

RF and ELECTRONICS

SOLID STATE POWER AMPLIFIER (SSPA)



C Band SSPA for Communication Satellites

A large percentage of GEOSAT transponders operate at C band, serving diverse applications like VSAT networks, telecoms, television relay etc. A typical C band payload would carry from twelve to twenty four numbers of normal C band SSPAs.

The indigenously developed and well-proven 15 Watt SSPA technology will therefore be a recurring requirement in the years to come.

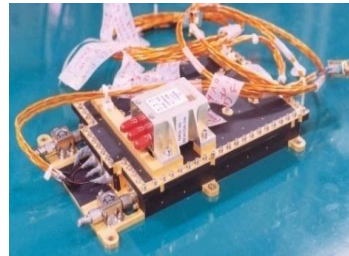
Heritage: GSAT 7

Specifications

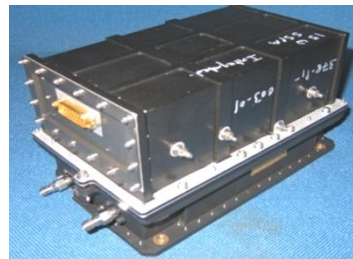
- Operating Frequency : 3700 – 4200 MHz
- Nominal RF Output Power : 15 W
- Large Signal Gain : 83 – 86 dB
- Mass : < 1.7 Kg
- Dimensions : 209 x 110 x 96 mm
- Temperature range (Qualification) : -10 °C to 60 °C

Features

- Integral EPC
- Tele-commandable Attenuation for on-board gain setting
- Thermally painted chassis for optimal heat balance



Ku-Beacon SSPA



C band SSPA

Ku-Band SSPA for Beacon of Satellites

Applications like DTH broadcasting, tele-education, telemedicine etc have driven a growing demand for Ku Band transponders. A typical Ku-band payload would carry two such Ku-Band Beacon SSPAs to enable tracking the spacecraft from ground stations.

Heritage

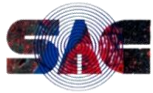
Flown in almost all Ku band satellites during the last several years.

Specifications

- Operating Frequency : 11700 ± 5 MHz
- Nominal RF Output Power : 24 dBm
- Efficiency : 32 %
- Gain : 24 dB (min.)
- Mass : 1 kg.
- Dimensions : 206 x 140 x 25.5 mm
- Temperature range : -5 °C to +55 °C

Features

- Dual SSPAs in single package
- Tele-commandable Attenuation for on-board gain setting
- Thermally painted chassis for optimal heat balance



SOLID STATE POWER AMPLIFIER (SSPA)

UHF Band SSPA for Mobile Communication Satellites

The indigenously designed and developed state of the art 100W UHF SSPA has been successfully deployed in GSAT-7.

Heritage: GSAT 7

Specifications

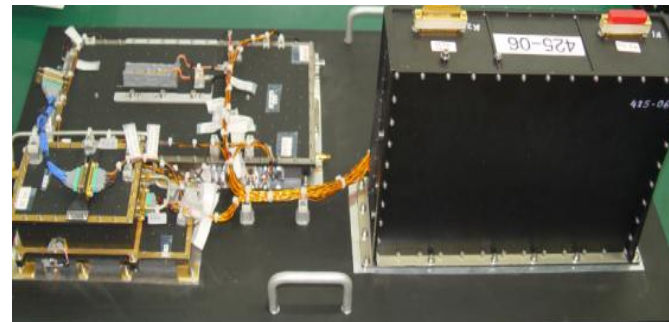
- Operating Frequency : 242 – 255 MHz
- Nominal RF Output Power : 100 W
- Large Signal Gain : 100 dB
- Efficiency : 32 %
- Output Power Limiting (ALC): 120 W
- 3rd order IMD @ 5 tone : -17 dBc
- Mass : ≤ 6.4 Kg (Integrated SSPA)
- Temperature range : -5 °C to 55 °C

