Terms & Definitions

ATTENUATION - Voltage loss in dB incurred by a signal in passing through a dissipative network or other medium.

BAND REJECT FILTER - A filter that rejects one band of frequencies and passes both higher and lower frequencies. Sometimes called a notch filter.

BANDWIDTH - The width of the passband of a bandpass filter is the frequency difference between lower and upper 3 dB points.

BANDPASS FILTERS - A filter that passes one band of frequencies and rejects both higher and lower frequencies.

BESSEL FUNCTION - A mathematical function used to yield maximally constant time delay in a filter with no consideration for amplitude response. This function is very close to a Gaussian function.

BUTTERWORTH FUNCTION - A mathematical function used to yield maximally constant amplitude response in a filter with no consideration for time delay, or phase response.

CENTER FREQUENCY (f_0) - In standard Bandpass Filters the center frequency is either geometrically or arithmetically calculated.

Geometrically: $f_0 = \sqrt{(F_1 \times F_2)}$

Arithmetically: $f_0 = 1/2\,(F_1 + F_2)$

CHARACTERISTIC IMPEDANCE - The characteristic impedance of a filter is usually taken as equal to L/C where L is the total series inductance in henries and C is the total shunt capacity in farads. Characteristic impedance is measured in ohms.

CHEBYSHEV FUNCTION - A mathematical function that produces a curve that ripples within certain bounds (see ripple). This produces a squarer amplitude response than the Butterworth Function but with less desirable phase, and time delay characteristics. There is a whole family of Tchebycheff functions (0.1 ripple, 0.5 ripple, etc.).

CUT-OFF FREQUENCY (f_c) - The upper passband edge in lowpass filters or the lower passband edge in highpass filters. The passband edge closest to the stop band, sometimes called the 3 dB point.

DECIBEL (dB) - A unit of gain or attenuation for expressing the ratio of two voltages. It is used to describe voltage gain, voltage loss, performance figure or anything which can be considered as a ratio of two voltages. A decibel is defined as 20 Log (E_1/E_2) where E_1 and E_2 are two voltages such as input and output voltages, or peak voltage and average voltage, etc.

DISSIPATION - Energy losses in a filter due to resistive or core losses, etc.

DISTORTION - Generally, the modification of signals which produce undesirable end effects. These modifications can relate to phase, amplitude, delay, etc. The distortion of a sine wave is usually defined as the percentage of signal power remaining after the fundamental sine wave component has been removed.

ELLIPTIC FUNCTION - A mathematical function used to yield the squarest possible amplitude filter response with a given number of circuit elements. The elliptic function has a Tchebycheff response in both the passband and the stop band. The elliptic function filter has a poorer phase response and transient response than any of the classical transfer functions.

ENVELOPE DELAY - The propagation time delay of the envelope of an amplitude modulated signal as it passes through a filter. Sometimes called time delay or group delay. Envelope delay is proportional to the slope of the phase shift response versus frequency curve. Envelope delay distortion occurs when the delay is not constant at all frequencies in the passband area.

FILTER Q - An important parameter of bandpass and band reject filters:

Bandpass & Band Reject: $Q = \dfrac{f_0}{\text{3 dB Bandwidth}}$

GAUSSIAN FUNCTION - A mathematical function used to design a filter which passes a step function with zero overshoot with maximum rise time. Similar to a Bessel Function filter.

HIGHPASS FILTER - A filter which passes high frequencies and rejects low frequencies.

INSERTION LOSS - The loss of signal caused by a filter being inserted in a circuit. It has many different definitions and is measured in dB. In general it is the ratio of voltage, delivered to the load (at peak frequency response) with the filter in the circuit to the voltage in the load if a perfect lossless matching transformer replaced the filter. When a filter is inserted between two circuits whose impedances differ widely, it is sometimes more practical to specify insertion loss some other way.

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LINEAR PHASE FILTER - A filter that exhibits a constant change in phase per unit of frequency. The resultant plot of frequency versus phase is a straight line. This type of filter ideally displays a constant delay in its passband.

LOAD IMPEDANCE - The impedance that normally must be connected to the output terminals of the filter in order to meet filter specifications; the filter will drive this load.

LOWPASS FILTER - A filter which passes low frequencies and rejects high frequencies.

OVERSHOOT - The amount in percent by which a signal exceeds its steady-state output on its initial rise.

