBs may have either Motorola or Freescale markings during the transition period. These changes will have no impact on form, fit or function of the current product.

**Figure 4. MW4IC2020NBR1(MBR1)(GNBR1)(GMBR1) Test Circuit Component Layout**

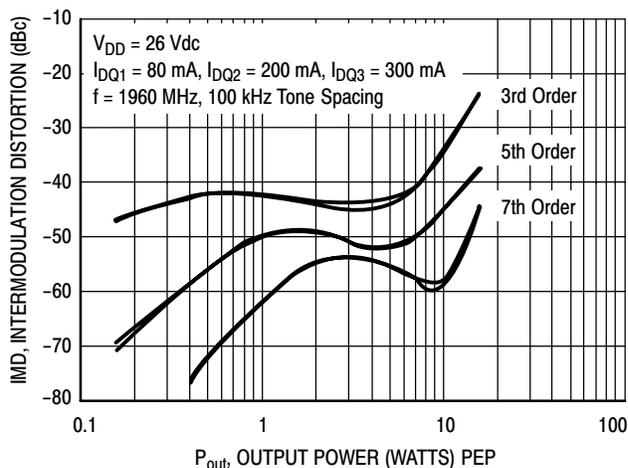
## TYPICAL CHARACTERISTICS



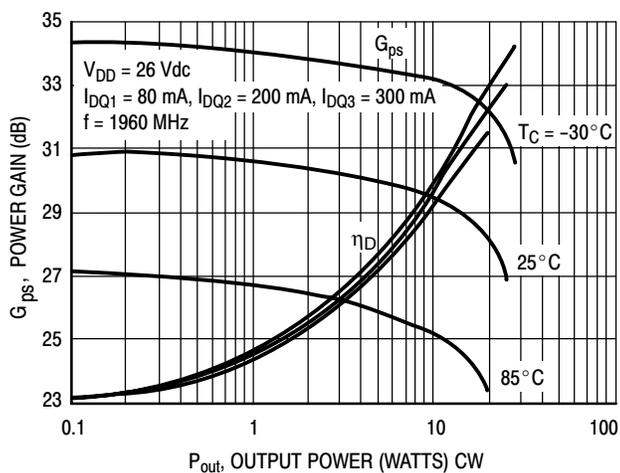
**Figure 5. Two-Tone Wideband Performance**



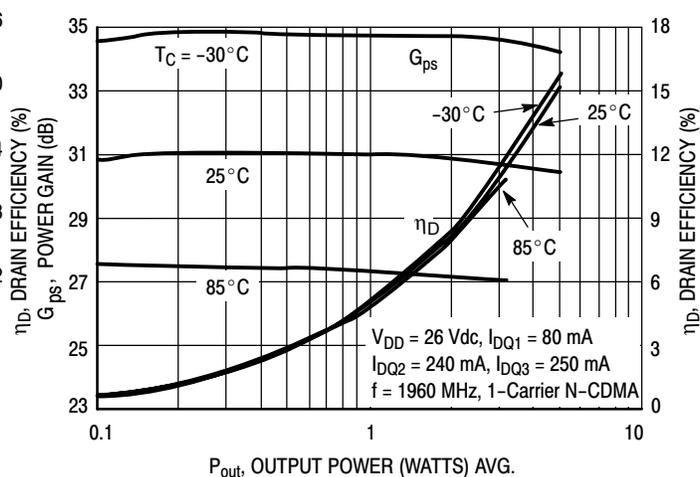
**Figure 6. Intermodulation Distortion Products versus Output Power @ 1840 MHz**



