Hi-Rel Components for Space Applications

The extreme operating conditions of the space environment combined with lack of access for repairs and zero tolerance for failure necessitate intensive qualification of electronic parts used in space missions. Mini-Circuits has a successful track record of screening components for space applications, and our experience in this area has led to robust testing and qualification programs for the parts we supply for these systems.

Qualification requirements for space applications vary by program, materials and component type. Mini-Circuits offers a wide variety of hi-rel, ceramic components capable of meeting space level screening requirements. These include our extensive line of LTCC filters and diplexers, couplers, splitter/combiners and baluns, as well as a broad selection of amplifiers, mixers, limiters, and attenuators utilizing our hermetic LTCC packaging platform. This article will present examples or "case studies" of components supplied for space systems and describe typical qualification processes used to screen each of these product groups for spaceborne systems. These examples highlight Mini-Circuits' advanced capabilities in meeting qualification requirements to ensure high reliability for space missions, but they are by no means an exhaustive representation of our capabilities. We invite you to contact our applications team (apps@minicircuits.com) to discuss the specific requirements of your program.

1. LTCC Passives

Mini-Circuits' LTCC passive components utilize rugged, multi-layer ceramic construction to achieve both extremely tiny size and outstanding reliability in harsh environments, making them excellent candidates for hi-rel applications. Our line of LTCC products includes an extensive variety of filters (high-pass, low-pass and band-pass), diplexers, couplers, splitter/combiners, 90° hybrids, and balun transformers, all available for space-level screening. This section will present a case study of the qualification process for an LTCC low pass filter to meet screening requirements for a particular spaceborne system.

Space Level Screening of an LTCC Low Pass Filter

The LTCC filter screened in this case is a modification of standard model LFCN-8400+. This is a 7 section filter with a passband from DC to 8400 MHz and RF input power handling up to 8W. The unit comes housed in a 1206 ceramic package with an operating temperature rating from -55°C to +100˚C. Beyond the standard electrical and environmental ratings of the part, the special model satisfies a series of special screening requirements defined by a particular space flight program. The requirements include a material restriction that the unit terminations be constructed with tin-lead finish with a maximum tin content of 97%. This is a standard requirement to prevent tin whisker growth. The special part also satisfies a date code restriction that shipped parts may be from a maximum of two lot date codes. If parts from two lots are shipped, one lot must be from new production and both lots must have passed screening independently.

Destructive Physical Analysis (DPA) is required on sample units from lots used for production to verify construction and termination composition. Units must also undergo a rigorous program of reliability testing including real time radiographic inspection in three views. The full qualification process performed to meet the program requirements is summarized below.

Qualification Process

Destructive Physical Analysis (DPA)

Prior to starting reliability testing, DPA is performed on 3 randomly selected sample units to verify the construction and termination composition on the lot to be used for production. MIL-STD-1580B is used to establish a general process for performing DPA on the units under test, but because pass/fail criteria for LTCC units are not defined by the standard, it is used as a guideline, and the units under test are compared to determine if there are any apparent anomalies. Photographs from external and internal examination of the sectioned devices are shown in Figure 1 and Figure 2. The DPA pass/fail criteria are summarized in Table 1.

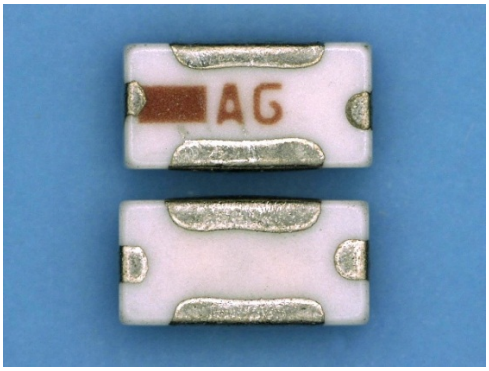
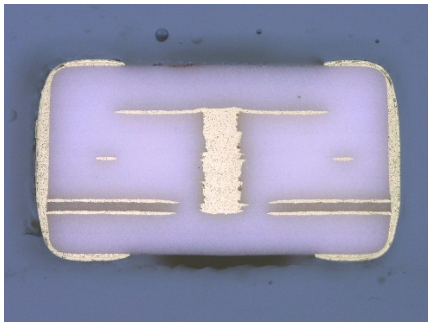
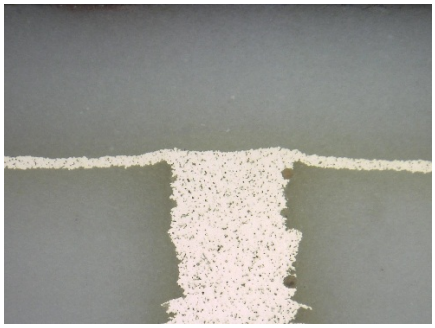


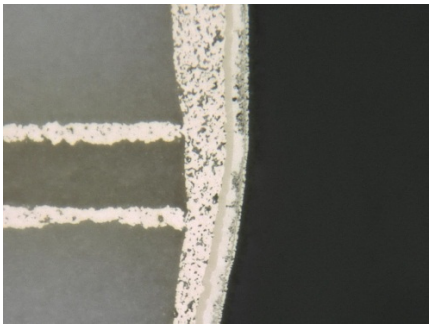
Figure 1: Overall view of devices at 18x magnification



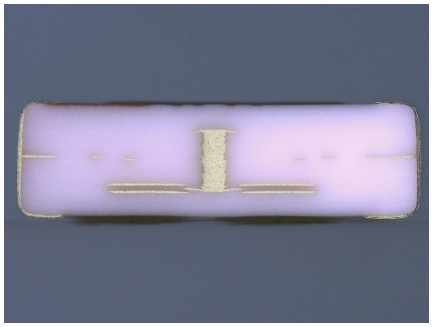
Overall view of parallel cross section at 56x magnification



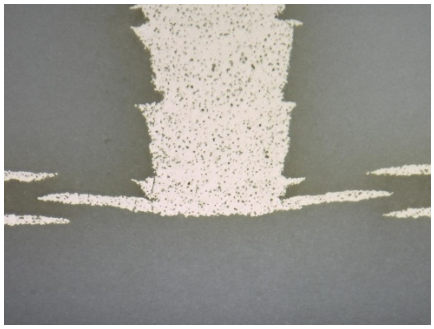
Detailed view of parallel cross section at 191x magnification



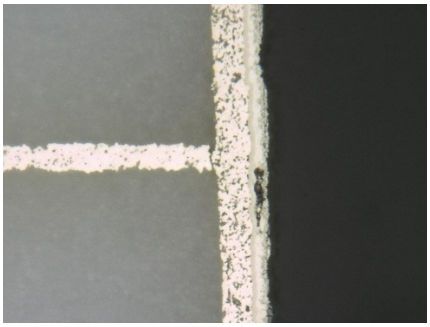
Detailed view of parallel cross section at 393x magnification



Overall view of transverse cross section at 56x magnification



Detailed view of transverse cross section at 191x magnification



Detailed view of transverse cross section at 393x magnification

Figure 2: Views of sectioned device from DPA

Reliability Testing

Following DPA, reliability testing consists of testing at 100% (Group A) and small sample testing (Group B) for a number of parameters summarized in Table 1.

