

Sub-Systems



TELEDYNE MICROWAVE SOLUTIONS
Everywhere you look™

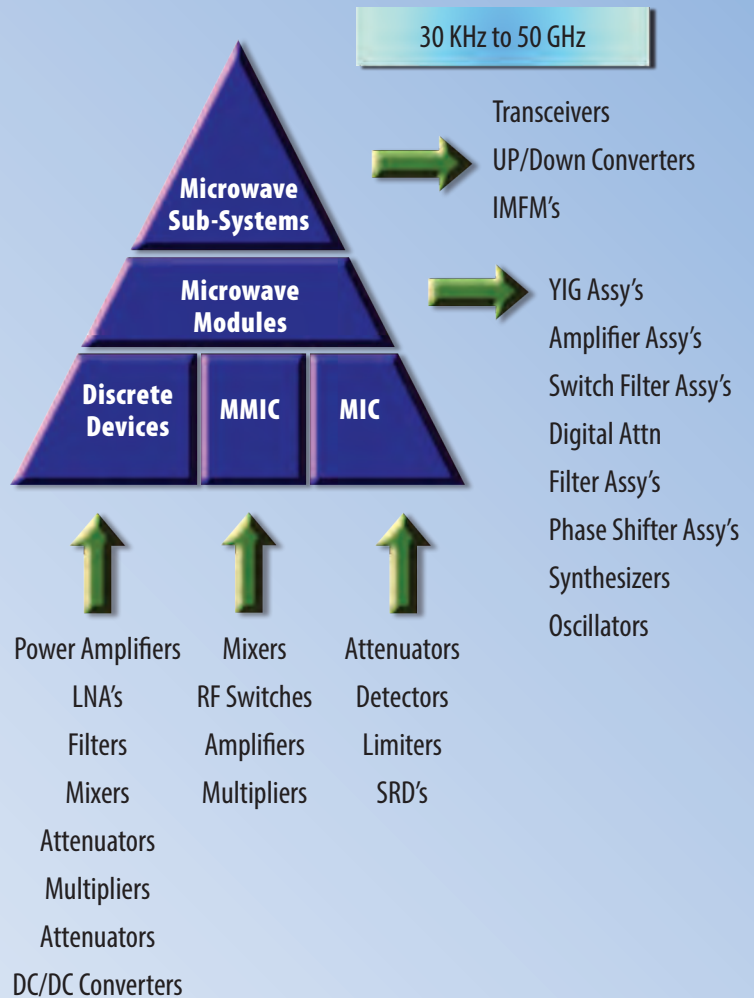
Sub-Systems

Teledyne Microwave has served the microwave industry for over 40 years. Committed to the design, development and production of a wide range of state-of-the-art active microwave components and sub-systems. These products find applications in radar jamming and receiving systems, communication systems, avionics, and electronic warfare systems. Teledyne Microwave is committed to providing the industry with reliable and innovative products. Realizing that rapid advances in microwave design and manufacturing technologies requires increasingly sophisticated equipment and facilities.

Many of Teledyne's designs are produced for operation in millimeter frequencies as high as 50 GHz. With our circuit design experience on integration at these high frequencies we provide a technical advantage to our customers. This also enables us to produce simpler and more robust and higher performing products.

With recent acquisitions of Filtronic Solid State, Celeritek Defense and KW Microwave, Teledyne Microwave has further enhanced its already strong sub-system and component capabilities. In addition to the extensive experience of Amplifier sub-systems from Filtronic Solid State, Celeritek Defense brought

many of the standard modules necessary to construct complex sub-systems. KW Microwave has also had a wide range of experience of sub-systems with switch filter banks and integrated LNA products for GPS applications. Teledyne Microwave has successfully incorporated all of these disciplines into one company without losing a single element or capability.



Sub-Systems

These products employ mixed transmission media for optimal performance and reduced manufacturing cost. Thin film hybrid MIC techniques are widely used in many of these products, with Teledyne Microwave committed to providing the industry with reliable and innovative products.

- ◆ Thin film hybrid circuits
- ◆ MMIC's
- ◆ Discrete
- ◆ Softboard
- ◆ Waveguide ..etc.

By combining components and modules on both the hybrid and board level we are able to produce very complex custom assemblies built to the customers fit and form for both commercial and military programs.

Teledyne Microwave is able to pull together an number of difference "Standard" modules to produce a customer defined "Sub-system" which is both cost effective and on-time. The majority of examples in this section were made form common module with little or no modifications.



With over 40 years experience and recent strategic acquisitions, Teledyne Microwave's ability to produce complex sub-systems is now second to none.

Amplifier Sub-Systems

Teledyne Microwave offer a wide variety of Amplifier sub-systems in addition to standard models listed on page 21. Teledyne Microwave, in addition to producing standard amplifiers, can also incorporate added functionality per customers requirements. Some examples are listed, but not limited to the following:

- ◆ Integrated Limiter
- ◆ Detection Circuits
- ◆ Switched Input and/or Output
- ◆ Sampling Ports
- ◆ TTL-Controlled Functions
- ◆ Amplifier Filter Assemblies
- ◆ High-Density Packaging (carrier or connectorized)

Microwave Amplifiers are a major building block for all the sub-systems Teledyne produces whether it's commercial or military. As a result amplifier performance is critical for all the sub-system examples shown in this section.