Mechanical Configuration

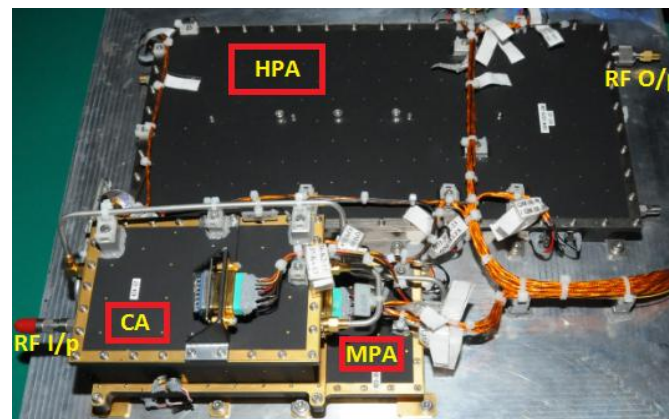
- High Power Amplifier (350 x 200 x 27 mm³)
- + Medium Power Amplifier (212 x 109 x 70 mm³)
- + Electronic Power Conditioner (339 x 108 x 229 mm³)

Features

- Integral EPC
- Output Power Telemetry (Analog Voltage)
- Over Power Protection Mechanism
- Tele-commandable Attenuation for onboard gain setting
- Multi-Carrier Operation (5)



100W UHF SSPA with EPC



RF Section of UHF SSPA

L-band DA for Navigation Satellites

Navigational signals are transmitted on L-Band besides the S-Band. Each IRNSS spacecraft would contain two L-Band Driver Amplifiers as part of the transmitter.

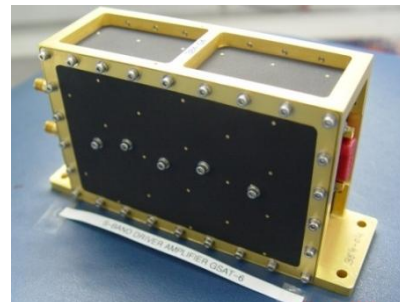
Heritage: IRNSS-1A, 1B

Specifications

- Operating Frequency : 1175 ± 15 MHz
- Gain : 45 dB (min)
- Telecommand : 12 dB
- Mass : 600 gms
- Dimensions : $150 \times 42 \times 90$ mm³
- Temperature : -5 °C to +55 °C

Features

- Dual DA in single package
- Tele-commandable Attenuation
- Thermally painted chassis for optimal heat balance



S-Band Driver Amplifier



L-Band Driver Amplifier

S Band DA for Communication Satellites

Mobile telecom and multimedia services on S-Band are expected to grow in importance. The indigenously developed S-Band Driver Amplifier is high output power amplifier specially design for applications like GSAT-6.

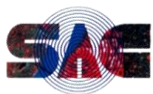
Heritage: GSAT-6

Specifications

- Operating Frequency : 2550 - 2600 MHz
- Band Width : 50 MHz
- Gain : 56 dB (min)
- Linear O/ P power : 16 dBm
- Overdrive : 12 dB
- Mass : 600 gms
- Dimensions : $153 \times 43 \times 81$ mm³
- Temperature : -5 °C to +55 °C

Features

- High gain & high output power
- Tele-commandable Attenuation for Gain setting
- Temperature Compensation



SOLID STATE POWER AMPLIFIER and DRIVER AMPLIFIER

ISRO is building up a constellation of IRNSS spacecrafts that will provide time, frequency and positioning services. A number of subsystems have been developed for this program, which will be used in large numbers. Some of these are shown here.

S-Band DA for Navigational Satellites

This amplifier is used in the S-Band transmitter which provides navigational data for the user receiver. Each IRNSS spacecraft would use two of these Driver Amplifiers.

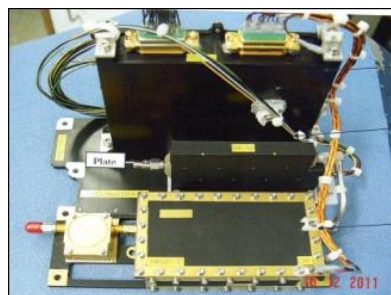
Heritage: IRNSS-1A, 1B

Specifications

- Operating Frequency : 2492 ± 15 MHz
- Gain : 45 dB (min)
- Command. Attenuator : 12 dB
- Mass : 600 gms
- Dimensions : 184 x 47 x 82 mm³
- Temperature range : -5 °C to +60 °C

Features

- Dual DA in single package
- Tele-commandable Attenuation for on-board gain setting
- Thermally painted chassis for optimal heat balance



C-Band SSPA



S-Band Driver Amplifier

C band SSPA for Navigational Satellites

The IRNSS spacecraft is equipped with a ranging transponder to help fix its position. This C-Band ranging payload would two normal C-Band SSPAs.

