

27.5 – 31 GHz 9W GaN PA MMIC

Product Overview

Microchip's GMICP2731-10 is a Ka Band MMIC power amplifier fabricated using GaN SiC technology. It achieves 39.5 dBm saturated output power from 27.5 – 31 GHz, with 22% PAE and 22 dB small signal gain. The balanced topology provides excellent broadband input and output match to 50Ω and DC blocking capacitors ensure simple integration.

Excellent linearity characteristics make GMICP2731-10 well suited to applications in Satellite Communications. The die are 100% DC and RF tested on wafer ensuring compliance to the electrical specifications.

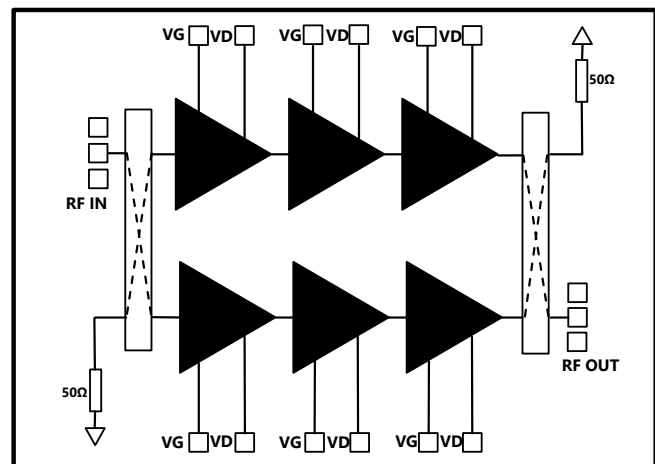
Key Features

- Frequency range: 27.5 – 31 GHz
- Pout: 39.5 dBm (Pin = 24 dBm)
- PAE: 22% (Pin = 24 dBm)
- Small Signal Gain: 22 dB (28 GHz)
- Return Loss: 15 dB
- Drain Bias 24V, IDQ = 112 mA – 224 mA
- Technology: GaN on SiC
- Lead-free and RoHS compliant
- Dimensions: 3.025 mm × 3.405 mm × 0.10 mm

Applications

- Satellite Communications
- Aerospace & Defense
- 5G

Functional Block Diagram



Typical Performances

Parameter	Typical	Units	Conditions ¹
Frequency range	27.5 – 31	GHz	
Saturated Output Power, Psat	39.5	dBm	Pin = 24 dBm
Power Added Efficiency, PAE	22	%	Pin = 24 dBm
Small Signal Gain, S21	22	dB	
Input Return Loss	-15	dB	
Output Return Loss	-15	dB	

Note:

1. Test conditions unless otherwise stated CW, VD = 24V, IDQ = 110 mA, VG ~ -1.84V typical, TA = 25 °C

Table of Contents

Product Overview.....	1
1. Electrical Specifications.....	3
1.1. Typical Electrical Performance.....	3
1.2. Absolute Maximum Ratings.....	3
1.3. Typical RF Performance.....	4
2. Die Specifications.....	12
3. Application Circuits.....	14
4. Ordering, Shipping, and Handling.....	17
4.1. Handling Recommendations.....	17
4.2. Ordering Information.....	17
5. Revision History.....	18
The Microchip Website.....	19
Product Change Notification Service.....	19
Customer Support.....	19
Product Identification System.....	20
Microchip Devices Code Protection Feature.....	20
Legal Notice.....	20
Trademarks.....	20
Quality Management System.....	21
Worldwide Sales and Service.....	22

1. Electrical Specifications

1.1 Typical Electrical Performance

Table 1-1. Electrical Specifications

Parameter	Min	Typical	Max	Units	Conditions(1)
Frequency Range	27.5		31	GHz	
Saturated Output Power, Psat	37	39.5		dBm	Pin = 24 dBm
Power Added Efficiency, PAE		22		%	Pin = 24 dBm
Small Signal Gain, S21		22		dB	
Input Return Loss		-15		dB	
Output Return Loss		-15		dB	
Power Detector Range	20		39	dBm	Temperature reference diode provided

(1) Test conditions unless otherwise stated CW, VD = 24V, IDQ = 110 mA, VG~ -1.84V typical, TA = 25 °C

Table 1-2. Recommended Operating Conditions

Parameters	Value
Drain Voltage (VD)	20V – 24V
Drain Quiescent Current (IDQ)	100 mA – 224 mA
Gate Voltage Range (VG)	-2V to -1.5V
Operating Temperature (TA)	-40 °C to +85 °C

1.2 Absolute Maximum Ratings

Table 1-3. Thermal and Reliability

Parameters	Value
Thermal Resistance	4.9 °C/W

Notes

1. Assumes silver sintered epoxy attach (15 μm thick) mounted on CuMo carrier.
2. Base temperature is assumed at the top of the CuMo carrier
3. Thermal resistance calculated using IR measurement of the channel temperature

Table 1-4. Absolute Maximum Ratings

Parameters	Absolute Maximum
Drain Voltage (VDG)	32V
Gate Voltage Range (VG)	-5V to 0V

.....continued	
Parameters	Absolute Maximum
Drain Current (ID)	3A
Gate Current (IG)	6.0 mA
CW Power Dissipation (85C)	40W
CW Input Power—no instability (4:1 VSWR, VD = 20V, IDQ = 112 mA, 25 °C)	+25 dBm
CW Input Power—no damage (10:1 VSWR, VD = 20V, IDQ = 112 mA, 25 °C)	+25 dBm
Channel Temperature	275 °C
Eutectic Die Attach Temperature (30s)	320 °C
Storage Temperature	-65 °C to +150 °C

Note:

Exceeding any one or combination of these limits may cause permanent damage to this device.

ICONIC RF does not recommend sustained operation near these survivability limits.

1.3 Typical RF Performance

1.3.1 Typical Small Signal Performance

Test Conditions (unless otherwise stated): Temp = 25 °C, CW, VD = 24V, ID = 110 mA.

