

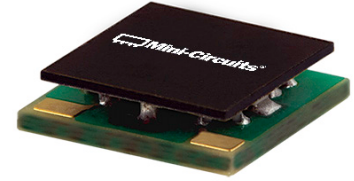


50Ω

DC to 158 MHz

KEY FEATURES

- High Rejection, 47 dB Typ.
- Sharp Insertion Loss Roll-off
- Good Return Loss, 20.8 dB Typ.
- Ultra Miniature Surface Mount Package



Generic photo used for illustration purposes only

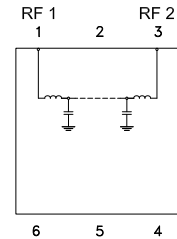
APPLICATIONS

- Wireless Communications
- Receivers / Transformers
- Lab Use

PRODUCT OVERVIEW

The ULP-158+ is a low pass filter in a top hat package (size of 0.25" x 0.25") fabricated using SMT technology. Covering DC to 158 MHz band width, these units offer good matching within the passband and high rejection. This model uses a miniature high Q capacitors and chip inductors for high reliability. In addition it has repeatable performance across production lots and consistent performance across temperature.

FUNCTIONAL DIAGRAM



ELECTRICAL SPECIFICATIONS^{1,2,3} AT +25°C

| Parameter | | F# | Frequency (MHz) | Min. | Typ. | Max. | Units |
|-----------|----------------|-------|-----------------|------|------|------|-------|
| Passband | Insertion Loss | DC-F1 | DC - 158 | — | 1.5 | 2 | dB |
| | Freq. Cut-Off | Fc | 172 | — | 3.0 | — | dB |
| | Return Loss | DC-F1 | DC - 158 | — | 20.8 | — | dB |
| Stopband | Rejection | F2-F3 | 220 - 255 | 20 | 27 | — | dB |
| | | F3-F4 | 255 - 1000 | 40 | 47 | — | |
| | | F4-F5 | 1000 - 3000 | — | 20 | — | |

1. Tested in Evaluation Board P/N TB-ULP-158+

2. This filter is bi-directional RF1 and RF2 ports may be interchanged, see S-Parameters for actual performance.

3. In applications where DC voltage and/or current is present at either the input or output ports, external DC blocking capacitors are required.

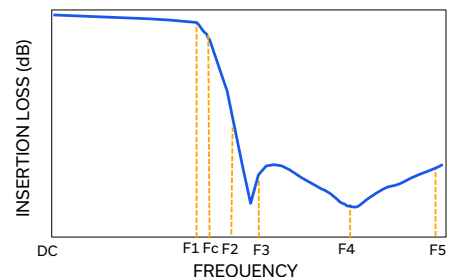
ABSOLUTE MAXIMUM RATINGS⁴

| Parameter | Ratings |
|--------------------------|-----------------|
| Operating Temperature | -40°C to + 85°C |
| Storage Temperature | -55°C to +100°C |
| Input Power ⁵ | 0.8 W max. |

4. Permanent damage may occur if any of these limits are exceeded.

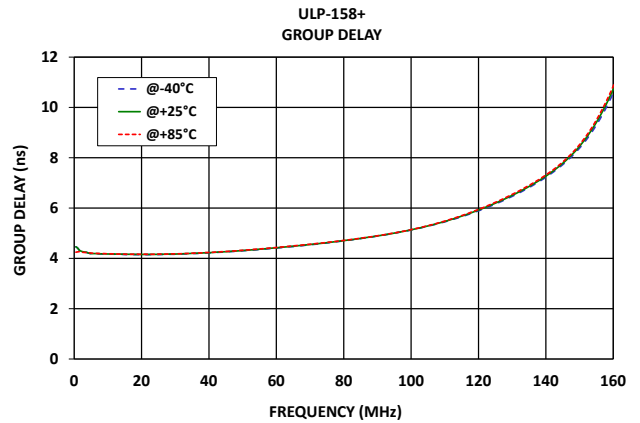
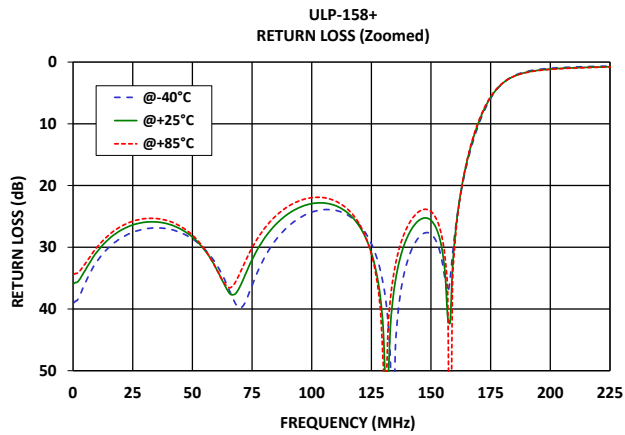
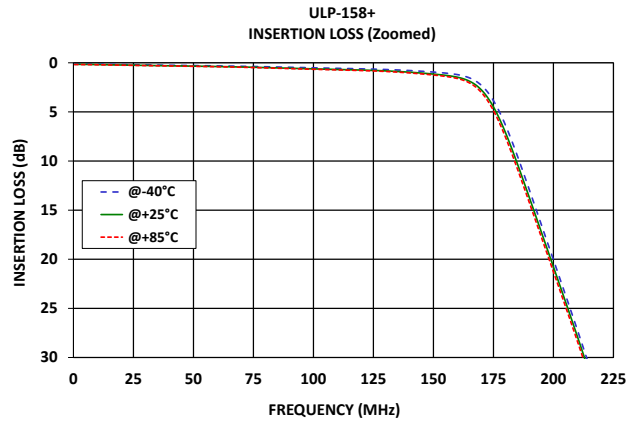
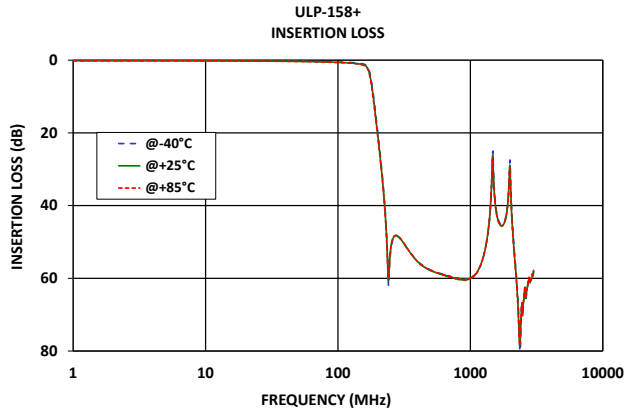
5. Power rating applies only to signals within the passband.