**Figure 7. Intermodulation Distortion Products versus Output Power @ 1960 MHz**



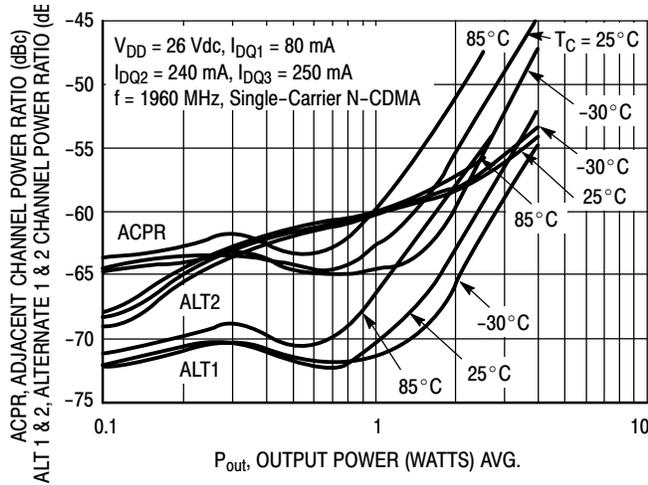
**Figure 8. Power Gain and Drain Efficiency versus Output Power**



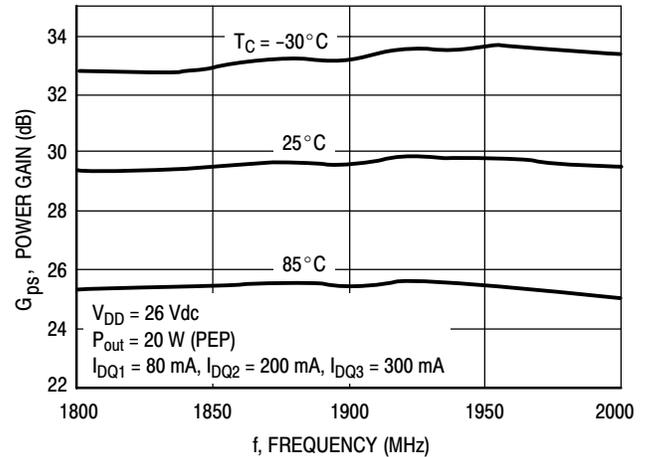
**Figure 9. Power Gain and Drain Efficiency versus Output Power**

MW4IC2020NBR1 MW4IC2020GNBR1 MW4IC2020MBR1 MW4IC2020GMBR1

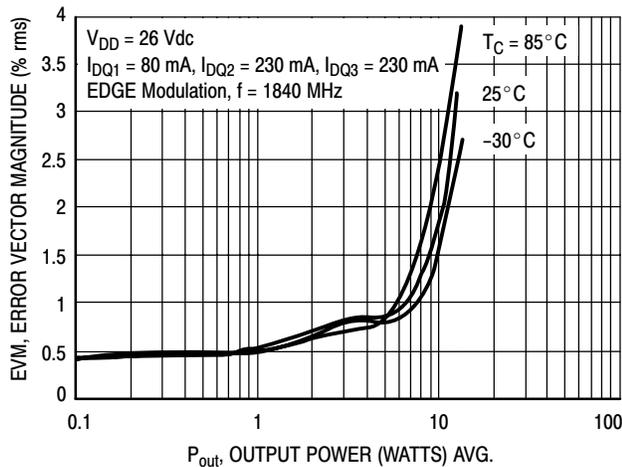
## TYPICAL CHARACTERISTICS



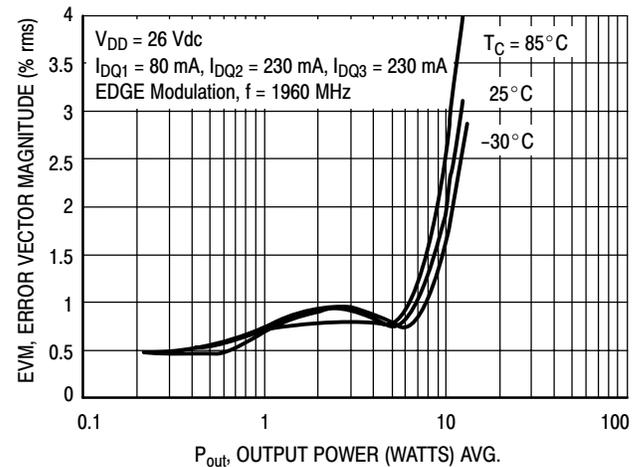
**Figure 10. Alternate Channel Power Ratio, Alternate 1 and 2 Channel Power Ratio versus Output Power**