Figure 1-1. Gain vs. Temperature @ 20V/110mA

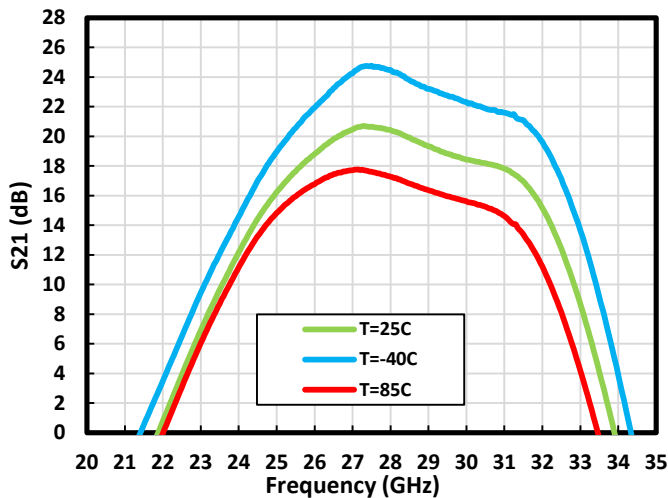


Figure 1-2. Gain vs. Temperature @ 24V/110mA

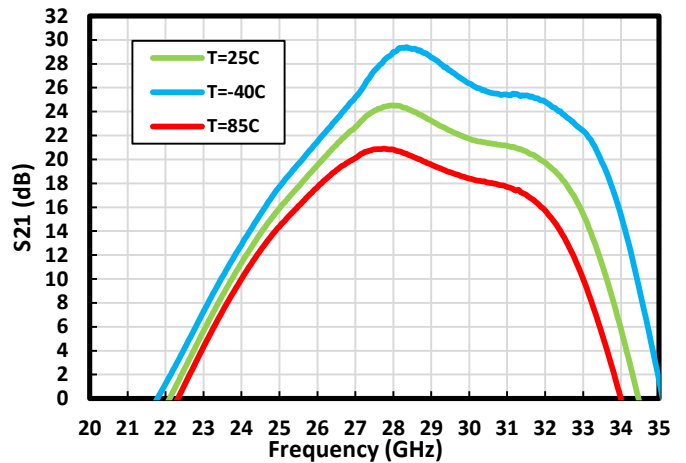


Figure 1-3. S11 vs. Temperature @ 20V/110mA

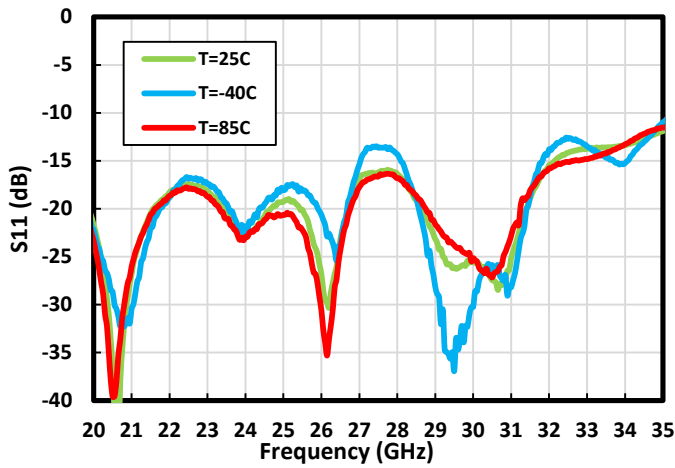


Figure 1-4. S11 vs. Temperature @ 24V/110mA

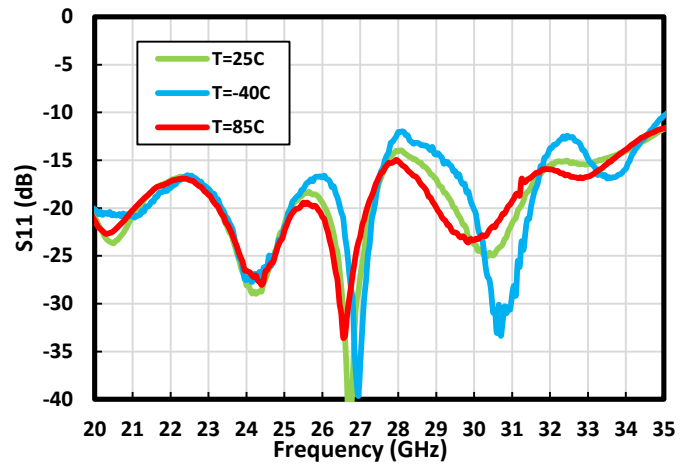


Figure 1-5. S22 vs. Temperature @ 20V/110mA

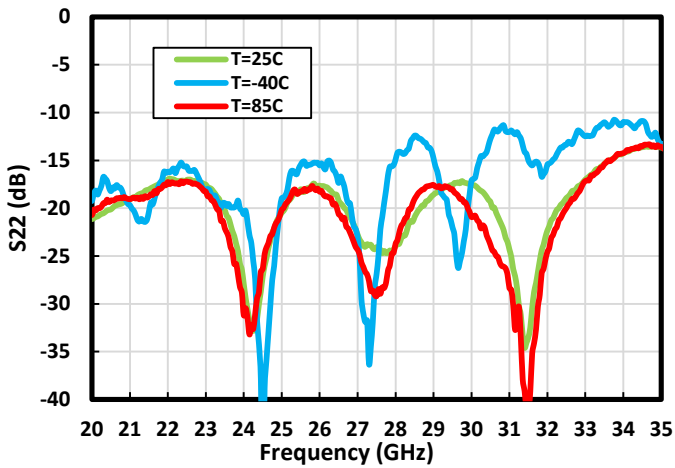
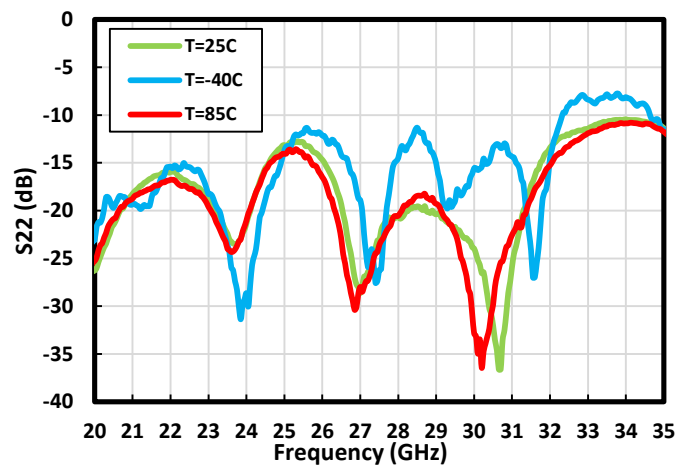


Figure 1-6. S22 vs. Temperature @ 24V/110mA



1.3.2 Typical Power Performance

Test Conditions (unless otherwise stated): Temp = 25 °C, CW, VD = 24V, ID = 110 mA.