Amplifier Sub-Systems

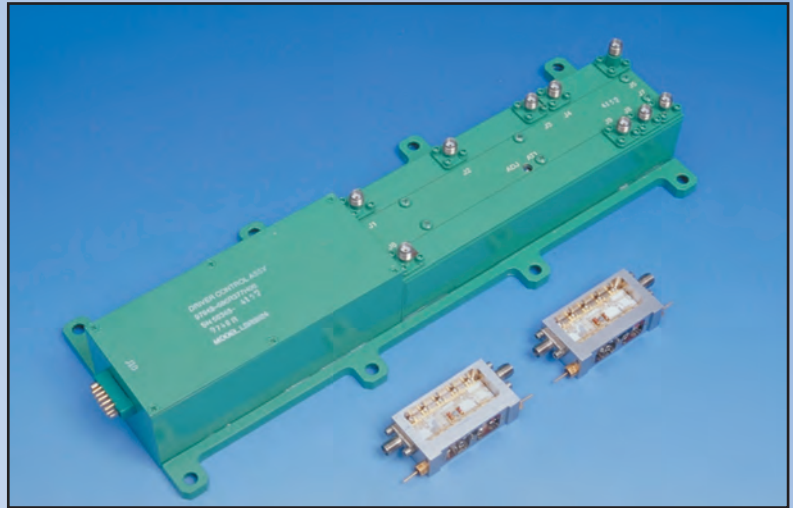
Dual Channel Broadband Amplifier

This amplifier is a broadband, multi-function, dual-channel gain controlled amplifier subsystem designed for military airborne applications. It consists of 3 gain stages, a wide dynamic range attenuator, a high-speed switch, and a sampling port for signal monitoring. The assembly also includes a power supply to allow operation from a single-phase 400 Hz AC power supply.

The microwave circuit construction uses Teledyne's state-of-the-art MIC (microwave integrated circuit) fabrication and automated assembly processes to achieve highly reliable operation. The unit is hermetically sealed using a laser welding process for full environmental protection.

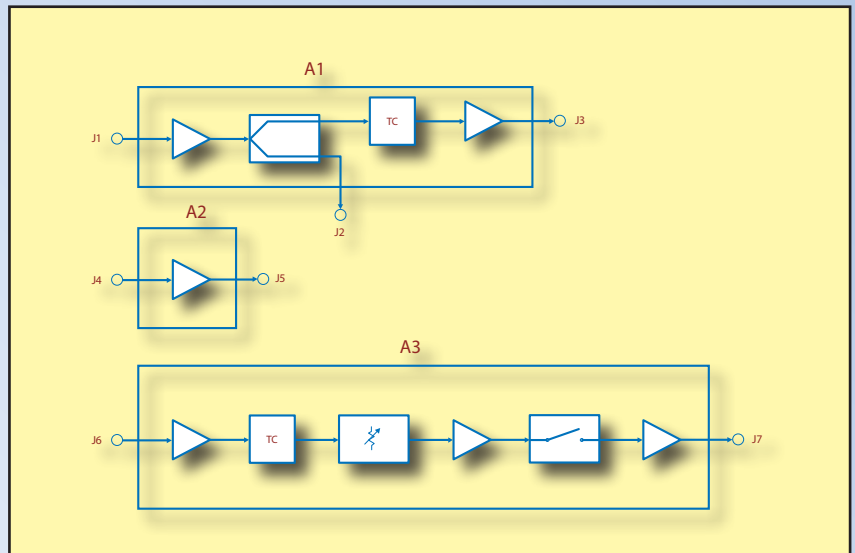
Operation covers approximately an octave frequency band. Interconnection of two of the amplifiers on the integrated assembly allows separate or combined operation; which provides discrete gain adjustment.

The unit provides a low noise small gain stage to be optionally connected in front of a high power amplifier for high-gain, low-noise operation. In addition, a wide dynamic range attenuator is provided for fine gain adjustment.



Broadband, multi-function, dual-channel gain controlled amplifier subsystem designed for military airborne applications.

Sub-Systems



Operation covers approximately an octave frequency band. Interconnection of two of the amplifiers on the integrated assembly allows separate or combined operation.

Military Converter Sub-Systems

IMFM

This multifunction assembly shows Teledyne Microwave's capabilities in producing a complex unit operating over a ultra-wide frequency range for a demanding military application. Operating in military environmental conditions over -40°C to +85°C this unit has been in production for a number of years with very reliable performance. The unit incorporates the latest Microwave Integrated Circuits (MIC's) designed to allow a high level of integration in a 7.23 x 4.00 x 1.00 inch housing. The unit is split into 6 sections, a Filter Bank, a Phase-locked Oscillator (PLO), a Converter, and a Power Conditioning and Control Section.

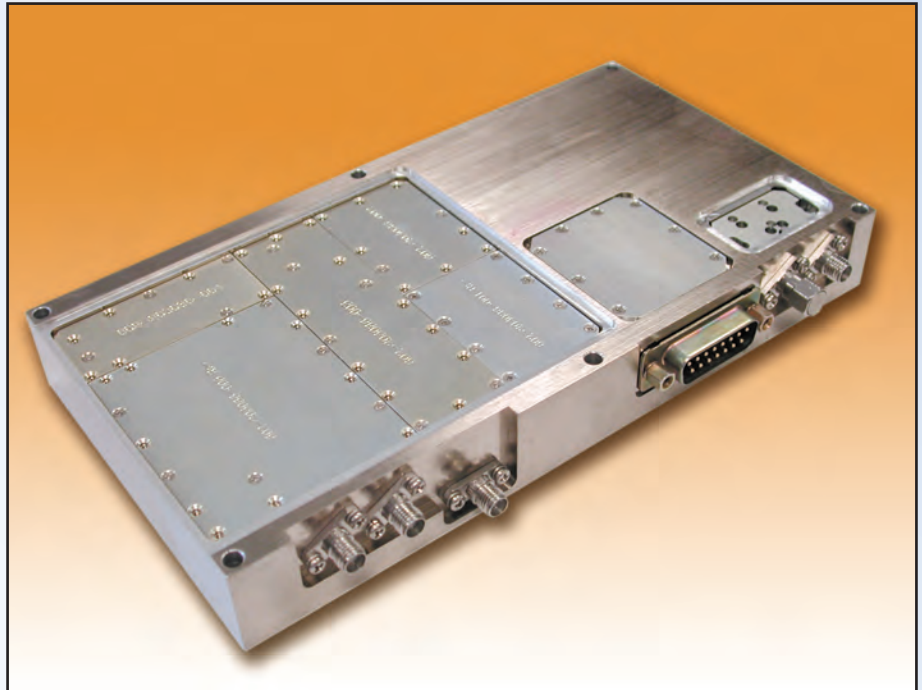
The Input Section includes a coupler, amplifier, attenuator, and switch. The attenuator is a voltage controlled 25 dB attenuator that is designed to set the output power to a specified level and to a level 15 dB below the specified level.

