

TELEDYNE COUGAR

A Teledyne Technologies Company

PRODUCT DESIGN AND DEVELOPMENT

Cougar's engineers use modern software design tools to layout and analyze component and integrated assembly designs, fully analyzing all circuit parameters, including RF, DC, mechanical, and thermal characteristics. We build engineering samples to further characterize performance parameters over full operating conditions, and understand mechanical and manufacturing characteristics.

Amplifier Circuit Design

We design virtually all of our amplifiers for both excellent stability and cascadability. Gain flatness is maintained to typically ± 0.5 dB or better, which improves cascaded flatness. Each module has internal power supply decoupling to minimize power supply cross talk and fine-grain ripple. All BJT models use temperature compensating bias to reduce DC current drift to typically $\pm 0.3\%$ from -55°C to $+85^{\circ}\text{C}$ case temperatures. The nominal bias on the majority of the models is 15 volts, while others are designed to operate in the 5- to 8-volt range. In addition, most 15-volt models have options for internal wire bond changes that provide full output power capability and third order intercept performance when supplied with a 12-volt source. Cougar uses an ultra broadband circuit technique to extend the usable frequency limit down to 100 kHz on some models.



Cougar's individual circuit designs are flexible and designed for easy combining. For example, model AR2589 represents a method for cascading two stages of gain in a single TO-8B package, which provides +28.3 dBm output power and 20.5 dB gain over the 100 to 2500 MHz bandwidth. The model AS6043 (see Table I), also a two-stage unit, typically produces +15.5 dBm output power and 15 dB gain from 10 to 6000 MHz.

Microwave Amplifier Circuit Design

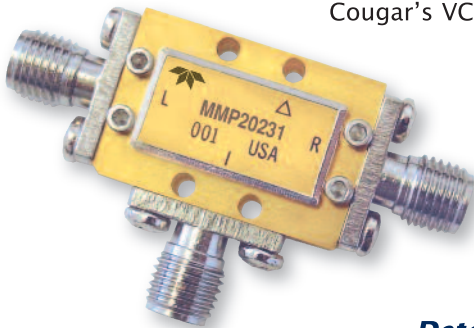
Each Cougar microwave amplifier is designed using Lange couplers to give a balanced amplifier design covering the 6 to 20 GHz frequency range. The nominal bias on the majority of the models is 12-volts, while others are designed to operate in the 5- to 8-volt range. One, two, or three stage designs are available to address most application requirements. Cougar uses our standard CougarPak® housings providing high performance capability in a connectorized, hermetically sealed package.

Power Amplifier Circuit Design

Cougar's power amplifiers (excess of 1 watt output) are targeted for a broad scope of applications and needs. We carefully select materials and processes to assure the highest reliability and quality while providing engineers superior RF performance options. For example, the 20 to 2500 MHz model A2CP2596 provides 24 dB gain at up to 6 watts saturated output power, and 3 watts P1dB power in a 2-stage CougarPak® (1.175 X 0.58 X 0.23 inches exclusive of SMA connectors). The output power stage operates at a nominal +28 V 500 mA, while the driver stage is biased at +15 volts and 360 mA. By using +15 volts on the driver stage Cougar's reduced total power dissipation. Input/Output VSWRs of this model are less than 2:1 across the band. Cougar continues expanding both our catalog and custom solutions for power applications in the commercial, military and space markets.

VCO Circuit Design

Cougar's uses silicon bipolar transistors and silicon varactor diodes in our VCO designs giving the best overall phase noise performance and lowest settling time. Oscillators covering 50 MHz to 9 GHz use a fundamental oscillator approach while oscillators covering the 9 to 20 GHz range use a doubling oscillator approach. Cougar's VCOs are designed to work over -55°C to $+85^{\circ}\text{C}$.



Mixer Circuit Design

Cougar's Mixer product line uses Schottky diodes and transformers in either double or triple balanced designs covering DC to 20 GHz. Cougar's Hi-Rel MixerPak is a seam-sealed hermetic package containing fired-in glass feed-thrus, eliminating any flux contamination for military or space applications. To make specifying mixers for military or space applications easier, Cougar has developed a screening flow based on MIL-DTL-28837. Cougar uses pre burned-in diodes in triple balanced designs rather than performing burn-in at the module level.

