

Cryogenic Measurement of two LTCC Commercial Filters for Interferences Reduction in Radio Astronomy Receivers

**I. Malo, J.D. Gallego, I. López, M. Diez, R.Amils,
A. García, R. García, G. Martínez.**

Technical Report **IT-CDT 2022-14**

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Revision 1



Observatorio de Yebes

Apartado 148

19080 Guadalajara

SPAIN

Phone: +34 949 29 03 11

Change Record

Revision	Date	Affected Paragraphs(s)	Reason/Initiation/Remarks
A	2022-12-30	All	First Issue

1. Introduction.

Two filters made by Minicircuits namely ZHFG-K3800+ and build with LTCC technology (Low Temperature Co-Fired Ceramic) have been measured in a laboratory cryostat (Yebes 1020-3). These filters can be useful for the reduction of interferences in the low part of the VGOS frequency band. As far as we know there is no public data on these filters at cryogenic temperature and it is interesting to learn whether this type of ceramic material is temperature stable and its dielectric constant does not change drastically when cooled.

Manufacturer datasheet is shown in the Appendix. Measurements at 300 and 18 K have been performed on both filters. Note that the filters have not been specifically built to operate at cryogenic temperatures. Only one cooling cycle was done so the long term survival to thermal cycling cannot be guaranteed.

2. Measurements.

MINICIRCUITS ZHFG-K3800+ PN#1

	Stop Band - S_{21}				Pass Band - S_{21}				S_{11}
Freq [GHz]	DC-2.7	2.7-3	2.93 / 2.97	3.8	4.2-4.7	4.7-5.5	5.5-14	14-16	4.2-16
Data Sheet [dB]	-48 (T) -40 (M)	-35 (T) -24 (M)		-3 (T)	-1.7 (T)	-1.3 (T) -2.1 (m)	-1.1 (T) -1.9 (m)	-1.4 (T) -2.4 (m)	-14 (T)
T=300 K	-49 (M)	-37 (M)	-41 / -39	-4	-1.6 (m)	-1.2 (m)	-1 (m)	-1.3 (m)	-16 (M)
T=18 K	-49 (M)	-48 (M)	-56 / -51	-7	-0.7 (m)	-0.5 (m)	-0.6 (m)	-0.6 (m)	-12 (M)

Nomenclature: (m) minimum value; (T) typical value; (M) maximum value.