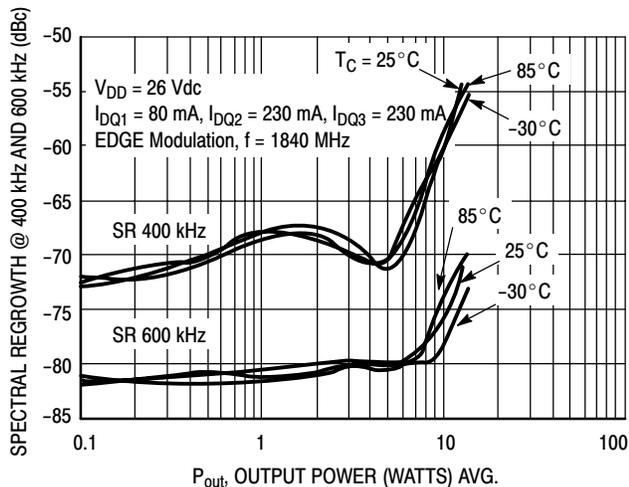
**Figure 11. Power Gain versus Frequency**



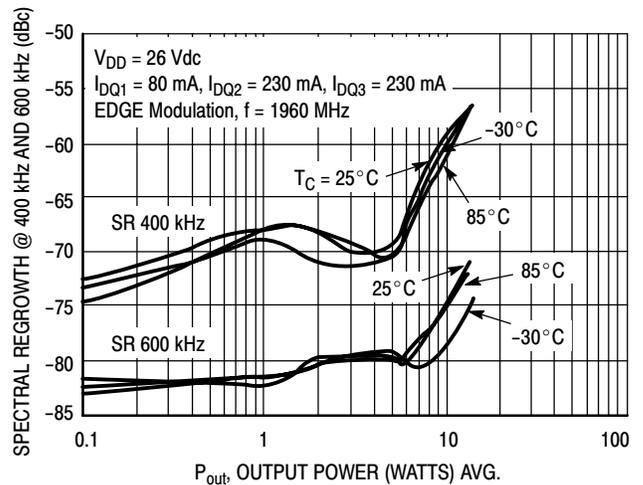
**Figure 12. EVM versus Output Power @ 1840 MHz**



**Figure 13. EVM versus Output Power @ 1960 MHz**



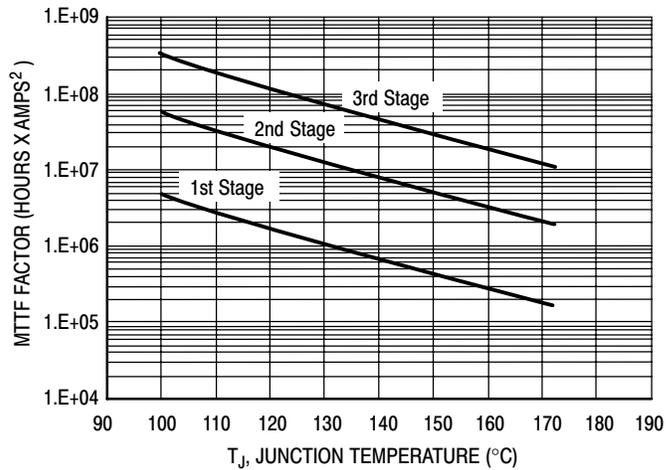
**Figure 14. Spectral Regrowth at 400 and 600 kHz versus Output Power @ 1840 MHz**