Heritage: IRNSS-1A, 1B

Specifications

- Operating Frequency : 3.4 – 3.425 GHz
- RF Output Power : 5 W
- Gain : 78 dB (min)
- Command. Attenuator : 12 dB
- Total Phase Shift : 22 deg max.
- Overdrive : 20 dB
- Mass : 1200 gms
- Dimensions : 185 x 145 x 135 mm³
- Temperature range : -5 °C to +55 °C

Features

- Integral EPC & DA
- Tele-commandable Attenuation for on-board gain setting
- Thermally painted chassis for optimal heat balance

DRIVER AMPLIFIERS (DA)



Direct-to-Home (DTH) television is one major application of GEOSAT Ku band satellites. To ensure good signal quality in all the weather conditions, Automatic Level Control (ALC) driver amplifiers have been developed, of which 12 to 24 units are found on any satellite.

Ku-Band ALC DA for Communication Satellites

The lower photograph shows the well proven amplifier design that has been used for several years.

Heritage: INSAT-4CR

Specifications

- Operating Frequency : 11450 – 11700 MHz
- Band Width : 250 MHz
- Gain : 44 dB (min)
- Command. Attenuator : 22 dB
- ALC Range : 20 dB
- Input Overdrive power : -4 dBm (max.)
- Mass : 450 gms
- Dimensions : 112 x 42 x 90 mm³
- Temperature range : -10 °C to +60 °C

Features

- Both operational mode FGM & ALC
- Driver Amplifier with 20dB ALC range
- Vertical mounting to reduce foot print on panel
- Tele-commandable Attenuation for on-board gain setting
- Thermally painted chassis for optimal heat balance



Ku-Band ALC Driver Amplifier



Ku-Band ALC Driver Amplifier

Ku-band ALC DA for Communication Satellites

On the top is a dual driver amplifier with improved mechanical design.

Heritage: GSAT-8 & GSAT-10

Specifications

- Operating Frequency : 11450 – 11700 MHz
- Band Width : 250 MHz
- Signal Gain : 44 dB (min)
- Command. Attenuator : 22 dB
- ALC Range : 20 dB
- Input Overdrive power : -4 dBm (max.)
- Mass : 900 gms.
- Dimensions : 200 x 85 x 47 mm³
- Temperature range : -10 °C to +60 °C

Features

- Dual DA in single package with 20dB ALC range
- Both operational mode FGM & ALC
- Tele-commandable Attenuation for on-board gain setting
- Thermally painted chassis for optimal heat balance



DRIVER AMPLIFIER and LINEARISERS

Pre-distortion Linearisers are used to improve the Quality of Service by compensating for distortion in Power Amplifiers. SAC, Ahmedabad has designed a series of Linearisers at L, S, C and Ku Bands.

Ku-band MMIC DA for Communication Satellites

MMIC based Ku-band driver amplifier is third generation of Driver Amplifier. Besides being low weight and card-size compact, the unit promises immense capabilities such as a wideband operation and high ALC dynamic range.

Heritage

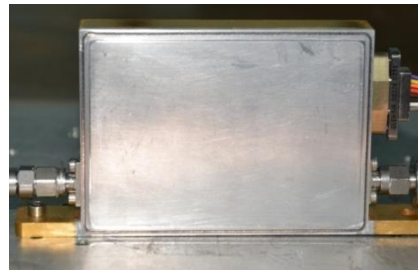
This Driver Amplifiers are under qualifications for future Ku-Band satellites.