Measurement resolution: 100 MHz

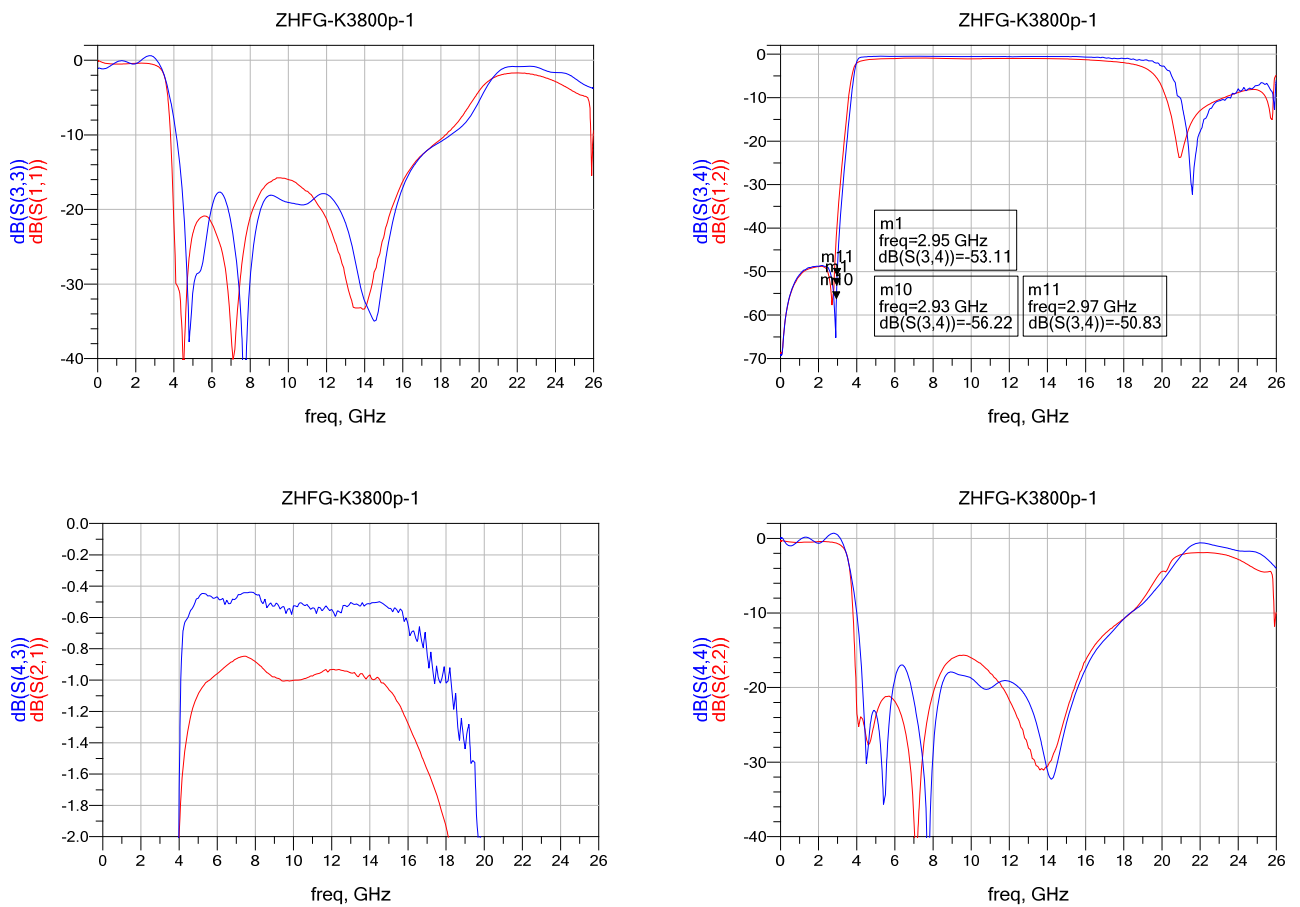


Figure 1. S-parameters measurement of the filter #1 at ambient (in red color) and cryogenic (in blue color) temperature

MINICIRCUITS ZHFG-K3800+ PN#2

	Stop Band - S_{21}				Pass Band - S_{21}				S_{11}
Freq [GHz]	DC-2.7	2.7-3	2.93/ 2.97	3.8	4.2-4.7	4.7-5.5	5.5-14	14-16	4.2-16
Data Sheet [dB]	-48 (T) -40 (M)	-35 (T) -24 (M)		-3 (T)	-1.7 (T) -2.1 (m)	-1.3 (T) -2.1 (m)	-1.1 (T) -1.9 (m)	-1.4 (T) -2.4 (m)	-14 (T)
T=300 K	-49 (M)	-36 (M)	-40 / -38	-3.6	-1.6 (m)	-1.2 (m)	-1.2 (m)	-1.4 (m)	-19 (M)
T=18 K	-49 (M)	-47 (M)	-55 / -50	-6	-0.6 (m)	-0.5 (m)	-0.6 (m)	-0.6 (m)	-17 (M)

Nomenclature: (m) minimum value; (T) typical value; (M) maximum value.

Measurement resolution: 100 MHz at ambient temperature, 25 MHz at cryogenic temperature