**Figure 15. Spectral Regrowth at 400 and 600 kHz versus Output Power @ 1960 MHz**

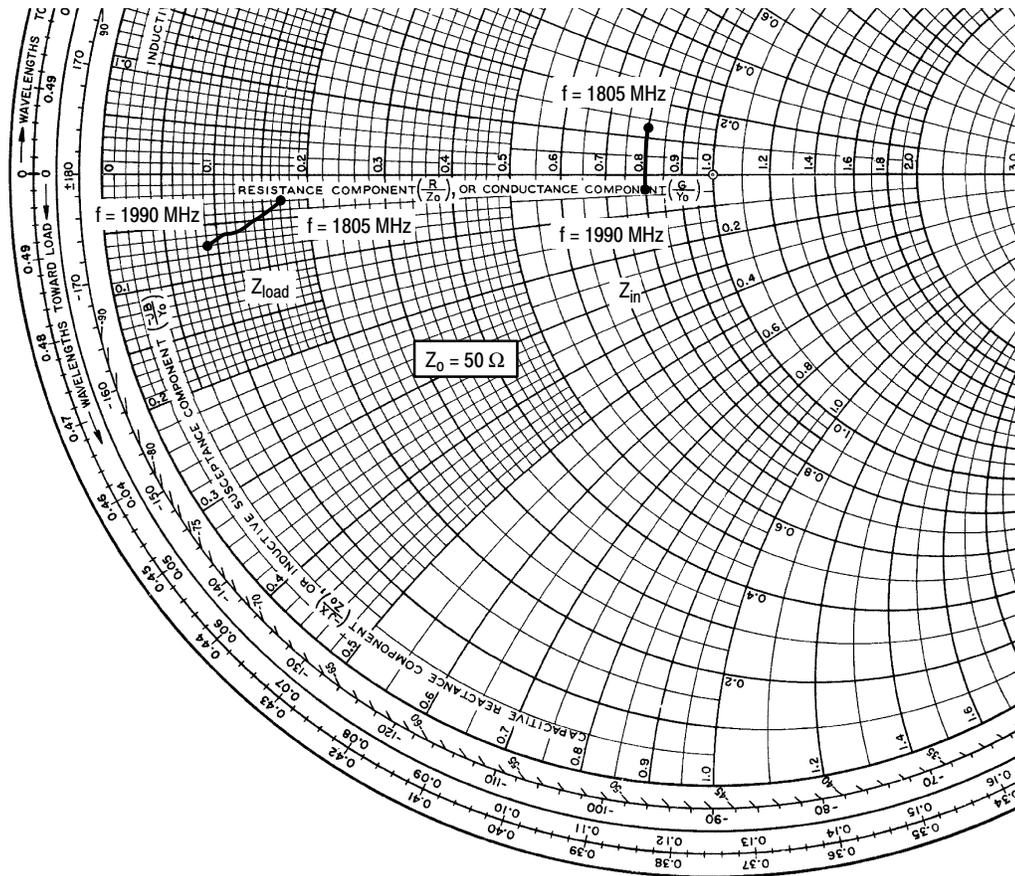
MW4IC2020NBR1 MW4IC2020GNBR1 MW4IC2020MBR1 MW4IC2020GMBR1

## TYPICAL CHARACTERISTICS



This above graph displays calculated MTTF in hours x ampere<sup>2</sup> drain current. Life tests at elevated temperatures have correlated to better than  $\pm 10\%$  of the theoretical prediction for metal failure. Divide MTTF factor by  $I_D^2$  for MTTF in a particular application.

**Figure 16. MTTF Factor versus Junction Temperature**



$V_{DD} = 26\text{ V}$ ,  $I_{DQ1} = 80\text{ mA}$ ,  $I_{DQ2} = 200\text{ mA}$ ,  $I_{DQ3} = 300\text{ mA}$ ,  $P_{out} = 20\text{ W PEP}$

f MHz	$Z_{in}$ $\Omega$	$Z_{load}$ $\Omega$
1805	$40.00 + j6.50$	$8.75 - j1.42$
1842	$40.00 + j2.00$	$7.00 - j2.70$
1880	$40.00 - j1.50$	$5.90 - j2.97$
1930	$40.00 - j1.80$	$5.46 - j3.20$
1960	$40.00 - j2.10$	$4.30 - j3.35$
1990	$40.00 - j2.60$	$4.45 - j3.30$

$Z_{in}$  = Device input impedance as measured from gate to ground.

$Z_{load}$  = Test circuit impedance as measured from drain to ground.

