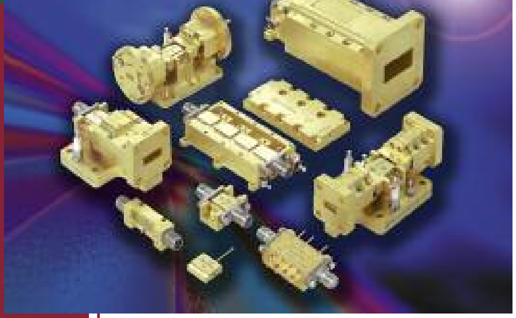
MITEQ AMPLIFIER SPECIFICATION DEFINITIONS

BIPOLAR AMPLIFIERS

General Specifications
- Operating Frequency Range
- Gain
- Gain Flatness
- Noise Figure
- Output Power at 1 dB Compression
- Input and Output VSWR
- Supply Voltage and Current Consumption

Addition Specifications
- Gain Variation vs. Temperature
- Overall Gain Window
- Intercept Point
- Dynamic Range
- Harmonic Suppression
- Reverse Isolation
- Phase and Amplitude Matching and Tracking
- Phase Linearity
- Recovery from Saturation



GaAs FET AMPLIFIERS

General Specifications
- Operating Frequency Range
- Output Power at 1 dB compression
- Gain
- Gain Flatness
- Noise Figure
- Input and Output VSWR
- DC Supply Voltage and Current Consumption

Addition Specifications
- Gain Variation vs. Temperature
- Overall Gain Window
- Intercept Point
- Dynamic Range
- Harmonic Suppression
- Reverse Isolation
- Phase and Amplitude Matching and Tracking
- Phase Linearity
- Recovery from Saturation

Thermal Considerations
- Gain
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- Heatsinking
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- Typical GaAs FET Specifications
- Typical Thermal Conductive Epoxies

Quality Assurance

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BIPOLAR SPECIFICATION DEFINITIONS

GENERAL SPECIFICATIONS

All models described in this catalog are classified by several specifications, namely:

- Operating Frequency Range
- Gain
- Gain Flatness
- Noise Figure
- Output Power at 1 dB Compression
- Input and Output VSWR
- DC Supply Voltage and Current Consumption

The following notes give detailed definitions to these and additional specifications which may relate to your system requirements.

OPERATING FREQUENCY RANGE

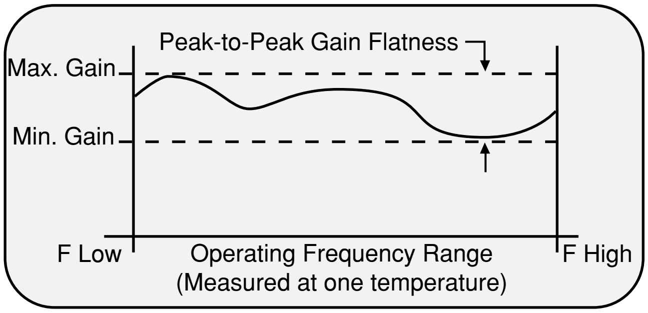
The operating frequency range is the range of frequencies over which the amplifier will meet or exceed the specification parameters. The amplifier may perform beyond this frequency range.

GAIN

Gain is defined as the ratio of the power measured at the output of an amplifier to the power provided to the input port. It is usually expressed in decibels and is typically measured in a swept fashion across the operating frequency range. The gain of all amplifiers is verified by a swept measurement before shipment from MITEQ.

GAIN FLATNESS

Gain flatness describes the variation in an amplifier's gain over the operating frequency range at any fixed temperature within the operating temperature range. As such, it does not include the variation of gain as a function of temperature (see Gain Variation vs. Temperature).



The gain flatness of an amplifier is measured by viewing the swept gain and determining the difference between the minimum gain and the maximum gain recorded over the operating frequency range. Unless the amplifier is specified to operate over a defined temperature range, this measurement is performed at room ambient temperature (+23°C). If a range of temperatures is specified, the measurement must also be verified at the temperature extremes.