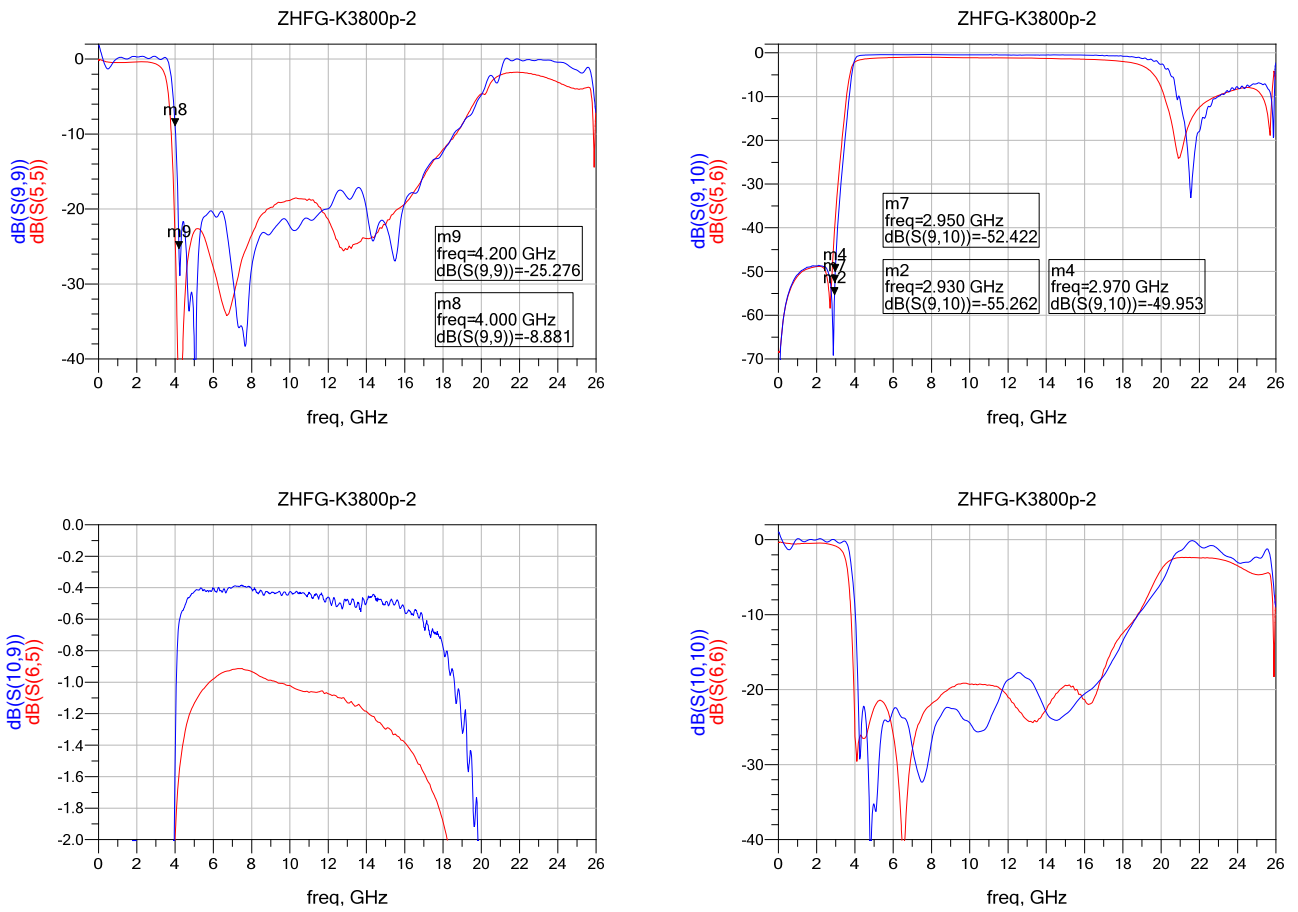
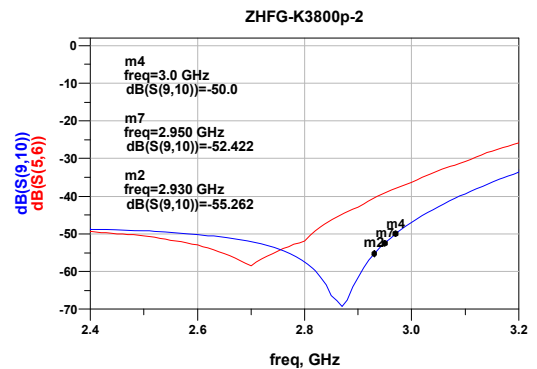


Figure 2. S-parameters measurement of the filter #2 at ambient (in red color) and cryogenic (in blue color) temperature

A zoom of the transmission graph in a frequency band of interest for VGOS is added for clarity:



3. Conclusions.

Two LTCC filters have been characterized in the cryostat Yebes 1020-3. The graphics with the results presented in section 2 show some markers at frequencies of particular interest for the RAEGE project.