PASSBAND - The frequency range in which a filter is intended to pass signals.

PASSBAND RIPPLE - Variations of attenuation of frequency within the passband of a filter.

PHASE SHIFT - The changing of phase of a signal as it passes through a filter. A delay in time of the signal is referred to as phase lag. In normal networks, phase lag increases with frequency, producing a positive envelope delay (see envelope delay).

RELATIVE ATTENUATION - Attenuation measured with the point of minimum attenuation taken as zero dB, or Relative Attenuation = Attenuation minus Insertion Loss.

RESPONSE - The term used to describe how a filter reacts to input signals. It is defined as the ratio of the input signal compared to the output signal (for amplitude response and phase response).

RIPPLE - Generally referring to the wavelike variations in the amplitude response of a filter. Tchebycheff and Elliptic Function filters ideally have equi-ripple characteristics, which means that the differences in peaks and valleys of the amplitude response in the passband are always the same. Butterworth, Gaussian, and Bessel functions have no ripple. Ripple is usually measured in dB.

RISE TIME - The length of time it takes a step-function at the output of a filter to move from 10% to 90% of its steady state value on the initial rise.

ROLL OFF - A term used to describe the stop band characteristics of a filter. For example, a filter may be specified to have a roll off of 42 dB per octave. This is a somewhat obsolete method of specifying a filter characteristic. It implies that the second octave would be down 84 dB and the third octave 126 dB and so on. In reality the ultimate attenuation levels off at somewhere around 80 dB and spurious "come-backs" are difficult to keep below 80 dB.

SHAPE FACTOR - An important parameter of all filters:

Bandpass & Band Reject: $S = \frac{\text{Attenuation Bandwidth}}{\text{3 dB Bandwidth}}$

Lowpass & Highpass: $S = \frac{\text{Attenuation Frequency}}{\text{3 dB Cut-Off}}$

STEP FUNCTION - A signal change in amplitude from one level to another which occurs in zero time. Usually refers to a rectangular front waveform used in testing transient response.

STOP BAND - The area of frequency where it is desirable to reject or attenuate all signals as much as practical. Also called reject band.

TIME DELAY - The amount of time it takes for certain signals to pass through a filter.

◆ Filter Structures

K&L filters are available in bandpass, lowpass, bandreject and highpass designs. When specifying your filter needs, be sure to supply all pertinent passband and stopband information. To achieve the best results, additional specifications such as phase, group delay, power, size and mechanical requirements should be supplied.

◆ Lumped Element

The elements in the filter are lumped (i.e. concentrated over a small area). The inductors are coils of wire wound around cylindrical formers, and the capacitors are parallel plate chips or simpler portions of substrate material.

◆ Combline

Combline filters replace the inductors in a lumped element filter with distributed inductors or lengths of transmission line leaving the capacitors lumped, although distributed capacitance is sometimes used.

Advantages:
- High "Q" factors can be obtained
- Small size can be traded off with "Q"
- Bandwidths from 3% to 18% can be obtained
- Designs cover 500 MHz to 40 GHz

◆ Interdigital

Interdigital filters are entirely distributed networks consisting of an array of short circuit quarter wavelength lines.

Advantages:
- High "Q" factors can be obtained
- Small size can be traded off with "Q"
- Bandwidths from 5% to 50% can be obtained
- Designs cover 1000 MHz to 18 GHz

◆ Suspended Substrate Stripline (S.S.S.)

These filters are also entirely distributed consisting of both series and shunt transmission line sections.

Advantages:
- Very selective devices are standard
- Designs cover 2 GHz to 18 GHz