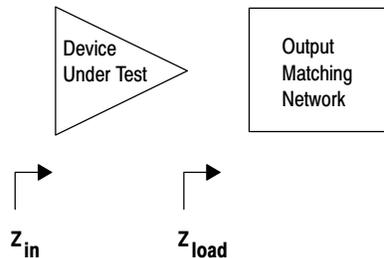
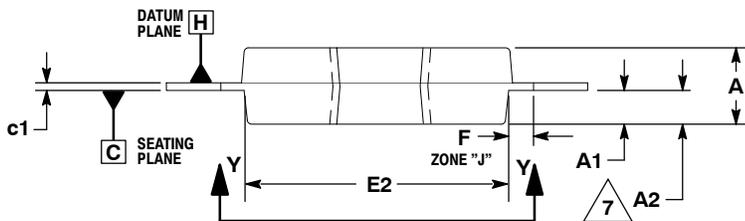
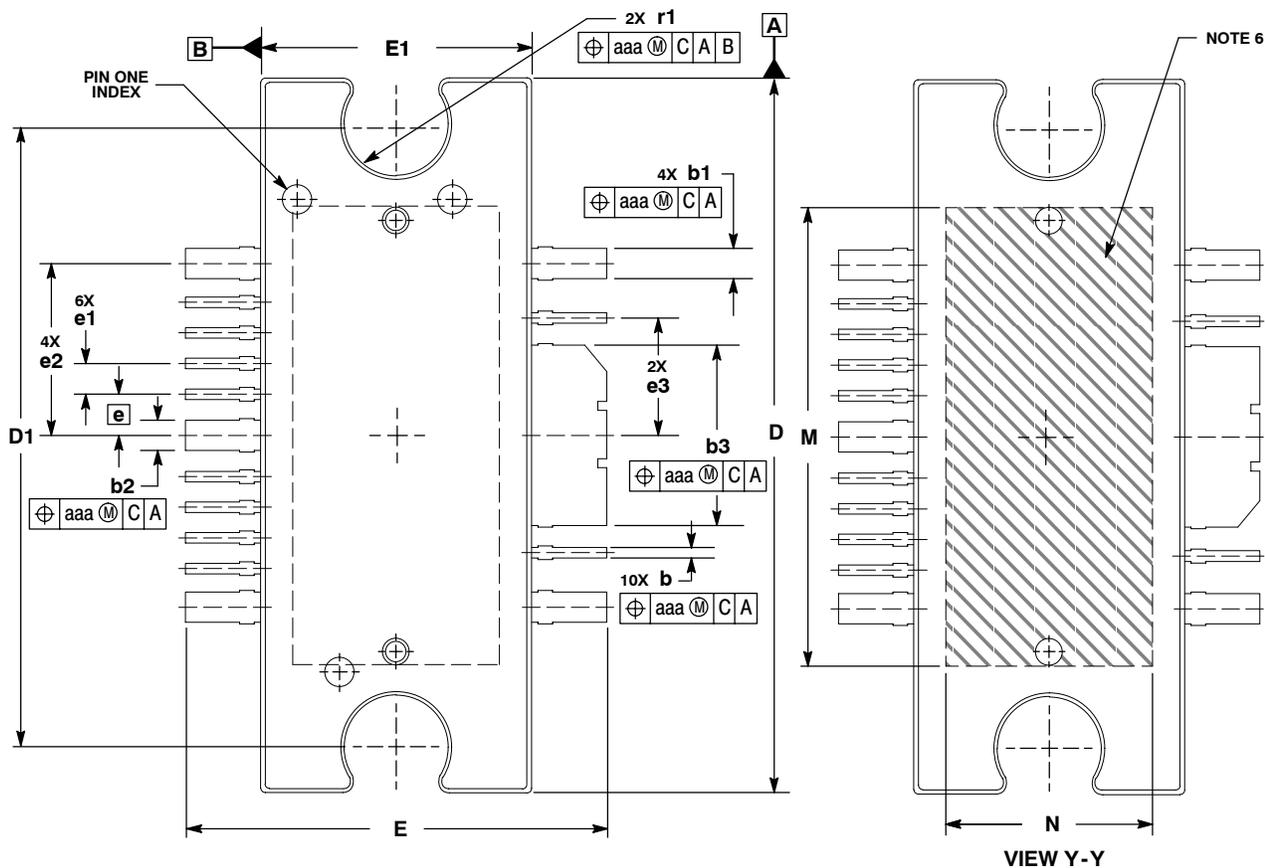