TYPICAL FREQUENCY RESPONSE AT +25°C





TYPICAL PERFORMANCE GRAPHS





FUNCTIONAL DIAGRAM

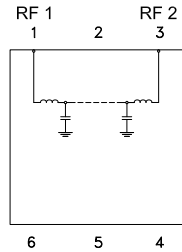


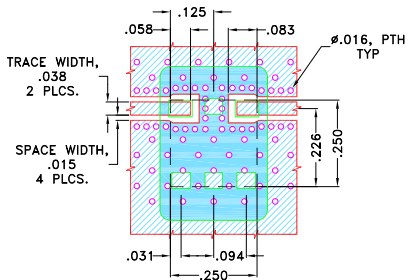
Figure 1. ULP-158+ Functional Diagram

PAD DESCRIPTION

| Function | Pad Number | Description |
|--------------------------|------------|--|
| RF ₁ (Note 2) | 1 | Connects to RF Input Port |
| RF ₂ (Note 2) | 3 | Connects to RF Output Port |
| GROUND | 2,4,5,6 | Connects to Ground on PCB, (See drawing PL-484) |
| NC | — | No connection, not used internally. See drawing PL-484 for connection to PCB |

SUGGESTED PCB LAYOUT (PL-484)

SUGGESTED MOUNTING CONFIGURATION FOR QA2224 CASE STYLE "06FL09" PIN CODE



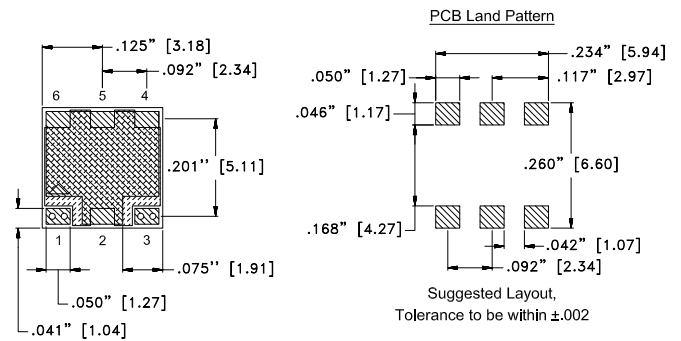
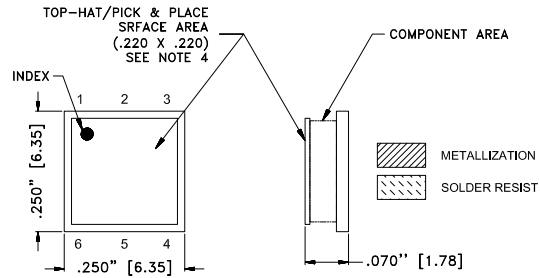
NOTES:

- TRACE WIDTH IS SHOWN FOR ROGERS (R04350B) WITH DIELECTRIC THICKNESS .020"±.0015". COPPER: 1/2 OZ. EACH SIDE. FOR OTHER MATERIALS TRACE WIDTH MAY NEED TO BE MODIFIED.
- BOTTOM SIDE OF THE PCB IS CONTINUOUS GROUND PLANE.

- DENOTES PCB COPPER LAYOUT WITH SMOBC (SOLDER MASK OVER BARE COPPER)
- DENOTES COPPER LAND PATTERN FREE OF SOLDERMASK

Figure 2. Suggested PCB Layout PL-484

CASE STYLE DRAWING



Weight: .25 gram

Dimensions are in inches (mm). Tolerances: 2PI. ± .03; 3PI. ± .015

PRODUCT MARKING*: ULP-158

*Marking may contain other features or characters for internal lot control.



LUMPED LC SURFACE MOUNT ^{top hat}

Low Pass Filter

ULP-158+

50Ω

DC to 158 MHz

ADDITIONAL DETAILED INFORMATION IS AVAILABLE ON OUR DASH BOARD.

[CLICK HERE](#)

| | |
|---------------------------------|---|
| Performance Data and Graphs | Data |
| | Graphs |
| | S-Parameter (S2P Files) Data Set (.zip file) De-embedded to device pads |
| Case Style | QA2224 Lead Finish: Gold over Nickel Plate |
| RoHS Status | Compliant |
| Tape and Reel | TR-F34 |
| Suggested Layout for PCB Design | PL-484 |
| Evaluation Board | TB-ULP-158+ |
| | Gerber File |
| Environmental Rating | ENV03T2 |

NOTES

- A. Performance and quality attributes and conditions not expressly stated in this specification document are intended to be excluded and do not form a part of this specification document.
- B. Electrical specifications and performance data contained in this specification document are based on Mini-Circuits' applicable established test performance criteria and measurement instructions.
- C. The parts covered by this specification document are subject to Mini-Circuits' standard limited warranty and terms and conditions (collectively, "Standard Terms"); Purchasers of this part are entitled to the rights and benefits contained therein. For a full statement of the standard terms and the exclusive rights and remedies thereunder, please visit Mini-Circuits' website at www.minicircuits.com/terms/viewterm.html