Figure 1-7. Pout vs. Pin @ 20V

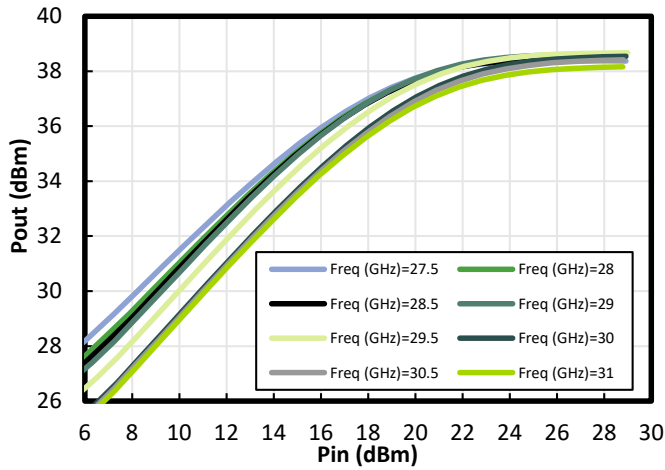


Figure 1-8. Gain vs. Pout @ 20V

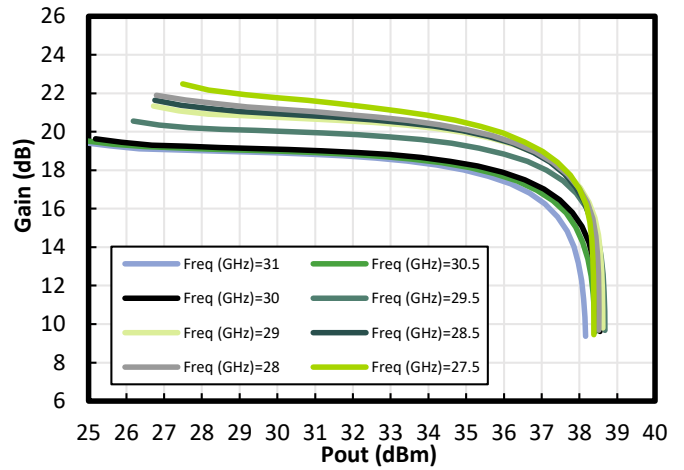


Figure 1-9. PAE vs. Pout @ 20V

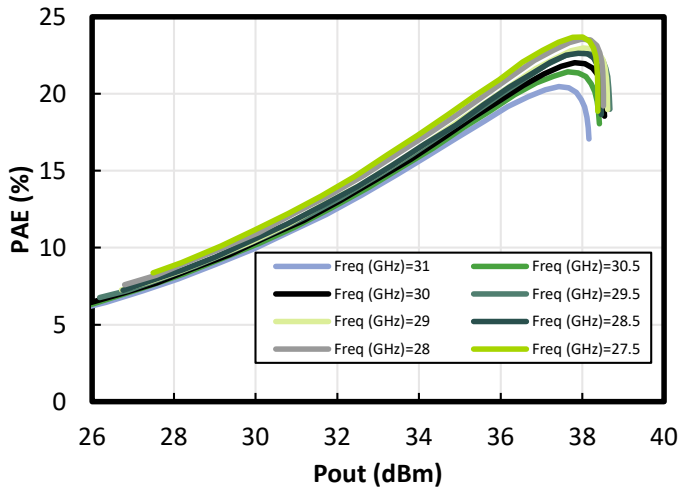


Figure 1-10. Id vs. Pout @ 20V

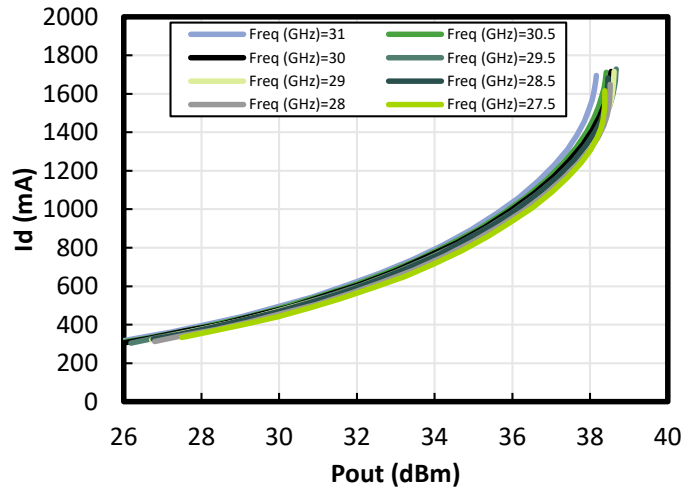


Figure 1-11. Pout vs. Pin @ 24V/100mA

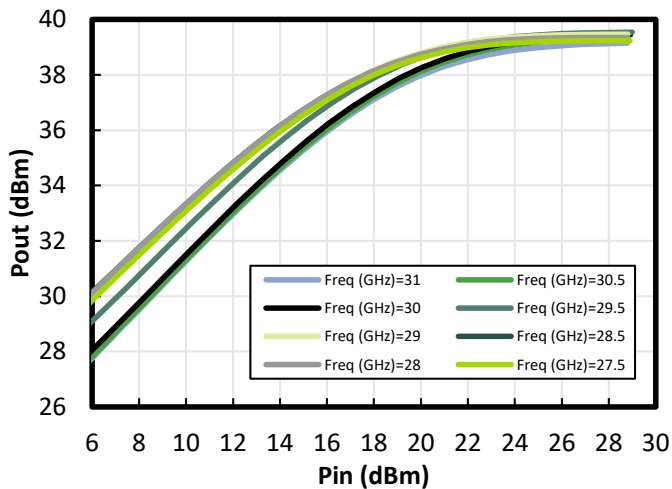


Figure 1-12. Gain vs. Pout @ 24V/100mA

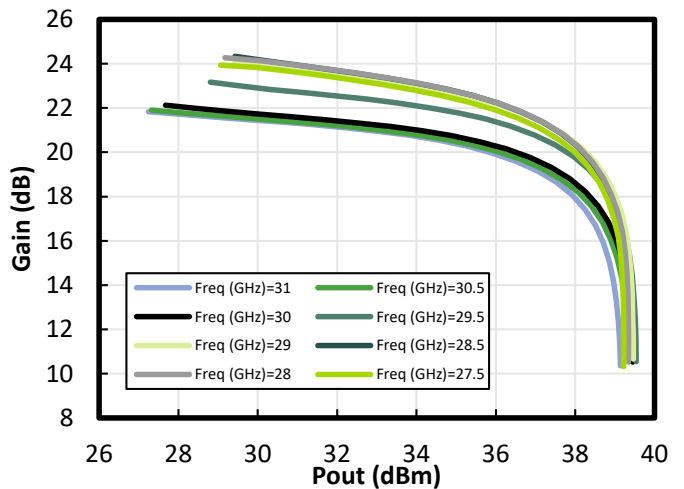


Figure 1-13. PAE vs. Pout @ 24V/100mA

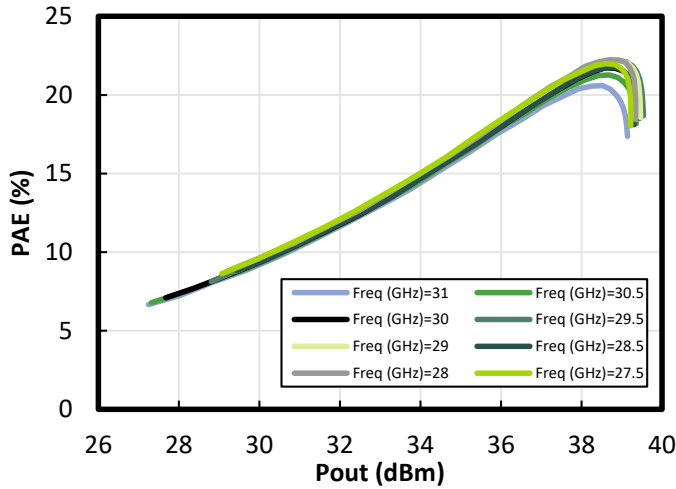


Figure 1-14. Id vs. Pout @ 24V/100mA

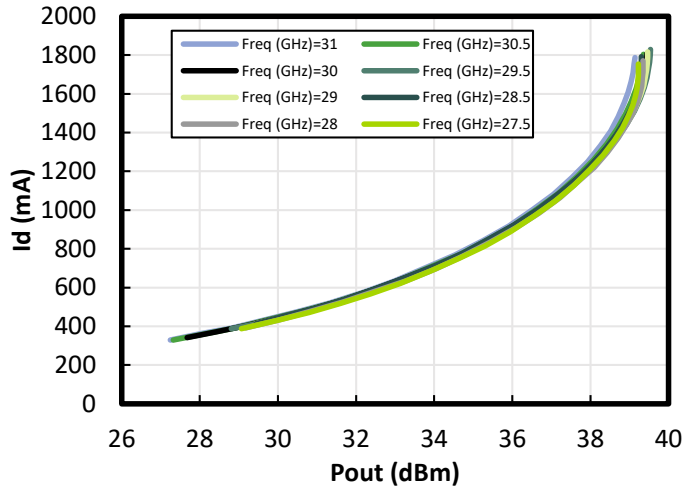


Figure 1-15. Pout vs. Freq @ 24V/110mA

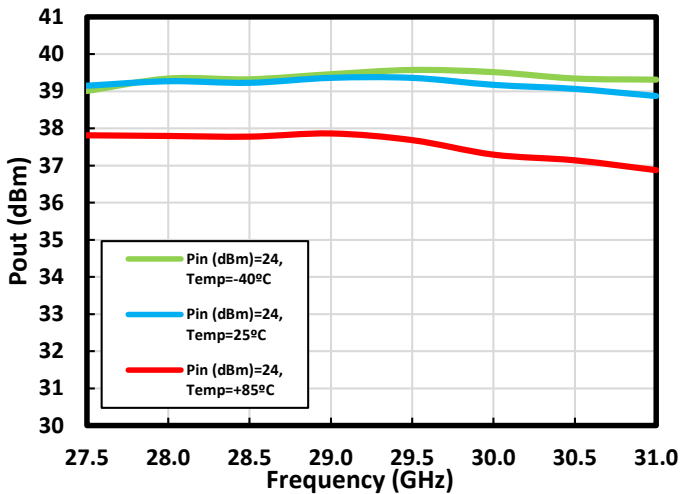