Detector Circuit Design

Cougar's designs incorporate either planar germanium tunnel diodes or silicon Schottky diodes with video amplifiers and comparators to provide analog or threshold detector functional blocks. The tunnel detector provides excellent temperature stability in a simple, unbiased configuration while the biased or unbiased Schottky designs are offered for the most demanding temperature environments. Precision video components offer low-level detection with low output offset voltage and drift and exhibit moderate pulse response times. High speed video models provide fast pulse response at generally lower dynamic range due to a higher offset and drift penalty. All designs focus on flat frequency response, low VSWR and good temperature stability in multiple package options.

Phase Noise

Whether the goal is improved subclutter visibility (SCV), increased signal-to-noise ratio (SNR), or reduced gap between the 1/f corner and the carrier, today's design engineers are increasingly more aware of component phase noise and its contribution to masking or clouding carrier signals. Engineers increasingly specify decreased component phase noise to achieve continually greater demands on system sensitivity.

Cougar's catalog components are designed to achieve the lowest possible phase noise. Initial design characterization now includes phase noise performance so design engineers can confidently select the correct components that meet all system requirements. For custom designs, Cougar selects circuits and elements to achieve specific phase noise requirements.

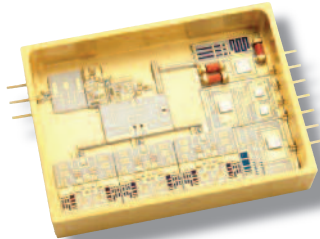
Many Cougar data sheets now include phase noise performance. And, Cougar's Sales and Applications Engineering can provide actual performance data on other components.

Deratings & Worst Case Circuit Analysis

Teledyne Cougar can perform Worst Case Circuit Analysis (WCCA) and Derating analysis on any of our Class K or Class H hybrid components or assemblies. A WCCA is performed using a combination of our non-linear microwave circuit analysis software and actual data measure from the components being analyzed. The WCCA will perform simulations to predict the worst case performance of the part during the mission life under various conditions including, but not limited to Beginning Of Life (BOL), End Of Life (EOL), aging effects, radiation effects, component variations, voltage and power supply variations and temperature effects to name a few. The WCCA will also include a thermal analysis, a loop stability analysis (if required) and the derating. Additional analysis can also be performed at the customer's request. We can also perform a derating analysis for any of our Class K or Class H components. Teledyne Cougar derating analysis is normally performed using MIL-STD-1547, but other derating standards, including customer specific standards, can be used to perform the analysis also. The derating analysis determines the stress (voltage, current, temperature, Power, etc) applied to all of the components in the hybrid in addition to providing a thermal analysis. Teledyne Cougar can analyze the thermal stress on the elements of the hybrid using either an empirically proven model or using complex 3 dimensional Finite Element Analysis software.

Substrate Fabrication

All substrates are manufactured using sputtered or plated thin-film gold metalization with a titanium-tungsten adhesion layer and tantalum nitride resistors, which provide top performance and low drift. We typically use as-fired Alumina, but some higher power applications require the thermal characteristics of polished or Tape-Cast BeO. We design resistor patterns to maintain power densities far below maximum ratings. By heat-treating the substrates, we can ensure long-term stability. The thin-film process provides precise geometries and precision RF alignment, which supports superior unit to unit matching and reduced lot to lot variation.



Low Noise Triple Band Voltage Controlled Oscillator

By integrating our own devices with other similar products, Cougar offers increased capabilities and value to its product line thereby saving customers time and money. We have experience integrating various functions into single hybrid modules or printed circuit board assemblies. Many of these assemblies have been designed for space or military applications. Examples include mixer-amps, switching-amps, selectable gain amps, IQ Demodulators, coupled detectors, multi-band VCO assemblies, up and down converters and more. To maximize performance and save on overall design space, contact our technical sales staff to discuss your block diagrams and Cougar's various available options. See the Integrated Assemblies Section for a broad sampling of Cougar's capabilities.