Specifications

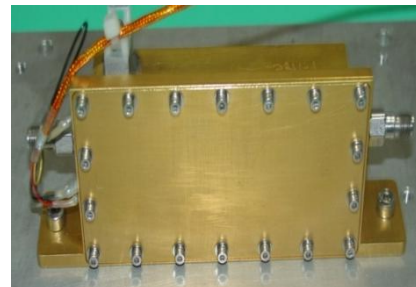
- Operating Frequency : 10.75 to 12.75 GHz
- Band Width : 2 GHz
- Gain : 44 dB (min)
- Gain Flatness : 0.3 dB (any 40 MHz)
0.8 dB (250 MHz)
- Command. Attenuator : 30 dB
- ALC Range : 20 dB
- Input Overdrive power : -4 dBm (max.)
- Mass : 200 gms
- Dimensions : 122 x 17 x 55 mm³
- Temperature range : -10 °C to +60 °C

Features

- High dynamic Range: 30 dB
- Tele-commandable Attenuation for on-board gain setting
- Thermally painted chassis for optimal heat balance
- Hermetically sealed MMIC package



Ku-Band MMIC Driver Amplifier



C-Band Linearizer

C-Band Lineariser for Communication Satellites

The indigenously developed C-Band Linearizer is compact and efficient to linearize the TWT Amplifier by adding reverse distortion characteristics at the input of the TWT amplifier. It has unique capability to nullify up to 10 dB AM/ AM and 50 degree AM/ PM component of the TWTA.

Heritage: Qualified and will be used in high power transponders future C-Band satellites.

Specifications

- Operating Frequency : 3700 - 4200 MHz
- Gain : 14 dB
- Gain Expansion : 10 dB
- Phase Expansion : 50 Deg.
- Mass : 200 gms.
- Dimensions : 133 x 43 x 49 mm³
- Temperature : -5 °C to +55 °C

Features

- Limiter for overdrive protection
- Compact & light weight
- Easily tunable anywhere within the full C-band



C_{ext}-Band MMIC Rx for Communication Satellites

The indigenously developed C_{ext}- band receiver is now a proven technology for all its C band communication satellites.

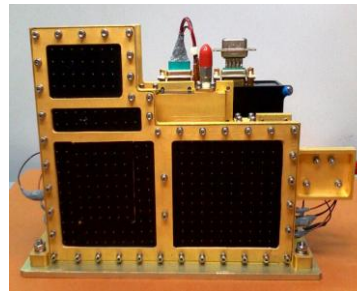
Heritage: This SSPA is already flown in INSAT-4CR satellite and they are working to the best of the performance.

Specifications

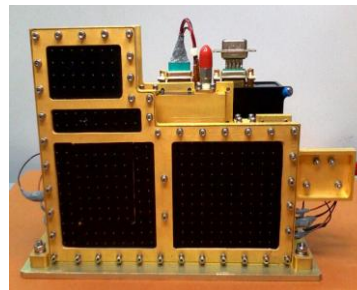
- Input Frequency : 6450 – 6690 MHz
- Output Frequency : 3425 – 3665 MHz
- Band Width : 240 MHz
- Nominal Input power : -75 to -57 dBm
- Linear Gain : 50 ~ 53 dB
- Input Overdrive power : -37 dBm (max.)
- Two tone IM3D @ -60 dBm : -44 dBc
- Mass : 450 gms
- Dimensions : 112 x 42 x 90 mm³
- Temperature range : -5 °C to +60 °C

Features

- With LNA auxiliary output
- Thermally painted chassis for optimal heat balance



C_{ext}-Band MMIC Receiver



C_{ext}-Band MMIC Receiver

C_{ext}-Band MMIC Rx for Communication Satellites

The indigenously developed C_{ext}- band receiver is now a proven technology for all its C-Band communication satellites.

Heritage: This SSPA is already flown in GSAT-8 & GSAT-10 satellites and they are working to the best of the performance.

Specifications

- Input Frequency : 6450 – 6690 MHz
- Output Frequency : 3425 – 3665 MHz
- Band Width : 240 MHz
- Nominal Input power : -51 to -33 dBm
- Linear Gain : 27 ~ 29 dB
- Input Overdrive power : -13 dBm (max.)
- Two tone IM3D @ -33 dBm : -44 dBc
- Mass : 450 gms
- Dimensions : 112 x 42 x 90 mm³
- Temperature range : -5 °C to +60 °C

Features

- Without LNA
- Thermally painted chassis for optimal heat balance

Ku-Band MMIC Rx for Communication Satellites

The indigenously developed MMIC based Ku-Band Receiver is now a proven technology for all its Ku-Band communication satellites.