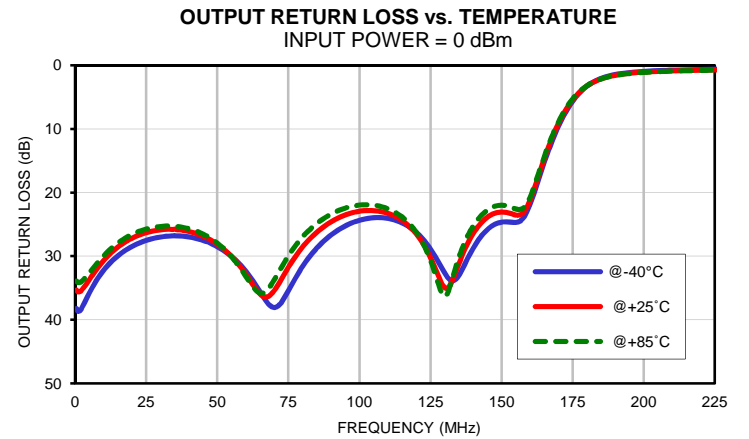
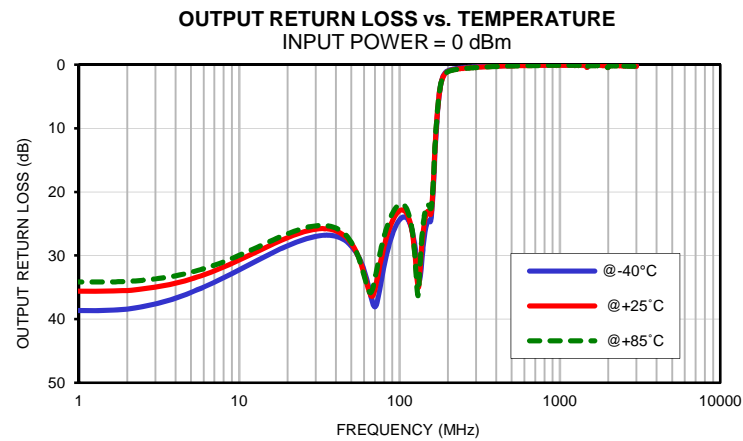
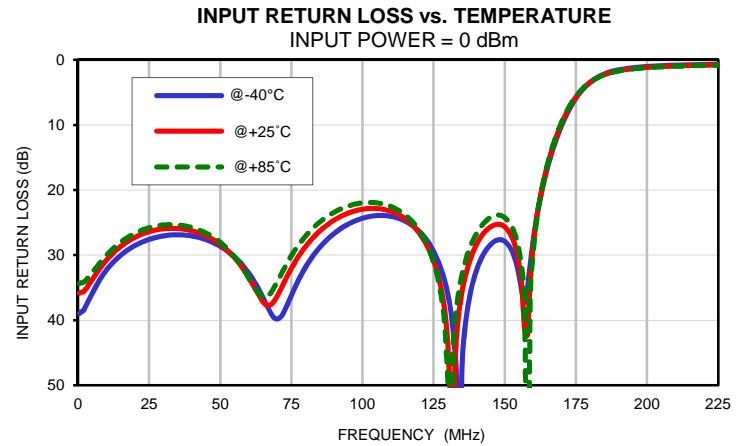
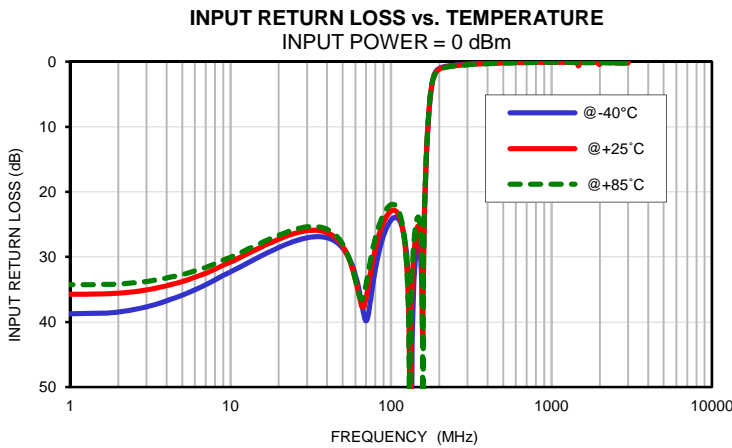
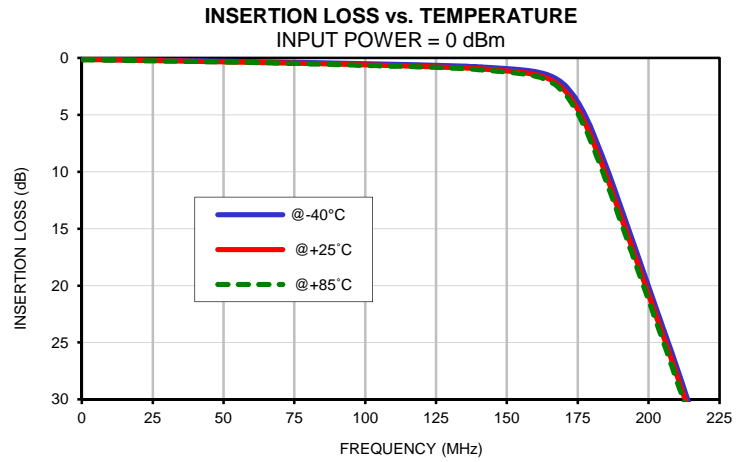
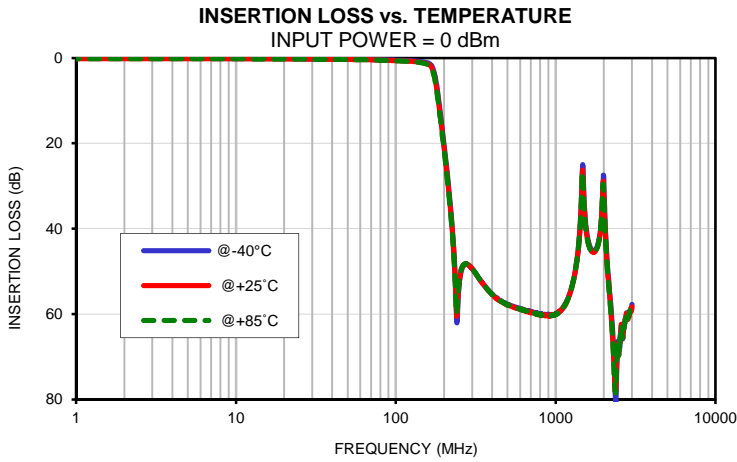
Typical Performance Data