Integrated Subassemblies

Cougar continues expanding capabilities and engineering solutions to meet the changing needs of our customers as they outsource more integrated subassembly requirements. With the acquisition of Tindall Technologies, Cougar has access to additional basic building blocks for use in developing higher level assemblies. These blocks consist of Digitally Tuned Oscillator (DTO), Instantaneous Frequency Measurement receiver (IFM), and Frequency Locked Source (FLO) technology. Using these blocks, in addition to using digital processing, microprocessor control and digital signal analysis, Cougar has developed a number of higher level assemblies, for example:

- A Deception Jammer front-end covering the 2-18 GHz band in desired frequency blocks. This modular assembly provides the following features: Up and Down frequency conversion, signal identification, emitter priority, signal tracking, predictor gates and transmitter power management. It also prioritizes multiple deception devices (I.E., SOR and or DRFM).

Custom Integrated Assemblies

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Set-On-Receiver (SOR)

Wideband, fast frequency set-on for EW radar jamming.



Component Packaging

Cougar products are available in a variety of package types including the standard TO-8, the larger TO-8B, various SMA connectorized housings, several flatpacks, both the SMTO-8 and SMTO-8B surface mount packages, the 10-pin gullwing flatpack, and two Power Pack designs for optimum heat sinking. The CougarPak® is a standard hybrid package which we offer in a variety of sizes including versions for 20 GHz operation, and one for our mixer line up. We supply these with our standard SMA connectors but we can accommodate custom form-fit packaging needs including SMP connectors. We also offer a variety of packages styles and sizes for customer selected die including a unique 70 mil hermetic package.

Note: some products are only available in selected packages. For instance, the ACH107 and ARH356 amplifiers are only available in TO-8H and TO-8BH packages, respectively, where the “H” suffix indicates a taller TO can. Call our technical sales staff to discuss the various package options available.

SALES, MARKETING AND SERVICE

Technical Sales and Support

Cougar’s highly trained technical sales staff is prepared to discuss application issues in depth. If your application is still in development, our staff can help guide the design function to best meet your needs with minimum cost and quickest delivery. Where the overall quality and reliability requirements have been established only at the system level, Cougar can help translate these criteria to the appropriate device level. If your application specifications are already established, our staff can help guide you to the best solution of Cougar’s components or integrated assemblies that match your requirements.

While we encourage customer visits, local representation is available for those unable to visit our manufacturing and sales headquarters. Visit our web site for a complete listing by area.

Conversion of Customer Requirements

Accurately generating hardware and services that meet or exceed customer expectations separates Cougar from the competition. To ensure that our customers’ expectations are fully satisfied, Cougar’s Technology Review Board helps convert drawings and specifications into travelers, test sheets and manufacturing specifications. By implementing a thorough review and follow-up system we address every option our customers may require. All complex purchase orders run through this group for review and implementation.

Detailed Data Sheets

Individual data sheets are available for most of the components listed in this product guide and are included on our web site. The data sheets contain detailed guaranteed temperature specifications; performance curves, automatic test data, absolute maximum ratings (such as continuous input power, storage temperature, and burn-in temperature), and package outline drawings. Note that the data points listed in this product guide are values indicating a specific frequency point in most cases. Consequently, the data sheet performance curves provide more datapoints across the band. Shortly following the introduction of new models, Cougar provides data sheets to quickly supplement customer needs. Visit our web site to download the most current edition of our data sheets.

PRODUCTION OPERATIONS

Quality Management Program

Cougar’s quality management system is certified by the Defense Supply Center, Columbus (DSCC) to MIL-PRF-38534, Classes H and K, Technology Review Board (TRB) Option, ISO 9001-2000 and AS9100. We remain one of very few companies worldwide certified to the TRB Option for Class K. Our Class K customers are welcome to join DSCC in these bi-annual audits.

Cougar has a complete in-house documentation and training system as required per MIL-PRF-38534 for design, workmanship and quality assurance activities and specifications. Each of our functional areas including manufacturing, test, materials, quality assurance, process engineering, procurement, document control, sales, mechanical and electrical design engineering have documented procedures in our Quality Management Portfolio that are readily available throughout the facility. We conduct internal audits and personnel training periodically to ensure continued compliance.