Figure 1-16. Gain vs. Freq @ 24V/110mA

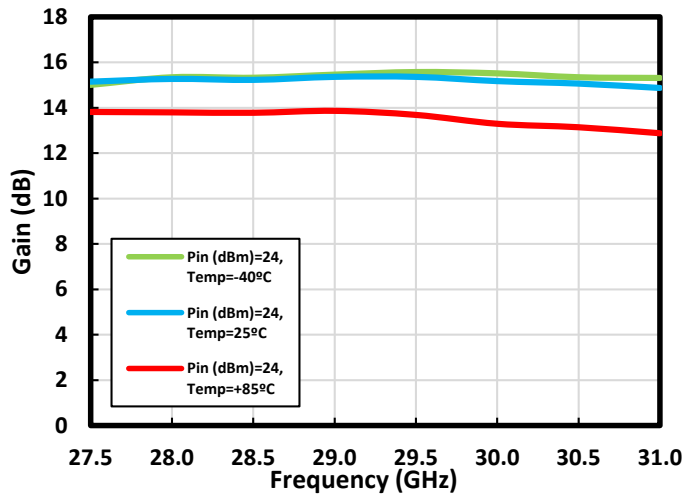


Figure 1-17. PAE vs. Freq @ 24V/110mA

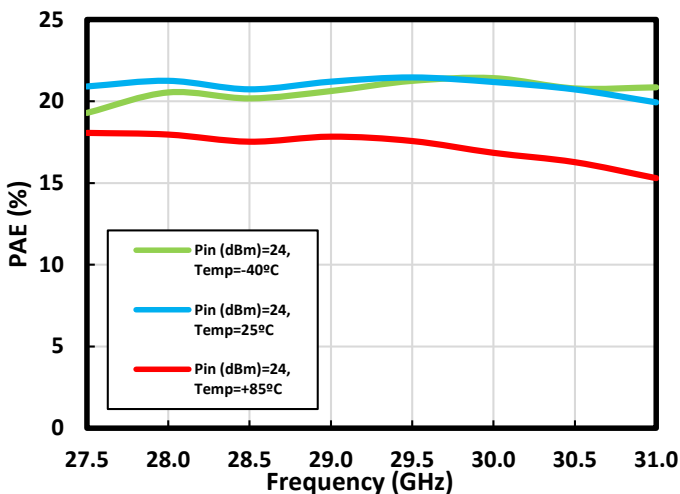


Figure 1-18. Id vs. Freq @ 24V/110mA

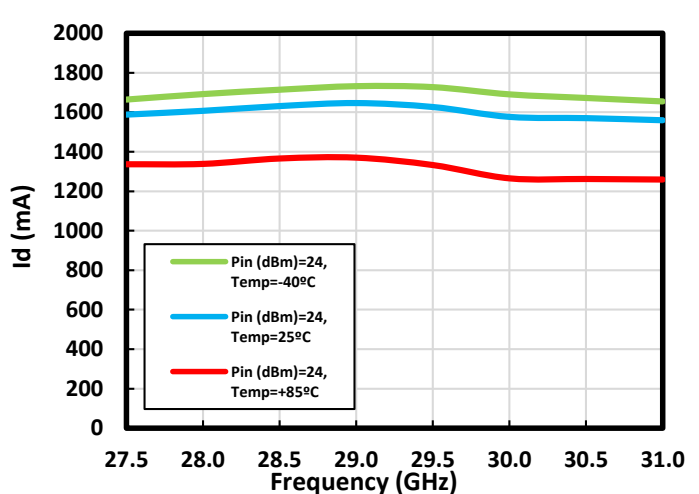


Figure 1-19. Pout vs. Pin @ 28GHz & 24V/110mA

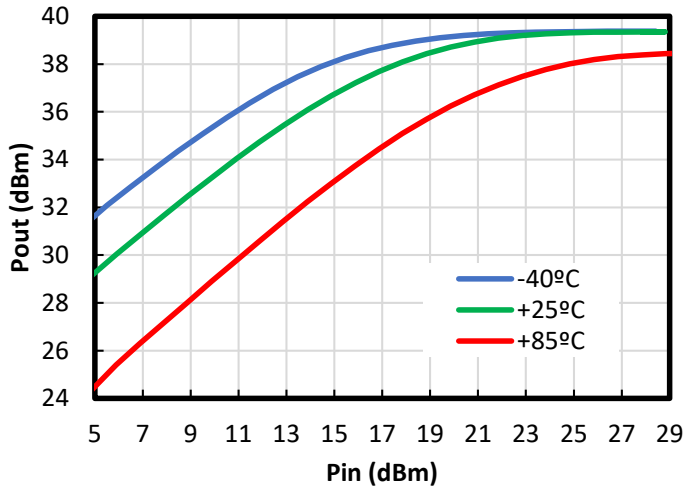


Figure 1-20. Gain vs. Pout @ 28GHz & 24V/110mA

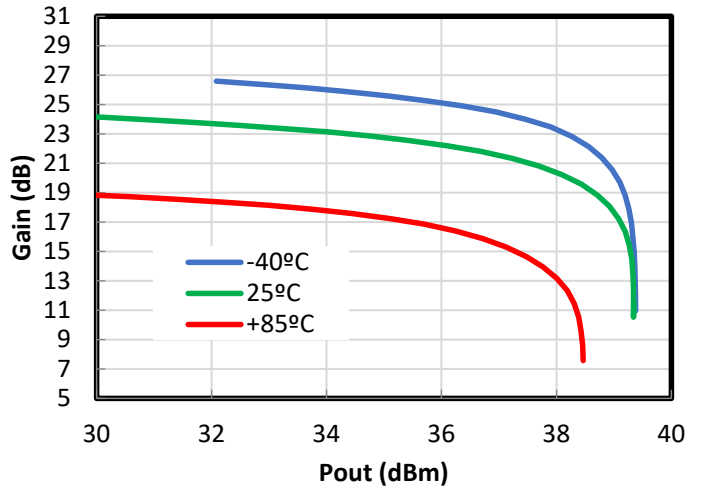


Figure 1-21. PAE vs. Pout @ 28GHz & 24V/110mA

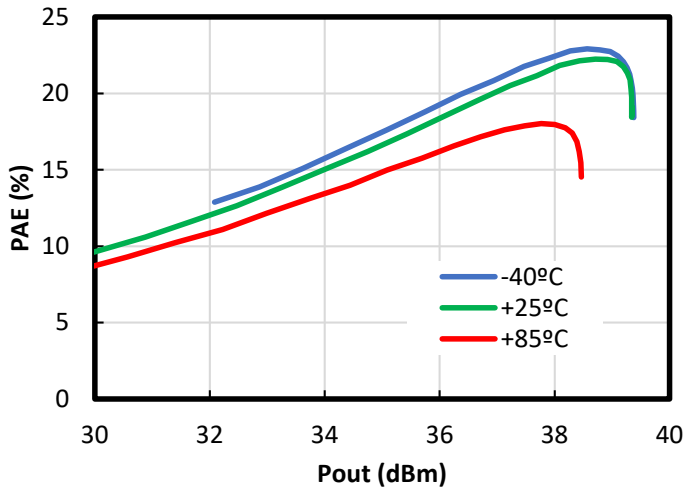


Figure 1-22. Id vs. Pout @ 28GHz & 24V/110mA

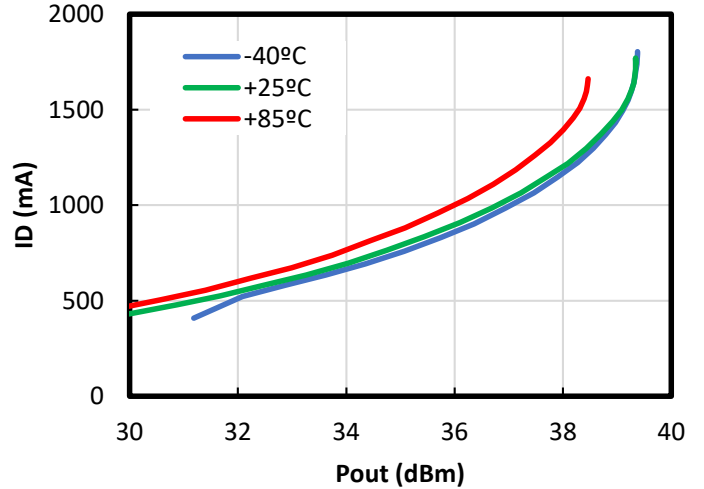


Figure 1-23. Pout vs. Pin @ 29GHz & 24V/110mA

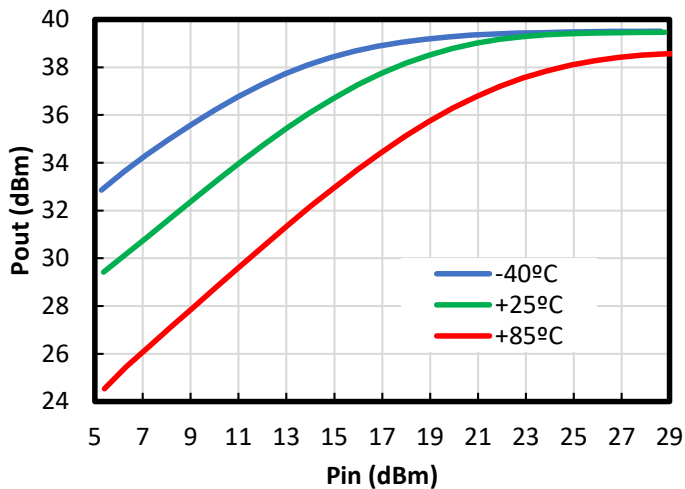


Figure 1-24. Gain vs. Pout @ 29GHz & 24V/110mA