| FREQ. (MHz) | INSERTION LOSS | | | INPUT RETURN LOSS | | | OUTPUT RETURN LOSS | | |
|--------------------|----------------|--------|--------|-------------------|--------|--------|--------------------|--------|--------|
| | (dB) | | | (dB) | | | (dB) | | |
| | @-40°C | @+25°C | @+85°C | @-40°C | @+25°C | @+85°C | @-40°C | @+25°C | @+85°C |
| 1 | 0.11 | 0.16 | 0.18 | 38.72 | 35.72 | 34.25 | 38.64 | 35.62 | 34.15 |
| 2 | 0.11 | 0.16 | 0.18 | 38.47 | 35.59 | 34.15 | 38.44 | 35.50 | 34.07 |
| 5 | 0.12 | 0.17 | 0.19 | 35.89 | 33.80 | 32.72 | 35.80 | 33.69 | 32.63 |
| 10 | 0.13 | 0.18 | 0.20 | 32.30 | 30.77 | 30.03 | 32.25 | 30.71 | 29.97 |
| 20 | 0.18 | 0.22 | 0.24 | 28.53 | 27.26 | 26.65 | 28.47 | 27.18 | 26.58 |
| 50 | 0.28 | 0.34 | 0.36 | 28.63 | 28.34 | 28.03 | 28.49 | 28.12 | 27.93 |
| 100 | 0.51 | 0.62 | 0.66 | 24.32 | 22.93 | 21.96 | 24.35 | 22.92 | 21.95 |
| 120 | 0.62 | 0.74 | 0.79 | 26.36 | 26.61 | 26.25 | 26.25 | 26.51 | 26.24 |
| 122 | 0.63 | 0.76 | 0.81 | 27.34 | 27.96 | 27.74 | 27.14 | 27.75 | 27.67 |
| 130 | 0.68 | 0.83 | 0.88 | 36.04 | 43.37 | 49.09 | 32.67 | 34.95 | 36.32 |
| 135 | 0.73 | 0.88 | 0.95 | 47.05 | 35.63 | 32.99 | 33.02 | 31.18 | 30.17 |
| 140 | 0.79 | 0.96 | 1.03 | 32.42 | 28.43 | 26.75 | 28.75 | 26.43 | 25.26 |
| 145 | 0.86 | 1.05 | 1.13 | 28.36 | 25.63 | 24.20 | 25.82 | 23.87 | 22.76 |
| 150 | 0.94 | 1.15 | 1.24 | 27.87 | 25.65 | 24.22 | 24.64 | 23.05 | 21.98 |
| 155 | 1.05 | 1.28 | 1.39 | 33.02 | 31.26 | 29.19 | 24.69 | 23.53 | 22.58 |
| 158 | 1.13 | 1.38 | 1.50 | 35.19 | 42.24 | 76.19 | 23.74 | 22.94 | 22.27 |
| 160 | 1.20 | 1.47 | 1.60 | 27.72 | 28.54 | 29.55 | 21.85 | 21.19 | 20.73 |
| 162 | 1.31 | 1.59 | 1.74 | 22.34 | 22.24 | 22.44 | 19.27 | 18.67 | 18.32 |
| 163 | 1.37 | 1.67 | 1.83 | 20.20 | 19.94 | 19.98 | 17.90 | 17.31 | 16.98 |
| 165 | 1.54 | 1.87 | 2.05 | 16.61 | 16.21 | 16.09 | 15.22 | 14.65 | 14.34 |
| 166 | 1.64 | 2.00 | 2.19 | 15.06 | 14.65 | 14.49 | 13.95 | 13.40 | 13.10 |
| 168 | 1.92 | 2.33 | 2.55 | 12.36 | 11.95 | 11.75 | 11.61 | 11.11 | 10.83 |
| 170 | 2.30 | 2.77 | 3.03 | 10.08 | 9.72 | 9.52 | 9.53 | 9.11 | 8.86 |
| 171 | 2.54 | 3.04 | 3.32 | 9.08 | 8.75 | 8.56 | 8.60 | 8.22 | 7.99 |
| 172 | 2.81 | 3.35 | 3.65 | 8.16 | 7.87 | 7.69 | 7.75 | 7.41 | 7.19 |
| 180 | 6.34 | 7.10 | 7.56 | 3.45 | 3.45 | 3.41 | 3.26 | 3.23 | 3.18 |
| 190 | 12.96 | 13.75 | 14.27 | 1.53 | 1.66 | 1.69 | 1.43 | 1.54 | 1.56 |
| 200 | 20.06 | 20.78 | 21.28 | 1.01 | 1.14 | 1.18 | 0.93 | 1.05 | 1.09 |
| 205 | 23.62 | 24.31 | 24.80 | 0.89 | 1.01 | 1.06 | 0.82 | 0.94 | 0.98 |
| 208 | 25.77 | 26.44 | 26.93 | 0.83 | 0.96 | 1.00 | 0.77 | 0.88 | 0.92 |
| 215 | 30.93 | 31.58 | 32.06 | 0.74 | 0.86 | 0.90 | 0.68 | 0.79 | 0.83 |
| 220 | 34.84 | 35.50 | 36.00 | 0.69 | 0.80 | 0.85 | 0.64 | 0.74 | 0.78 |
| 255 | 50.37 | 50.09 | 49.92 | 0.48 | 0.58 | 0.62 | 0.45 | 0.54 | 0.57 |
| 300 | 49.38 | 49.35 | 49.34 | 0.35 | 0.43 | 0.47 | 0.32 | 0.40 | 0.43 |
| 350 | 52.76 | 52.89 | 52.88 | 0.26 | 0.33 | 0.36 | 0.23 | 0.31 | 0.33 |
| 400 | 55.34 | 55.47 | 55.36 | 0.20 | 0.27 | 0.29 | 0.18 | 0.24 | 0.26 |
| 500 | 57.76 | 57.83 | 57.87 | 0.12 | 0.18 | 0.20 | 0.11 | 0.17 | 0.19 |
| 750 | 59.81 | 59.85 | 59.98 | 0.03 | 0.09 | 0.11 | 0.03 | 0.09 | 0.11 |
| 1000 | 60.01 | 60.07 | 60.06 | 0.01 | 0.07 | 0.09 | 0.00 | 0.07 | 0.09 |
| 1250 | 54.21 | 54.20 | 54.19 | 0.02 | 0.06 | 0.09 | 0.02 | 0.07 | 0.09 |
| 1300 | 51.63 | 51.64 | 51.57 | 0.03 | 0.07 | 0.09 | 0.02 | 0.07 | 0.10 |
| 1350 | 48.20 | 48.11 | 47.95 | 0.03 | 0.07 | 0.09 | 0.01 | 0.08 | 0.10 |
| 1400 | 43.09 | 42.85 | 42.62 | 0.02 | 0.08 | 0.11 | 0.01 | 0.08 | 0.11 |
| 1450 | 33.54 | 32.87 | 32.31 | 0.06 | 0.19 | 0.24 | 0.04 | 0.16 | 0.20 |
| 1500 | 31.92 | 33.18 | 33.97 | 0.08 | 0.17 | 0.18 | 0.05 | 0.14 | 0.16 |
| 1600 | 42.96 | 43.39 | 43.59 | 0.02 | 0.08 | 0.11 | 0.01 | 0.09 | 0.12 |
| 1750 | 45.21 | 45.44 | 45.52 | 0.02 | 0.09 | 0.12 | 0.01 | 0.10 | 0.13 |
| 1800 | 44.61 | 44.79 | 44.83 | 0.02 | 0.09 | 0.12 | 0.01 | 0.10 | 0.13 |
| 1900 | 40.80 | 40.78 | 40.65 | 0.01 | 0.11 | 0.14 | 0.01 | 0.12 | 0.15 |
| 2000 | 29.04 | 31.39 | 32.65 | 0.26 | 0.30 | 0.29 | 0.27 | 0.31 | 0.30 |
| 2100 | 47.64 | 48.56 | 48.99 | 0.00 | 0.12 | 0.15 | 0.03 | 0.13 | 0.17 |
| 2200 | 57.03 | 57.91 | 58.37 | 0.01 | 0.12 | 0.15 | 0.03 | 0.14 | 0.17 |
| 2300 | 67.64 | 69.67 | 70.00 | 0.01 | 0.13 | 0.16 | 0.04 | 0.15 | 0.17 |
| 2400 | 75.35 | 72.89 | 72.26 | 0.03 | 0.14 | 0.17 | 0.05 | 0.16 | 0.19 |
| 2500 | 68.23 | 67.34 | 67.21 | 0.03 | 0.15 | 0.17 | 0.07 | 0.18 | 0.20 |
| 2600 | 63.89 | 63.21 | 64.09 | 0.05 | 0.16 | 0.20 | 0.08 | 0.19 | 0.21 |
| 2700 | 62.46 | 62.16 | 62.09 | 0.06 | 0.17 | 0.20 | 0.09 | 0.19 | 0.22 |
| 2800 | 60.27 | 59.95 | 60.73 | 0.07 | 0.18 | 0.21 | 0.10 | 0.21 | 0.23 |
| 2900 | 59.42 | 59.82 | 59.47 | 0.06 | 0.18 | 0.21 | 0.12 | 0.23 | 0.25 |
| 3000 | 57.75 | 58.32 | 58.07 | 0.07 | 0.19 | 0.21 | 0.11 | 0.23 | 0.25 |