Table 1: Screening process summary for LTCC low pass filter

DPA					
Test	**Condition/s**	**Duration or Cycles**	**Reference**	**Sample Size**	**Pass/Fail Criteria**
DPA	Sample units sectioned along 2 planes (parallel and transverse)	-	MIL-STD-1580B Para. 14.1.1.1 Para. 14.1.1.3	3 Units	a) External visual inspection b) Prohibited materials analysis of external surfaces c) Internal visual inspection of sectioned devices
GROUP A – 100% Screening					
Test	**Condition/s**	**Duration or Cycles**	**Reference**	**Sample Size**	**Pass/Fail Criteria**
Thermal Shock	-55/+125˚C	10 Cycles, 10 Min.	MIL-STD-202, Method 107	100%	Pass electrical
Bake-In	24 hr. stabilization bake exposure at +100˚	24 hr.	QCP-06-21	100%	Pass electrical
Real Time Radiographic Inspection	3 views	-	MIL-STD-202 Method 209	100%	Pass visual
Final Visual and Mechanical Inspection	10x magnification; 5 units inspected for dimension	-	-	100%	External visual
GROUP B – Sample Screening					
Test	**Condition/s**	**Duration or Cycles**	**Reference**	**Sample Size**	**Pass/Fail Criteria**
Humidity	+85˚C and +85RH, 1.3VDC ±0.25VDC test voltage applied	240 hr.	-	12 Units	a) Pass Electrical b) Visual Inspection
Destructive Electrical Screening	Standard Electrical Measurements @ +25˚C, -55˚C, and +100˚C; samples soldered on PCB	-	-	10 Units	Pass Electrical at +25˚C; Summary data provided for all testing
Solderability	Units soldered on test board and inspected per IPC-A-610	-	MIL-STD-202 Method 208	5 Units	Meet requirements of MIL-STD-202
Leach Resistance	Immersion in +260˚C solder	10 sec.	MIL-STD-202	3 Units	a) Visual Inspection b) Electrical Test c) Bubble Test
Terminal Strength	Push force of 0.5mm/s applied to samples soldered to test board	until electrode pads are peeled off or ceramic is broken	MIL-STD-202 Method 211	3 Units	1 kg minimum solder strength

Qualification Flow

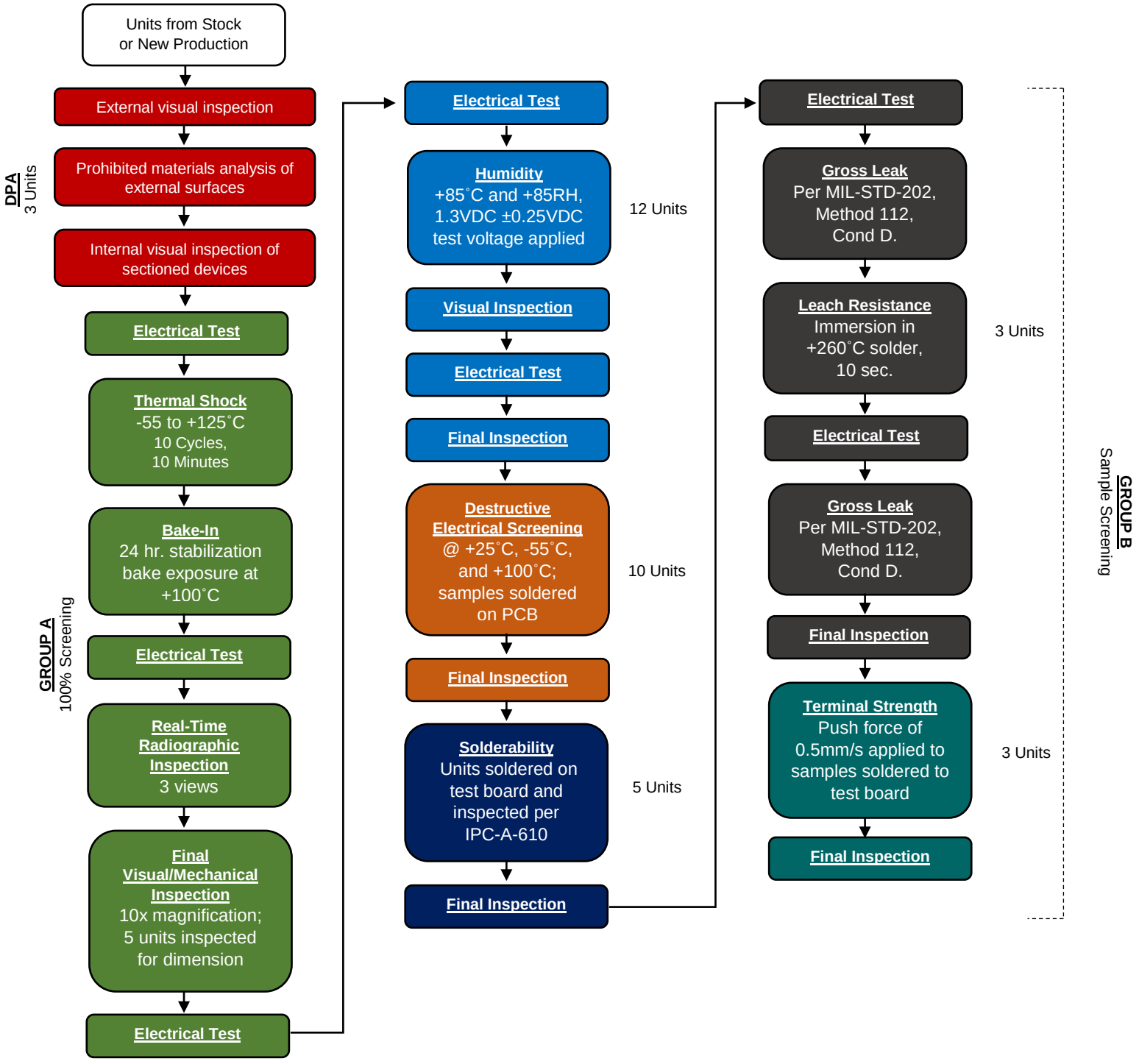


Figure 3: Qualification flow for LTCC low pass filter for a space flight program.

2. Hi-Rel Ceramic Packaging Platform for Amplifiers, Attenuators, Limiters and Mixers

Mini-Circuits has highly sophisticated systems and processes for ultra-high reliability ceramic, hermetically sealed packaging which is adaptable to a wide range of components including amplifiers (CMA-series), attenuators (RCAT-series), limiters (CLM-series) and mixers (MAC- and MRA-series). Utilizing LTCC ceramics, multilayer distributed circuitry, and automated processing, our flexible platform is suitable for integration and designs employing mixed technologies. For example, Mini-Circuits' MAC-series of hi-rel mixers incorporate diode quads utilizing semiconductor IC technology on GaAs wirebonded to baluns embedded in an LTCC multilayer substrate (see Figure 4). The diode quads are then hermetically sealed in a controlled nitrogen atmosphere with gold-plated covers and eutectic AuSn solder. The same packaging platform is adapted to realize ultra-high reliability amplifiers, attenuators, and limiters as well.

This packaging platform provides advantages of very low parasitics and thermal impedance, very wide operating temperature range, and outstanding reliability in extreme environments. All Mini-Circuits' hi-rel ceramic components are qualified to meet a whole battery of reliability standards shown in Table 2. These hermetic LTCC components are capable of meeting additional space level screening requirements and are available for screening. A case study of a ceramic, hermetic amplifier screened for a particular space flight program is presented in the next section.