NOISE FIGURE

Noise figure is classically defined as:

$$\text{Noise Figure} = \frac{S_i/N_i}{S_o/N_o} = \frac{\text{Signal-to-noise ratio at the amplifier input}}{\text{Signal-to-noise ratio at the amplifier output}}$$

Since all realistic amplifiers add thermal noise, the signal-to-noise ratio at the output will be degraded; therefore, noise figure will be a ratio greater than one, or when expressed in decibels, a positive number ($NF_{dB} = 10 \log_{10}(NF_{Ratio})$). The additive noise of an amplifier can also be expressed in a parameter referred to as noise temperature. In this approach, the noise temperature of the amplifier is equal to the temperature (in degrees Kelvin) of a 50 Ω termination at the input of an ideal noiseless amplifier with the same gain and generating the same output noise power.

The relationship between noise figure and noise temperature is:

$$\text{Noise Figure} = 10 \text{ Log}_{10} \left\{ \frac{\text{Noise Temperature (Kelvin)}}{\text{290 Kelvin}} + 1 \right\}$$

Noise figure data is measured at discrete frequencies throughout the band at +23°C unless specified otherwise.

OUTPUT POWER AT 1 dB COMPRESSION

The 1 dB output compression point of an amplifier is simply defined as the output power level at which the gain deviates from the small signal gain by 1 dB.

All active components have a linear dynamic range. This is the range over which the output power varies linearly with respect to the input power. As the output power increases to near its maximum capability, the device will begin to saturate. The point at which the saturation effects are 1 dB from linear is defined as the 1 dB compression point. Because of the nonlinear relation between the input and output power at this point, the following relationship holds:

$$P_{out} \text{ 1 dB} = P_{in} \text{ 1 dB} + \text{Linear Gain} - \text{1 dB}$$

BIPOLARSPECIFICATION DEFINITIONS (CONT.)

INPUT AND OUTPUT VSWR

Most RF and microwave systems are designed around a 50 Ω impedance system. An amplifier's impedance is designed to be as close as possible to 50 Ω; however, this is not always possible, especially when attempting to simultaneously achieve a good noise figure. The VSWR of an amplifier is a measure of an amplifier's actual impedance (Z) with respect to the desired impedance (Z_o) in most cases 50 Ω.

The VSWR is derived from the reflection coefficient ρ, where ρ is a ratio of the normalized impedance:

$$\rho = \frac{Z - Zo}{Z + Zo}$$

and:

$$VSWR = \frac{1 + |\rho|}{1 - |\rho|}$$

VSWR is "measured" with either a scalar or vector network analyzer by analyzing the incident power and the reflected power at both ports of the device to determine the reflection coefficients which in turn are converted and displayed as VSWR. The ratio of the reflected power to the incident power is also known as the return loss.

SUPPLY VOLTAGE AND CURRENT CONSUMPTION

All standard models are internally voltage regulated. Most amplifiers are specified for +15 V operation but may be safely operated at +30 V. Many models employ an internal 8-volt regulator, permitting operation over a range of +11 to +30 V. Operation above +15 V may require a heatsink for some medium power amplifiers. All models are reverse voltage protected. The use of a regulator allows normal operation even in the presence of power supply variations, as long as the minimum voltage is above the drop-out voltage of the regulator plus the 0.7 V drop across the reverse polarity protection diode. An amplifier with an internal 8-volt regulator requires a minimum voltage of about +10.7 V. Please ask about your specific model.

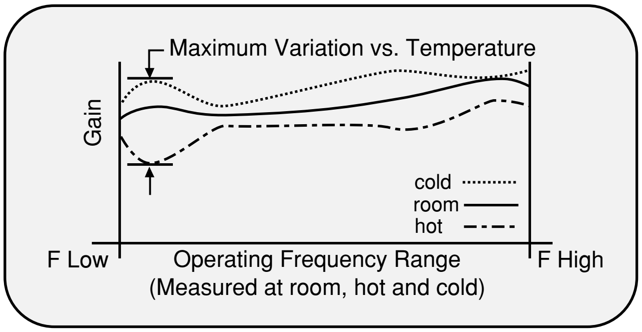
ADDITIONAL SPECIFICATIONS

In addition to the electrical specifications included for most of the models within this catalog, there are additional specifications which are useful to the engineer designing around stringent system requirements:

- Gain Variation vs. Temperature
- Overall Gain Window
- Intercept Point
- Dynamic Range
- Harmonic Suppression
- Reverse Isolation
- Phase and Amplitude Matching and Tracking
- Phase Linearity
- Recovery from Saturation

GAIN VARIATION VS. TEMPERATURE

Gain variation versus temperature defines the maximum allowable variation of the linear gain due to temperature at any discrete frequency. As a result, this parameter does not account for drift over frequency.