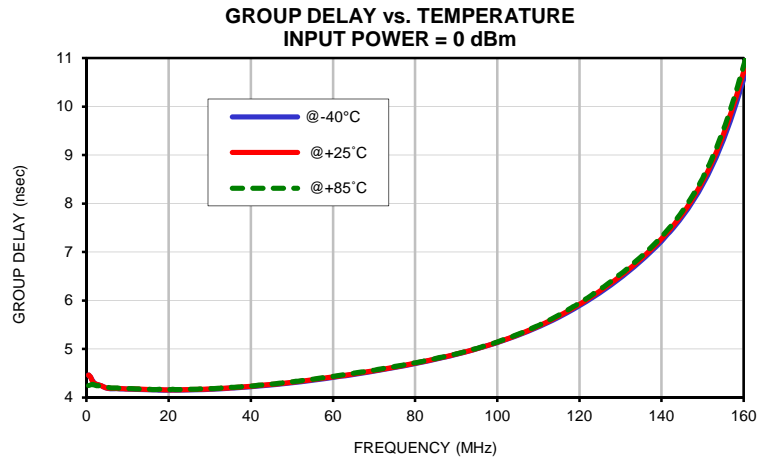
Typical Performance Data

| FREQ. (MHz) | GROUP DELAY | | |
|--------------------|-------------|--------|--------|
| | (nsec) | | |
| | @-40°C | @+25°C | @+85°C |
| 1 | 4.41 | 4.41 | 4.26 |
| 2 | 4.29 | 4.29 | 4.25 |
| 4 | 4.22 | 4.22 | 4.23 |
| 6 | 4.18 | 4.19 | 4.20 |
| 8 | 4.18 | 4.18 | 4.19 |
| 10 | 4.17 | 4.17 | 4.18 |
| 12 | 4.17 | 4.17 | 4.18 |
| 14 | 4.16 | 4.17 | 4.17 |
| 16 | 4.15 | 4.16 | 4.16 |
| 18 | 4.15 | 4.16 | 4.17 |
| 20 | 4.15 | 4.16 | 4.16 |
| 22 | 4.15 | 4.16 | 4.16 |
| 24 | 4.16 | 4.16 | 4.16 |
| 26 | 4.16 | 4.16 | 4.17 |
| 28 | 4.16 | 4.17 | 4.18 |
| 30 | 4.16 | 4.17 | 4.18 |
| 32 | 4.17 | 4.18 | 4.19 |
| 34 | 4.18 | 4.19 | 4.20 |
| 35 | 4.20 | 4.20 | 4.21 |
| 40 | 4.22 | 4.23 | 4.23 |
| 45 | 4.26 | 4.27 | 4.27 |
| 50 | 4.30 | 4.31 | 4.32 |
| 55 | 4.35 | 4.36 | 4.37 |
| 60 | 4.41 | 4.42 | 4.43 |
| 65 | 4.47 | 4.48 | 4.50 |
| 70 | 4.54 | 4.55 | 4.56 |
| 75 | 4.62 | 4.62 | 4.64 |
| 80 | 4.70 | 4.71 | 4.71 |
| 85 | 4.79 | 4.79 | 4.80 |
| 90 | 4.89 | 4.89 | 4.90 |
| 95 | 5.00 | 5.00 | 5.01 |
| 100 | 5.13 | 5.13 | 5.14 |
| 103 | 5.22 | 5.22 | 5.23 |
| 105 | 5.28 | 5.29 | 5.30 |
| 108 | 5.38 | 5.39 | 5.41 |
| 110 | 5.45 | 5.47 | 5.48 |
| 112 | 5.53 | 5.55 | 5.57 |
| 114 | 5.61 | 5.64 | 5.65 |
| 116 | 5.70 | 5.72 | 5.74 |
| 118 | 5.79 | 5.82 | 5.84 |
| 120 | 5.89 | 5.92 | 5.95 |
| 122 | 6.00 | 6.03 | 6.05 |
| 124 | 6.10 | 6.14 | 6.17 |
| 126 | 6.22 | 6.25 | 6.29 |
| 128 | 6.34 | 6.38 | 6.41 |
| 130 | 6.47 | 6.51 | 6.55 |
| 132 | 6.60 | 6.64 | 6.68 |
| 134 | 6.74 | 6.78 | 6.83 |
| 136 | 6.89 | 6.94 | 6.98 |
| 138 | 7.05 | 7.10 | 7.14 |
| 140 | 7.22 | 7.27 | 7.32 |
| 142 | 7.41 | 7.46 | 7.51 |
| 144 | 7.62 | 7.67 | 7.72 |
| 146 | 7.84 | 7.90 | 7.95 |
| 148 | 8.10 | 8.16 | 8.22 |
| 150 | 8.38 | 8.46 | 8.52 |
| 152 | 8.71 | 8.80 | 8.87 |
| 154 | 9.09 | 9.19 | 9.28 |
| 156 | 9.53 | 9.64 | 9.74 |
| 158 | 10.02 | 10.15 | 10.27 |