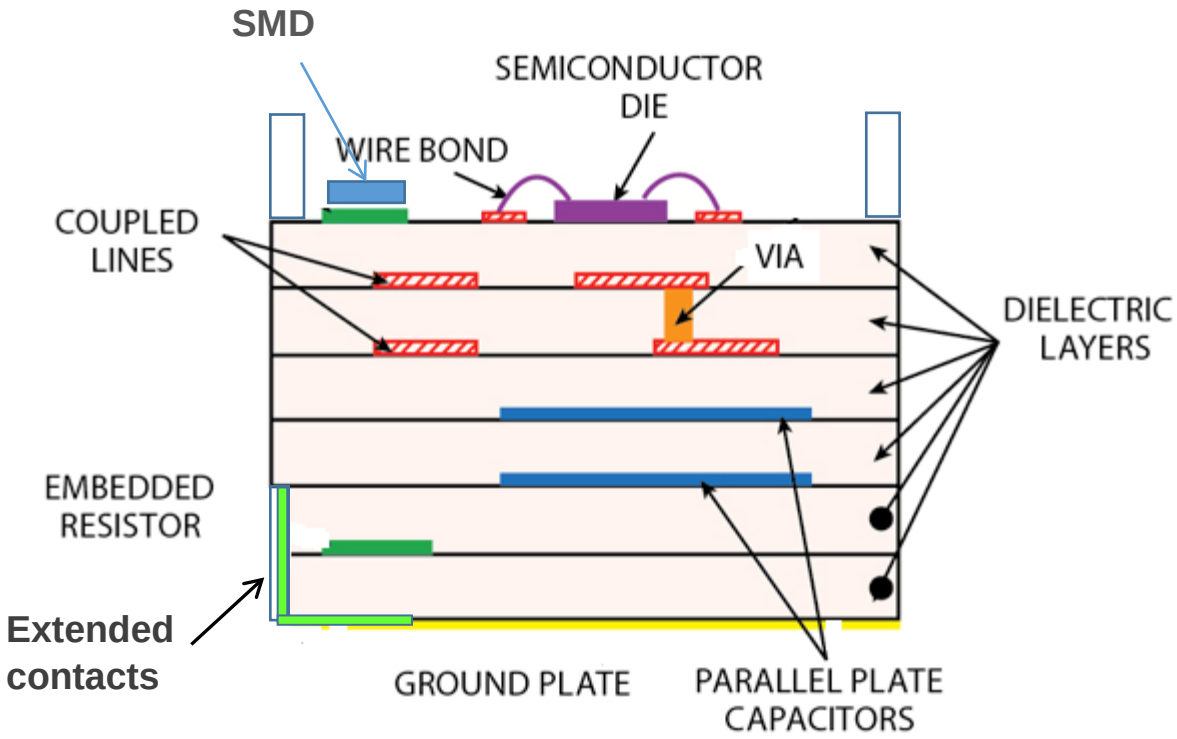


Figure 4: Mini-Circuits hi-rel ceramic packaging platform incorporating a semiconductor die wirebonded to an LTCC multilayer substrate.

Table 2: Device level and board level qualifications of Mini-Circuits hermetic LTCC packaging platform

	Test Description	*Test Method/Process*
Device Level	**Hermeticity (fine and gross leak)**	**MIL-STD-202 Method 112, Cond. C & D**
	Vibration , 10-2000Hzsine, 20g, 3 axis	**MIL-STD-202 Method 204, Cond. D**
	Temp Cycle -55C/+105C (-55C/+125C), 100 Cycles	**MIL-STD-202 Method 107**
	Acceleration, 30Kg, Y1 Direction	**MIL-STD-883 Method 2001 Cond. E**
	Mechanical shock	**MIL-STD-202 Method 213, Cond . A**
	PIND Test 20G's @ 130 Hz	**MIL-STD-750 method 2052.2**
	Autoclave, 121C, RH 100%, 15 Psig, 96 hrs	**JESD22-A102C**
	HTOL 1000hrs, 125C (105C) at rated LO/voltage level	**MIL-STD-202 Method 108, Cond . D**
	Moisture Sensitivity level- MSL-1 by design	**Hermetic package**
Board level	**Bend Test**	**JESD22-B113**
	Resistance to soldering heat, 3x reflow, 260˚C peak	**JESD22-B102**
	Drop Test	**JESD22-B111**
	Adhesion Strength	**Push Test>10 lb**
	Temp cycle -55C to 125C, 1000 Cycle	**MIL-STD-202 Method 107**

Case Study: CMA-Series Hi-Rel Ceramic Amplifier

Mini-Circuits' CMA-series of hi-rel ceramic amplifiers comprises a selection of standard catalog models with various combinations of performance parameters to meet different system requirements. All models utilize ceramic, hermetically sealed, nitrogen filled packaging to achieve outstanding reliability, operating temperature range from -55 to +105˚C, low inductance, and excellent reliability.

The amplifier screened for space flight in this case is a modification of standard model CMA-545+. This model has a wide operating frequency range from 0.05 to 6.0 GHz and provides ultra-low noise (0.8 dB typ.) and high IP3 (+35 dBm). The amplifier is fabricated using E-PHEMT technology on GaAs, then bonded to a multi-layer LTCC substrate and hermetically sealed under a controlled nitrogen atmosphere with gold plated covers and eutectic Au-Sn solder. The unit operates on a single +3V to +5V supply and comes in a 3 x 3 x 1.14mm package with nickel-palladium-gold termination finish.

The screening process for the special model consists of testing in 3 groups as summarized in table 3 below:

Table 3: Screening process summary for CMA-series amplifier

GROUP A – 100% Screening					
Test	**Condition/s**	**Duration or Cycles**	**Reference**	**Sample Size**	**Pass/Fail Criteria**
Thermal Shock	-65/+125˚C	20 Cycles, 10 Min.	MIL-STD-202, Method 107	100%	Pass electrical
Acceleration	5000g constant acceleration in each axis	24 hrs.	MIL-STD-883, Method 2001.2, Cond. A	100%	Pass visual inspection for physical damage
Mechanical Inspection	3 views	-	MIL-STD-883 Method 2010	100%	
Burn-In	160 hours @ 95˚C	160 hrs.	MIL-STD-883, Method 1015	100%	Pass electrical at +25˚C, -55˚C, and +105˚C
Gross Leak	Immersion in fluorocarbon liquid at 125˚C	30 sec.	MIL-STD-202, Method 112, Cond. D	100%	Pass bubble test
Fine Leak	Helium bomb @ 60±2 PSI	2 hrs. (+12 MIN/-0 MIN)	MIL-STD-202, Method 112, Cond. C	100%	Pass leak detector 5.0 x 10^{-8} ATM cm^3/S
GROUP C – Sample Screening					
Test	Condition/s	Duration or Cycles	Reference	Sample Size	Pass/Fail Criteria
Life Test	1000 hours @ 95˚C	1000 hrs.	MIL-STD-883, Method 1005	5 Units	Pass electrical at +25˚C, -55˚C and +105˚C
GROUP C – Sample Screening					
Test	Condition/s	Duration or Cycles	Reference	Sample Size	Pass/Fail Criteria
Thermal Shock	-65/+125˚C	100 Cycles		5 Units	
Vibration	0.06” amplitude, 20 Hz to 2000 Hz sweep, units mounted in test fixture	4 Sweep Cycles 4 Min. cycle 16 Min total vibration time per axis	MIL-STD-883E, Method 2007.3, Cond. A	5 Units	Pass visual inspection
Acceleration	Units mounted in test fixture subjected to 5000g constant acceleration in each axis	1 min.	MIL-STD-883, Method 2001.2, Cond. A	5 Units	Pass visual inspection
Fine Leak	Helium bomb @75 PSI	2 hours	MIL-STD-883, Method 1014, Cond. A1	5 Units	Pass leak detector 5.0 x 10^{-8} ATM cm^3/S
Gross Leak	5 torr pressure for 30 minutes, then submerged in leak indicator fluid and increased to 75 PSI using helium for 2 hours	30 min. @ 5 torr 2 hrs. @ 75 PSI	MIL-STD-883, Method 1014, Cond. C1	5 Units	Pass bubble test

