HIGH-Q CERAMIC RESONATOR FILTERS FOR GNSS APPLICATIONS

Mini-Circuits®

www.minicircuits.com

INTRODUCTION

THE HISTORY & MODERN USES OF GNSS APPLICATIONS

GNSS (Global Navigation Satellite Systems) has become an increasingly prevalent RF application for both military and commercial use. Early GNSS technology, or location-based services (LBS), was developed exclusively for military use and operated with a margin of error of about 10-yards (9.14m), which was sufficient at the time, but limited its suitability for end uses requiring a higher degree of precision. In the time since the first launch of GPS more than 40 years ago, the evolution of the technology has improved precision to the order of 2-3 yards (1.83-2.74m). This advancement of the technology combined with significant miniaturization and cost reduction of LBS-enabled devices has opened up a large and growing commercial market for GNSS services. For example, GNSS is now used in the agricultural market to calculate statistics for weather, soil conditions, and crop health to help farmers maximize their yields and profits. Such innovations have stimulated demand for components that support military, industrial and consumer applications.

There are four GNSS systems that provide global coverage. GPS (Global Positioning System) is owned and operated by the United States government. GLONASS (Global Navigational Satellite System) is owned by Russia, Galileo by the European Union, and BeiDou (Compass) by China. These systems orbit the earth in Medium Earth Orbit (MEO) and complete one revolution around the earth in 12 hours and one minute on average, roughly half a sidereal day. In addition to the global systems, there are two regional systems that belong to Japan and India. The Japa nese system, Quasi-Zenith Satellite System (QZSS), covers the Asia-Oceania region, and the Indian System, Navigation with Indian Constellation (NavIC), covers India and nearby regions.

The satellites in these systems each transmit signals over L-band frequencies that are picked up by system-specific receivers in LBS-capable devices on Earth. The receiver accepts the incoming carrier frequencies from four satellites, and takes the coordinates from each in order to determine its current position in relation to a given programmed destination.

DESIGN REQUIREMENTS

L-Band frequencies occupy the 1-2 GHz range, which makes them accessible and relatively cheap to operate within. However, this region of the spectrum is also occupied by multiple application bands for other communication systems. The dense development of L-band frequencies creates an increased risk of interference between different system bands. In GNSS systems, that interference can result in errors that present either as missing information or incorrect information.

For these reasons, when selecting filters for GNSS applications, it is important to choose a filter that is capable of high rejection with high selectivity or "sharp skirts" on an insertion loss vs. frequency plot. Narrow bandwidths are ideal for L-band applications where spectrum allocations are crowded, and low insertion loss is important for processing the relatively weak signals transmitted from satellites to receivers on Earth.

GPS, Galileo and GLONASS sometimes share center frequencies, particularly in the GPS L1 and L5 bands (see Figure 1), which allows one filter to be usable in multiple systems, depending on the specific application. GPS generally has the widest bandwidth (approximately 15 MHz) compared to Galileo (12 MHz) and GLONASS (6 to 10 MHz).

CHOOSING THE RIGHT FILTER TECHNOLOGY

Several filter technologies are potentially capable of meeting the requirements for GNSS applications. Ideally the filter needs to have a high Q value to prevent interference from adjacent signals and low insertion loss to preserve the integrity of relatively weak incoming signal. Cavity filters offer the highest Q value of practically any filter technology as well as low insertion loss. However, cavity filters are typically large and expensive. These practical limitations preclude their suitability for most real-world GNSS applications in which both size and cost are important factors.

L-C lumped element filters are generally smaller and more cost effective. In theory, they are capable of achieving deep rejection with very high selectivity, but this might require designing nine or ten poles into the filter response. Although more poles will create high rejection and sharp skirts, this approach comes with a compromise on insertion loss on the order of roughly 5-7 dB which degrades the sensitivity of the receiver.

Ceramic resonator filters, by contrast, can achieve high rejection and selectivity with much lower insertion loss (typically 1.5 dB or better) than L-C filters and comparable rejection performance. Although they are slightly larger than L-C filters, ceramic resonator filters are still an acceptable size and cost for GNSS application requirements. This combination of performance, size and cost makes ceramic resonator filters an ideal solution for use in GNSS applications.