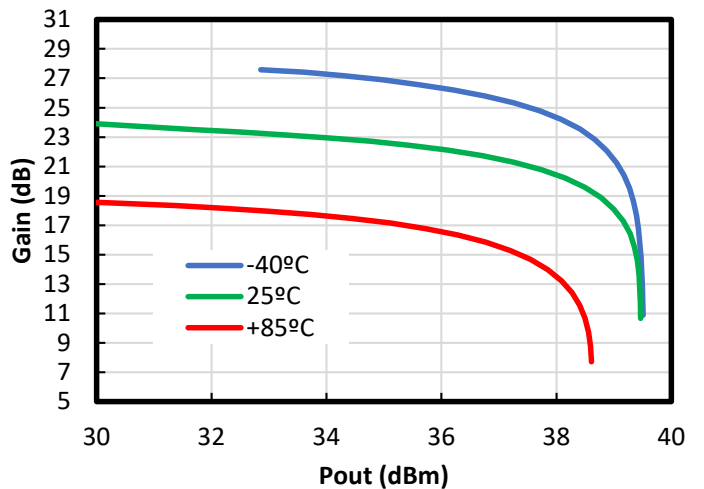


Figure 1-25. PAE vs. Pout @ 29GHz & 24V/110mA

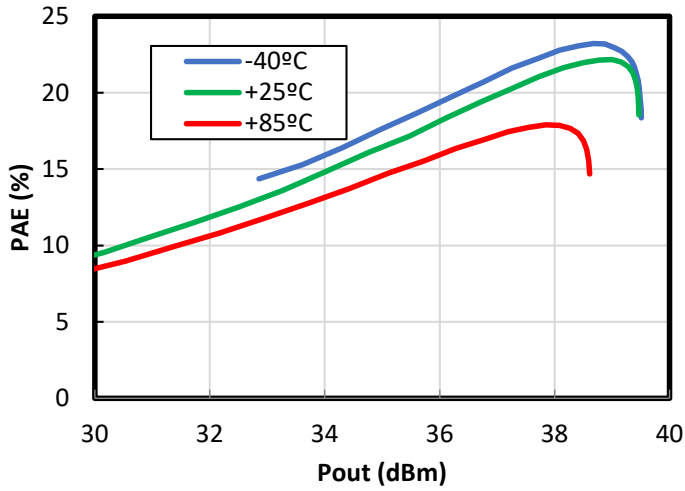


Figure 1-26. Id vs. Pout @ 29GHz & 24V/110mA

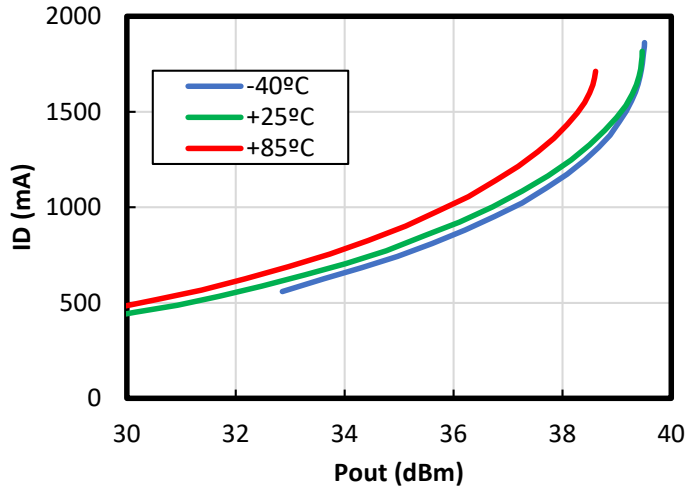


Figure 1-27. Pout vs. Pin @ 30GHz & 24V/110mA

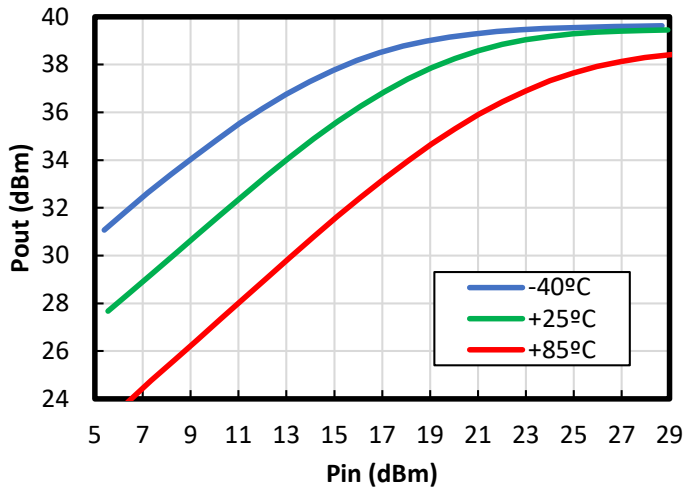


Figure 1-28. Gain vs. Pout @ 30GHz & 24V/110mA

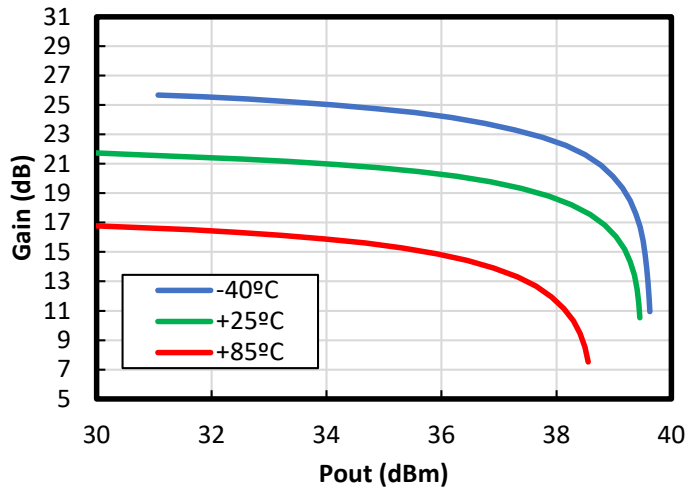


Figure 1-29. PAE vs. Pout @ 30GHz & 24V/110mA

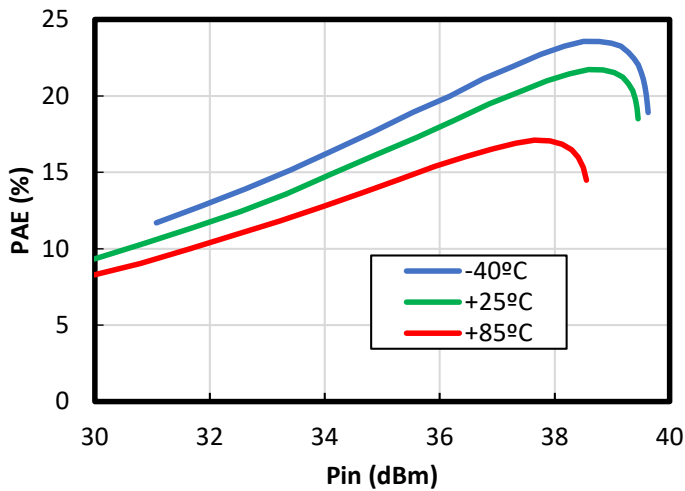
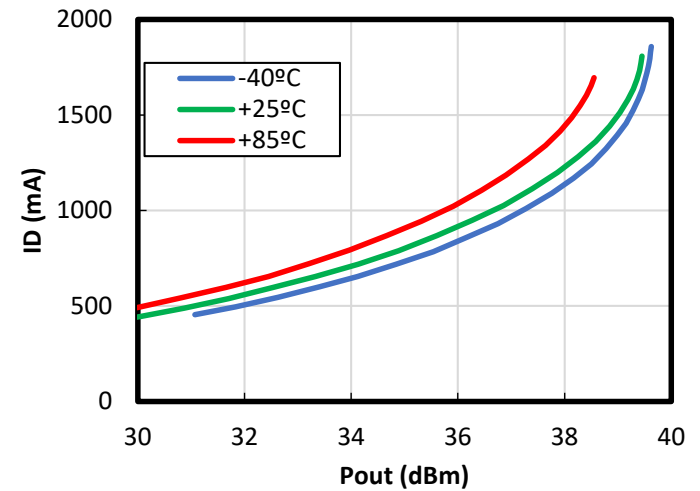


Figure 1-30. Id vs. Pout @ 30GHz & 24V/110mA



1.3.3 Typical 2-Tones RF Performance

Test Conditions (unless otherwise stated): Temp = 25 °C, VD = 20V, ID = 110 mA, CW Tone spacing of 10 MHz.