Insertion loss in the pass band is reduced by a factor of ≈ 2 (in dB) when cooled probably due to the improvement of the conductivity in metals.

Return loss in the pass band does not deteriorate drastically when cooled.

A slight shift of transmission zeros to higher frequency is observed (probably caused by a reduction of the dielectric constant of the LTCC material).

The Q factor of the resonances increases when cooled. This shows up in the reduction of the bandwidth of the transmission resonances and in the increment of the slope in the rejected band.

A time domain window has been applied to the cryogenic reflection data. This causes some artifacts especially at the edges of the measured band, although it does not affect the features of interest shown in the graphs.

Appendix.

Coaxial High Pass Filter

ZHFG-K3800+

50Ω 4200 to 16000 MHz



Generic photo used for illustration purposes only
CASE STYLE: UK3042

The Big Deal

- Good power handling, 3W
- Temperature stable
- Broadband connectorized package
- Good rejection, 48 dB typical

Product Overview

ZHFG-K3800+ is a 50Ω high pass filter built in broadband connectorized package. Covering 4200-16000 MHz bandwidth, these units offer good matching within the passband and good rejection in stopband. ZHFG-K3800+ offer low insertion loss, and good power handling capability. It handles up to 3W RF input power and provides a wide operating temperature range from -55°C to 125°C.

Key Features

Feature	Advantages
Low passband insertion loss	Suitable for high performance application.
3W Power handling	Supports a range of system power requirements.
Connectorized package	The connectorized package is easy to interface with other devices and well suited for test setups.

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-Circuit's 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/MCLStore/terms.jsp



High Pass Filter

ZHFG-K3800+

50Ω 4200 to 16000 MHz



Generic photo used for illustration purposes only

CASE STYLE: UK3042
Connectors Model
2.92mm-F ZHFG-K3800+

+RoHS Compliant

The +Suffix identifies RoHS Compliance. See our web site for RoHS Compliance methodologies and qualifications

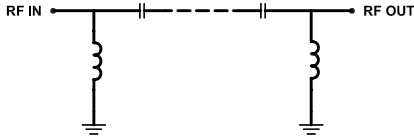
Features

- Very good rejection, 48dB typ.
- Temperature stable

Applications

- Test and measurements
- Military applications
- Telecommunications and broadband wireless system
- 5G Sub 6 GHz
- WiFi 6E and X-band Radar

Functional Schematic



Electrical Specifications at 25°C

Parameter		F#	Frequency (MHz)	Min.	Typ.	Max.	Unit
Stop Band	Rejection Loss	DC-F1	DC - 2700	40	48	-	dB
		F1-F2	2700 - 3000	24	35	-	dB
	Freq. Cut-Off	F3*	3800	-	3.0	-	dB
Pass Band	Insertion Loss	F4-F5	4200 - 4700	-	1.7	-	dB
		F5-F6	4700 - 5500	-	1.3	2.1	dB
		F6-F7	5500 - 14000	-	1.1	1.9	dB
	Return Loss	F7-F8	14000 - 16000	-	1.4	2.4	dB
		F4-F8	4200 - 16000	-	14	-	dB

In Applications where DC voltage is present at either input or output ports, DC blocks are required.
* Typically, a ±5% frequency deviation from the stated value may occur on a unit-to-unit basis.