The Filter Bank Section splits the input into 4 bands for harmonic filtering. Harmonics in Bands 1, 2, and 3 can be minimized with proper filtering. Harmonics in Band 4 can be minimized with amplifiers operating small signal.

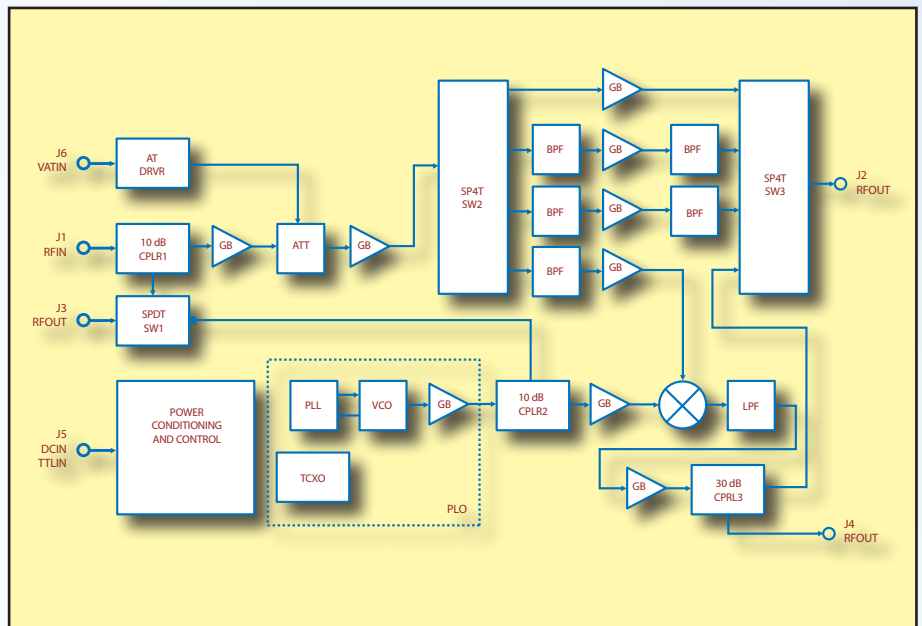
The PLO Section includes a Crystal Oscillator (TCXO), phase locked-loop (PLL) circuitry, Oscillator, and Divider.

The Converter Section includes the mixer, filters, couplers, and amplifiers for generating Band 4 and further outputs.

The Power Conditioning and Control Section include input bias filtering, voltage regulation, control signal conditioning, and switch drivers.



Operating in military environmental conditions over -40°C to +85°C this unit has been in production for a number of years with very reliable performance.



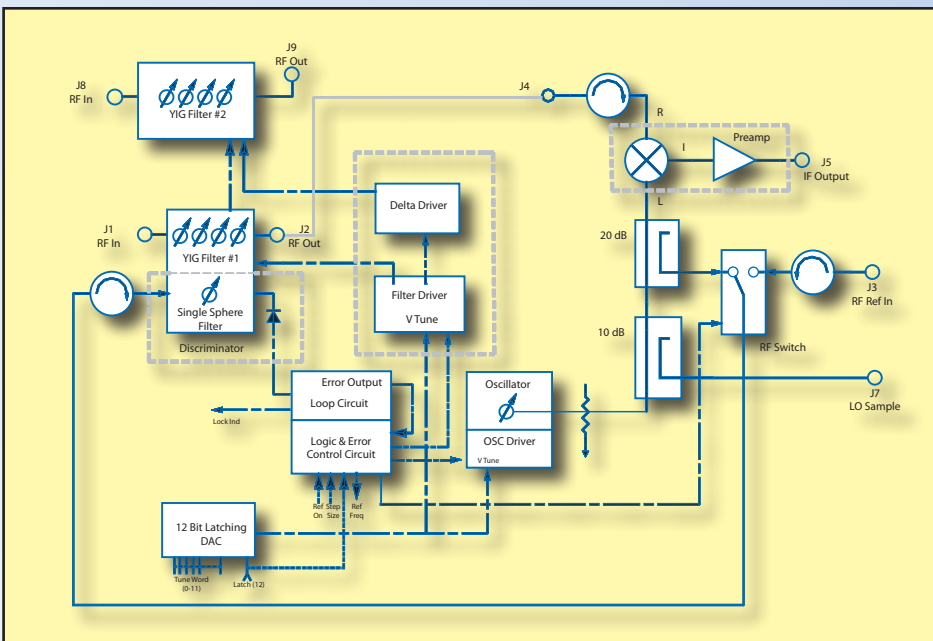
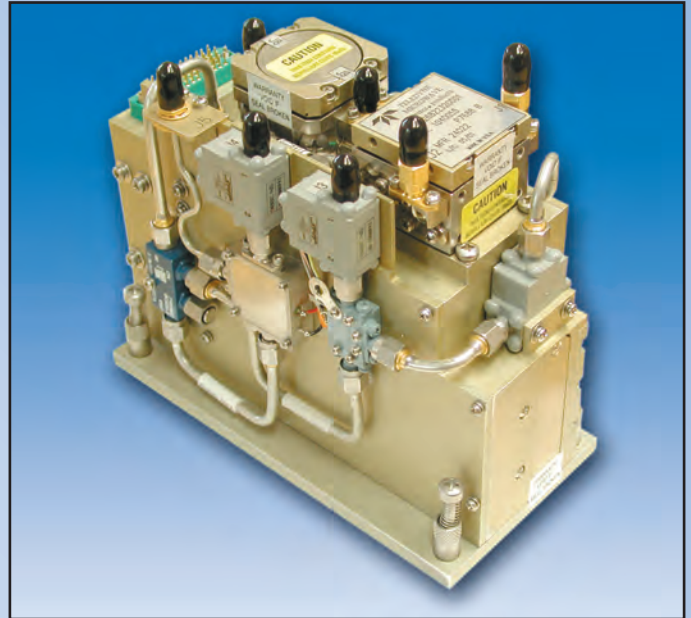
The unit is split into 6 sections, a Filter Bank, a Phase-locked Oscillator (PLO), a Converter, and a Power Conditioning and Control Section.