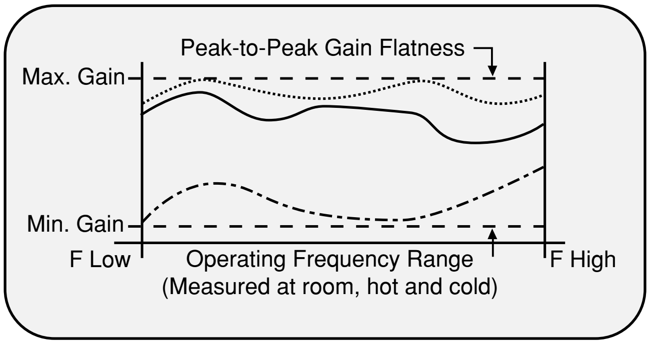


Gain variation versus temperature is measured by performing swept gain measurements at the specified temperature extremes and comparing the deviations between the two sweeps at each frequency to determine the greatest change. When a ± value is used, then the delta is taken at both temperature extremes with respect to room temperature (+23°C).

BIPOLAR SPECIFICATION DEFINITIONS (CONT.)

OVERALL GAIN WINDOW

An overall gain window specification defines the absolute minimum and maximum gain values over both temperature and frequency.



It is the most complete way to specify an amplifier; however, it also impacts the price due to the additional testing and alignment required from adding this constraining parameter.

INTERCEPT POINT

Solid state amplifiers use transistors, either bipolar or field effect, to provide gain. Although these transistors are generally used in a linear mode (except in the case of other than a Class A amplifier), they still exhibit nonlinear phenomenon, such as intermodulation effects and harmonic generation. These effects are evident in spurious products present at the output. In the case of the single-tone condition, the spurious signals are the harmonics of the fundamental input signal. In the case of the two-tone condition, the spurious signals are a mixing product of two input signals at the frequencies f_1 and the other at f_2. The most commonly discussed being the second order and the third order two-tone spurs.

Second order two-tone spurs are the sum and difference product of the fundamental input frequencies, i.e.;

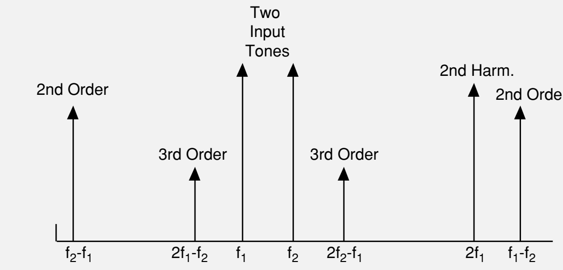
$$f_{SPUR} = f_1 \pm f_2$$

These spurious signals are only of concern when the band is greater than one octave. If the frequency range is less than one octave, the two-tone second order spurs will be out of band.

These spurious signals are characterized with respect to the input signal by means of a theoretical tool called an intercept point. These points are defined as the point where the linear curve of input vs. output power of the fundamental would intersect with the linear curve of the spurious signal if saturation effects would not limit the output levels of these signals. Since it is known that the second order spurious products have a slope of 2:1 with respect to the fundamental input power, the value of the spurs can be estimated if the input signal power (P_{IN}) and the output second order intercept point (OIP_2) are known. The relationship is as follows:

$$\text{Two-Tone Second Order Spurious Suppression} = OIP_2 - (P_{IN} + G)$$

$$\text{Two-Tone Second Order Spurious Level} = 2\,(P_{IN} + G) - OIP_2$$



Intermodulation Spurious Frequency Spectrum

Third order spurious products result from combinations of the fundamental signal and the second harmonics.