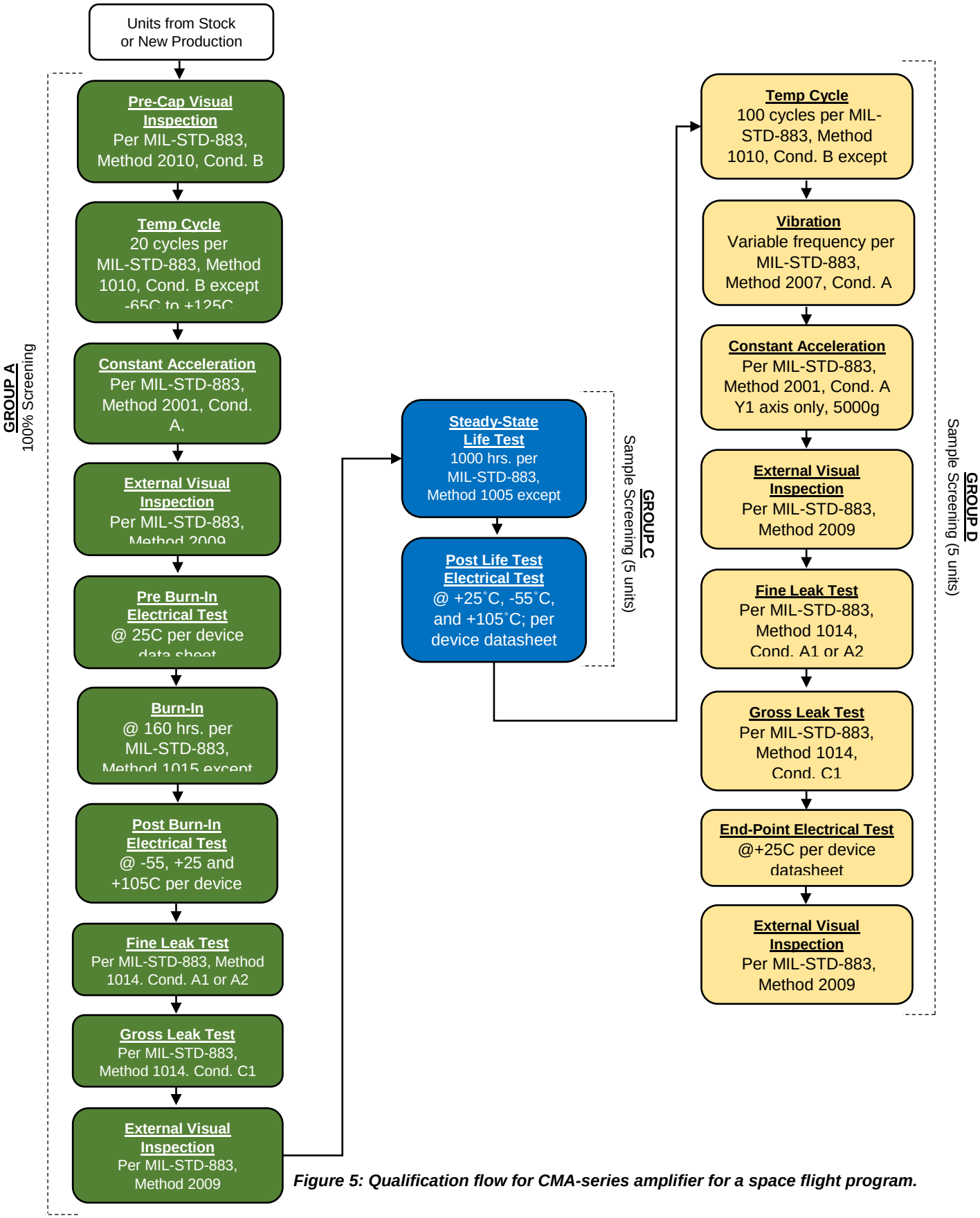


Figure 5: Qualification flow for CMA-series amplifier for a space flight program.

Conclusion

The qualification processes presented in this article meet the requirements for two different components used in space flights. Requirements vary widely depending on many factors including the component type, materials, and other details specific to the flight program. Mini-Circuits has successfully screened hi-rel components for a range of space flight requirements, and through this experience we have established robust qualification processes support these demanding applications.

Beyond the two examples shown here, Mini-Circuits has hundreds of hi-rel components available for space-level screening. A full listing of these components is provided in the appendix, and we encourage you to browse our offering.

For more information about qualifying parts for space applications and to discuss your project needs, please contact our applications team at apps@minicircuits.com.

Appendix: Hi-Rel Models Available for Space Screening[1]

Low Pass Filters

LFCN-Series, LFCG-Series, LFCV-Series, LFCW-Series

Model Number	Passband (MHz)		fco, MHz Nom. (loss 3 dB)	Stop Band Frequency (MHz)				VSWR (:1)		Power Input (W)
	Low	High		(loss > 20 dB)	(loss > 30 dB)	(loss > 40 dB)	Reentry (loss > 20 dB)	Stopband Typ.	Passband Typ.	
LFCG-42+	DC	435	475	625	1	-	-	20	1.5	1
LFCG-92+	DC	990	1400	1700	2	5000	-	20	1.45	2
LFCG-612+	4900	6100	7500	8200	1	-	14700-18300	20	1.7	1
LFCN-80 (+)	DC	80	145	200	8.5	225-1550	4500	20	1.2	8.5
LFCN-95 (+)	DC	95	165	230	8.5	255-1600	4500	20	1.2	8.5
LFCN-105 (+)	DC	105	180	250	8.5	265-1650	4750	20	1.2	8.5
LFCN-113+	DC	11000	12250	14000	8	14500-20000	-	20	1.6	8
LFCN-120 (+)	DC	120	195	280	8.5	300-1850	4750	20	1.2	8.5
LFCN-123+	DC	12000	13000	15000	8	15500-20000	-	20	1.6	8
LFCN-160+	DC	160	230	330	8	-	6100	17	1.2	8
LFCN-180 (+)	DC	180	270	370	8	525-2350	6400	17	1.2	8
LFCN-190+	DC	190	280	400	8	510-2850	6550	17	1.2	8
LFCN-225 (+)	DC	225	350	460	8.5	510-2500	5500	20	1.2	8.5
LFCN-320 (+)	DC	320	460	560	8.5	640-2500	5300	20	1.2	8.5
LFCN-400 (+)	DC	400	560	660	8.5	680-3000	5500	20	1.2	8.5
LFCN-490 (+)	DC	490	650	800	8.5	880-2500	6000	20	1.2	8.5
LFCN-530 (+)	DC	530	700	820	8.5	945-3000	6000	20	1.2	8.5
LFCN-575 (+)	DC	575	770	900	8.5	1050-3200	5500	20	1.2	8.5
LFCN-630 (+)	DC	630	830	1000	8.5	1020-3500	6000	20	1.2	8.5
LFCN-722+	DC	7200	7940	8980	12	-	15000	20	2	12
LFCN-800 (+)	DC	800	990	1400	9	-	4500	20	1.2	9
LFCN-900 (+)	DC	850	1075	1275	10	-	5100	20	1.2	10
LFCN-1000 (+)	DC	1000	1300	1550	10	-	5500	20	1.3	10
LFCN-1200 (+)	DC	1200	1530	1850	10	-	6200	20	1.2	10
LFCN-1325 (+)	DC	1325	1560	2100	9	-	4250	20	1.4	9
LFCN-1400 (+)	DC	1400	1700	2015	10	-	6800	20	1.2	10
LFCN-1450 (+)	DC	1450	1825	2025	10	-	6700	20	1.2	10
LFCN-1500 (+)	DC	1500	1825	2100	10	-	6800	20	1.2	10
LFCN-1525 (+)	DC	1525	1750	2040	10	-	6700	20	1.2	10
LFCN-1575 (+)	DC	1575	1875	2175	10	-	7100	20	1.2	10
LFCN-1700 (+)	DC	1700	2050	2375	10	-	7000	20	1.2	10
LFCN-1800 (+)	DC	1800	2125	2425	10	-	8600	20	1.2	10
LFCN-2000 (+)	DC	2000	2275	3000	9	-	4600	20	1.3	9
LFCN-2250 (+)	DC	2200	2575	2900	10	-	7200	20	1.2	10
LFCN-2400 (+)	DC	2400	2900	3600	9	-	5000	20	1.2	9
LFCN-2500 (+)	DC	2500	3075	3675	10	-	8000	20	1.2	10
LFCN-2600 (+)	DC	2600	3125	3750	10	-	8400	20	1.2	10
LFCN-2750 (+)	DC	2750	3150	4000	10	-	8400	20	1.2	10