FOM

The FOM (Filter Oscillator Mixer) Assy incorporates a number of elements unique to Teledyne Microwave.

In essence the FOM is a tracking down-converter utilizing Teledyne's closed loop filter covering a ultra wideband frequency range. With a flexible IF Output, Locking range of ± 150 MHz and Military Temperature range, this subsystem would be a far more complex design if it were not for the Ferretac[®] (see page 107) unique to Teledyne Microwave.



FOM is a tracking downconverter utilizing Teledyne's closed loop filter

Commercial Converter Sub-Systems

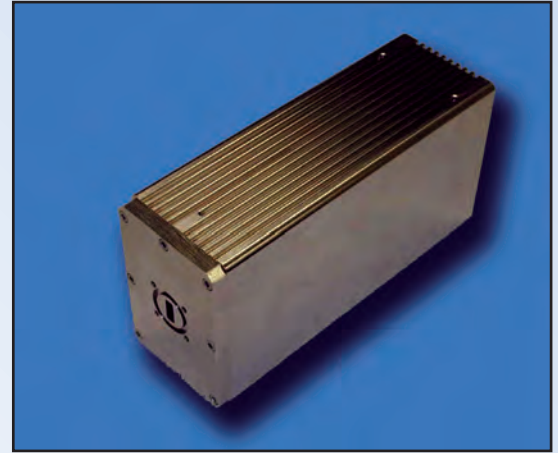
Ka-Band High Performance LNB

This LNB is a standard unit designed to meet requirements for a Ka-band low noise block-converter (LNB) with a typical noise figure of 1.4 dB. Its input is in the band 20.2 to 21.2 GHz range. The block-converter translates the signal to L-band in the 1-2 GHz range. The main elements of the block-converter are illustrated in the high level block diagram.

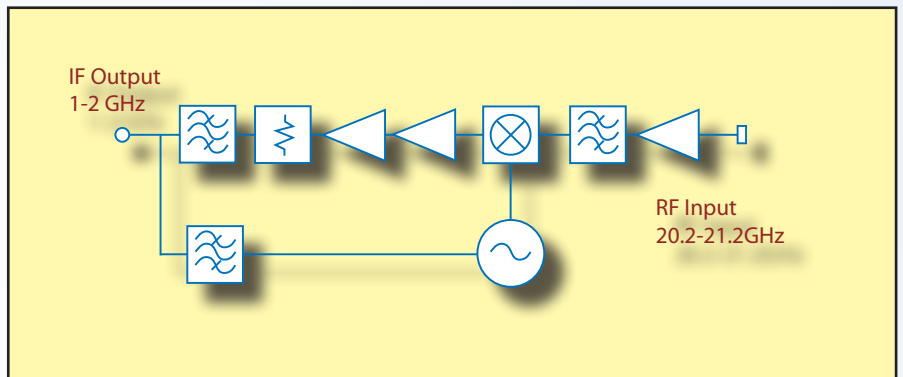
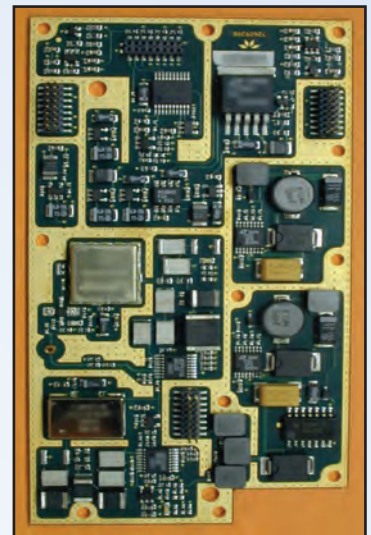
The input signal enters the unit through the WR-42 waveguide port. The first major element is an ultra-low-noise amplifier. The low noise amplifier is designed with extreme care, so as to present the minimum noise figure at the specified frequency. In addition, the design of the low noise amplifier is such to guarantee stability and the best input match. Finally, a special design assures that added insertion losses for the waveguide transition are minimized by selecting the proper materials and configuration so as to keep noise figure at a minimum. After the low noise amplifier, a filter inserted before the mixer is used to reject image frequencies and also improve rejection of LO leakage towards the input RF port. IF amplification and an adjustable attenuation bring the signal to appropriate level to achieve the nominal gain requirement. The signal exits the unit through the coaxial connector.

The N-Type connector also provides DC input to the unit, as well as, a 10 MHz reference signal input, which is used in the local oscillator phase locked loop.

Phase noise performance of the unit is -64 dBc / Hz @ 100 Hz Offset at 19.2 GHz.



Ka-band low noise block-converter (LNB) with a typical noise figure of 1.4 dB



The input signal enters the unit through the WR-42 waveguide port. The first major element is an ultra-low-noise amplifier. The low noise amplifier is designed with extreme care.



L-Band to Ka-Band Upconverter (BUC)

This product is designed to meet the growing market needs for an L-band to Ka-band upconverter. Its input is an L-band signal in the 1-2 GHz range. The upconverter translates the signal to Ka-band in the 30-31 GHz range. It maintains high quality signal integrity due to the low noise characteristics of its local oscillator and the linearity of the components used in the conversion, filtering and amplification processes.

The main elements of the upconverter are illustrated in the high level block diagram. The IF section includes amplification and attenuation for gain setting

and stability over temperature. After upconversion filtering is required to eliminate unwanted spurious mixing products and the LO signal.