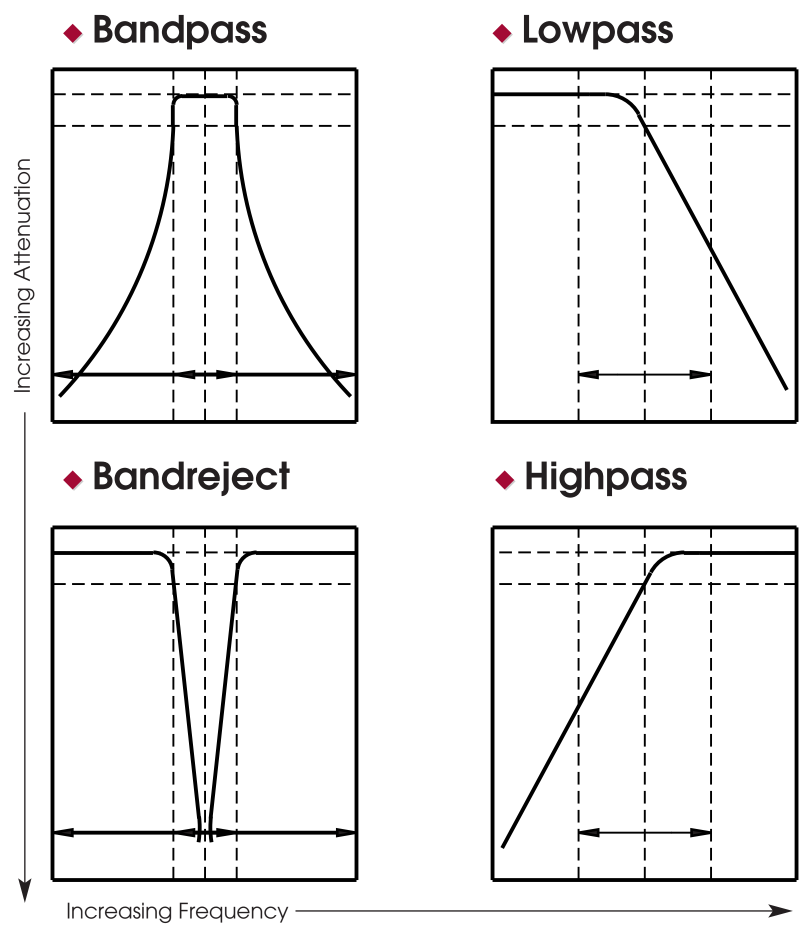
◆ Waveguide

Waveguide filters consist of half wavelength cavities separated by inductive irises. These are made by placing posts through the guide and soldering them to the waveguide at both top and bottom.

Advantages:
- Extremely high "Q" factor can be realized
- Very selective devices can be made
- Designs cover 1 GHz to 40 GHz

◆ Ceramic

- Use coaxial ceramic resonators
- May achieve higher "Q" than a lumped element filter in a comparable package
- Extremely temperature stable
- Good choice where bandwidth doesn't exceed 10%.



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◆ Tables

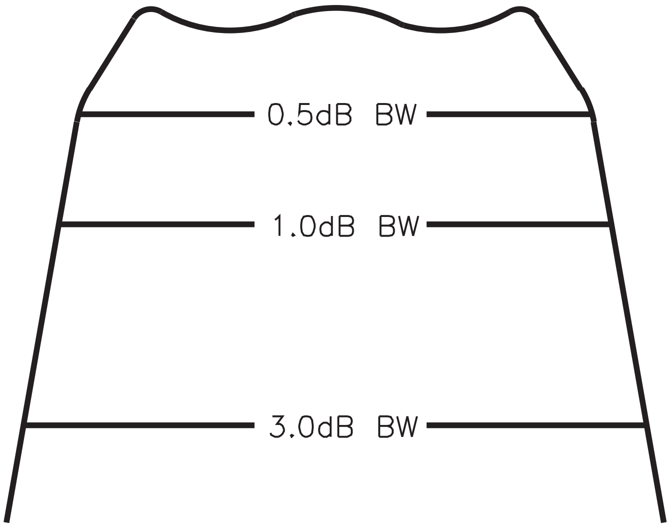
The tables on this page indicate the 0.5, 1.0, 1.5:1 VSWR and ± 5° phase bandwidths with regard to the normalized 3 dB bandwidth.

Example:
Determine all the bandwidths below for our filter model 5B121-500/T80-O/O
1. The insertion loss is

$$\frac{(2)(5.5)}{16} + 0.2 = 0.9 \text{ dB}$$

From the tables:

The 0.5 dB BW = (83%)(80) = 66 MHz
The 1.0 dB BW = (88%)(80) = 70 MHz
The 1.5:1 VSWR BW = (85%)(80) = 68 MHz
The ±5 phase BW = (78%)(80) = 63 MHz



* Custom tolerances available on request.