[1] As of 4/7/16

Low Pass Filters Continued

Model Number	Passband (MHz)		fco, MHz Nom. (loss 3 dB)	Stop Band Frequency (MHz)				VSWR (:1)		Power Input (W)
	Low	High		(loss > 20 dB)	(loss > 30 dB)	(loss > 40 dB)	Reentry (loss > 20 dB)	Stopband Typ.	Passband Typ.	
LFCN-2850 (+)	DC	2800	3300	4000	4200-7400	-	9000	20	1.2	10
LFCN-3000 (+)	DC	3000	3600	4550	4780-7500	-	10000	20	1.2	10
LFCN-3400+	DC	3400	3950	4300	4600-7800	-	8300	17	1.2	8
LFCN-3800 (+)	DC	3900	4850	6000	5700-8300	-	13000	17	1.3	8
LFCN-4400 (+)	DC	4400	5290	6700	6280-9800	-	13000	17	1.2	8
LFCN-5000 (+)	DC	5000	5580	6850	7050-10000	-	18000	20	1.2	9
LFCN-5500+	DC	5500	6200	7200	6770-9500	-	12100	17	1.3	8
LFCN-5850+	DC	5850	6540	7600	7100-9900	-	12500	17	1.3	8
LFCN-6000 (+)	DC	6000	6800	8500	8700-10500	-	18000	20	1.3	9
LFCN-6400+	DC	6400	7200	8300	7770-10200	-	12500	17	1.2	8
LFCN-6700 (+)	DC	6700	7600	9300	9500-11000	-	18000	20	1.3	9
LFCN-7200+	DC	7200	8150	9500	8850-9600	-	12300	17	1.3	8
LFCN-8400+	DC	8400	9100	10300 - 15000	-	-	-	17	1.6	8
LFCV-45+	DC	45	77	120	-	150-910	1000	20	1.2	8.5
LFCV-52+	DC	52	93	140	-	170-1100	1200	20	1.2	8.5
LFCV-1450+	DC	1450	1500	1650	-	1800-2300	3000	20	1.3	0.5
LFCW-133+	DC	13250	13650	14910-15410	-	-	-	30	2.7	12.6
LFCW-272+	DC	2690	3200	4400	4800-5400	-	10000	20	1.6	3
LFCW-1062+	DC	10600	10800	12160-12860	-	-	-	62	2.2	4
LFCW-1142+	DC	11400	11700	12860-13860	-	-	-	25	1.85	6.3
LFTC-850+	DC	850	1078	1500	-	2000-3500	5500	18	1.2	16
LFTC-1350+	DC	1350	1550	2100	2700-4500	-	7000	18	1.2	15
LFTC-1700+	DC	1700	1980	2700	-	3300-3750	7200	18	1.2	14
LFTC-2000+	DC	2000	2430	3450	-	4500-5400	8000	18	1.2	10
LFTC-3300+	DC	3300	4100	5600	-	-	10000	18	1.2	10
LFTC-4000+	DC	4000	5325	7250	-	-	9500	18	1.2	10
LFTC-5400+	DC	5400	6410	9000-11000	-	-	12000	18	1.1	19
LFCN-225D+	DC	225	350	485	-	510-2500	5500	20	1.2	8.5
LFCN-320D+	DC	320	460	610	640-2500	-	5300	20	1.2	8.5
LFCN-400D+	DC	400	560	695	720-3000	-	5500	20	1.2	8.5
LFCN-490D+	DC	490	650	840	880-2500	-	6000	20	1.2	8.5
LFCN-530D+	DC	530	700	870	-	945-3000	6000	20	1.2	8.5
LFCN-575D+	DC	575	770	945	-	1050-3200	5500	20	1.2	8.5
LFCN-630D+	DC	630	830	1020	-	1020-3500	6000	20	1.2	8.5
LFCN-800D+	DC	800	990	1400	1500-2000	-	4500	20	1.2	9
LFCN-900D+	DC	850	1075	1275	1350-4850	-	5100	20	1.2	10
LFCN-900D-1+	DC	850	1075	1275	1350-4850	-	5100	20	1.2	10
LFCN-1000D+	DC	1000	1300	1600	1900-5000	-	5500	20	1.3	10
LFCN-1200D+	DC	1200	1530	1850	2000-5000	-	6200	20	1.2	10
LFCN-1400D+	DC	1400	1700	2100	2200-6600	-	6800	20	1.2	10

Low Pass Filters Continued

Model Number	Passband (MHz)		fco, MHz Nom. (loss 3 dB)	Stop Band Frequency (MHz)				VSWR (:1)		Power Input (W)
	Low	High		(loss > 20 dB)	(loss > 30 dB)	(loss > 40 dB)	Reentry (loss > 20 dB)	Stopband Typ.	Passband Typ.	
LFCN-1500D+	DC	1500	1825	2175	2300-6600	-	6800	20	1.2	10
LFCN-1525D+	DC	1525	1750	2150	2425-6600	-	6700	20	1.2	10
LFCN-1575D+	DC	1575	1875	2275	2325-6800	-	7100	20	1.2	10
LFCN-1700D+	DC	1700	2050	2375	2500-6500	-	7000	20	1.2	10
LFCN-1800D+	DC	1800	2125	2550	3000-7200	-	8600	20	1.2	10
LFCN-1800D-1+	DC	1800	2125	2550	3000-7200	-	8600	20	1.2	10
LFCN-2000D+	DC	2000	2275	3000	3100-3500	-	4600	20	1.3	9
LFCN-2250D+	DC	2250	2575	2900	3000-5000	-	7200	20	1.2	10
LFCN-2400D+	DC	2400	2900	3600	3700-4000	-	5000	20	1.2	9
LFCN-2400D-1+	DC	2400	2900	3600	3700-4000	-	5000	20	1.2	9
LFCN-2500D+	DC	2500	3075	3675	3800-6100	-	8000	20	1.2	10
LFCN-2600D+	DC	2600	3125	3750	3900-6600	-	8400	20	1.2	10
LFCN-2750D+	DC	2750	3150	4000	4150-6800	-	8400	20	1.2	10
LFCN-2850D+	DC	2800	3300	4000	4200-7400	-	9000	20	1.2	10
LFCN-3000D+	DC	3000	3600	4550	4780-7500	-	10000	20	1.2	10
LFCN-3400D+	DC	3400	3950	4300	4600-7800	-	8300	17	1.2	8
LFCN-3400D-1+	DC	3400	3950	4300	4600-7800	-	8300	17	1.2	8
LFCN-3800D+	DC	3900	4850	6000	5700-8300	-	13000	17	1.3	8
LFCN-4400D+	DC	4400	5290	6700	6280-9800	-	13000	17	1.2	8
LFCN-5000D+	DC	5000	5580	6850	7050-10000	-	18000	20	1.2	9
LFCN-5500D+	DC	5500	6200	7200	6770-9500	-	12100	17	1.3	8
LFCN-5850D+	DC	5850	6540	7600	7100-9900	-	12500	17	1.3	8
LFCN-6000D+	DC	6000	6800	8500	8700-10500	-	18000	20	1.3	9
LFCN-6400D+	DC	6400	7200	8300	7770-10200	-	12500	17	1.2	8
LFCN-6700D+	DC	6700	7600	9300	9500-11000	-	18000	20	1.3	9
LFCN-7200D+	DC	7200	8150	9500	8850-9600	-	12300	17	1.3	8