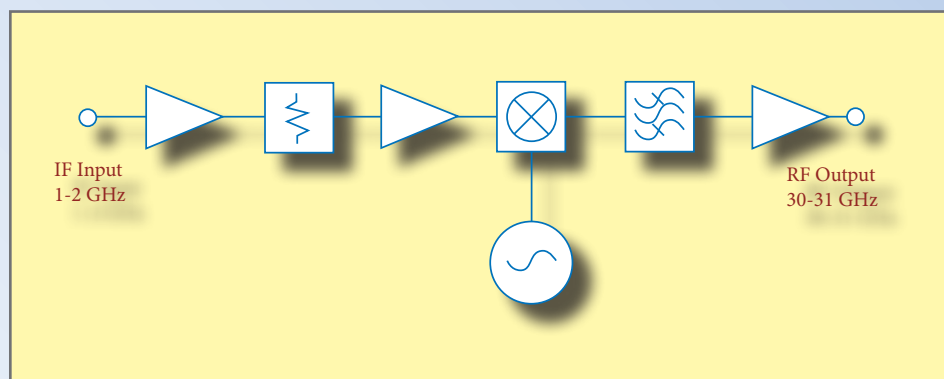
The local oscillator is a high performance phase locked oscillator, which is locked to the reference signal. Reference signal is multiplexed on input IF signal. The technology employed in the phase locked oscillator utilizes low noise VCO's followed by multiplication. The result is a mechanically robust unit which operates well over wide temperature ranges and serve environments.



With higher frequencies and more demands on performance, Teledyne Microwave is developing a number of new sub-systems specifically aimed at the COTS market.

Key Features

- ◆ L, S, C, X, Ku & Ka Bands available
- ◆ High Output Powers
- ◆ Superior Phase Noise Performance
- ◆ Severe Environments
- ◆ Short Design Cycle
- ◆ Low Cost Surface Mount Manufacturing
- ◆ Low Power Consumption
- ◆ Finite Analysis & 6 Sigma Design



The local oscillator is a high performance phase locked oscillator, which is locked to the reference signal.



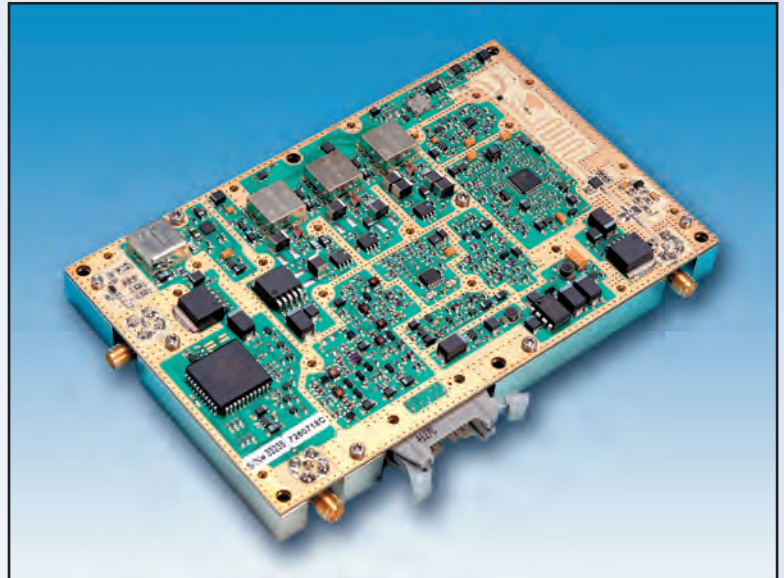
Commercial Synthesizers

9700 Series

Advanced Single Loop Frequency Synthesizer

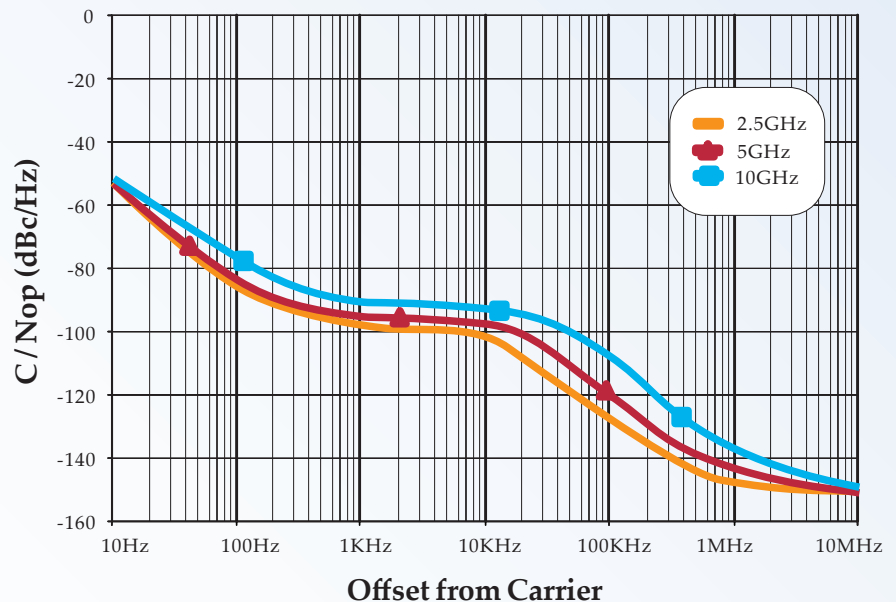
The Advanced Single Loop Frequency Synthesizer is another example of Teledyne Microwave's ability to incorporate unique technological features to create an exceptional design. This Synthesizer offers exceptional phase noise performance over bands covering from 700 MHz to 12.8 GHz with a maximum bandwidth of 25%. The novel design (patented) exhibits excellent microphonic performance with no phase hits. This very low cost design, incorporates a unique modular design enabling multiple component usage no matter what the output frequency or options adopted. The modular approach enables custom frequencies to be adopted easily, in most cases this requires only modifying the multiplier stage. The 9700 series unit comes with an optional fixed frequency oscillator. Wide input voltage range and selectable control protocol, enable this unit to be incorporated in any modern converter system with little modification to the supporting architecture.