Heritage: This receivers are already flown in GSAT-7 satellite and they are working to the best of the performance.

Specifications

- Input Frequency : 14000 – 14250 MHz
- Output Frequency : 10950 – 11200 MHz
- Translation Frequency : 3050 MHz
- Nominal Input power : -75 dBm
- Linear Gain : 55 ~ 57 dB
- Noise figure : 2.0 dB
- Two tone IM3D @ -62 dBm : -44 dBc
- Mass : 1500 gms
- Temperature range : -5 °C to +60 °C
- Dimensions : 120 x 50 x 90 mm³

Features

- Thermally painted chassis for optimal heat balance



Ku-Band Receiver



Ku-Band MMIC Receiver

Ku-Band Rx for Communication Satellites

The indigenously developed MIC based Ku-Band Receiver is now a proven technology for all its Ku-Band communication satellites.

Heritage: This receivers already flown in GSAT-3, INSAT-4A,4B satellite and they are working to the best of the performance.

Specifications

- Input Frequency : 14000 – 14250 MHz
- Output Frequency : 10950 – 11200 MHz
- Translation Frequency : 3050 MHz
- Linear Gain : 55 ~ 57 Db
- Noise figure : 2.5 dB
- Nominal Input power : -75 dBm
- Two tone IM3D @ -62 dBm : -44 dBc
- Mass : 1700 gms
- Dimensions : 120 x 80 x 90 mm³
- Temperature range : -5 °C to +60 °C

Features

- Thermally painted chassis for optimal heat balance



Transmit – Receive Diplexers

SAC has an extensive experience in the field of satellite filters. A multitude of Tx-Rx diplexers from L to Ka-band and frequencies of up to 30 GHz have been designed, manufactured and qualified in various programs in the last 30 years. The function of the Tx-Rx diplexer is the separation of receive and transmit bands served by one polarization of a dedicated antenna.

Specifications

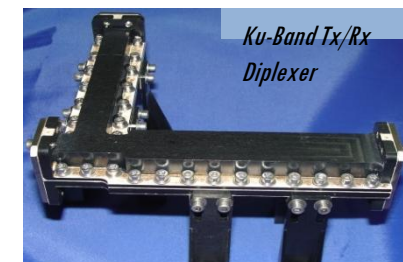
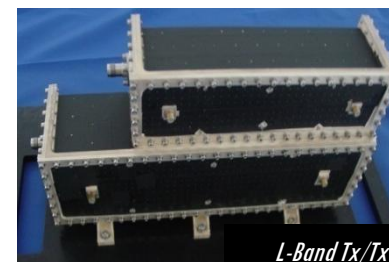
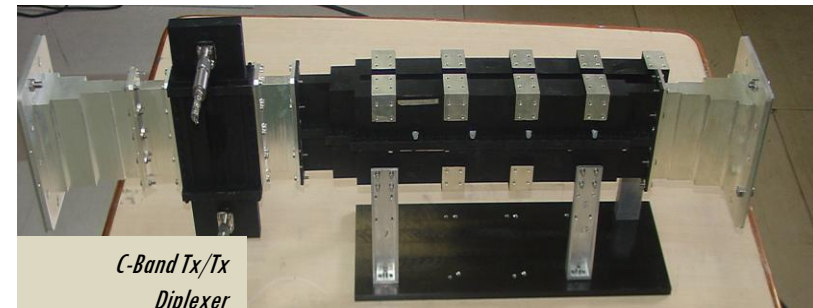
- Insertion Loss: < 0.15 dB over temperature range
- Rejection over Receive Band: > 60 dB
- Power handling capability: Up to 140 W/ CH in Ku-Band, 40W/ CH in L-Band and 60 W/ CH in C-band.