$$f_{SPUR} = |2f_1 \pm f_2| \pm |f_1 \pm 2f_2|$$

The slope of the third order spurious signals is 3:1 with respect to the fundamental input power, and again the value of the spurs can be estimated if the input signal power (P_{IN}) and the output third order intercept point (OIP_3) are known. The relationship is as follows:

$$\text{Two-Tone Third Order Spurious Suppression} = 2\,\{OIP_3 - (P_{IN} + G)\}$$

$$\text{Two-Tone Third Order Spurious Level} = 3\,(P_{IN} + G) - 2\,OIP_3$$

DYNAMIC RANGE

Dynamic range can be defined in several ways. The two classical approaches are to define the linear dynamic range, and the second being the spurious free dynamic range.

The linear dynamic range defines the difference between the minimum detectable signal (MDS), referred to the input of the amplifier or receiver and the maximum signal level at which the amplifier remains linear. This is typically defined by the input 1 dB compression point (P_{IN} 1 dB). The minimum detectable signal is defined by system constraints such as noise figure, bandwidth, and predetection signal-to-noise ratio.

Spurious free dynamic range is defined as the difference between the minimum detectable signal and the point at which the intermodulation signals generated from two equal tones would either equal this MDS or some other acceptable level.

REVERSE ISOLATION

Reverse isolation of an amplifier simply defines the isolation between the input and output of an amplifier. It is tested by injecting a signal to the output port and measuring its level at the input.

PHASE LINEARITY

A phase of a signal versus frequency will be distorted due to the nonlinear phase elements within the amplifier. This distortion is called phase linearity and is measured by means of a vector network analyzer across the operating frequency range.

PHASE MATCHING

Phase matching in the strict sense is defined as the difference in insertion phase between any two units. This parameter is usually defined across the operating frequency band; however, in some cases it is defined over frequency segments (ΔF) within the overall operating band. In the case of the definition over the entire band, the insertion phase is measured by means of a vector network analyzer, stepped across the band. The values at each frequency for two amplifiers are subtracted to provide a delta plot across frequency. Since each system has its own peculiarities, there are a wide variety of variations of this definition. Therefore, if your system requirements are such that this definition does not accurately meet your needs, or if this level of definition exceeds your real need and results in higher cost, you should contact MITEQ's engineering staff to discuss the most cost effective options.

PHASE TRACKING

Phase tracking is very similar to phase matching. However, in the case of phase tracking, an arbitrary fixed offset is removed that can usually be compensated in system software. The offset, sometimes referred to as the DC component (because all that remains is the phase versus frequency ripple and slope), is calculated at each temperature based upon an average over the band. As with phase matching, there are many variations on this theme that also should be discussed with MITEQ's engineering before committing to a final specification.

AMPLITUDE MATCHING

Same as phase matching, except substitute gain for phase.

AMPLITUDE TRACKING

Same as phase tracking, except substitute gain for phase.

AM TO PM CONVERSION

This specification parameter defines the change in phase at any fixed frequency across the operating band with respect to input signal power. It is usually defined in terms of degrees per dB (°/dB) over a specified input dynamic range. Most GaAs FET amplifiers exhibit well-behaved AM/PM conversion (less than 1°/dB) up to the 1 dB compression point. Beyond that level of input power, the variation can be quite large, depending mainly on the devices and biasing conditions used.

PULSE CONDITIONS

A variety of pulse conditions can be specified on an amplifier, including amplitude or phase overshoot and ringing, amplitude or phase settling time, recovery time, etc. As with the matching and tracking specifications, they are typically system dependent and rarely fall into a standard definition. Therefore, it is best to contact MITEQ's engineering staff when attempting to define the operation of an amplifier in the presence of pulsed signals.