Figure 1-31. IM3 vs. Pout @ 20V & -40°C

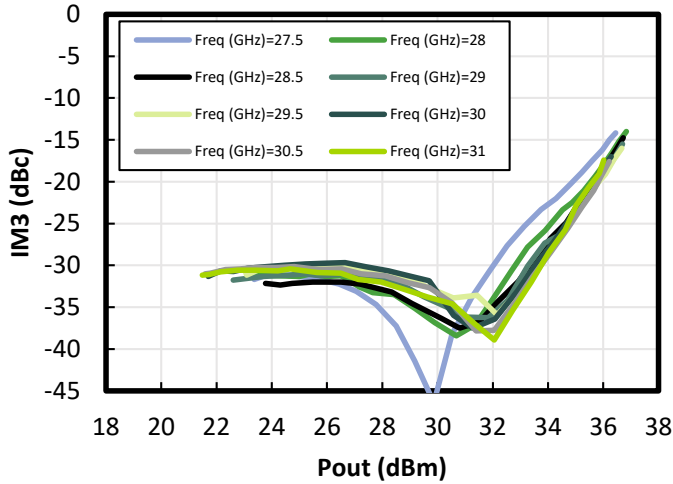


Figure 1-32. IM3 vs. Pout @ 24V & -40°C

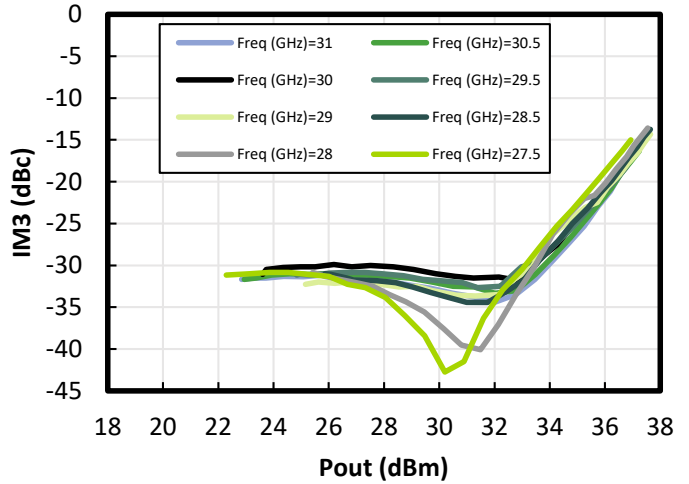


Figure 1-33. IM3 vs. Pout @ 20V & 25°C

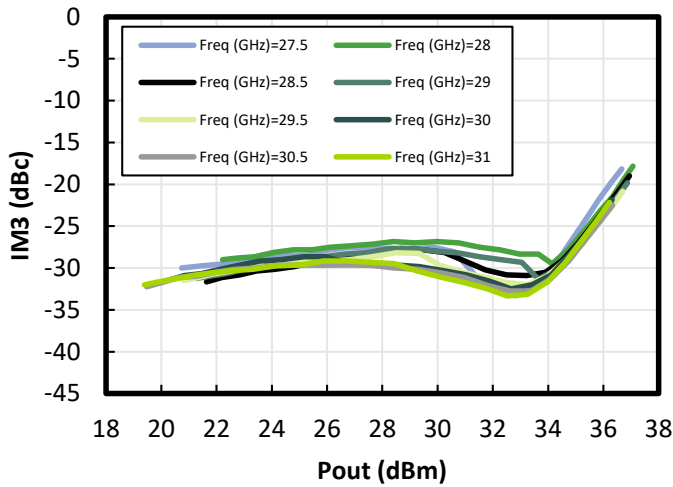


Figure 1-34. IM3 vs. Pout @ 24V & 25°C

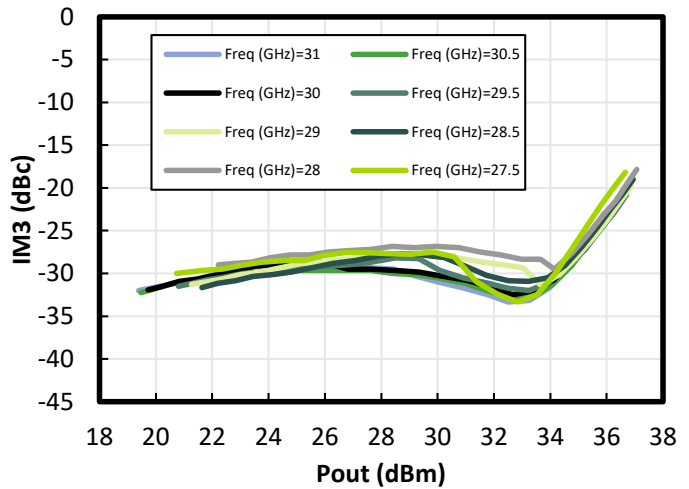


Figure 1-35. IM3 vs. Pout @ 20V & +85°C

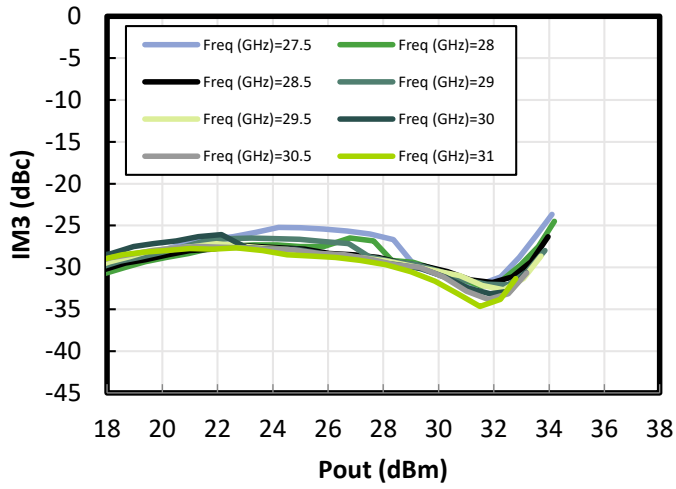
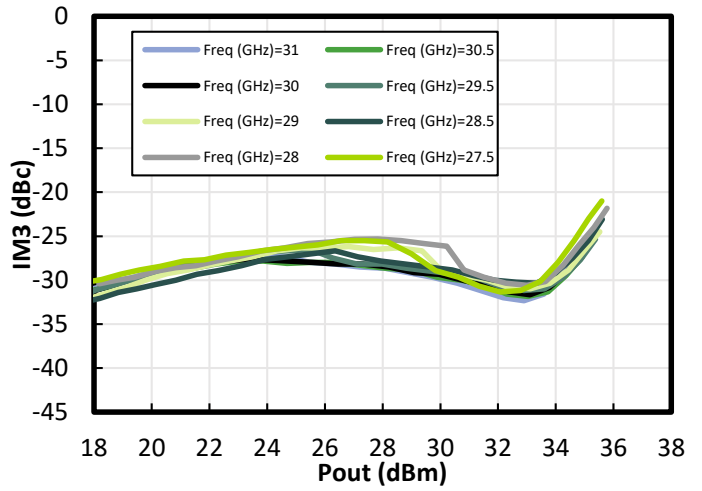


Figure 1-36. IM3 vs. Pout @ 24V & +85°C



2. Die Specifications

- Units: μm
- Thickness: 100 μm
- Die size tolerance: $\pm 50 \mu\text{m}$
- Backside is RF and DC ground
- Amplifier must be biased from both sides (N) North, (S) South

Figure 2-1. Die Outline Drawing

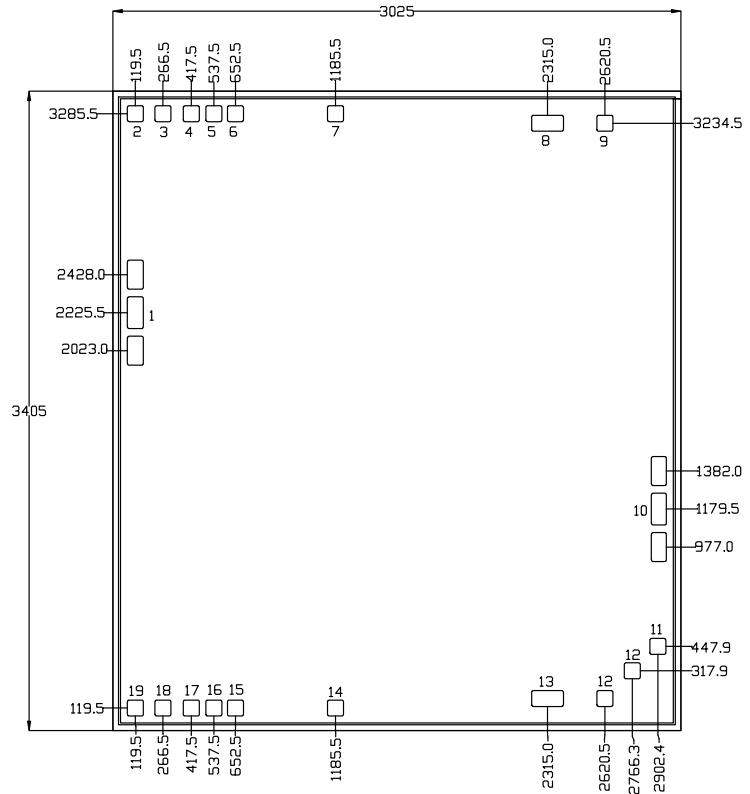


Table 2-1. I/O Description

Pad No	Pad Size (μm)	Function	Description
1	85×170	RFIN	DC blocked and 50 Ω matched
2	85×85	GND	Ground Pad
3	85×85	VG1N	Gate voltage, decoupling and bypass caps required
4	85×85	VG2N	Gate voltage, decoupling and bypass caps required
5	85×85	VG3N	Gate voltage, decoupling and bypass caps required
6	85×85	GND	Ground Pad
7	85×85	VD1N & VD2N	Drain voltage, decoupling and bypass caps required
8	170×170	VD3N	Drain voltage, decoupling and bypass caps required
9	85×85	GND	Ground Pad
10	85×170	RFOUT	DC blocked and 50 Ω matched
11	85×85	VREF	Detector reference voltage