Features

- The diplexers are realized using low pass-band pass filter combination.
- The Tx filter is a stepped impedance low pass filter realized using corrugated waveguide sections. The receive filter is a Chebyshev BPF realized using inductive iris coupled waveguide resonators.
- The diplexers are realized without the use of tuning screws, which can degrade multipaction threshold and generate PIM.
- The diplexers are fabricated from aluminium alloy by cutting it in to two halves and clamping them together & silver plated internally
- The designs have met all the structural requirements of payloads where the stiffness is greater than 125 Hz and the maximum temperature is found to be 98 °C.

Performance

- Low insertion loss (<0.15 dB)
- Good Return Loss (>26 dB)
- High receive/ transmit isolation of > 60 dB
- Flat amplitude and group delay response
- High power handling capability
- – Low dissipated power (Good thermal design)
- No generation of passive inter-modulation products (Tested up to –150 dBm)



Ku-Band Output Multiplexers

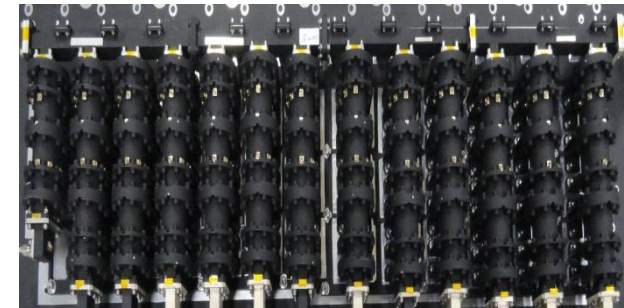
SAC has an extensive experience in the field of satellite filters. A multitude of filters and multiplexers from L- to Ka-band and frequencies of up to 30 GHz have been designed, manufactured and qualified in various programs in the last 30 years. The function of the Output Multiplexer is to recombine the various downlink channel frequency bands into a broadband signal after amplification. A typical output multiplexer used in spacecraft communication payload consists of channel filters and a common manifold.

Specifications

- Insertion Loss: <math><0.75\text{ dB}</math> over temp. range
- Rejection: >30 dB
- Power handling capability: Up to 140 Watts

Performance

- Extremely low loss channel filter design
- $Q > 15000$
- Measured ELFD <math><0.4\text{ ppm / }^{\circ}\text{C}</math>
- High power handling capability and low PIM level designs
- Design verification by test up to 30 kW



Ku-Band 13 Ch OMUX

Features

- Channel Filters realized using 5-Pole Quasi elliptic filtering function
- Channel Filters in 7-Channel OMUX operates in TE113 resonant mode
- Channel Filters in 6-Channel OMUX operates in TE114 resonant mode
- Channel Bandwidth = 36 MHz Average Power Handling = 140 W per Ch.
- Peak Power Handling (n2Pi)=5.04 kW
- Channel Filters are combined using Manifold Multiplexing technique
- Manifold realized using full height WR75 waveguide
- Filters & Manifold waveguides constructed from silver plated Super Invar material for temperature stability & best possible quality factor



Ku-Band 7 CH OMUX



Ku-Band 6 CH OMUX



Helical Band Pass Filters

SAC has an extensive experience in the field of satellite filters. Helical Resonators based filters from 200 to 800 MHz have been designed, manufactured and qualified in various mission programmes in the last 20 years. These are most suitable type of filters in VHF/ UHF Band considering size, weight, Insertion loss and out of band rejection parameters & widely used in communication payload subsystems. The functions of the Helical Resonators based filters are as Pre Select Filter, Image Reject BPF in Receiver at UHF, for harmonic rejection after Multipliers in Local Oscillators.

Specifications

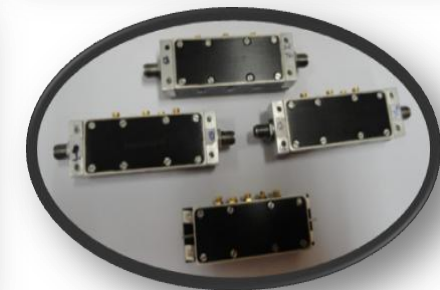
- Centre Frequency range: 200 to 800 MHz
- Insertion Loss range: <1 to 5 dB over temp. range
- 3 dB Bandwidth range for different types are: 2.1 MHz to 60 MHz
- Flatness: < 1 dB
- I/ P & O/ P Impedance: 50 Ohm