Typical Performance Curves

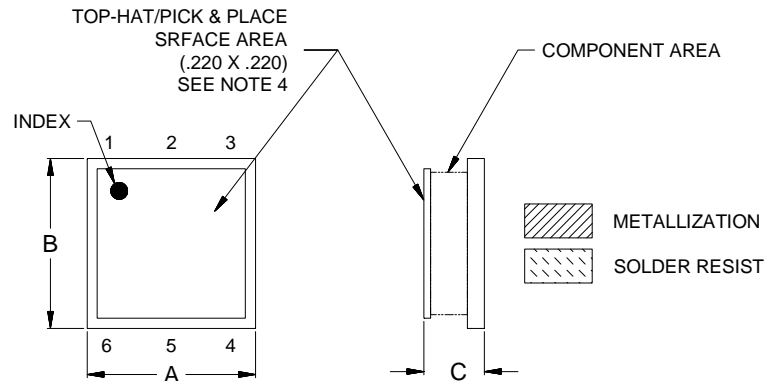


Typical Performance Curves

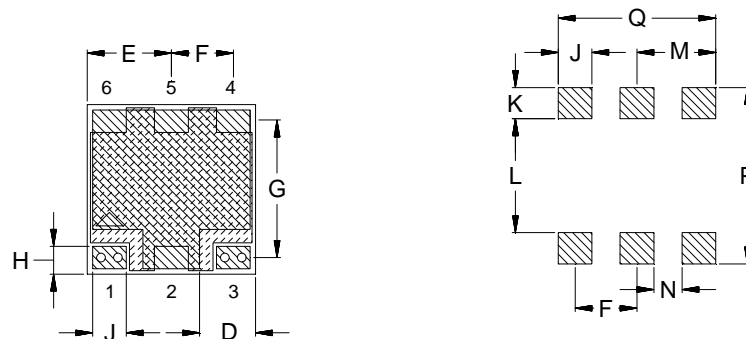


Outline Dimensions

QA2224



PCB Land Pattern



Suggested Layout,
Tolerance to be within $\pm .002$

| CASE# | A | B | C | D | E | F | G | H | J | K | L | M |
|--------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| QA2224 | .250 (6.35) | .250 (6.35) | .070 (1.78) | .075 (1.91) | .125 (3.18) | .092 (2.34) | .201 (5.11) | .041 (1.04) | .050 (1.27) | .046 (1.17) | .168 (4.27) | .117 (2.97) |

| CASE# | N | P | Q | WT. GRAM |
|--------|----------------|----------------|----------------|----------|
| QA2224 | .042 (1.07) | .260 (6.60) | .234 (5.94) | 0.25 |

Dimensions are in inches (mm). Tolerances: 2Pl. $\pm .03$; 3Pl. $\pm .015$

Notes:

- Case material: Ceramic base.
- Base: Printed wiring laminate.
- Termination finish:
For RoHS Case Styles: 3-5 μ inch Gold over 120-240 μ inch Nickel plate.
For RoHS-5 Case Styles: Tin-Lead plate.
- Top-Hat total thickness: .013 inches MAX



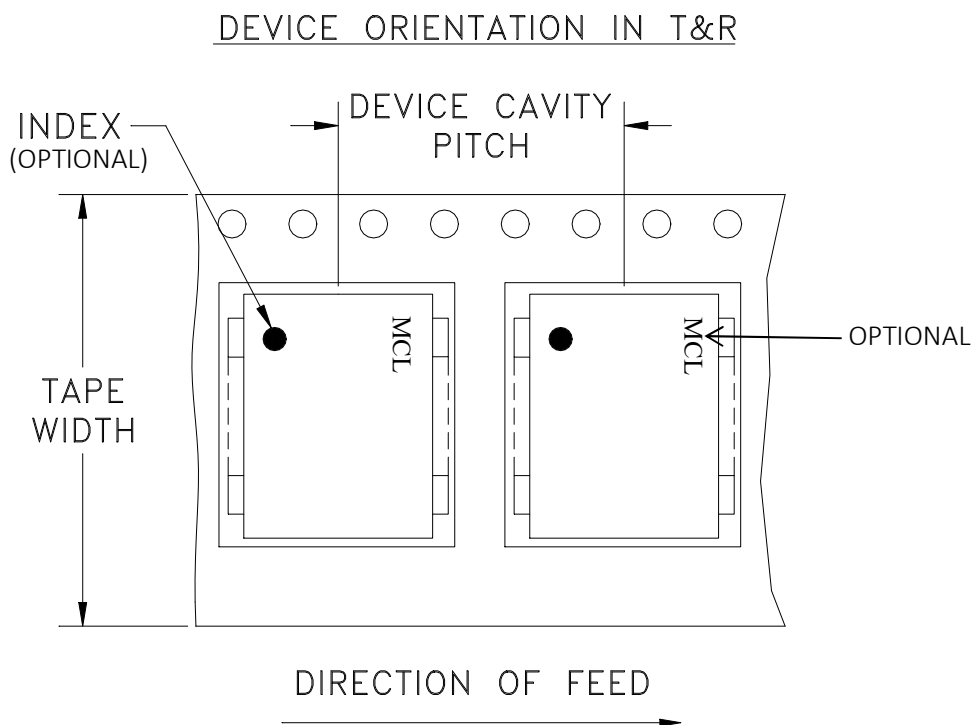
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661 For detailed performance specs & shopping online see Mini-Circuits web site



The Design Engineers Search Engine Provides ACTUAL Data Instantly From MINI-CIRCUITS At: www.minicircuits.com

RF/IF MICROWAVE COMPONENTS

Tape & Reel Packaging TR-F34



| Tape Width, mm | Device Cavity Pitch, mm | Reel Size, inches | Devices per Reel see note | |
|----------------|-------------------------|-------------------|------------------------------------|------|
| 16 | 12 | 7 | Small quantity standard (see note) | 20 |
| | | | | 50 |
| | | | Standard | 100 |
| | | | | 200 |
| | | 13 | Standard | 500 |
| | | | | 1000 |

Note: Availability of small reel quantity varies by model.
Refer to pricing and availability on individual model dashboard.