CERAMIC RESONATOR FILTERS AND DIPLEXERS FOR GNSS APPLICATIONS

Mini-Circuits offers a broad range of ceramic resonator filters specifically designed for GNSS applications, including both off-the-shelf models and custom designs. Our ceramic resonator filters are designed with high Q resonators that provide narrow passbands with low insertion loss ranging from 0.9 to 3.0 dB. They boast excellent rejection and selectivity as well as low profile packaging for dense system layouts. They also offer excellent temperature stability and rugged construction, making them suitable for critical applications in harsh operating conditions.

For systems with special requirements, Mini-Circuits' applications engineers can advise on solutions to accommodate additional screening, qualification, and custom designs. For example, stopband rejection of standard models can be further extended by cascading LTCC filters in series. Mini-Circuits also has the in-house design and production capability to make passband modifications of existing filters or any other customization on demand.

GNSS Band Designations

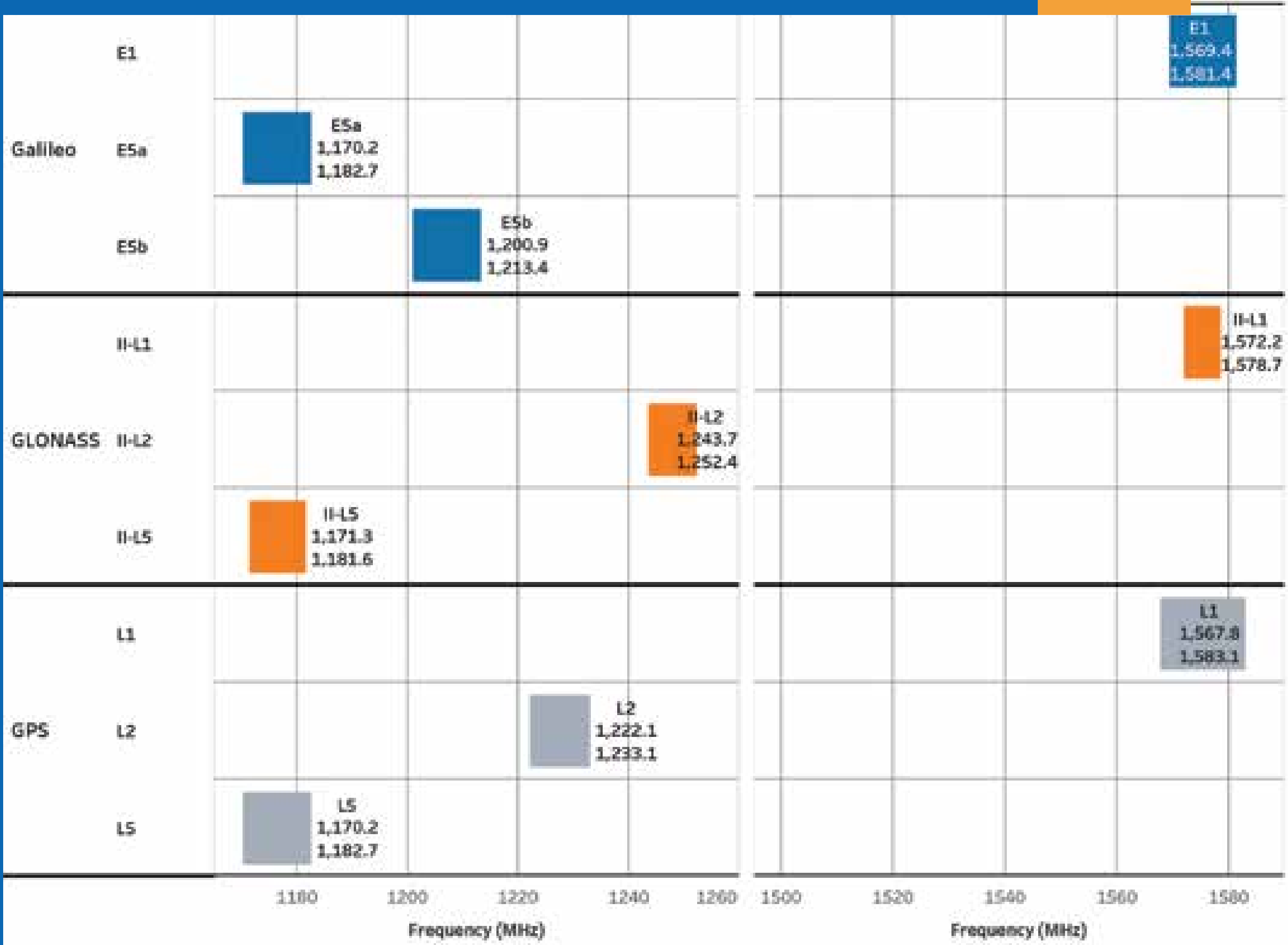
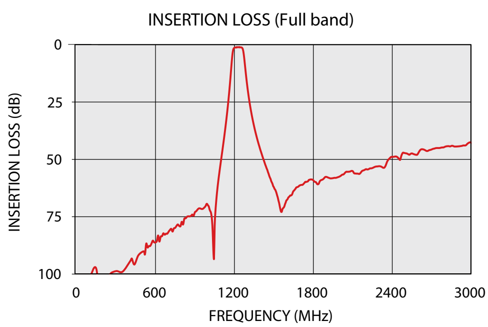