High Pass Filters

HFCN-Series, HFCV-Series

Model Number	Stop Band Frequency (MHz)		fco, MHz Nom. (loss 3 dB) Typ.	Passband Frequency (MHz)		VSWR (:1)		Power Input (W)
	(loss > 30 dB)	(loss > 20 dB)		(loss < 1.3 dB) Max.	(loss < 2 dB) Typ.	Stopband Typ.	Passband Typ.	
HFCN-103+	5700	6500	8400	-	9700-15000	20	2	7
HFCN-440+	230	350	440	600-1700	500-2500	20	1.5	7
HFCN-650 (+)	390	480	650	850-2000	710-2490	20	1.5	7
HFCN-740 (+)	430	550	740	900-2200	780-2800	20	1.5	7
HFCN-880 (+)	500	640	880	1060-2500	950-3200	20	1.5	7
HFCN-1000+	570	740	1000	1150-3700	1080-4000	20	1.5	7
HFCN-1080+	600	700	1080	1250-3730	1140-4240	20	2	7
HFCN-1100+	530	700	1100	1400-3500	1500-3900	20	1.5	7
HFCN-1150+	650	850	1150	1320-3700	1220-4500	20	2	7
HFCN-1200 (+)	750	910	1180	1380-4000	1220-4600	20	1.5	7
HFCN-1300 (+)	680	930	1300	1510-4000	1400-5000	20	1.5	7
HFCN-1320 (+)	880	1060	1320	1700-3800	1400-5000	20	1.5	7
HFCN-1500 (+)	1060	1250	1550	1850-4400	1600-5500	20	1.5	7
HFCN-1600 (+)	1090	1290	1600	1950-4000	1650-5000	20	1.5	7
HFCN-1760 (+)	950	1230	1760	2100-5200	1900-5500	20	1.5	7
HFCN-1810 (+)	1100	1480	1810	2250-3850	1950-4750	20	1.5	7
HFCN-1910 (+)	1075	1400	1910	2200-4400	2000-5200	20	1.5	7
HFCN-2000 (+)	1300	1530	2000	2410-5550	2260-6250	20	1.5	7
HFCN-2100 (+)	1050	1530	2100	2500-5000	2200-6000	20	1.5	7
HFCN-2275 (+)	1400	1770	2275	2640-6230	2450-7000	20	1.5	7
HFCN-2700 (+)	1500	1800	2500	3000-5700	2650-6500	20	1.5	7
HFCN-3800 (+)	3100	3200	3800	4500-9000 †	4250-10000	20	1.5	7
HFCN-5500 (+)	4000	4500	5500	6600-10000 †	6000-11500	20	1.5	7
HFCN-8400 (+)	5700	6000	8400	9500-13000 ‡	9000-13000	20	1.5	7
HFCN-650D+	390	480	650	850-2000	710-2490	20	1.5	7
HFCN-740D+	430	550	740	900-2200	780-2800	20	1.5	7
HFCN-880D+	500	640	880	1060-2500	950-3200	20	1.5	7
HFCN-1200D+	780	940	1180	1380-4000	1220-4600	20	1.5	7
HFCN-1300D+	680	930	1300	1510-4000	1400-5000	20	1.5	7
HFCN-1320D+	910	1060	1320	1700-3800	1400-5000	20	1.5	7
HFCN-1500D+	1090	1250	1550	1850-4400	1600-5500	20	1.5	7
HFCN-1600D+	1090	1290	1600	1950-4000	1650-5000	20	1.5	7
HFCN-1810D+	1100	1480	1810	2250-3850	1950-4750	20	1.5	7
HFCN-1910D+	1100	1400	1910	2200-4400	2000-5200	20	1.5	7
HFCN-2100D+	1050	1530	2100	2500-5000	2200-6000	20	1.5	7
HFCN-2700A+	2000	2150	2700	3070-8500	2900-8700	20	1.5	7
HFCN-2700AD+	2000	2150	2700	3070-8500	2900-8700	20	1.5	7
HFCN-3100+	2250	2450	3100	3500-9500	3400-9900	20	1.5	7

High Pass Filters Continued

Model Number	Stop Band Frequency (MHz)		fco, MHz Nom. (loss 3 dB) Typ	Passband Frequency (MHz)		VSWR (:1)		Power Input (W)
	(loss > 30 dB)	(loss > 20 dB)		(loss < 1.3 dB) Max.	(loss < 2 dB) Typ.	Stopband Typ.	Passband Typ.	
HFCN-3100D+	2250	2450	3100	3500-9500	3400-9900	20	1.5	7
HFCN-3500+	2600	2800	3500	4000-8800	3900-9800	20	1.5	7
HFCN-3500D+	2600	2800	3500	4000-8800	3900-9800	20	1.5	7
HFCN-3800D+	3100	3200	3800	4500-9000	4250-10000	20	1.5	7
HFCN-4400+	3300	3500	4400	5000-9900	5000-10100	20	1.5	7
HFCN-4400D+	3300	3500	4400	5000-9900	5000-10100	20	1.5	7
HFCN-4600+	3700	3800	4600	5200-10500	5000-11000	20	1.5	7
HFCN-5050+	3600	4200	5050	5650-9700	5500-10000	20	1.5	7
HFCN-5500D+	4000	4500	5500	6600-10000	6000-11500	20	1.5	7
HFCN-6010+	5190	5200	6010	6350-13000	6300-15000	20	1.5	7
HFCN-7150+	5100	6150	7150	8500-10500	7900-11000	20	1.5	7
HFCN-8400D+	5700	6000	8400	9500-13000	9000-13000	20	1.5	7
HFCV-145+	80	115	132	155-1050	140-1150	20	1.5	8.5

Band Pass Filters

BFCN-Series, BFCG-Series, BFCW-Series

Model Number	Fc (MHz)	Passband (MHz)		Stop Bands (MHz)		VSWR (:1)	
		From	To	(loss > 20 dB)	(loss > 35 dB)	Passband Max.	Stopband Typ.
BFCG-162W+	1575	950	2200	DC-770 & 3000-5000	---	2	30
BFCG-5600+	5600	5150	5990	DC-4200 & 9310-15750	---	2.3	30
BFCN-152W-75+	1460	950	1970	630-730 & 2300-3000	DC-630	1.6	30
BFCN-1445+	1445	1420	1470	1190 & 2050	1000 & 2850-3840	2.5	30
BFCN-1525+	1525	1480	1570	1250 & 2180	1050 & 3000-4000	2.5	30
BFCN-1560+	1560	1500	1620	1100 & 2100	1040 & 2105-4200	1.7	20
BFCN-1575+	1575	1530	1620	1290 & 2220	1050 & 3100-4000	2.5	30
BFCN-1690+	1690	1570	1810	DC-1200 & 2170-4400	---	5	20
BFCN-1840+	1840	1750	1930	1480 & 2860	1320 & 4100-5100	2.5	30
BFCN-1855+	1855	1790	1920	1510 & 2810	1310 & 3880-4880	2.5	30
BFCN-1900+	1900	1893	1920	DC-1687 & 2153-5500	---	2	30
BFCN-1945+	1945	1850	2040	1400 & 2900	1400 & 3880-4880	2.8	30
BFCN-2275+	2275	2170	2380	1800 & 3430	1510 & 4390-5390	2.5	30
BFCN-2360+	2360	2250	2470	1850 & 3600	1550 & 4470-5470	2.5	30
BFCN-2435+	2435	2340	2530	1940 & 3850	1660 & 4390-5390	2.8	30
BFCN-2450+	2450	2400	2550	DC-2100 & 3400-12000	---	2	30
BFCN-2555+	2555	2500	2610	1970 & 3200	2000 & 3250-5500	1.6	20
BFCN-2700+	2700	2600	2800	1500 & 4150	1400 & 4200-5600	2.8	20
BFCN-2840+	2840	2750	2930	1550 & 4000	1500 & 4050-6000	1.6	20
BFCN-2850+	2850	2750	2950	1500 & 4300	1450 & 4350-5900	1.9	20
BFCN-2900+	2900	2700	3100	1850 & 4200	1800 & 4900-7000	2.3	20
BFCN-2910+	2910	2850	2970	1600 & 4200	1550 & 4250-6000	2.3	20
BFCN-2975+	2975	2570	3440	DC-1700 & 4000-7500	---	3	24

Band Pass Filters Continued

Model Number	Fc (MHz)	Passband (MHz)		Stop Bands (MHz)		VSWR (:1)	
		From	To	(loss > 20 dB)	(loss > 35 dB)	Passband Max.	Stopband Typ.
BFCN-3010+	3010	2920	3100	1530 & 4450	1300 & 4650-6600	3	20
BFCN-3085+	3085	2800	3400	4250 & 7800	---	3	24
BFCN-3085A+	3085	2800	3400	4210 & 7800	---	3	40
BFCN-3115+	3115	2720	3570	DC-1850 & 4300-8160	---	3	24
BFCN-3600+	3600	3300	3900	1850 & 5000	---	1.5	16
BFCN-4100+	4100	3700	4500	2200	---	2	20
BFCN-4440+	4440	4200	4700	2000 & 6750	2000 & 6650-12000	1.6	20
BFCN-4800+	4800	4400	5200	DC-1800 & 7500-12000	---	1.7	15
BFCN-5100+	5100	3100	7100	DC-2400 & 9500-17000	---	3	30
BFCN-5750+	5750	5650	5850	DC-4300 & 8000-9000	---	2	30
BFCN-7200+	7200	7100	7300	6650 & 8150	6500 & 8500-14000	1.4	30
BFCN-7350+	7350	7150	7550	6500 & 8500	6325 & 8700-14000	1.3	30
BFCN-7500+	7500	7450	7650	6700 & 8800	6400 & 9300-14000	1.5	30
BFCN-7700+	7700	7500	7900	6800 & 9000	6500 & 9600-14000	1.4	30
BFCN-7900+	7900	7800	8100	6800 & 9300	6600 & 9600-15000	1.4	30
BFCN-8000+	8000	7900	8100	7000 & 9300	6800 & 10000-15000	1.6	30
BFCN-8350+	8350	8250	8450	7400 & 9600	7200 & 9700-15000	1.6	30
BFCN-8450+	8450	8350	8550	7500 & 9800	7300 & 10000-15000	1.4	30
BFCN-8650+	8650	8550	8750	7700 & 9900	7500 & 10000-15000	1.5	30
BFCW-542+	5350	4700	6000	DC-2500 & 9800-12000	---	2	30