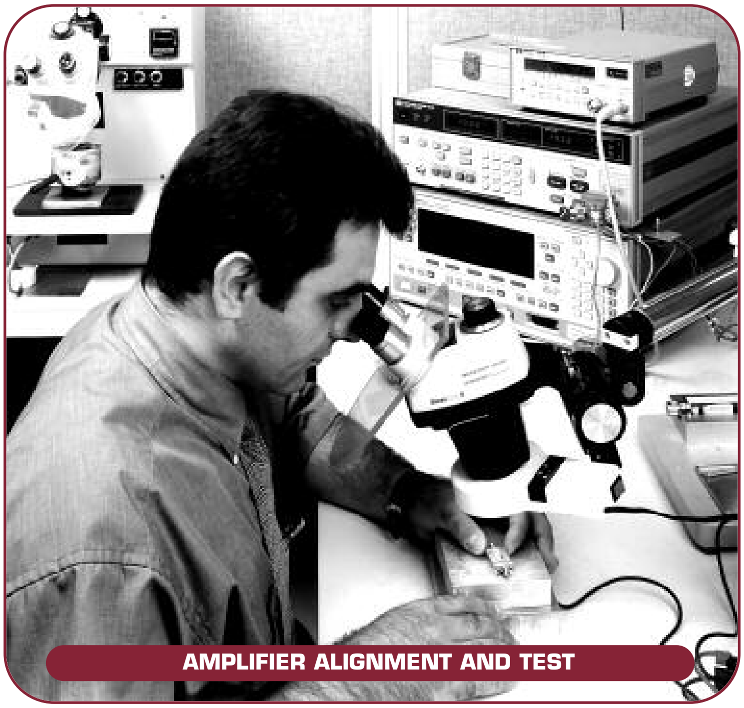
GaAS FET AMPLIFIER SPECIFICATION DEFINITIONS

GENERAL SPECIFICATIONS

Most models defined within this catalog are classified by several specifications, namely:

- Operating frequency range
- Output power at 1 dB compression
- Gain
- Gain flatness
- Noise figure
- Input and output VSWR
- DC supply voltage and current consumption

Most of the specifications for the MITEQ amplifiers listed in this catalog are based on operation at normal room ambient conditions of 23°C. For amplifier requirements at other temperatures and environments, please consult the factory or your local representative.



AMPLIFIER ALIGNMENT AND TEST

OPERATING FREQUENCY RANGE

The operating frequency range is the range of frequencies over which the amplifier will meet or exceed the specification parameters. The amplifier may perform beyond this frequency range, and in cases where the amplifier is specified over less than an octave, the actual frequency response may be significantly greater than the specified operating frequency range.

PLEASE NOTE: If an engineer is interested in limiting the response beyond the specified operating frequency range, this should be defined as a separate specification item. In this case, MITEQ can usually incorporate band limiting elements to meet the desired response.

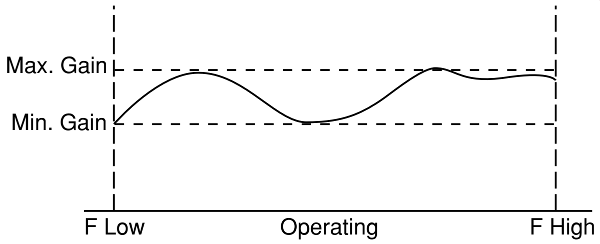
GAIN

Gain is defined as the ratio of the power measured at the output of an amplifier to the power provided to the input port. It is usually expressed in decibels and is typically measured in a swept fashion across the operating frequency range. Unless specified, 100% test data supplied by MITEQ will include gain data taken at several points within the band; however, in all cases, the amplifier gain has been measured in a swept fashion with performance verified over the entire frequency band.

GAIN FLATNESS

Gain flatness describes the variation in an amplifier's gain over the operating frequency range at any fixed temperature within the operating temperature range. As such, it does not include the variation of gain as a function of temperature (see Gain Variation vs. Temperature).

The gain flatness of an amplifier is measured by viewing the swept gain and determining the difference between the minimum gain and the maximum gain recorded over the operating frequency range. Unless the amplifier is specified to operate over a defined temperature range, this measurement is performed at room ambient temperature (23°C). If a range of temperatures is specified, the measurement must also be verified at the temperature extremes.