Figure 17. Series Equivalent Input and Load Impedance

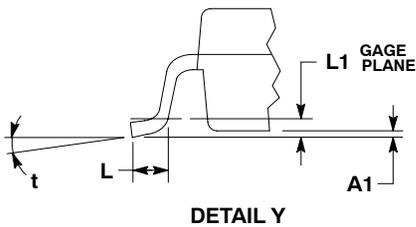
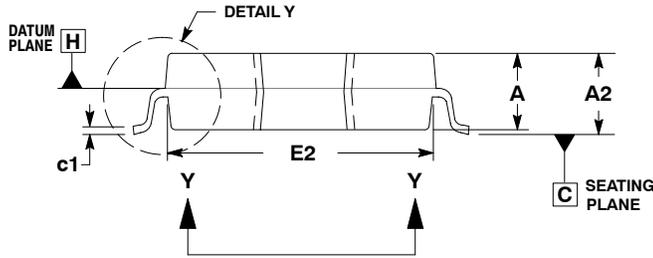
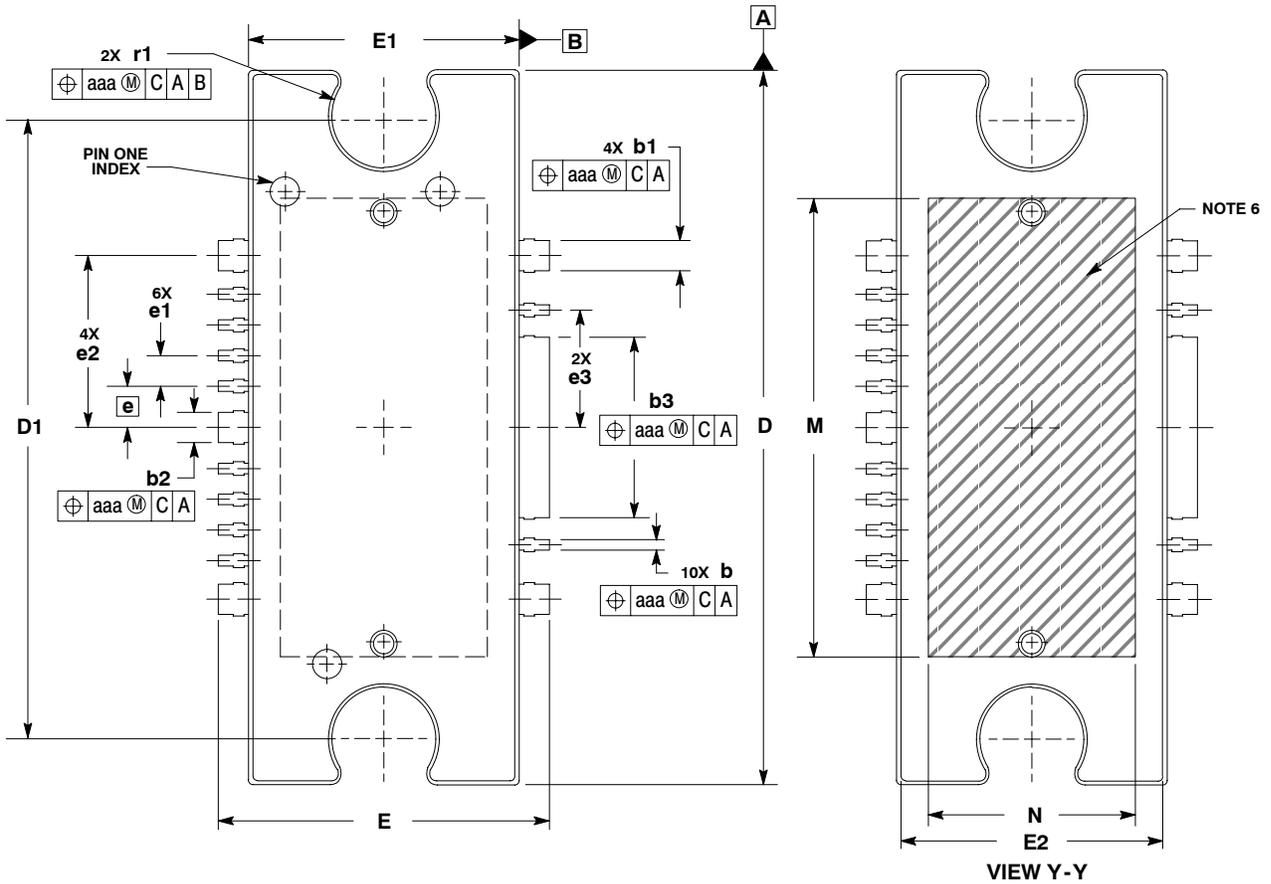
# PACKAGE DIMENSIONS