GMICP2731-10

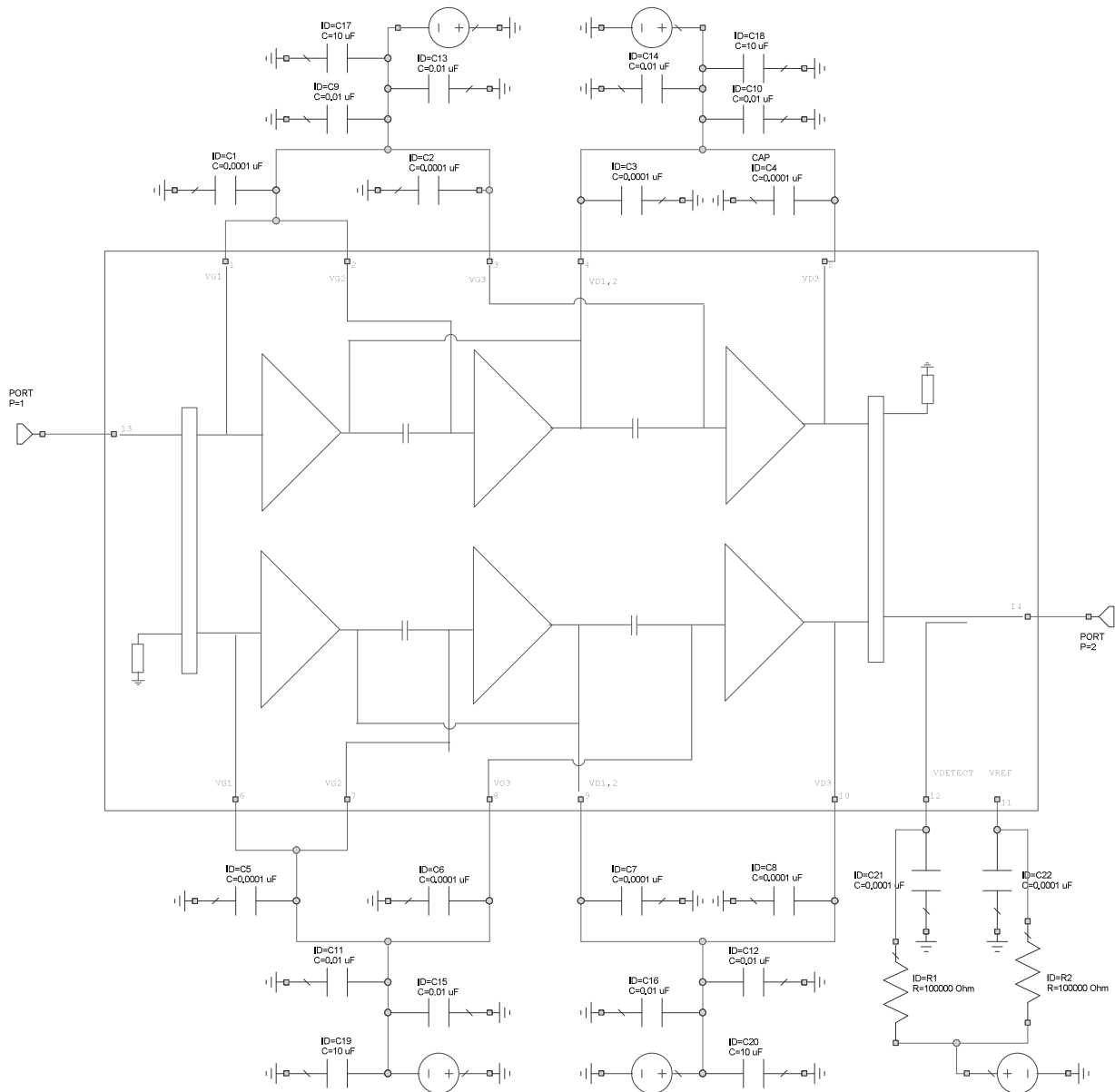
Die Specifications

.....continued

Pad No	Pad Size (μm)	Function	Description
12	85×85	VDET	Detector reference voltage
13	85×85	GND	Ground Pad
14	170×85	VD3S	Drain voltage, decoupling and bypass caps required
15	85×85	GND	Drain voltage, decoupling and bypass caps required
16	85×85	GND	Ground Pad
17	85×85	VG3S	Gate voltage, decoupling and bypass caps required
18	85×85	VG2S	Gate voltage, decoupling and bypass caps required
19	85×85	VG1S	Gate voltage, decoupling and bypass caps required
20	85×85	GND	Ground Pad

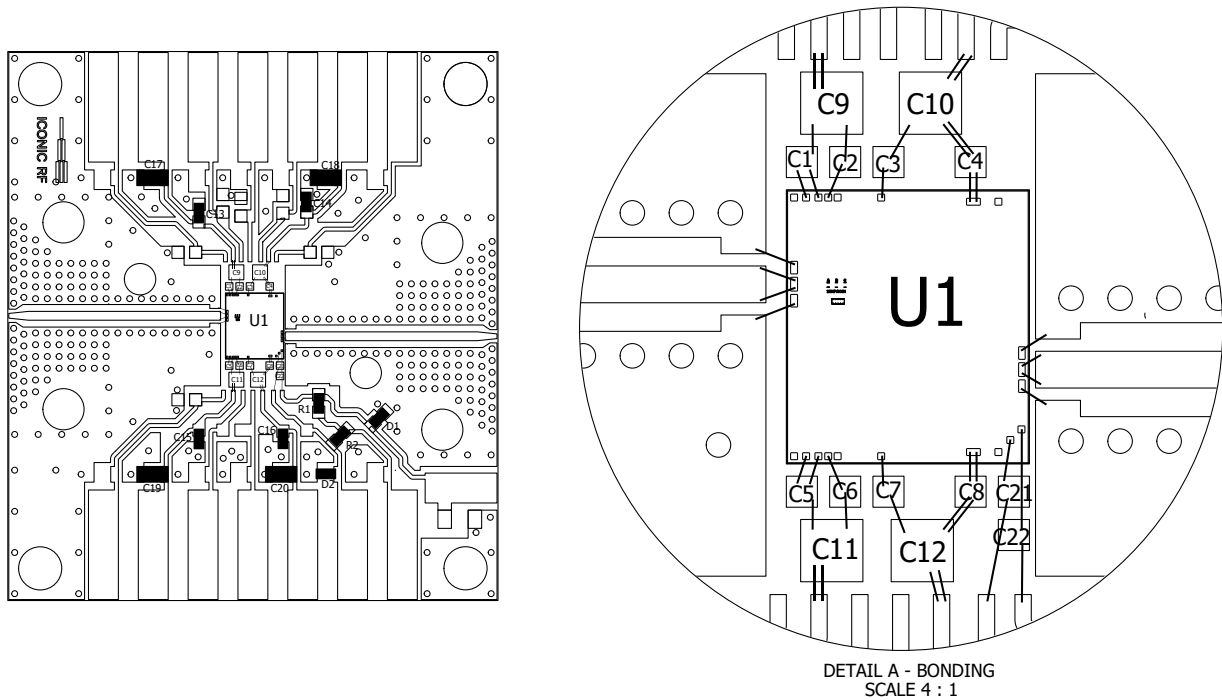
3. Application Circuits

Figure 3-1. Application Circuits



Component ID	Value	Description
C1-C8	100 pF	50V ±20% Single Layer Chip Capacitor (500U01A101MT4W)
C9-C12	10 nF	100V ±20% Single Layer Chip Capacitor (V30BZ103M1SX)
C13-C16	10 nF	50V ±5% 0402 Multilayer Ceramic Capacitor
C17-C20	10 µF	35V ±10% 0805 Multilayer Ceramic Capacitor
R1, R2	100 kΩ	±5% 0402 Resistor

Figure 3-2. Assembly Drawing



Assembly Guidance

Amplifier must be biased from both sides.

Optimum RF power performance achieved by minimizing output RF bond wire length.

Interconnect assembly notes:

- Ball bonding is the preferred technique.
- Force, time, and ultrasonic parameters are critical.
- Aluminum wire bonding is not recommended.
- Bond wire diameter of 1 mil is recommended.

Die attach of component using adhesive:

- Vacuum collets are the preferred method of pickup.
- Pickup method must consider the avoidance of die air bridges.
- Die suitable for eutectic and epoxy die attach.
- Where epoxy is used, high thermal conductivity Silver Sintered Epoxy is recommended:
 - Namics H9890–6
 - Kyocera CT2700R7S

Reflow Process

- Maximum temperature 320 °C for 30 seconds.
- Material matching for Coefficient of thermal expansion is crucial for long-term reliability

Bias-Up Procedure

1. Set VG = -5V
2. Set VD to 20V – 24V
3. Adjust VG positive until ID quiescent is 112 mA
4. Limit ID to 2A
5. Apply RF Signal

Bias-down Procedure

1. Turn off RF.
2. Turn off VD, allow drain capacitor to discharge.
3. Turn off VG.

Handling Procedures

Please observe the following precautions to avoid damage:

Static Sensitivity

Integrated Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these devices. Class 1A HBM (250V – 500V) ESD Classification is anticipated.

4. Ordering, Shipping, and Handling

4.1 Handling Recommendations

Integrated circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. It is recommended to follow all procedures and guidelines outlined in the Microsemi application note AN01: GaAs MMIC Handling and Die Attach Recommendations.

4.2 Ordering Information

For additional ordering information, contact your Microchip sales representative.

Part Number	Package	Standard Packing Format
GMICP2731-10	Die	Gel Pack

5. Revision History

Table 5-1. Revision History

Revision	Date	Description
A	06/2021	Document created.

The Microchip Website

Microchip provides online support via our website at www.microchip.com/. This website is used to make files and information easily available to customers. Some of the content available includes:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip design partner program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

Product Change Notification Service

Microchip's product change notification service helps keep customers current on Microchip products. Subscribers will receive email notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, go to www.microchip.com/pcn and follow the registration instructions.

Customer Support

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Embedded Solutions Engineer (ESE)
- Technical Support

Customers should contact their distributor, representative or ESE for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in this document.

Technical support is available through the website at: www.microchip.com/support

Product Identification System

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

Microchip Devices Code Protection Feature

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specifications contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is secure when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods being used in attempts to breach the code protection features of the Microchip devices. We believe that these methods require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Attempts to breach these code protection features, most likely, cannot be accomplished without violating Microchip's intellectual property rights.
- Microchip is willing to work with any customer who is concerned about the integrity of its code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of its code. Code protection does not mean that we are guaranteeing the product is "unbreakable." Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Legal Notice

Information contained in this publication is provided for the sole purpose of designing with and using Microchip products. Information regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications.

THIS INFORMATION IS PROVIDED BY MICROCHIP "AS IS". MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF NON-INFRINGEMENT, MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE OR WARRANTIES RELATED TO ITS CONDITION, QUALITY, OR PERFORMANCE.