◆ 0.5 dB Bandwidth vs. 3 dB Bandwidth

Insertion Loss dB	Number Sections 2	3	4-10
0.5-1.0 dB	58%	75%	83%
1.0-1.5 dB	53%	71%	79%
1.5-2.0 dB	49%	67%	74%
2.0-2.5 dB	44%	62%	70%
2.5-3.0 dB	40%	58%	66%
3.0-4.0 dB	35%	54%	61%
4.0-5.0 dB	26%	45%	52%

◆ 1.0 dB Bandwidth vs. 3 dB Bandwidth

Insertion Loss dB	Number Sections 2	3	4-10
0.5-1.0 dB	69%	82%	88%
1.0-1.5 dB	65%	80%	85%
1.5-2.0 dB	61%	78%	83%
2.0-2.5 dB	58%	76%	81%
2.5-3.0 dB	54%	74%	79%
3.0-4.0 dB	50%	72%	77%
4.0-5.0 dB	42%	68%	72%

All dimensional tolerances shown in the catalog, unless otherwise stated, shall be in accordance with DOD-STD-100 and ANSI Y14.5M.
.XX+ .030 inches
.XXX + .010 inches

Metric Conversion:
1" = 25.4mm

◆ 1.5:1 VSWR Bandwidth vs. 3 dB Bandwidth

Insertion Loss dB	Number Sections 2	3	4	5	6-10
.5-1.5 dB	50%	60%	80%	85%	90%
1.5-2.0 dB	50%	60%	80%	85%	90%
2.0-2.5 dB	51%	61%	80%	85%	90%
2.5-3.0 dB	52%	63%	81%	85%	91%
3.0-3.5 dB	55%	66%	83%	88%	94%
3.5-4.0 dB	57%	70%	86%	91%	97%
4.0-4.5 dB	59%	70%	91%	95%	102%

◆ 3 dB Bandwidth Tolerance (Percent of f_c)

Percent Bandwidth	Tolerance on Percent BW
1-4%	-0. + 0.5%
4.1-30%	-0. + 2%
30.1-60%	-0. + 4%
60.1-100%	-0. + 6%

◆ ±5° Phase Bandwidth vs. 3 dB Bandwidth for Linear Phase Filters

Insertion Loss dB	Number Sections 2	3	4-10
0.5-1.0 dB	53%	70%	78%
1.0-1.5 dB	48%	66%	74%
1.5-2.0 dB	44%	62%	69%
2.0-2.5 dB	39%	51%	65%
2.5-3.0 dB	35%	53%	61%
3.0-4.0 dB	30%	49%	56%
4.0-5.0 dB	21%	40%	47%

◆ Testing & Environmental Capabilities

Test Function	Capabilities	Reference Military Standard
Temperature Altitude Barometric Pressure Thermal Vacuum Gross Leak Fine Leak	70,000 Ft. -54°C to 105°C 70,000 Ft. -54°C to 105°C 7.5 X 10^{-7} 1 X 10^{-5} 1 X 10^{-8}	MIL-STD-810 MIL-STD-202 MIL-STD-202 MIL-STD-202 MIL-STD-202
Low Temperature High Temperature Thermal Shock Temperature Cycling Life	-65°C 130°C -65°C to 130°C -65°C to 125°C 85°C to 130°C	MIL-STD-810 MIL-STD-810 MIL-STD-202 MIL-STD-202 MIL-STD-202
Sine Vibration Random Vibration Random over Sine Vibration	5 Hz to 3,000 Hz 10 Hz to 2,000 Hz 10 Hz to 2,000 Hz	MIL-STD-810 & MIL-STD-202 MIL-STD-810 & MIL-STD-202 MIL-STD-810
Mechanical Shock - Half Sine Mechanical Shock - Sawtooth	30 g to 150 g – 11 ms 10 g to 50 g – 11 ms	MIL-STD-202 & MIL-STD-810 MIL-STD-202 & MIL-STD-810
Humidity Moisture Resistance Salt Fog Salt Atmosphere	35°C to 75°C – 95% Humidity 35°C to 75°C – 95% Humidity 35°C – 95% Humidity 35°C – 95% Humidity	MIL-STD-810 MIL-STD-202 MIL-STD-810 MIL-STD-202
Insulation Resistance Dielectric Withstand Voltage Resistance to Solvents Radiographic Inspection	100 volts – 1 X 10 6 100 volts to 500 volts	MIL-STD-202 MIL-STD-202 MIL-STD-202 MIL-STD-202
Power Testing	1 MHz to 250 MHz – 1000 watts 1,000 MHz to 2,000 MHz – 100 watts 1,800 MHz to 2,500 MHz – 60 watts	

Preferred test methods per MIL-STD-202. Testing per MIL-STD-810 and MIL-STD-883 available upon request.