Mini-Circuits carrier tape materials provide protection from ESD (Electro-Static Discharge) during handling and transportation. Tapes are static dissipative and comply with industry standards EIA-481/EIA-541.

Go to: www.minicircuits.com/pages/pdfs/tape.pdf



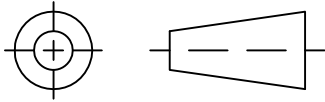
INTERNET <http://www.minicircuits.com>

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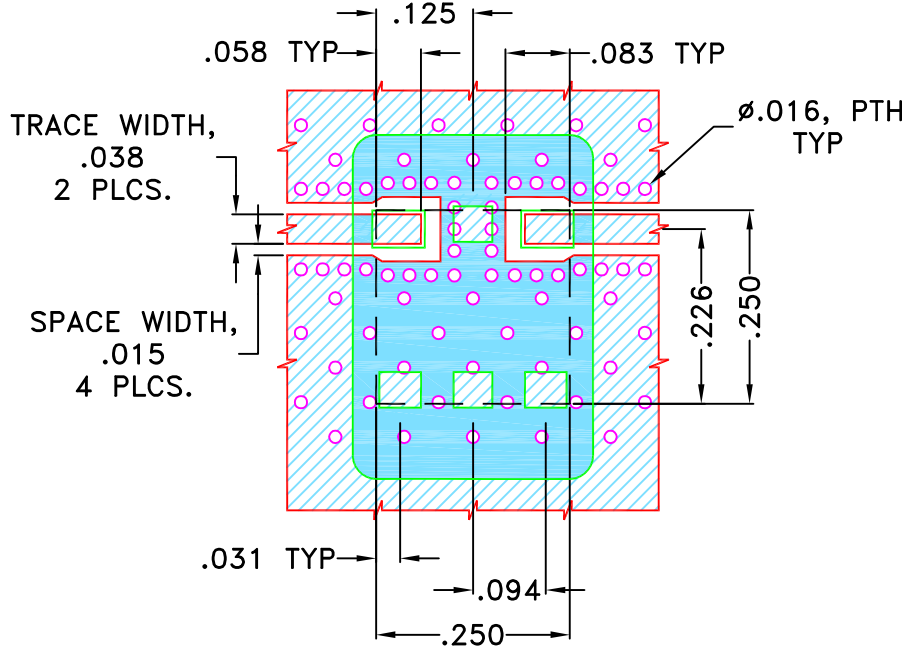
THIRD ANGLE PROJECTION



REVISIONS

| REV | ECN No. | DESCRIPTION | DATE | DR | AUTH |
|-----|---------|-----------------------------|--------|----|------|
| OR | M156213 | NEW RELEASE | MAY 16 | TM | MD |
| A | M161508 | COPPER LAND PATTERN UPDATED | APR 17 | EJ | MD |
| | | | | | |

SUGGESTED MOUNTING CONFIGURATION FOR QA2224 CASE STYLE "06FL09" PIN CODE



NOTES:

1. TRACE WIDTH IS SHOWN FOR ROGERS (R04350B) WITH DIELECTRIC THICKNESS .020"±.0015". COPPER: 1/2 OZ. EACH SIDE.
FOR OTHER MATERIALS TRACE WIDTH MAY NEED TO BE MODIFIED.
2. BOTTOM SIDE OF THE PCB IS CONTINUOUS GROUND PLANE.



DENOTES PCB COPPER LAYOUT WITH SMOBC (SOLDER MASK OVER BARE COPPER)



DENOTES COPPER LAND PATTERN FREE OF SOLDERMASK

| UNLESS OTHERWISE SPECIFIED | INITIALS | DATE |
|---|----------|--------------|
| DIMENSIONS ARE IN INCHES TOLERANCES ON: 2 PL DECIMALS ± 3 PL DECIMALS ± .005" ANGLES ± FRACTIONS ± | DRAWN | TM 02 MAY 16 |
| | CHECKED | MD 02 MAY 16 |
| | APPROVED | MD 02 MAY 16 |