Maximum Ratings

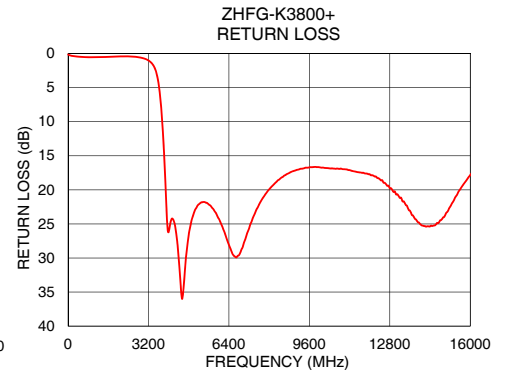
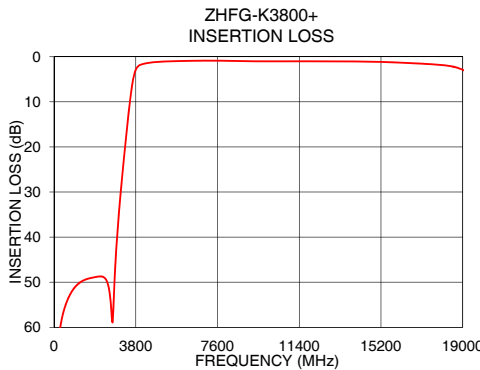
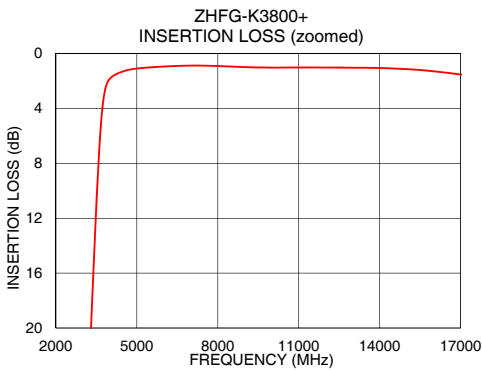
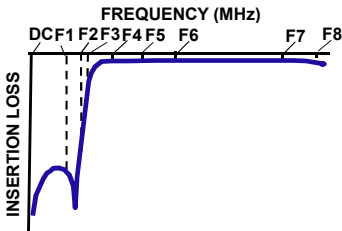
Operating Temperature	-55°C to 125°C
Storage Temperature	-55°C to 125°C
RF Power Input*	3W max. @25°C

*Passband rating, derate linearly to 0.6W at 125°C ambient
Permanent damage may occur if any of these limits are exceeded.

Typical Performance Data at 25°C

Frequency (MHz)	Insertion Loss (dB)	Return Loss (dB)
10	78.26	0.14
50	74.23	0.23
100	68.69	0.29
500	55.57	0.48
1000	50.94	0.54
2000	48.79	0.43
2700	58.65	0.49
3000	35.56	0.69
3100	29.98	0.82
3300	20.05	1.29
3520	10.23	2.88
3800	2.86	13.16
4200	1.53	24.49
4700	1.18	29.65
5000	1.09	23.50
5500	1.00	21.91
7000	0.87	27.74
10000	1.02	16.69
14000	1.05	24.99
16000	1.28	17.84

Typical Frequency Response



Notes

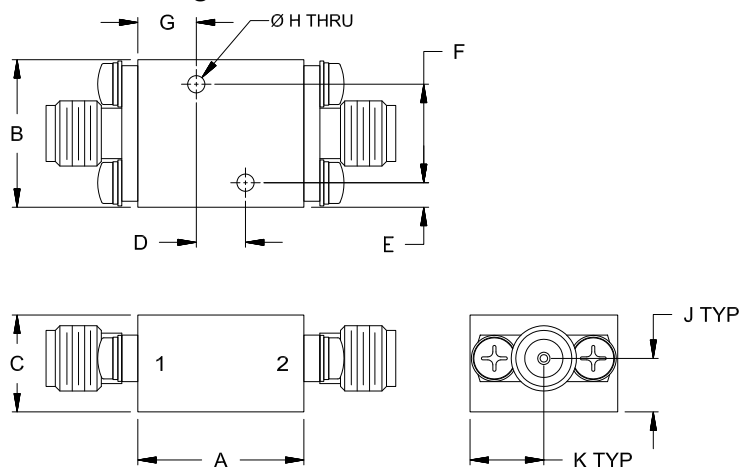
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Coaxial Connections

PORT - 1	2.92mm-Female
PORT - 2	2.92mm-Female

Outline Drawing



Outline Dimensions (inch / mm)

A	B	C	D	E	F
.68	.60	.39	.200	.10	.400
17.1	15.2	10.0	5.08	2.5	10.16
G	H	J	K	Wt.	
.24	.070	.22	.30	grams	
6.0	1.78	5.5	7.6	24	

Note: Please refer to case style drawing for details

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