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◆ Explanation of Supplemental Codes

(Can be one or two characters)
/A Amplitude Matched
/B Bessel Response
/C Contiguous Multiplexer
/D Delay Matched
/E Equiripple Bandwidth
/H Half dB Bandwidth
/N Non-contiguous Multiplexer
/P Phased Matched
/Q High Power Requirements
/T Three dB Bandwidth
/U One dB Bandwidth
/W Butterworth Response
/X Special

◆ Multiplexer

Four character medium and topology code
_ Z _ _ Diplexer
_ M _ _ Multiplexer

◆ Special Packaging

"1" is used as 3rd character in medium topology code.
__ __ 1 __

◆ Explanation of Topology of Codes

LP/HP/BP
0 - Special
1 - Chebyshev
2 - S.E.L.F.
Symmetrical Equiripple Lumped Filter

BP
0 - Special
1- Resonant Ladder
2 - Capacitively Coupled "tank"
3 - "tank" with Tubular End Sections
4 - Lowpass/Highpass Cascade
5 - Lumped Tubular or "mesh"
6 - Narrowband S.E.L.F.
7 - Broadband S.E.L.F.
8 - General Parameter
9 - Unspecified

◆ Specific Examples for Each Product Line are:

9B111-500/H50-O/O 9 section Chebyshev filter in a **one and a quarter inch tubular,** center frequency 500 MHz with a half dB bandwidth of 50 MHz and SMA female connectors on both ends.

6C42-1000/UW30-O/OP 6 section Butterworth **cavity filter** in a 42 series package, center frequency 1000 MHz, one dB bandwidth 30 MHz, SMA female on input and SMA male on the output.

9ED30-4000/U2000-N/NP 9 section **interdigital filter** in a 30 series package, center frequency of 4000 MHz, its 1 dB bandwidth is 2000 MHz and it has N-type connectors, input female and output male.

6IB33-2500/TA212-O/O 6 section **IB filter**, tank circuit with tubular end sections in an IB package, center frequency 2500 MHz with a 3 dB bandwidth of 212 MHz, SMA female connectors on both ends, amplitude matching is specified.

3MC10-500/TD45-O/OP 3 section **miniature cavity filter,** center frequency of 500 MHz with a 3 dB bandwidth of 45 MHz. Delay matching is specified and the connectors are SMA female on input and SMA male on the output.

◆ Multiplexers

In a multiplexer the second character in the medium and topology code is replaced by a Z in the case of a diplexer and by M in case of any other multiplexer. The lowest and highest passband frequencies are specified in the part number.

◆ Multiplexers

7FZ30-3000/TC4500-O This **diplexer** consists of 2 seven-section combline filters in a 30 series package. The lower channel bandedge is at 3000 MHz and the channels are contiguous passing up to 4500 MHz. All three connectors are SMA female.

Topology vs. Frequency Range

◆ Bandpass Filters

Topology	Page	Frequency	(GHz)	% BW
Tubular				
B250 Series	39		.20 — 6	4 — 40
B120 Series			.10 — 2.5	
B340 Series			.08 — 1.7	
B110 Series			.06 — 1.0	
Cavity				
C20 Series	50		.03 — .14	.2 — 3.5
C30 Series			.14 — .45	
C40 Series			.45 — 2	
C42 Series			.8 — 2.5	
C45 Series			1 — 3	
C50 Series			2 — 10	.2 — 3
C52 Series			8 — 12	
C60 Series			6 — 30	.1 — .8
C62 Series			21 — 40	.1 — 1.5
Interdigital				
ED10 Series	53		7 — 18	*5 — 50
ED20 Series			4 — 10	
ED30 Series			3 — 8	
ED40 Series			2 — 5	
ED50 Series			.5 — 2	
Combline				
FV10 Series	51		7 — 40	*3 — 18
FV20 Series			4 — 10	
FV30 Series			3 — 8	
FV40 Series			2 — 5	
FV50 Series			.5 — 2	
Microminiature				
IB Series	25		.01 — 3	3 — 70
UB Series	28		.3 — 2.5	5 — 20
Lumped Component				
LB Series	18		.0005 — .2	1 — 200
Miniature Cavity				
MC Series	36		.1 — 6	1 — 70
KeL-Com				
KCB Series	48		.010 — 3	5 — 7
Mini-Max				
MMB Series	46		.2 — 3	3 — 20
Dielectric Resonators				
DR Series	68		.5 — 3	1 — 10
Ceramic				
KeL-fil Series	70		.27 — 3	1 — 30
Waveguide				
WP Series	63		5 — 94	1 — 20
Tunable				
BT Series	85		.03 — 8	1 — 5
Suspended Substrate				
SB Series	77		2 — 18	50 — 100
Combline				
Mini-Pack	61		6 — 18	3 — 10
Surface Mount Cavity	62		2 — 10	3 — 10
Printed				
AB Series	Contact Factory		2 — 18	3 — 65