GAIN FLATNESS = $\pm \dfrac{\text{(Max. Gain - Min. Gain)}}{2}$

NOISE FIGURE

Noise figure is classically defined as:

$$\text{Noise figure} = \frac{S_i/N_i}{S_o/N_o} = \frac{\text{Signal-to-noise ratio at the amplifier input}}{\text{Signal-to-noise ratio at the amplifier output}}$$

GaAS FET AMPLIFIER SPECIFICATION DEFINITIONS

Since all amplifiers add thermal noise, the signal-to-noise ratio at the output will be degraded. Therefore, the noise figure will be a ratio greater than one, or when expressed in decibels, a positive number i.e. NF dB = 10 Log_{10} (NF Ratio). The additive noise of an amplifier can also be expressed in a parameter referred to as noise temperature. In this approach, the noise temperature of the amplifier is equal to the temperature (in Kelvin) of a 50 ohm termination at the input of an ideal noiseless amplifier with the same gain and generating the same output noise power.

The relationship between noise figure and noise temperature is :

$$\text{Noise Figure} = 10\ \text{Log}_{10} \left\{ \frac{\text{Noise Temp. (K)}}{290\ \text{K}} + 1 \right\}$$

Noise figure data is measured at discrete frequencies throughout the band. Test data is supplied at +23°C unless specified otherwise.

OUTPUT POWER AT 1 dB COMPRESSION

The 1 dB output compression point of an amplifier is simply defined as the output power level at which the gain drops 1 dB below the small signal.

All active components have a linear dynamic range. This is the range over which the output power varies linearly with respect to the input power. As the output power increases to near its maximum, the device will begin to saturate. The point at which the saturation effects are 1 dB from linear is defined as the 1 dB compression point. Because of the nonlinear relation between the input and output power at this point, the following relationship holds:

$$P_{out}\ 1\ \text{dB} = P_{IN}\ 1\ \text{dB} + \text{Linear Gain} - 1\ \text{dB}$$

INPUT AND OUTPUT VSWR

Most RF and microwave systems are designed around a 50 ohm impedance system. An amplifier's impedance is designed to be as close as possible to 50 ohms; however, this is not always possible, especially when attempting to simultaneously achieve a good noise figure. The Voltage Standing Wave Radio (VSWR) of an amplifier is a measure of an amplifier's actual impedance (Z) with respect to the desired impedance (Zo), in most cases 50 ohms.

The VSWR is derived from the reflection coefficient Γ, where Γ is a ratio of the normalized impedance:

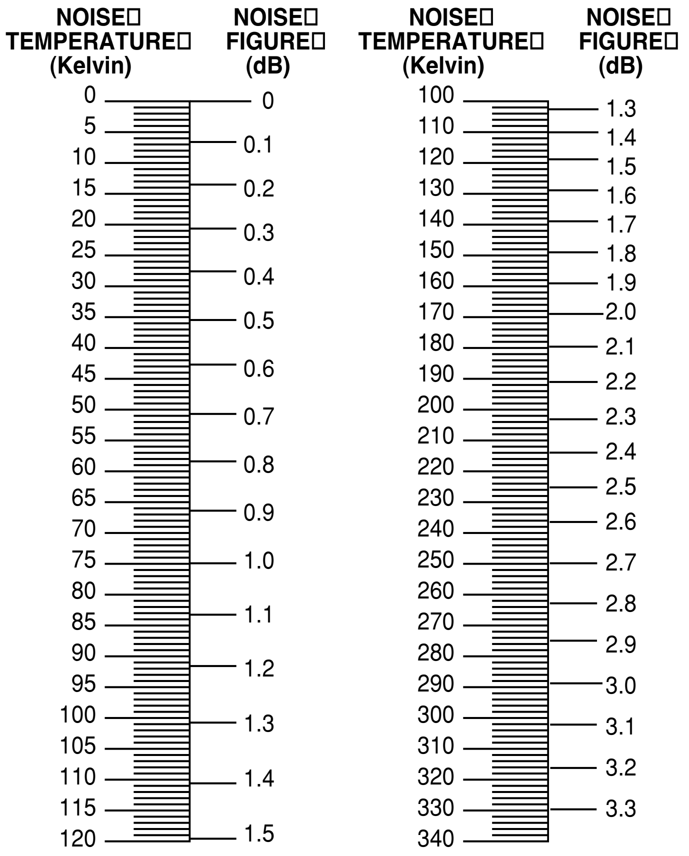
$$\Gamma = \frac{Z - Zo}{Z + Zo}$$

and:

$$\text{VSWR} = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

VSWR is "measured" with either a scalar or vector network analyzer. The reflection coefficients are determined by comparing the incident power and the reflected power at both ports of the device which in turn are converted and displayed as VSWR. The ratio of the reflected power to the incident power is also known as the return loss.