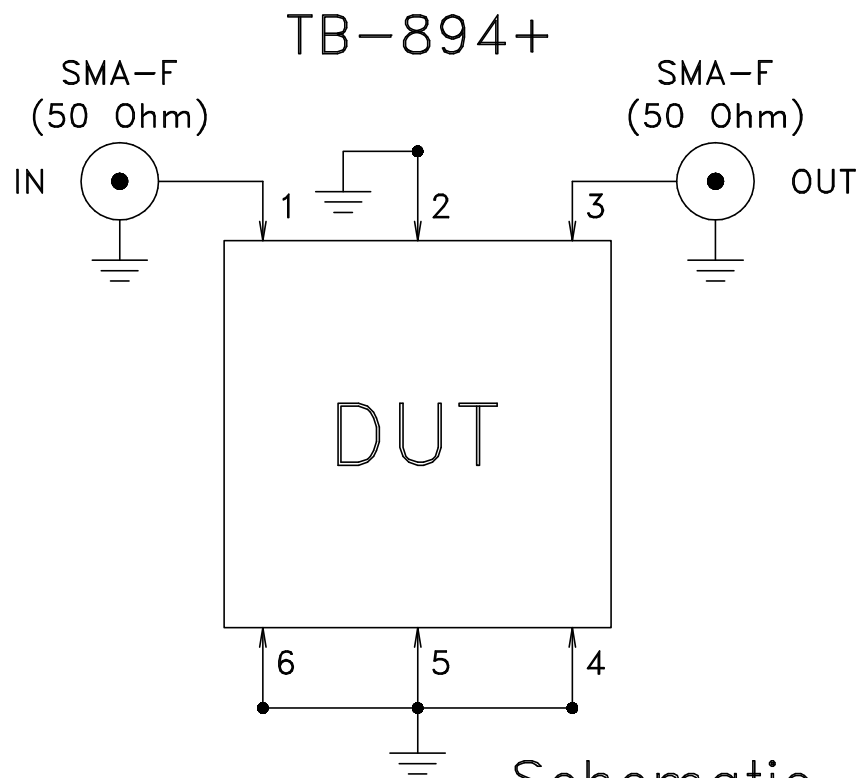
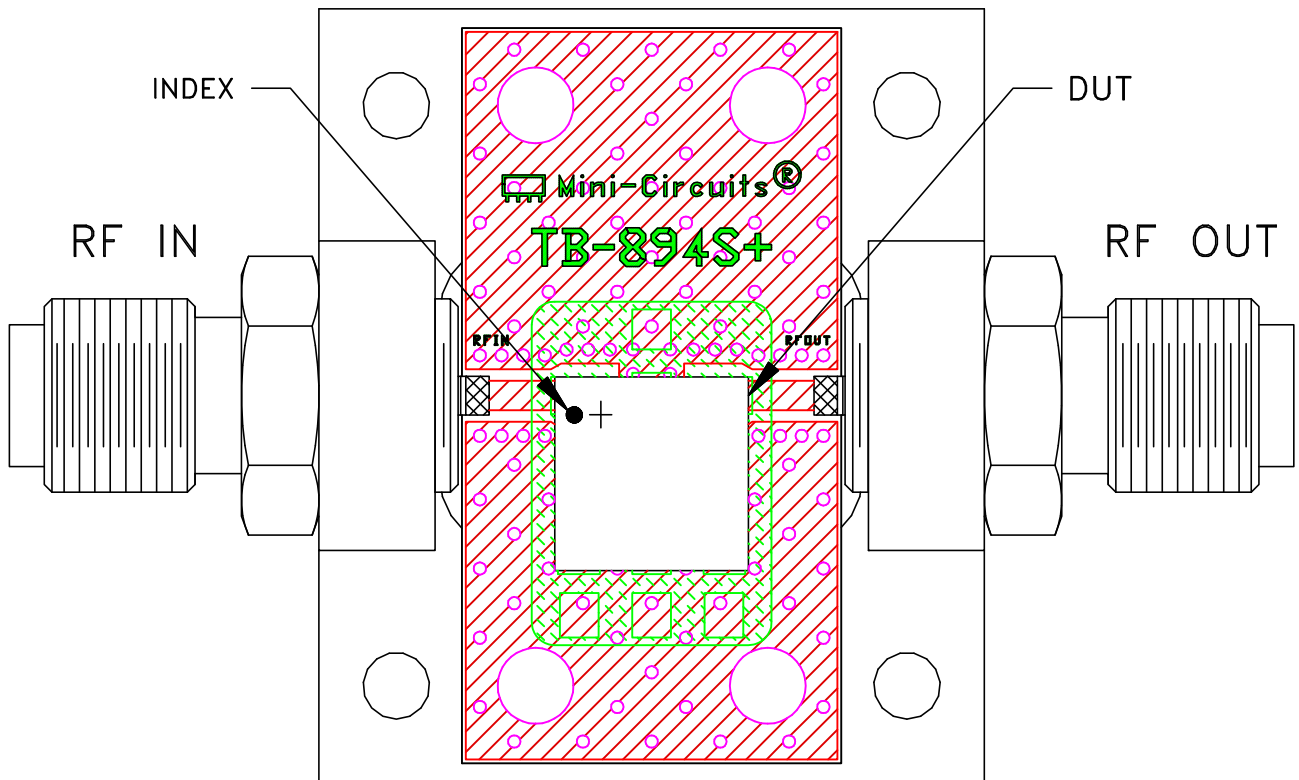
Mini-Circuits® 13 Neptune Avenue
Brooklyn NY 11235

PL, 06FL09, QA2224, ULP,
TB-894+, 50 Ohm

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|------------------|---------------------|--------------------------|-----------|
| SIZE A | CODE IDENT 15542 | DRAWING NO: 98-PL-484 | REV: A |
| FILE: 98PL484 | SCALE: 4:1 | SHEET: 1 OF 1 | |


Evaluation Board and Circuit



NOTES:

1. 50 Ohm SMA Female connectors.
2. PCB Material: ROGERS (RO4350B) OR Equivalent
Dielectric Constant=3.48±.05, Thickness=.020 inch.

Schematic Diagram

 **Mini-Circuits®**

All Mini-Circuits products are manufactured under exacting quality assurance and control standards, and are capable of meeting published specifications after being subjected to any or all of the following physical and environmental test.

| Specification | Test/Inspection Condition | Reference/Spec |
|--------------------------------|---|--|
| Operating Temperature | -40° to 85° C Ambient Environment | Individual Model Data Sheet |
| Storage Temperature | -55° to 100° C Ambient Environment | Individual Model Data Sheet |
| HAST | 130°C, 85% RH, 96 hours | JESD22-A110 |
| Humidity | 90 to 95% RH, 240 hours, 50°C | MIL-STD-202, Method 103, Condition A, Except 50°C and end-point electrical test done within 12 hours |
| Thermal Shock | -55° to 100°C, 100 cycles | MIL-STD-202, Method 107, Condition A-3, except +100°C |
| Solder Reflow Heat | Sn-Pb Eutectic Process: 225°C peak Pb-Free Process, 245°C peak | J-STD-020, Table 4-1, 4-2 and 5-2, Figure 5-1 |
| Solderability | 10X Magnification | J-STD-002, Para 4.2.5, Test S, 95% Coverage |
| Vibration (High Frequency) | 20g peak, 20-2000 Hz, 4 times in each of three axes (total 12) | MIL-STD-883, Method 2007.3, Condition A |
| Mechanical Shock | 50g, 11 ms, 1/2-sine, 18 shocks: 3 each direction, each of 3 axes | MIL-STD-202, Method 213, Condition A |
| Marking Resistance to Solvents | Isopropyl alcohol + mineral spirits at 25°C; terpene defluxer at 25°C; distilled water + proylene glycol monomethyl ether + monoethanolamine at 63°C to 70°C | MIL-STD-202, Method 215 |