Specific models have been designed to cover L, C, X, Ku & Ka-Band agile converter applications



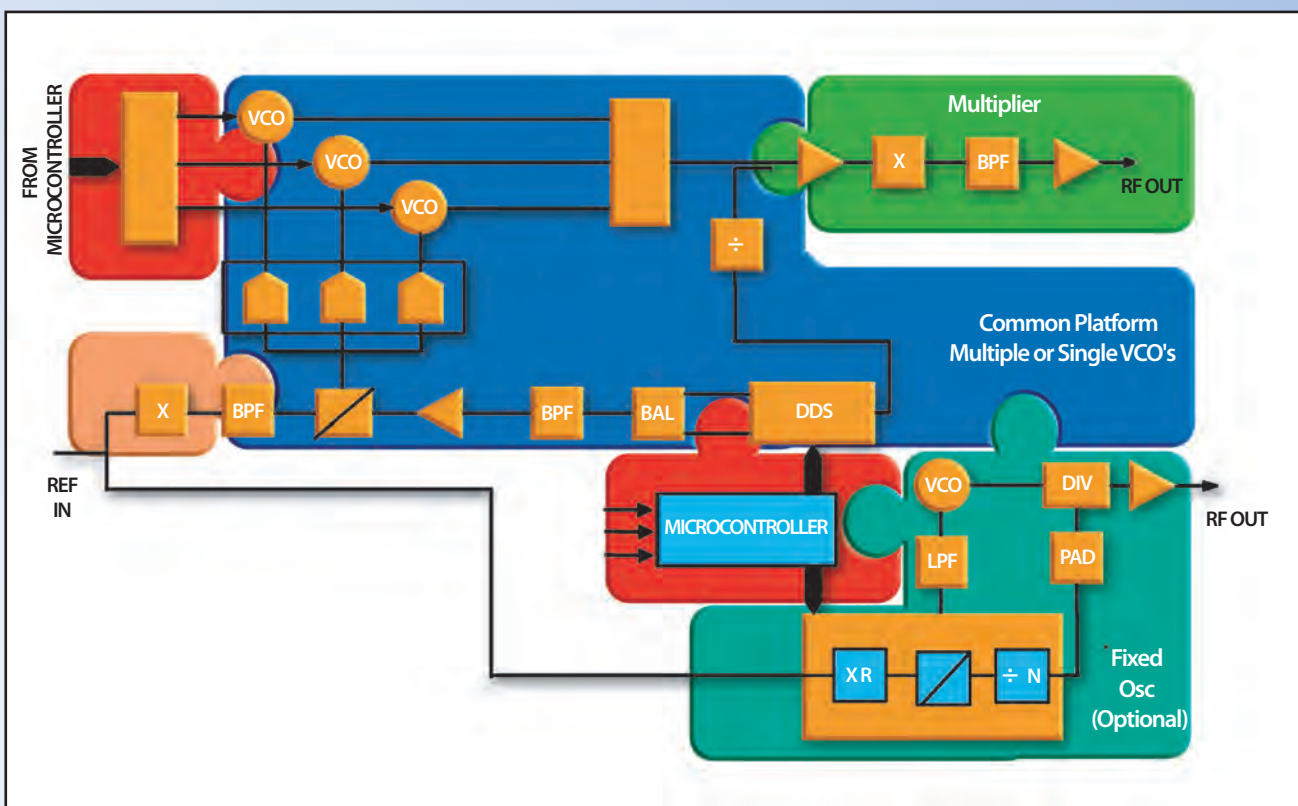
This Synthesizer offers exceptional phase noise performance over bands covering from 700 MHz to 12.8 GHz

TYPICAL PHASE NOISE PERFORMANCE



Key Features

- ◆ Very Low Phase Noise
- ◆ Excellent Microphonic Performance
- ◆ Programmable Step Size (1 KHz Standard)
- ◆ Any Reference Frequency from 5-100 MHz
- ◆ Wide Temperature Range
- ◆ Selectable Binary or BCD Control
- ◆ Optional Fixed Frequency Oscillator
- ◆ Custom Integrated Board Level Products Available



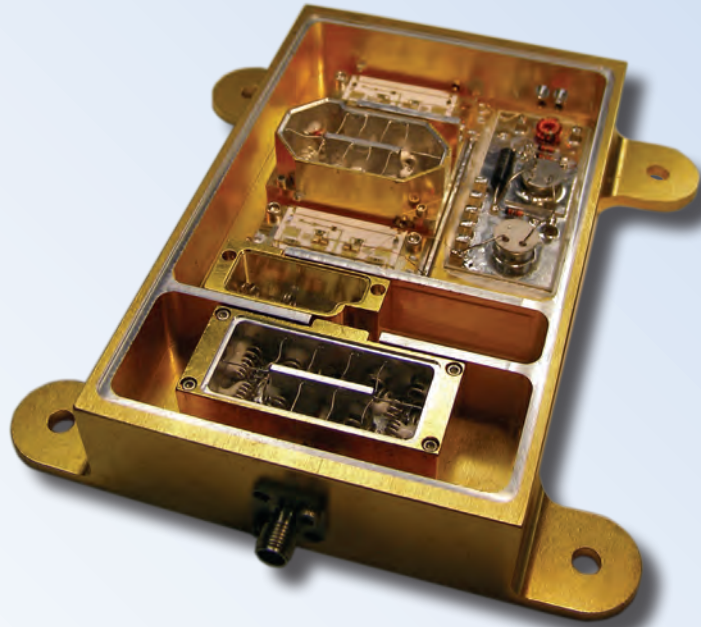
This very low cost design, incorporates a unique modular concept enabling multiple component usage no matter what the output frequency or options adopted.