Features

- Helical Filters realized using 3-Pole,4-Pole & 5-pole having Butterworth & Chebyshev filtering function
- Small size & compact
- Light weight
- I/ P & O/ P interface SFT Pin or SMA (F)
- Filters constructed from silver plated Aluminium material & for Helix Teflon supports for best possible quality factor
- Outer surface finish Black paint/ Anodized

Performance

- Extremely compact with low loss filter design
- PCB mountable & SMA connector version



C_{ext} Upper band Harmonic Rejection Filter

C-ext upper Harmonic Rejection Filter is a low pass filter used at the output of C ext upper OMux. It provides rejection of > 60 dB over receive frequency range and at second and third harmonic frequencies. It is a 9-section stepped impedance corrugated waveguide low pass filter.

Specifications

- Frequency band: 4500 – 4800 MHz
- Insertion Loss: <0.10 dB
- Input / Output Return loss: >20 dB
- Operating Temperature: -15 to 60 deg C



Ku band Harmonic Rejection Filter

Ku-Band 12 GHz Harmonic Rejection Filter is used for Tx frequency range of 10.95-11.7 GHz. It provides rejection of > 60 dB over receive frequency range of 13.75-14.5 GHz and at second and third harmonic frequencies. It is a 9-section stepped impedance corrugated waveguide low pass filter. Critical gaps in the HRF are designed such that it has multipaction threshold of > 1.2 KW.

Specifications

- Frequency band: 10950 – 11700 MHz
- Insertion Loss: <0.20 dB
- Input / Output Return loss: >20 dB
- Operating Temperature: -15 to 60 deg C





Ku band PIM Filter

The PIM filter is a stepped impedance corrugated waveguide low pass filter. The filter is realized without the use of tuning screws. The filter is fabricated in two halves & clamped together with grooved joints to generate high contact pressure. The filter is silver plated internally to achieve lowest possible insertion loss and also have low PIM generation. The Ku-band PIM filter suppresses the PIM signals generated by high power carriers in the 10.95 -11.7 GHz from falling in 13.75-14.5 GHz by more than > 60 dB. The PIM performance of the filter itself should be <-175 dBc. The gaps in the filters are sufficiently large to achieve the required multipaction threshold of 5.04 kW.

Specifications

- Frequency range: 10950 – 11700 MHz
- Insertion Loss range: < 0.15 dB
- Operating Temperature: - 15 to 60 deg C
- Input / Output Return Loss: > 20 dB

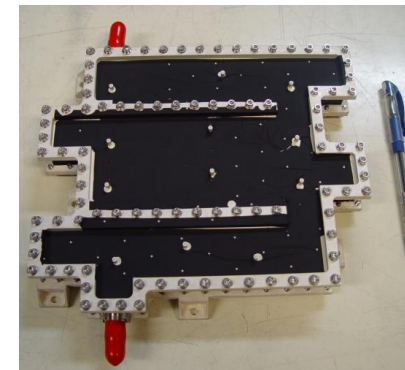


UHF band PIM FILTER

PIMP filter is realized as a Band-stop filter as it provides better rejection in the stop-band compared to a low-pass filter, for a given no. of sections. It is a 4-pole filter and consists of a tx line coupled to quarter wavelength Tx lines resonating at Rx frequency. Teflon is filled between inner and outer conductors to avoid multipaction. The unit was tested for a peak power of 1.5 KW and was multipactor free at both the temperature extremes of the operating temperature.

Specifications

- Frequency range: 242.1 – 254.7 MHz
- Insertion Loss range: < 0.10 dB
- Operating Temperature: - 40 to 80 deg C
- Input / Output Return Loss: > 20 dB



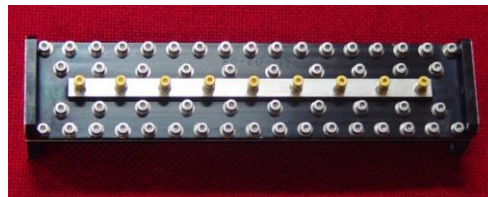
Ku band Pre Select Filter

Pre-select filter is required to reject the transmit band signal, which may get coupled in the transponder receive chain. Pre-select filter is used before the LNAs to limit the input noise bandwidth, which may otherwise saturate the LNAs.