Diplexers

LDP-Series

Model Number	Common Port (MHz)	Output Port Freq. (MHz)	Insertion Loss/Isolation (dB, typ.)			VSWR (:1, typ.)		
			COM-LP	COM-HP	LO-HP	COM	LP	HP
LDP-1050-252+	1-1050, 1650-2500	1-1050	0.6	25	-	1.5	1.43	-
		1650-2500	31	1	-	1.33	-	1.67
LDPG-272-492+	DC-2700, 4900-5750	DC-2700	0.5	30	-	1.38	1.38	-
		4900-5750	23	0.7	-	1.5	-	1.5
LDPW-162-242+	DC-1650, 2400-6000	DC-1650	0.6	20	-	1.22	1.22	-
		2400-2500	15	0.6	-	1.15	-	1.15
		4900-6000	15	0.3	-	1.38	-	1.38

Amplifiers

CMA-Series

Model Number	Frequency Range (MHz)		Gain (dB) Typ.	IP3 (dBm) Typ.	Max. Power Output @ 1 dB comp.	N.F. (dB) Typ.	VSWR (:1) Typ.		Device DC Operating Power	
	Low	High					In	Out	Voltage (V)	Current (mA)
CMA-81+	DC	6000	10	34	19.6	7.4	1.3	1.6	5	103
CMA-82+	DC	7000	14.1	36.4	20.6	6.7	1.4	1.9	5	106
CMA-84+	DC	7000	20.2	34.5	21	5.5	1.4	3	5	108
CMA-62+	10	6000	15.4	33	19.2	5.1	1.5	1.8	5	82
CMA-162LN+	700	1600	23.2	30.3	19.9	0.49	1.4	1.2	4	55
CMA-252LN+	1500	2500	16.8	30	17.8	1	1.5	1.3	4	57
CMA-5043+	50	4000	18.4	13.9	19.8	0.75	1.7	1.5	5	58
CMA-545+	50	6000	14.2	35	20	0.8	2.3	1.5	3	80
CMA-545G1+	400	2200	31.8	36.5	23.3	0.9	1.9	1.4	5	158

Mixers

MAC-Series

Model Number	LO Level (dBm)	RF in @ 1 dB Comp. (dBm) Typ.	Frequency Range (MHz)				Conversion Loss (dB)			LO-RF Isolation (dB)	LO-IF Isolation (dB)	IP3 (dBm) Typ.
			LO/RF		IF		Typ.	σ	Max.			
MAC-12GL+	4	-1	3800	12000	DC	1500	6.6	0.3	9.5	26	15	7
MAC-85L+	4	0	2800	8500	DC	1200	7	0.15	8.9	31	15	8
MAC-12G+	7	1	3800	12000	DC	1800	6.3	0.25	8.8	26	15	9
MAC-24+	7	1	300	2400	DC	700	6	0.1	8.8	40	24	10
MAC-42+	7	1	1000	4200	DC	1500	6.1	0.1	8.9	35	20	10
MAC-60+	7	1	1600	6000	DC	2000	6.4	0.1	8.5	35	15	10
MAC-85+	7	1	2800	8500	DC	1250	6.1	0.15	8.2	31	15	9
MAC-24LH+	10	5	300	2400	DC	700	6.1	0.1	8.9	40	24	12
MAC-42LH+	10	5	1000	4200	DC	1500	6.1	0.1	8.9	38	20	12
MAC-60LH+	10	5	1600	6000	DC	2000	6.5	0.1	8.3	35	15	12
MAC-80LH+	10	5	2800	8000	DC	1250	5.8	0.1	8.3	29	15	12
MAC-24MH+	13	9	300	2400	DC	700	6.1	0.1	8.9	40	24	14
MAC-42MH+	13	9	1000	4200	DC	1500	6.1	0.1	8.9	35	20	16
MAC-60MH+	13	9	1600	6000	DC	2000	6.5	0.1	8.9	35	17	15
MAC-80MH+	13	9	2800	8000	DC	1250	5.8	0.15	8.3	29	13	16
MAC-80H+	17	14	2800	8000	DC	1250	6.5	0.15	8.9	29	17	21
MAC-113H+	17	14	3800	11000	DC	1800	6.5	0.15	8.9	28	17	19

Mixers (Active)

MRA-Series

Model Number	LO Level (dBm)	RF in @ 1 dB Comp. (dBm) Typ.	Frequency Range (MHz)				Conversion Gain (dB) Typ.	LO-RF Isolation (dB) Typ.	LO-IF Isolation (dB) Typ.	Output IP3 (dBm) typ.	Case Style
			LO/RF		IF						
MRA-42+	7	0	1000	4200	10	800	11.5	35	20	18	DZ1650
MRA-42LH+	10	4	1000	4200	10	800	11.5	35	20	21	DZ1650
MRA-42MH+	13	7	1000	4200	10	800	11.5	35	20	24	DZ1650

Attenuators

RCAT-Series

Model Number	Frequency Range (GHz)		Attenuation(dB) Typ.				Return Loss (dB) Typ.			Max Input Power (W) @ 25°C
	Low	High	Nom.	1	10	20	1 GHz	10 GHz	20 GHz	
RCAT-00+	DC	20	0	0	0.2	0.5	30	19	12	2
RCAT-01+	DC	20	1	1	1.3	1.7	30	19	12	2
RCAT-02+	DC	20	2	2	2.4	2.7	30	18	16	2
RCAT-03+	DC	20	3	3	3.4	3.9	31	20	14	2
RCAT-04+	DC	20	4	4	4.4	5.1	30	19	15	2
RCAT-05+	DC	20	5	5	5.5	6.2	30	20	16	2
RCAT-06+	DC	20	6	6.1	6.5	7.5	30	21	15	2
RCAT-07+	DC	20	7	7	7.6	8.6	30	19	15	2
RCAT-08+	DC	20	8	8	8.6	9.8	30	20	17	2
RCAT-09+	DC	20	9	9	9.7	11.1	30	20	17	2
RCAT-10+	DC	20	10	10.1	10.7	12.3	30	20	15	2
RCAT-12+	DC	20	12	12	12.8	14.8	32	20	16	1.8
RCAT-15+	DC	20	15	15.1	16	19	30	20	15	1.6
RCAT-20+	DC	20	20	20.1	21.4	27	30	21	14	1.5
RCAT-30+	DC	20	30	30	30.3	29.5	32	20	13	1.3

Limiters

CLM-Series

Model Number	Frequency Range (MHz)		Low Input Power Insertion Loss (dB) Typ.	Input (dBm)		Output (dBm) Typ.	Limiting Δ Output/Δ1 dB Input (dB/dB) Typ.
	Low	High		Min.	Max.		
CLM-83-2W+	30	8200	0.5	12	32	11.5	0.4