Technology Review Board

Our TRB is a cross-functional team of senior staff members from all the technical disciplines, led by Cougar’s Quality Assurance Manager. Cougar’s TRB directs the implementation of our Quality Management Program and makes broad decisions affecting quality and performance for the entire manufacturing operation. These decisions are not geared for the short-term but are by definition meant to guide the operation through long-term process stability and high performance capability. See our TRB report later in this section for more details.

Program Management

We can offer customers dedicated project coordination for the program's duration. This ability is particularly useful for space or integrated assembly jobs requiring special documentation, source inspections, design reviews, milestone schedules and other types of support. A cross-functional team assists the program manager's and coordinator's until the customer is completely satisfied with the product and service. The teams are staffed by people from quality assurance, manufacturing, test, materials, procurement, and document control. Other functional areas are pulled into the loop as required.

Material Procurement and Logistics

We conduct all procurement activities using lot traceability and specification control as primary objectives. In an effort to manufacture products that perform consistently, we have always rejected the notion that low bid alone wins our business. Instead we select suppliers based upon their success in delivering high performance and highly reliable products while providing unparalleled service. Once we select a supplier, our procurement staff works to build strong relationships, strengthening Cougar's overall delivery and quality performance levels.

Using both on-site and desktop audits and a world class rating system, our Supplier Assessment Program governs all procurement activity including qualification and performance ratings. Suppliers are reviewed semi-annually for key performance metrics including quality, on-time delivery and customer service and we award bonus points for "wow" performance where a supplier has gone above and beyond the call. Score cards are shared with each supplier and our procurement office works together with them to continuously improve performance.

Cougar uses a client-server based MRP system on the Windows® platform to aid the planning and control of the entire production flow. There are many advantages of MRP in our manufacturing setting such as capacity and time-phased material planning. Ideal for both large and small production runs, our system allows us to produce kit quantities of less than 10 or greater than 100 for maximum flexibility.

Our production control staff is located in Sunnyvale and handles production requirements in our facilities and CM's around the world with supreme accuracy. Our production planning staff works closely with customer service personnel to support customer delivery inquiries and status updates. Complete and timely production information is only a quick phone call or e-mail away. Our delivery goal is 100% on time.

Manufacturing

All hybrid assembly procedures and materials are specified to meet or exceed manufacturing and screening requirements similar to MIL-PRF-38534 for military or space applications. Alumina or BeO substrates are brazed to gold plated hybrid packages using either gold-tin or gold-germanium preforms for good thermal characteristics and mechanical integrity. Substrate attach is performed using a proprietary process developed by Cougar's process engineering group. We also attach passive and active devices using a eutectic or epoxy attachment depending on the thermal requirements. We then bond all inter-connects with gold thermocompression or thermosonic wedge or gold thermosonic ball bond wires. We employ both manual and automatic wirebonding machines. All circuits receive argon plasma cleaning prior to wirebond operations. Using assembly and circuit alignment procedures, we can consistently control performance parameters. This approach ensures the highest level of electrical compliance from prototype to full-scale production. Finally, we hermetically seal each device in a dry nitrogen atmosphere (adding helium for Class K modules) to ensure minimum moisture content.

Printed circuit board assemblies are built with through-hole, surface mount technology (SMT) or a combination of the two. Our processes and materials are specified to meet or exceed manufacturing and inspection requirements similar to J-STD-001. This compliance is an important part of our manufacturing capabilities as many integrated assemblies we produce are based on printed circuit board designs in connectorized packages or as stand-alone circuit cards.

Test and Measurement

We have automated all appropriate electrical test functions in our test labs using HPVee ATE software written for the Windows® environment. We can perform highly complex tests over a wide temperature range, -55° to +125° Celsius, as well as -24 to +32 volts, and DC to 40 GHz for many tests. ATE equipment includes Network, Scaler and Spectrum Analyzers; Noise, Power and Digital Volt Meters; Synthesizers; Signal Generators; Phase Noise Test Sets and others.