- NOTES:
1. CONTROLLING DIMENSION: INCH.
  2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
  3. DATUM PLANE -H- IS LOCATED AT TOP OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE TOP OF THE PARTING LINE.
  4. DIMENSIONS "D" AND "E1" DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 (0.15) PER SIDE. DIMENSIONS "D" AND "E1" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE -H-.
  5. DIMENSIONS "b", "b1", "b2" AND "b3" DO NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 (0.13) TOTAL IN EXCESS OF THE "b", "b1", "b2" AND "b3" DIMENSIONS AT MAXIMUM MATERIAL CONDITION.
  6. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG.
  7. DIM A2 APPLIES WITHIN ZONE "J" ONLY.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.100	.104	2.54	2.64
A1	.038	.044	0.96	1.12
A2	.040	.042	1.02	1.07
D	.928	.932	23.57	23.67
D1	.810 BSC		20.57 BSC	
E	.551	.559	14.00	14.20
E1	.353	.357	8.97	9.07
E2	.346	.350	8.79	8.89
F	.025 BSC		0.64 BSC	
M	.600	---	15.24	---
N	.270	---	6.86	---
b	.011	.017	0.28	0.43
b1	.037	.043	0.94	1.09
b2	.037	.043	0.94	1.09
b3	.225	.231	5.72	5.87
c1	.007	.011	.18	.28
e	.054 BSC		1.37 BSC	
e1	.040 BSC		1.02 BSC	
e2	.224 BSC		5.69 BSC	
e3	.150 BSC		3.81 BSC	
r1	.063	.068	1.6	1.73
aaa	.004		.10	

**CASE 1329-09  
ISSUE K  
TO-272 WB-16  
PLASTIC  
MW4IC2020NBR1(MBR1)**



- NOTES:
1. CONTROLLING DIMENSION: INCH.
  2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
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  6. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SINK.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.100	.104	2.54	2.64
A1	.001	.004	0.02	0.10
A2	.099	.110	2.51	2.79
D	.928	.932	23.57	23.67
D1	.810 BSC		20.57 BSC	
E	.429	.437	10.90	11.10
E1	.353	.357	8.97	9.07
E2	.346	.350	8.79	8.89
L	.018	.024	4.90	5.06
L1	.01 BSC		0.25 BSC	
M	.600	---	15.24	---
N	.270	---	6.86	---
b	.011	.017	0.28	0.43
b1	.037	.043	0.94	1.09
b2	.037	.043	0.94	1.09
b3	.225	.231	5.72	5.87
c1	.007	.011	.18	.28
e	.054 BSC		1.37 BSC	
e1	.040 BSC		1.02 BSC	
e2	.224 BSC		5.69 BSC	
e3	.150 BSC		3.81 BSC	
r1	.063	.068	1.6	1.73
t	2°	8°	2°	8°
aaa	.004		.10	

**CASE 1329A-03  
ISSUE D  
TO-272 WB-16 GULL  
PLASTIC  
MW4IC2020GNBR1(GMBR1)**

MW4IC2020NBR1 MW4IC2020GNBR1 MW4IC2020MBR1 MW4IC2020GMBR1

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Freescale Semiconductor  
Technical Information Center, CH370  
1300 N. Alma School Road  
Chandler, Arizona 85224  
+1-800-521-6274 or +1-480-768-2130  
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Freescale Halbleiter Deutschland GmbH  
Technical Information Center  
Schatzbogen 7  
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+33 1 69 35 48 48 (French)  
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**Japan:**  
Freescale Semiconductor Japan Ltd.  
Headquarters  
ARCO Tower 15F  
1-8-1, Shimo-Meguro, Meguro-ku,  
Tokyo 153-0064  
Japan  
0120 191014 or +81 3 5437 9125  
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