Splitter/Combiners

SCN-Series

Model Number	Frequency Range (MHz)		Isolation (dB) Typ.	Insertion Loss (dB) Above 3 dB Typ.	Phase Unbalance (degrees) Typ.	Amplitude Unbalance (dB) Typ.
	Low	High				
SCN-2-11 (+)	800	1175	20	0.5	1	0.1
SCN-2-15 (+)	1100	1450	23	0.5	1.5	0.25
SCN-2-19 (+)	1425	1900	23	0.5	2.5	0.25
SCN-2-22 (+)	1850	2200	22	0.5	2	0.25
SCN-2-27 (+)	2225	2700	21	0.5	3.5	0.6
SCN-2-35 (+)	2825	3700	25	0.4	1	0.1
SCN-2-45 (+)	3700	4200	21	0.7	1.5	0.2
SCN-2-65 (+)	5500	6500	17	0.8	2	0.1

90˚ Hybrids

QCN-Series, QBA-Series, QCC-Series, QCS-Series, QCV-Series

Model Number	Frequency Range (MHz)		Isolation (dB)		Insertion Loss (dB) Above 3 dB Typ.		Phase Unbalance (degrees) Max.	Amplitude Unbalance (dB) Max.	Power Input W
	Low	High	Typ.	Min.	Typ.	Max.			
QBA-07 (+)	340	680	22	16	0.8	0.8	7	2	21
QBA-12N (+)	800	900	28	20	0.25	0.3	3	1	50
QBA-12+	800	1200	23	14	0.25	0.45	6	1.2	50
QBA-20+	1800	2000	23	17	0.45	0.55	4	0.7	25
QBA-20W+	1500	2200	23	16	0.4	0.6	5	1.2	25
QBA-24+	1900	2400	21	17	0.54	0.73	6	0.8	20
QBA-24W+	1700	2400	21	15	0.49	0.73	6	1.2	20
QCC-20+	1200	2200	35	16	0.4	0.9	5	1	17.5
QCC-22+	1500	2500	28	15	0.8	0.4	4	1.3	17.5
QCN-3+	220	470	24	18	0.6	0.8	8	1.7	15
QCN-5 (+)	330	580	20	14	0.3	0.6	8	1.3	15
QCN-5D+	330	580	20	14	0.3	0.6	8	1.3	15
QCN-7 (+)	425	675	17	11	0.4	0.7	8	1	15
QCN-7D+	425	675	17	11	0.4	0.7	8	1	15
QCN-8+	450	750	16	13	0.6	0.9	8	1	15
QCN-12 (+)	800	1375	19	14	0.4	0.8	12	0.9	15
QCN-12A (+)	800	1250	17	13	0.3	0.7	5	0.8	15
QCN-12D+	800	1375	19	14	0.4	0.8	12	0.9	15
QCN-12AD (+)	800	1250	17	13	0.3	0.7	5	0.8	15
QCN-13D+	675	1300	20	14	0.4	0.9	8	1.3	15
QCN-19 (+)	1100	1925	25	19	0.4	0.9	4	1.1	15
QCN-19D (+)	1100	1925	25	19	0.4	0.9	4	1.1	15
QCN-25 (+)	1350	2450	25	18	0.4	0.9	5	1.1	15
QCN-25D (+)	1350	2450	25	18	0.4	0.9	5	1.1	15
QCN-27 (+)	1700	2700	26	18	0.4	0.9	6	1	15
QCN-27D (+)	1700	2700	26	18	0.4	0.9	6	1	15
QCN-34 (+)	2500	3400	32	20	0.4	0.7	4	1.2	15
QCN-34D (+)	2500	3400	32	20	0.4	0.7	4	1.2	15
QCN-45+	2500	4500	19	15	0.5	0.8	6	2.5	15
QCN-45D+	2500	4500	19	15	0.5	0.8	6	2.5	15
QCS-83+	4000	8000	16	13	0.7	1	6	1.1	15
QCS-152+	820	1600	20	17	0.5	0.7	6	0.8	15
QCS-312+	1700	3100	25	17	0.5	0.8	7	1.2	15
QCS-332+	1800	3300	18	17	0.5	0.8	5	1.2	15
QCS-442+	2800	4400	23	16	0.5	0.8	7	1.1	15
QCS-592+	3100	5900	25	16	0.7	1	5	1.4	15
QCS-722+	4000	7200	23	13	0.6	1.1	10	1.4	15
QCS-981+	540	980	20	17	0.5	0.8	4	0.8	15
QCV-151+	90	150	15	11	0.9	1.1	5	1.6	10
QCV-211+	130	210	18	16	0.6	0.7	5	1.4	10
QCV-271+	150	265	17	16	0.5	0.8	8	1.4	10

Couplers

BDCN-Series, BDCA-Series

Model Number	Frequency Range (MHz)		Coupling (dB) Nom.	Mainline Loss (dB) Typ.	Directivity (dB) Typ.	VSWR (:1) Typ.	Power Input (W) Max.
	Low	High					
BDCN-7-25+	824	2525	8.2	1.3	20	1.15	15
BDCN-10-25+	824	2525	10.2	1	17	1.2	15
BDCN-14-22+	1930	2710	13.8	0.05	23	1.25	16
BDCN-14-342+	1700	3400	14	0.4	14	1.22	16
BDCN-20-13+	360	1000	20.7	0.2	12	1.08	16
BDCA-6-16+	800	1600	6.3	1.6	24	1.05	65
BDCA-7-25+	1200	2500	7.1	1.6	22	1.05	35
BDCA-10-25 (+)	800	2500	10.1	1	22	1.05	24
BDCA-15-25+	800	2500	15	0.5	27	1.2	23
BDCA-16-30+	1800	4200	15.5	0.4	23	1.3	20
BDCA1-6-11+	600	1100	6.3	1.8	27	1.08	38
BDCA1-6-22+	950	2200	6.5	1.7	25	1.1	37
BDCA1-7-33+	1600	3300	7	1.6	23	1.15	24
BDCA1-10-40+	1600	4000	10	1.05	21	1.1	12
BDCN-15-25 (+)	824	2525	14.5	0.6	13	1.2	16
BDCN-17-25 (+)	824	2525	16.8	0.6	13	1.2	16

Transformers and Baluns

NCR-Series, NCS-Series, TCN-Series, TCW-Series

Model Number	Impedance Ratio	Frequency (MHz)		Insertion Loss		
		Low	High	3 dB (MHz)	2 dB (MHz)	1 dB (MHz)
NCR2-113+	2	3500	11000	3500-11000	-	-
NCR2-123+	2	4700	12000	4700-12000	-	-
NCS1-23+	1	1300	2000	-	-	1300-2000
NCS1-63+	1	4900	6000	-	-	4900-6000
NCS1-112+	1	700	1100	-	-	700-1100
NCS1-222-75+	1	950	2200	-	950-2200	-
NCS1-292+	1	1650	2850	-	-	1650-2850
NCS1-422+	1	3300	4000	-	-	3300-4000
NCS1.5-232+	1.5	400	2300	-	400-2300	-
NCS2-33+	2	1500	3100	-	-	1500-3100
NCS2-62+	2	390	590	-	390-590	460-470
NCS2-83+	2	3000	8000	-	-	3000-8000
NCS2-112+	2	800	1100	-	800-1100	-
NCS2-222+	2	1275	2200	-	-	1275-2200
NCS2-232+	2	900	2300	-	900-2300	-
NCS2-392+	2	3000	3900	-	-	3000-3900
NCS2-592+	2	4900	5875	-	-	4900-5875
NCS2-622+	2	5600	6200	-	-	5600-6200
NCS2-771-75+	2	240	770	-	-	240-770
NCS3-72+	3	250	760	-	-	250-760
NCS3-272+	3	2250	2725	-	-	2250-2725
NCS4-63+	4	4500	6000	-	-	4500-6000
NCS4-102+	4	700	1000	-	-	700-1000
NCS4-232+	4	1600	2300	-	-	1600-2300
NCS4-272+	4	2300	2700	-	-	2300-2700
NCS4-442+	4	3300	4200	-	-	3300-4200
TCN1-152-75+	1	950	1450	-	-	950-1450
TCN2-122+	2	600	1200	-	-	600-1200
TCN4-22 (+)	4	1200	2200	-	-	1200-2200
TCN4-162+	4	720	1600	-	-	720-1600
TCW2-272+	2	2100	2700	-	2100-2700	-

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