Figure 1: Spectrum Designations for GNSS Applications

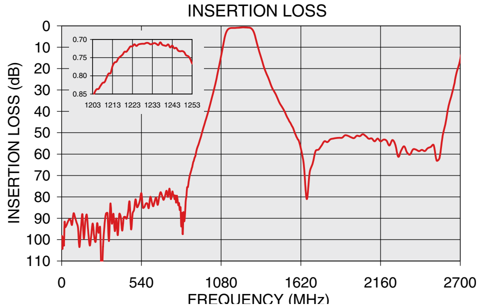
Below are just a few examples of standard, off-the-shelf ceramic resonator band pass filters recommended for GNSS applications:

- **CBP-1228C+** (1217-1238 MHz) is a narrow band filter with low insertion loss, 1.3 dB Typ. It works in the **GPS L2 band** (1215- 1239.6 MHz).



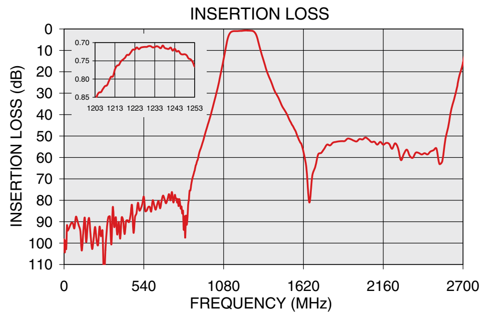
Offers excellent rejection and high-power handling, equipped with miniature, shielded SMT package.

- **CSBP-D1228+** (1203-1253 MHz) operates with low pass band insertion loss of 0.9 dB (Typ.) and is suitable for **GLONASS G2 band** (1237-1254 MHz).



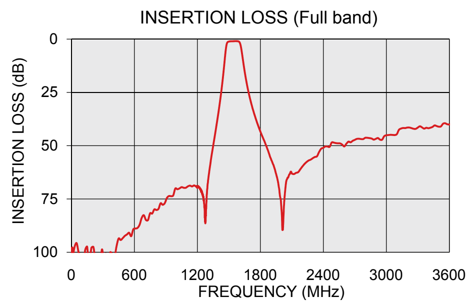
Offers excellent rejection and stable insertion loss vs. temperature at 0.3 dB Typ.

- **CSBP-D1228+** (1203-1253 MHz) operates with low pass band insertion loss of 0.9 dB (Typ.) and is suitable for **GLONASS G2 band** (1237-1254 MHz).



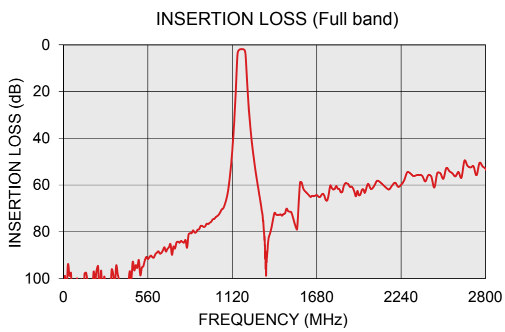
Offers excellent rejection and stable insertion loss vs. temperature at 0.3 dB Typ.

- **CBP-1555C+** (1525-1585 MHz) works in the **GPS L1 band** (1563-1587 MHz). It provides low insertion loss of 1.1 dB Typ.



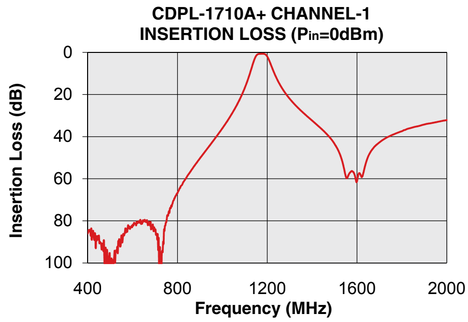
Offers a narrow bandwidth with excellent rejection, high power handling, and low pass band VSWR.