Pre-select filters are inductively coupled iris band pass filter. This configuration will give low insertion loss. The filters are fabricated using Aluminium and in standard wave guide.

Specifications

- Frequency band: 12750 – 13250 MHz
14000 – 14500 MHz
- Insertion Loss: 0.5 dB
- Input / Output Return loss: 20dB/ 18dB
- Operating Temperature: -15 to +55 deg C



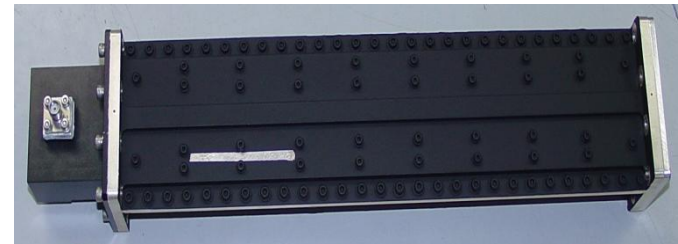
C band Pre Select Filter

Pre-select filter is required to reject the transmit band signal, which may get coupled in the transponder receive chain. Pre-select filter is used before the LNAs to limit the input noise bandwidth, which may otherwise saturate the LNAs.

Pre-select filters are inductively coupled iris band pass filter. This configuration will give low insertion loss. The filters are fabricated using Aluminium and in standard wave guide.

Specifications

- Frequency band: 5930 – 6470 MHz
- Insertion Loss: <0.5 dB
- Input / Output Return loss: 18 dB
- Operating Temperature: -15 to 60 deg C





3 dB Quadrature Hybrid Coupler

SAC has developed various class of modern communication systems and Quadrature couplers which remained an integral part of the system development. A wide range of frequency spectrum is covered starting from UHF band (375MHz) to Ka-band (28GHz). The Quadrature couplers are having a strong heritage of use in various INSAT/ GSAT projects and still evolving as per the requirement. Lesser weight and superior performance is an inevitable requirement and has to be maintained as better as possible.

Specifications

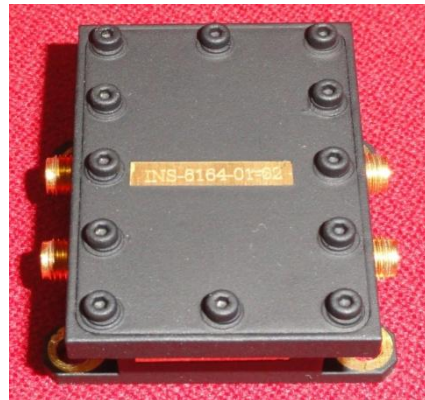
- Frequency: UHF, S, C, Ku and Ka bands
- Insertion Loss: <1.5 dB over temp. range
- Amplitude imbalance: <0.5-0.8dB
- Return loss: >17 dB
- Isolation: >17 dB
- Phase Imbalance: <5°

Performance

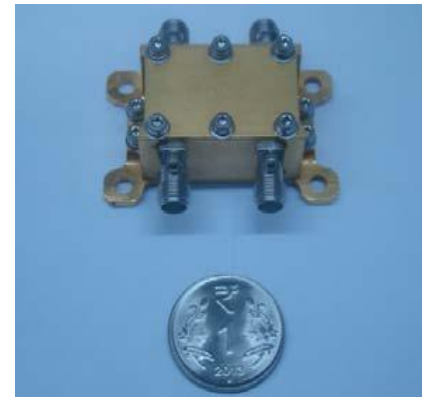
- An up to date design with high end performance
- Wideband temperature (-22°C to 65 °C) stability
- Wide communication band coverage

Features

- Hybrid couplers are realized using various approaches i.e. branch line, lange patterns etc
- Mode of operation is quasi TEM
- Widely used for combining and splitting operations and also provide redundancy in different subsystems.
- Various operational fractional bandwidths starting from 8% to 53%



UHF/ S/ C band Coupler



Ku band transmit Coupler



Ka band Coupler