0 .01 .1 1 10 20 30 40 94
(GHz)

* Varies with package and frequency.

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◆ Highpass Filters

Topology	Page	Frequency	(GHz)
Microminiature IH Series	30		.01 — 2
Lumped Component LH Series	20		.002 — .25
Suspended Substrate SH Series	78		2 — 18
KeL-Com KCH Series	Contact Factory		.01 — 1.99
Mini-Max MMH Series	Contact Factory		.02 — 3

0 .01 .1 1 10 20 30 40
(GHz)

◆ Lowpass Filters

Topology	Page	Frequency	(GHz)
Microminiature IL Series	33		.01 — 6
Tubular L250 Series	42		.2 — 20
L120 Series			.08 — 3
L340 Series			.10 — 2
L110 Series			.06 — 1
Lumped Component LL Series	22		.0001 — 2.5
Suspended Substrate SL Series	79		2 — 18
KeL-Com KCL Series	Contact Factory		.01— 1.99
Mini-Max MML Series	Contact Factory		.02 — 3

0 .01 .1 1 10 20 30 40
(GHz)

◆ Notch Filters

Topology	Page	Frequency	(GHz)	% BW
Lumped Component LN Series	Contact Factory		.001 — .1	10 — 40
Cavity N Series	Contact Factory		.03 — 10	.5 — 5
Tunable TNF Series	87, 93		.03 — 2	4 — 8
Microminiature IN Series	Contact Factory		.1 — 2	10 — 40

0 .01 .1 1 10 20 30 40
(GHz)

Topology vs. Frequency Range

Duplexers

Frequency Range	Receive	Transmit	Page #
AMPS Full-Band	824 — 849 MHz	869 — 894 MHz	102-104
EGSM Band	880 — 915 MHz	925 — 960 MHz	105-107
800 MHz SMR Band	806 — 821 MHz	851 — 866 MHz	Contact Factory
900 MHz SMR Band	869 — 901 MHz	935 — 940 MHz	Contact Factory
DCS Full-Band	1710 — 1785 MHz	1805 — 1880 MHz	108-110
PCS Full-Band	1850 — 1910 MHz	1930 — 1990 MHz	111-114
UMTS / IMT Full-Band	1920 — 1980 MHz	2110 — 2170 MHz	115-116

Dual Band Duplexers

AMPS Band	824 — 849 MHz	869 — 894 MHz	Contact Factory
PCS Band	1850 — 1910 MHz	1930 — 1990 MHz	117-118
EGSM Band	880 — 915 MHz	869 — 894 MHz	Contact Factory
DCS Band	1710 — 1785 MHz	1805 — 1880 MHz	Contact Factory
DCS Band	1710 — 1785 MHz	1805 — 1880 MHz	Contact Factory
UMTS / IMT Band	1920 — 1980 MHz	2110 — 2170 MHz	Contact Factory

Receive Filters

AMPS Full-Band	824 — 849 MHz		121
EGSM Band	890 — 915 MHz		122
DCS Full-Band	1710 — 1785 MHz		123
PCS Full-Band	1850 — 1910 MHz		124
UMTS / IMT Band	1920 — 1980 MHz		125

Transmit Filters

AMPS Full-Band		869 — 894 MHz	Contact Factory
EGSM Band		925 — 960 MHz	Contact Factory
DCS Full-Band		1805 — 1880 MHz	Contact Factory
PCS Full-Band		1930 — 1990 MHz	126
UMTS / IMT Band		2110 — 2170 MHz	127

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