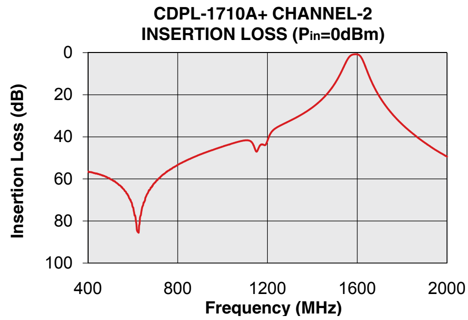
- **CBP-1183A+** (1165-1201 MHz) is a high selectivity, low insertion loss filter that can be used at the **GPS L5 band** (1164-1189 MHz) and **Galileo E5a band** (1164-1189 MHz).



Offers pass bands up to 6000 MHz with excellent temperature stability, low profile and rugged construction to withstand harsh environmental conditions.

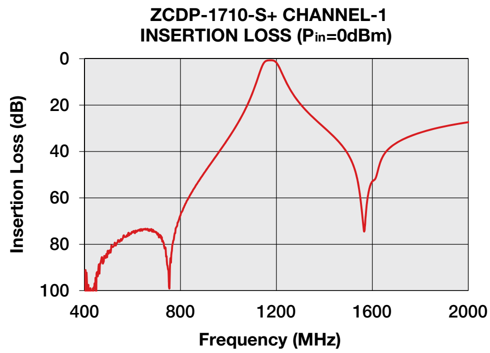
- **CDPL-1710+** is an SMT diplexer with channel-1 operating at 1176 MHz **(GPS L5 band and Galileo E5a band)** and channel-2 operating at 1590 MHz **(Galileo E1 +-band)**.

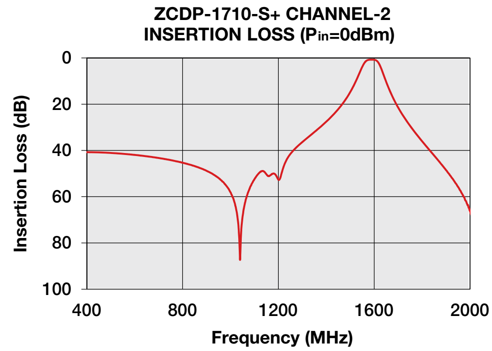




This surface mount configuration offers low insertion loss, low pass band insertion loss, high rejection, and good return loss.

- **ZCDP-1710A+** is **CDPL-1710A+** in a connectorized package.





This connectorized diplexer offers low insertion loss, high rejection, and good return loss.

LISTING OF MINI-CIRCUITS CERAMIC RESONATOR FILTERS FOR GNSS APPLICATIONS

Bandpass Connectorized Filters:

Model Number	Passband F1 (MHz)	Passband F2 (MHz)	Stopband F3 (MHz)	Rejection @ F3 (dB)	Stopband F4 (MHz)	Rejection @ F4 (dB)
ZX75BP-1450-S+	1320	1580	DC-1100	46	2000-2500	54
ZX75BP-A1060-S+	1015	1105	DC-880	25	1350-4000	30
ZX75BP-A1230-S+	1160	1300	DC-950	30	1670-3500	20
ZX75BP-B1230-S+	1120	1340	DC-940	25	1750-3500	20
ZX75BP-B1280-S+	1160	1400	DC-955	40	1700-2200	40

Bandpass Surface Mount Filters:

Model Number	Passband F1 (MHz)	Passband F2 (MHz)	Stopband F3 (MHz)	Rejection @ F3 (dB)	Stopband F4 (MHz)	Rejection @ F4 (dB)
CBP-1000F+	900	1100	DC-790	20	1260-1800	20
CBP-1023A+	1005	1041	DC-970	20	1075-2400	20
CBP-1034C+	978	1090	DC-790	20	1400-2000	20

Bandpass Surface Mount Filters:

Model Number	Passband F1 (MHz)	Passband F2 (MHz)	Stopband F3 (MHz)	Rejection @ F3 (dB)	Stopband F4 (MHz)	Rejection @ F4 (dB)
CBP-1060Q+	1030	1090	500-930	20	1190-1400	20
CBP-1062C+	960	1164	DC-735	20	1620-1900	20
CBP-1090C+	1060	1120	DC-955	20	1255-2200	20
CBP-1120F+	1020	1220	DC-880	20	1420-2000	20
CBP-1170C+	1110	1230	DC-900	20	1560-2200	20
CBP-1183A+	1165	1201	DC-1130	20	1235-2800	20
CBP-1228C+	1217	1238	DC-1140	20	1330-3000	20
CBP-1250C+	1215	1285	DC-1055	20	1510-2500	20
CBP-1260C+	1200	1320	DC-1025	20	1640-2450	20
CBP-1280C+	1170	1390	DC-950+	20	1850-2450	20
CBP-1280F+	1160	1400	DC-1000	20	1570-2100	20
CBP-1300A+	1200	1400	DC-1040	20	1640-3100	20
CBP-1307C+	1215	1400	DC-1000+	20	1820-2500	20
CBP-1320Q+	1280	1360	900-1170	20	1490-20000	20
CBP-1350C+	1300	1400	DC-1125	20	1665-2700	20
CBP-1400E+	1320	1480	DC-1150+	20	1600-2400	20
CBP-1400F+	1300	1500	DC-1090+	20	1740-2450	20
CBP-1423AF+	1333	1513	DC-1113	60	1669-2600	55
CBP-1450F+	1320	1580	DC-1150	20	1775-2350	20
CBP-1475E+	1375	1575	DC-1230	40	1750-2600	40
CBP-1490A+	1465	1515	DC-1430	20	1550-3000	20
CBP-1538J+	1518	1559	DC-1390	20	1750-3000	20
CBP-1555C+	1525	1585	DC-1415	20	1700-3600	20
CBP-1598AF+	1505.5	1690.5	DC-1264	60	1888-2900	60
CBP-1630F+	1500	1760	DC-1320	20	1960-2600	20
CBP-1645J+	1616	1675	DC-1500	20	1850-3000	20
CBP-A1060C+	1015	1105	DC-865	20	1350-2250	20
CBP-A1230C+	1160	1300	DC-950	20	1670-2400	20
CBP-B1230C+	1120	1340	DC-980	20	1750-2350	20
CSBP-B1300-75+	1210	1390	DC-1080	20	1545-2500	20
CSBP-D1189+	1130	1246	DC-950	20	1550-2400	20
CSBP-D1228+	1203	1253	DC-1020	20	1425-2500	20

Connectorized Diplexers:

Model Number	Channel	Passband (MHz)	Passband IL (dB)	Rejection (dB)	Return loss (dB)
ZCDP-1710-S+	High	1590	0.8	40 @ 1176	11
	Low	1176	0.8	50 @ 1590	11

Surface Mount Diplexers:

Model Number	Channel	Passband (MHz)	Passband IL (dB)	Rejection (dB)	Return loss (dB)
CDPL-1710A+	High	1176	0.8	50.6 @ 1590	10.9
	Low	1590	0.8	39.7 @ 1176	10.9

Mini-Circuits®
www.minicircuits.com

Technical Support

- **NORTH , CENTRAL and SOUTH AMERICA**
  apps@minicircuits.com
  +1 718-934-4500
- **SINGAPORE, MALAYSIA, THAILAND, INDONESIA, PHILLIPINES, VIETNAM**
  sales@minicircuits.com.my
  +604-646-2828
- **ISRAEL**
  app@ravon.co.il
  +972 4 8749100
- **TAIWAN**
  robert@min-kai.com.tw
  +886 3 318 4450
- **EUROPE**
  apps@uk.minicircuits.com
  +44 1252 832600
- **INDIA**
  apps@minicircuits.com
  +91 44 2 2622575
- **CHINA**
  yuanzhong@minicircuits.com
  +86 20 87340992
  Or
  Finchw@minicircuits.com
  +86 139 1735 1196
- **JAPAN, SOUTH KOREA**
  thomasj@minicircuits.com
  +81-45-548-5058

Direct Sales

- **BROOKLYN**
  sales@minicircuits.com
  +1 718-934-4500
- **MISSOURI**
  sales@minicircuits.com
  +1 417-335-5935
- **EUROPE**
  sales@uk.minicircuits.com
  +44 1252-832600
- **TAIWAN**
  robert@min-kai.com.tw
  +886 3 318 4450
- **CHINA**
  yuanzhong@minicircuits.com
  +86 20 87340992
  Or
  Finchw@minicircuits.com
  +86 139 1735 1196
- **JAPAN, SOUTH KOREA**
  thomasj@minicircuits.com
  +81-45-548-5058