The increased flexibility and productivity the software provides allows us to customize testing for specific customer requirements. We can also use this automation for matching, statistical analysis, and other labor-intensive tasks, as required.

Production Environment

Our 15,000 square feet of production space is maintained well below Class 100,000, 0.5 micron particles per million (Class 100 for space level modules), and between 30% and 65% relative humidity. We have ESD controls in place to meet or exceed the intent of MIL-STD-1686, including a complete network of earth-to-ground rods and wrist straps, which are tested regularly. We store raw material and work-in-process components in nitrogen back-filled desiccators to minimize oxidation and other storage related problems. And finally, our facilities offer a lean layout for manufacturing flow - including greater visibility and reduction of production bottlenecks - thereby increasing productivity and capacity.

Process Development and Control

Cougar has implemented one of the most current process development tools available – Design of Experiments (DOE). The benefits of thoroughly characterized processes are many, including high capability and low variability. Our policy is to couple the front-end DOE work with Statistical Process Control (SPC) at the back-end where practical. We currently control all wirebonding processes – including manual wedge, ball and ribbon – and automatic wedge and ball bonding with SPC. We also control all gap welding processes and our lab particle count processes statistically. We expand the use of SPC to other key processes as required. Finally, our SPC program feeds our Continuous Quality Improvement (CQI) program with useful data for further improvements in process performance, thus closing the process improvement loop. Tightening process control limits through variation reduction simply means fewer defective parts per million – the objective behind statistical analysis.

Other process controls include our equipment calibration and maintenance programs. We calibrate all required manufacturing and test equipment per MIL-STD-45622 and maintain records for easy review upon request. Preventive maintenance on all types of equipment is conducted regularly and thoroughly to ensure minimal downtime during critical production builds.

We also perform what we call in-line process verification (IPV) at various steps for Hi Rel hybrid fabrication. Some of these steps included bond pull and die shear on a sample of the production lot. Other IPV steps include in-line x-ray, resistance to solvents and RGA or residual gas analysis.

Process control at Cougar also has a human element. Cougar's highly qualified personnel provide the necessary infrastructure to support production requirements from high-end commercial applications to Hi Rel programs requiring vigorous screening and qualification testing. To ensure we have qualified employees, we formally train each employee to exceed the requirements of their respective processes. Because our staff is responsible for much of our process control and improvement, we go to great lengths to teach them and listen to their improvement ideas. The result is superior process control and manufacturing productivity.

CONTINUOUS IMPROVEMENT AND LEAN PRODUCTION

With Quality as a key ingredient to Cougar's success, the company has long maintained continuous quality improvement (CQI) through its CQI Program. Our CQI teams employ several tools to ensure improvements in quality and to the company's processes, including Kaizen, Kan Ban, 5S, Value Stream Mapping, SPC, and DOE, among others.

Each employee at Cougar is allowed the freedom to vigorously attack areas in need of improvement throughout their day-to-day business. Cougar employees understand continuous improvement to mean continuously searching for improvement in all processes of the company from product development to shipping. And every Cougar employee is involved in the continual improvement of manufacturing and business processes to meet our overriding objective – Quality · Performance · On Time.

Our continuous improvement effort is primarily based on the principles of the late Dr. W. Edwards Deming and many of his quality engineering colleagues, though we adapt the latest improvement tools including those uniquely related to Lean including 5S and value stream mapping.

Again, we use the matrix team approach to attain insights and expertise from a variety of perspectives to solve tough problems. Our goal is to achieve the highest levels of quality and reliability. In many companies barriers form between departments, inhibiting the flow of information and process improvement. At Cougar we strive to eliminate these barriers through communication and awareness. Information flows freely for quick response to customer demands. Our continuous improvement efforts take full advantage of these built-in information paths for real-time improvements.

The continuous improvement and lean production program enables Cougar to increase capacity by eliminating non-value added activities throughout the production process, from order entry to production to test to shipment. The program also results in better communications with our customers and suppliers, reduced cycle times, increased capacity, and ultimate competitiveness in the market.

Formal CQI projects are documented in a standard format and kept on file (both hard copy and electronic) in accordance with records management standards. These records serve as references for future CQI teams and are available for customer review.