Filter Sub-Systems

GPS PREAMPLIFIERS & LOW NOISE AMPLIFIERS

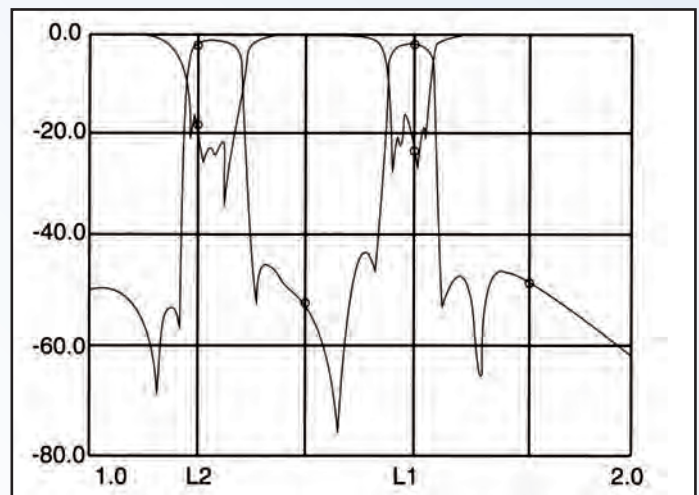
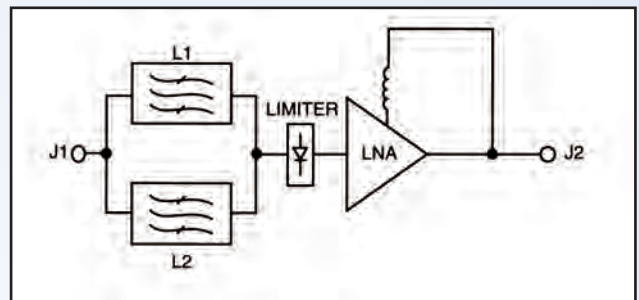
Teledyne KW Microwave has designs for almost thirty (30) GPS low-noise amplifiers and preamplifiers. Applications range from agricultural, railroad cars, ships, submarines, glide bombs, missiles, UAV's, rotary wing and fixed wing aircraft.

This particular GPS preamplifier is a state-of-the-art high performance preamplifier. It incorporates filtering with spurious free response up to 18 GHz, a low noise figure amplifier and a high power limiter. Plots 1 and 2 show the frequencies where superior, when combined with a receiver, rejection performance is obtained.



SPECIFICATIONS:

Gain:	14 ±2 dB
Noise Figure:	2.9 dB nom, 3.5 dB MAX @ 71 °C
Rejection:	40 dB min L1 or L2 ±100 MHz, 45 dB min to 20 GHz
Frequency Range:	GPS L1 & L2
L1, L2 differential group delay:	2nS max
D.C. Power:	+5v nom, +4.5v min, 30mA nom, 40mA max.
P1 dB:	+11 dBm min.
Temp range:	55 °C to +90 °C
VSWR:	Input/Output 1.5:1 max
RF Pwr. Max:	313 W peak, 10 μS pulse, .001 duty cycle, 1 W CW
Connectors:	SMA size - 3.50" x 1.56" x .50"



Plot 1 & 2 showing rejection characteristics.

Military Synthesizers

Multi-Function Frequency Synthesizer

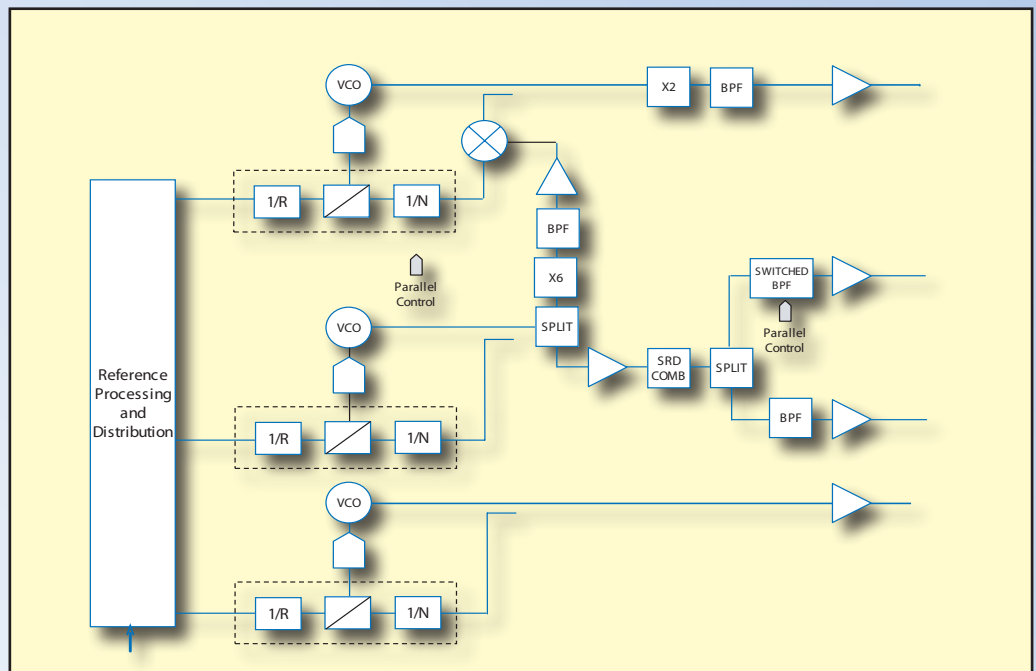
This particular sub-system shows a number of Teledyne Microwave's capabilities with integration of a number of standard and non-standard Microwave Modules. Each individual area is screened to ensure low spurs and intermods. With common use of amplifier modules, SRD's and thin film filters, this assembly truly shows Teledyne Microwave's capabilities in the Sub-system arena.

Key Features

- ◆ Fast Switching Programmable PLL (50 μ S) 0.5 MHz Steps
- ◆ Low Phase Noise (-105dBc/Hz @ 100 KHz) in X Band
- ◆ Comb Output 14 to 17 MHz
- ◆ Switch-able Output 8, 14 or 18 GHz
- ◆ Fixed output 2325 MHz



Sub-Systems



Commercial Point to Point Transceivers

Transceivers for Digital Radio

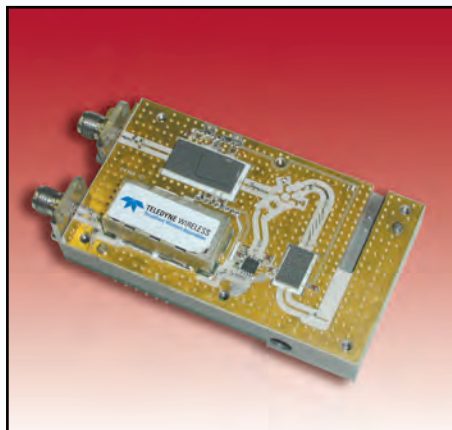
Teledyne's transceiver capability covers both point-to-point and point-to-multi-point applications. Transceiver designs are realized as fully integrated assemblies using a common platform architecture to cover the principal digital radio bands with a minimum number of designs.