IN NO EVENT WILL MICROCHIP BE LIABLE FOR ANY INDIRECT, SPECIAL, PUNITIVE, INCIDENTAL OR CONSEQUENTIAL LOSS, DAMAGE, COST OR EXPENSE OF ANY KIND WHATSOEVER RELATED TO THE INFORMATION OR ITS USE, HOWEVER CAUSED, EVEN IF MICROCHIP HAS BEEN ADVISED OF THE POSSIBILITY OR THE DAMAGES ARE FORESEEABLE. TO THE FULLEST EXTENT ALLOWED BY LAW, MICROCHIP'S TOTAL LIABILITY ON ALL CLAIMS IN ANY WAY RELATED TO THE INFORMATION OR ITS USE WILL NOT EXCEED THE AMOUNT OF FEES, IF ANY, THAT YOU HAVE PAID DIRECTLY TO MICROCHIP FOR THE INFORMATION. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

Trademarks

The Microchip name and logo, the Microchip logo, Adaptec, AnyRate, AVR, AVR logo, AVR Freaks, BesTime, BitCloud, chipKIT, chipKIT logo, CryptoMemory, CryptoRF, dsPIC, FlashFlex, flexPWR, HELDO, IGLOO, JukeBlox, KeeLoq, Kleer, LANCheck, LinkMD, maXStylus, maXTouch, MediaLB, megaAVR, Microsemi, Microsemi logo, MOST, MOST logo, MPLAB, OptoLyzer, PackeTime, PIC, picoPower, PIC32 logo, PolarFire, Prochip Designer, QTouch, SAM-BA, SenGenuity, SpyNIC, SST, SST Logo, SuperFlash, Symmetricom, SyncServer, Tachyon, TimeSource, tinyAVR, UNI/O, Vectron, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

AgileSwitch, APT, ClockWorks, The Embedded Control Solutions Company, EtherSynch, FlashTec, Hyper Speed Control, HyperLight Load, IntelliMOS, Libero, motorBench, mTouch, Powermite 3, Precision Edge, ProASIC, ProASIC Plus, ProASIC Plus logo, Quiet-Wire, SmartFusion, SyncWorld, Temux, TimeCesium, TimeHub, TimePictra, TimeProvider, WinPath, and ZL are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Adjacent Key Suppression, AKS, Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, Augmented Switching, BlueSky, BodyCom, CodeGuard, CryptoAuthentication, CryptoAutomotive, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, Espresso T1S, EtherGREEN, IdealBridge, In-Circuit Serial Programming, ICSP, INICnet, Intelligent Paralleling, Inter-Chip Connectivity, JitterBlocker, maxCrypto, maxView, memBrain, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICKit, PICtail, PowerSmart, PureSilicon, QMatrix, REAL ICE, Ripple Blocker, RTAX, RTG4, SAM-ICE, Serial Quad I/O, simpleMAP, SimpliPHY, SmartBuffer, SMART-I.S., storClad, SQI, SuperSwitcher, SuperSwitcher II, Switchtec, SynchroPHY, Total Endurance, TSHARC, USBCheck, VariSense, VectorBlox, VeriPHY, ViewSpan, WiperLock, XpressConnect, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

The Adaptec logo, Frequency on Demand, Silicon Storage Technology, and Symmcom are registered trademarks of Microchip Technology Inc. in other countries.

GestIC is a registered trademark of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2021, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

ISBN: 978-1-5224-8425-7

AMBA, Arm, Arm7, Arm7TDMI, Arm9, Arm11, Artisan, big.LITTLE, Cordio, CoreLink, CoreSight, Cortex, DesignStart, DynamIQ, Jazelle, Keil, Mali, Mbed, Mbed Enabled, NEON, POP, RealView, SecurCore, Socrates, Thumb, TrustZone, ULINK, ULINK2, ULINK-ME, ULINK-PLUS, ULINKpro, μ Vision, Versatile are trademarks or registered trademarks of Arm Limited (or its subsidiaries) in the US and/or elsewhere.

Quality Management System

For information regarding Microchip's Quality Management Systems, please visit www.microchip.com/quality.

Worldwide Sales and Service

AMERICAS	ASIA/PACIFIC	ASIA/PACIFIC	EUROPE
<p>Corporate Office 2355 West Chandler Blvd. Chandler, AZ 85224-6199 Tel: 480-792-7200 Tel: 480-792-7277 Technical Support: www.microchip.com/support Web Address: www.microchip.com</p> <p>Atlanta Duluth, GA Tel: 678-957-9614 Fax: 678-957-1455</p> <p>Austin, TX Tel: 512-257-3370</p> <p>Boston Westborough, MA Tel: 774-760-0087 Fax: 774-760-0088</p> <p>Chicago Itasca, IL Tel: 630-285-0071 Fax: 630-285-0075</p> <p>Dallas Addison, TX Tel: 972-818-7423 Fax: 972-818-2924</p> <p>Detroit Novi, MI Tel: 248-848-4000</p> <p>Houston, TX Tel: 281-894-5983</p> <p>Indianapolis Noblesville, IN Tel: 317-773-8323 Fax: 317-773-5453 Tel: 317-536-2380</p> <p>Los Angeles Mission Viejo, CA Tel: 949-462-9523 Fax: 949-462-9608 Tel: 951-273-7800</p> <p>Raleigh, NC Tel: 919-844-7510</p> <p>New York, NY Tel: 631-435-6000</p> <p>San Jose, CA Tel: 408-735-9110 Tel: 408-436-4270</p> <p>Canada - Toronto Tel: 905-695-1980 Fax: 905-695-2078</p>	<p>Australia - Sydney Tel: 61-2-9868-6733</p> <p>China - Beijing Tel: 86-10-8569-7000</p> <p>China - Chengdu Tel: 86-28-8665-5511</p> <p>China - Chongqing Tel: 86-23-8980-9588</p> <p>China - Dongguan Tel: 86-769-8702-9880</p> <p>China - Guangzhou Tel: 86-20-8755-8029</p> <p>China - Hangzhou Tel: 86-571-8792-8115</p> <p>China - Hong Kong SAR Tel: 852-2943-5100</p> <p>China - Nanjing Tel: 86-25-8473-2460</p> <p>China - Qingdao Tel: 86-532-8502-7355</p> <p>China - Shanghai Tel: 86-21-3326-8000</p> <p>China - Shenyang Tel: 86-24-2334-2829</p> <p>China - Shenzhen Tel: 86-755-8864-2200</p> <p>China - Suzhou Tel: 86-186-6233-1526</p> <p>China - Wuhan Tel: 86-27-5980-5300</p> <p>China - Xian Tel: 86-29-8833-7252</p> <p>China - Xiamen Tel: 86-592-2388138</p> <p>China - Zhuhai Tel: 86-756-3210040</p>	<p>India - Bangalore Tel: 91-80-3090-4444</p> <p>India - New Delhi Tel: 91-11-4160-8631</p> <p>India - Pune Tel: 91-20-4121-0141</p> <p>Japan - Osaka Tel: 81-6-6152-7160</p> <p>Japan - Tokyo Tel: 81-3-6880-3770</p> <p>Korea - Daegu Tel: 82-53-744-4301</p> <p>Korea - Seoul Tel: 82-2-554-7200</p> <p>Malaysia - Kuala Lumpur Tel: 60-3-7651-7906</p> <p>Malaysia - Penang Tel: 60-4-227-8870</p> <p>Philippines - Manila Tel: 63-2-634-9065</p> <p>Singapore Tel: 65-6334-8870</p> <p>Taiwan - Hsin Chu Tel: 886-3-577-8366</p> <p>Taiwan - Kaohsiung Tel: 886-7-213-7830</p> <p>Taiwan - Taipei Tel: 886-2-2508-8600</p> <p>Thailand - Bangkok Tel: 66-2-694-1351</p> <p>Vietnam - Ho Chi Minh Tel: 84-28-5448-2100</p>	<p>Austria - Wels Tel: 43-7242-2244-39 Fax: 43-7242-2244-393</p> <p>Denmark - Copenhagen Tel: 45-4485-5910 Fax: 45-4485-2829</p> <p>Finland - Espoo Tel: 358-9-4520-820</p> <p>France - Paris Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79</p> <p>Germany - Garching Tel: 49-8931-9700</p> <p>Germany - Haan Tel: 49-2129-3766400</p> <p>Germany - Heilbronn Tel: 49-7131-72400</p> <p>Germany - Karlsruhe Tel: 49-721-625370</p> <p>Germany - Munich Tel: 49-89-627-144-0 Fax: 49-89-627-144-44</p> <p>Germany - Rosenheim Tel: 49-8031-354-560</p> <p>Israel - Ra'anana Tel: 972-9-744-7705</p> <p>Italy - Milan Tel: 39-0331-742611 Fax: 39-0331-466781</p> <p>Italy - Padova Tel: 39-049-7625286</p> <p>Netherlands - Drunen Tel: 31-416-690399 Fax: 31-416-690340</p> <p>Norway - Trondheim Tel: 47-72884388</p> <p>Poland - Warsaw Tel: 48-22-3325737</p> <p>Romania - Bucharest Tel: 40-21-407-87-50</p> <p>Spain - Madrid Tel: 34-91-708-08-90 Fax: 34-91-708-08-91</p> <p>Sweden - Gothenberg Tel: 46-31-704-60-40</p> <p>Sweden - Stockholm Tel: 46-8-5090-4654</p> <p>UK - Wokingham Tel: 44-118-921-5800 Fax: 44-118-921-5820</p>