The microwave/millimeterwave circuits feature extensive use of MMIC's with low cost, softboard interconnects where possible. High performance filters are fabricated using thin film techniques.

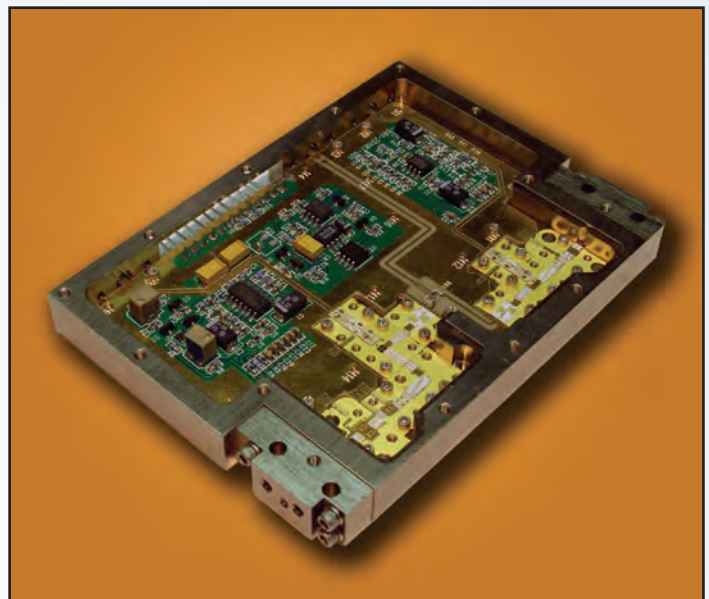
Our "design-to-spec" solutions incorporate innovative circuits developed using the latest modeling and simulation software. Our design team includes industry acknowledged experts in the design of Low Noise and Power Amplifiers, Frequency Synthesizers, Mixers and Control Components



Custom Designed Transceiver for Commercial Point to Point Digital radio



38 GHz Transceiver



23 GHz Transceiver with dual waveguide configuration



Key Features

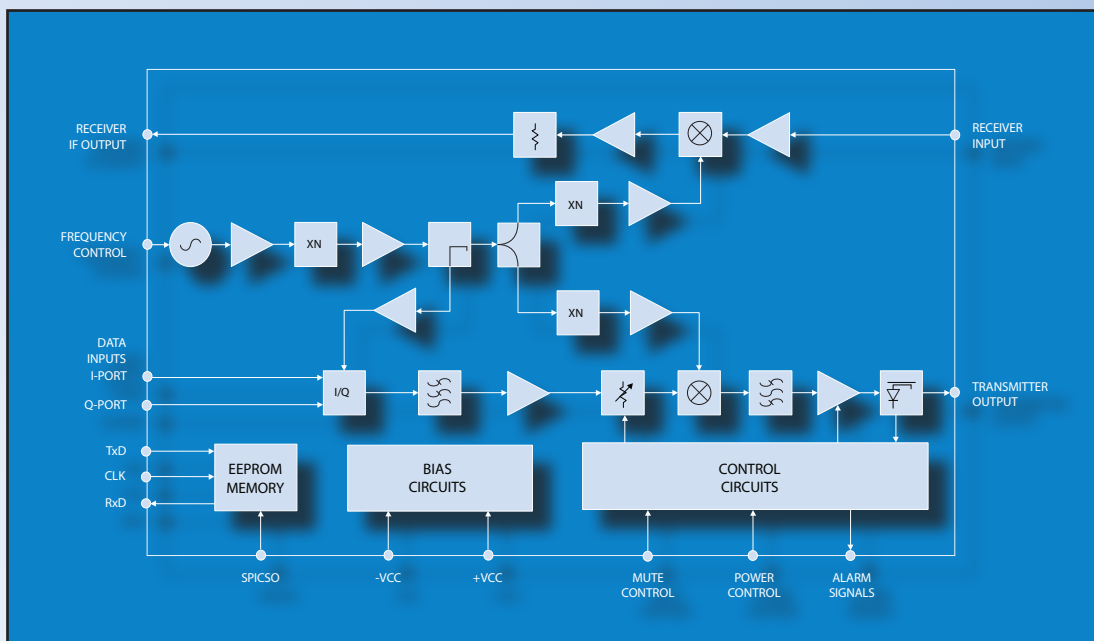
- ◆ Frequency Bands: 7 to 40 GHz
- ◆ Output Power: +25 dBm Typical
- ◆ Noise Figure: 3.5 dB Typical
- ◆ Superior RBER Performance
- ◆ Low Intermodulation Products: -35 dBc Typical
- ◆ Baseband Data Input
- ◆ Broadband IF Output
- ◆ Low Spurious: < 50 dBc
- ◆ DC Bias: +5 Volts Nominal @ 1.85 Amps DC Current
- ◆ Tx Power Control with Mute Capability
- ◆ EEPROM Data Storage
- ◆ Designed for FCC and ETSI Standards

Manufacturing

Our extensive experience with offshore manufacturing for both thin film and SMT technology means we can offer state of the art performance at very competitive prices.

Key to our success is running our pilot production concurrently with the offshore sites, ensuring a consistent communication stream. Our offshore partners get involved early at the product planning stage to ensure a common understanding of the design details in preparation for production.

Our production lines are set up using demand flow concepts with highly automated test equipment and effective use of statistical process controls. This ensures very efficient use of labor and equipment, producing highly reliable products. Another added benefit is the ability to re-configure our production lines to accommodate several different jobs at once. Additionally, our highly sophisticated MRP system and established supplier relationships mean we can react quickly to customer forecasts.



Typical configuration of a commercial Point to Point Transceiver





TELEDYNE MICROWAVE SOLUTIONS
Everywhereyoulook™



Teledyne Microwave Solutions designs and manufactures the most extensive line of hybrid amplifiers and signal processing components on the market today.

- Strong heritage of pushing the envelope of performance
- Flexibility to tune for application/customer specific requirements
- Unparalleled experience in the Hi-Rel arena

Prices subject to change without notice.

The Power of Consolidation  Cougar • Defence • LabTech • MEC • Microwave • Paradise Datacom

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