NOISE FIGURE CHART



NOISE FIGURE VERSUS NOISE TEMPERATURE

GaAS FET AMPLIFIER SPECIFICATION DEFINITIONS

DC SUPPLY VOLTAGE AND CURRENT CONSUMPTION

Amplifiers, being active devices, require DC power supplies for their operation. MITEQ's amplifiers typically require 15 volts and include an internal voltage regulator. The use of a regulator allows for specification compliant operation even in the presence of power supply voltage variations, as long as minimum voltage supplied is greater than the specified dropout voltage of the regulator. MITEQ also includes reverse voltage protection diodes on the DC line to prevent damage due to the application of a negative voltage.


AUTOMATED TEST STATION

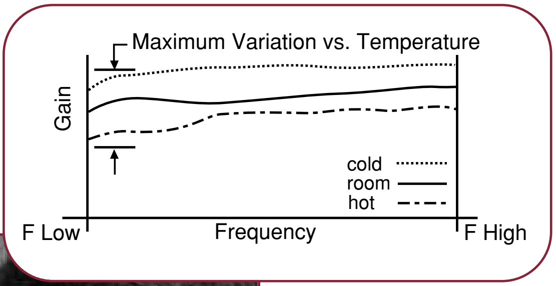
ADDITIONAL SPECIFICATIONS

In addition to the electrical specifications for most of the models within this catalog, there are additional specifications useful to the engineer designing around stringent system requirements:

- Gain variation vs. temperature
- Overall gain window
- Intercept point
- Dynamic range
- Harmonic suppression
- Reverse isolation
- Phase and amplitude matching and tracking
- Phase linearity
- Recovery from saturation

GAIN VARIATION VS. TEMPERATURE

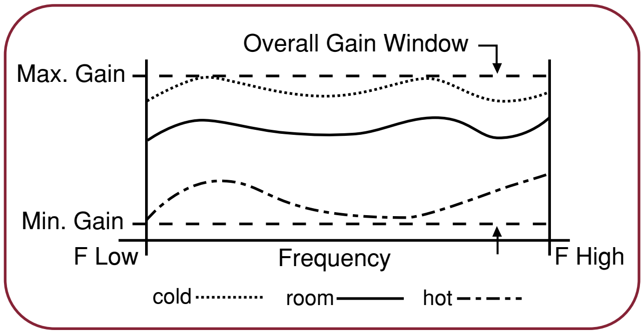
Gain variation versus temperature defines the maximum allowable variation of the linear gain due to temperature at any discrete frequency. As a result, this parameter does not account for drift over frequency.



Gain variation versus temperature is measured by performing swept gain measurements at the specified temperature extremes and comparing the deviations between the two sweeps at each frequency to determine the greatest change. When a ± value is used, then the delta is taken at both temperature extremes with respect to room temperature (23°C). (For typical gain variation values vs. temperature see Thermal Considerations section.)

OVERALL GAIN WINDOW

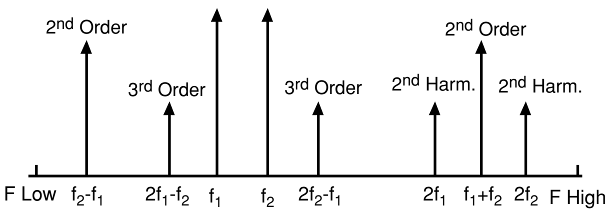
An overall gain window specification defines the absolute minimum and maximum gain values over both temperature and frequency.



It is the most complete way to specify an amplifier; however, it also impacts the price due to the additional testing and alignment required by adding this constraining parameter.

INTERCEPT POINT

Solid state amplifiers use transistors, either bipolar or field effect, to provide gain. Although these transistors are generally used in a linear mode (except in the case of other than a Class A amplifier), they still exhibit nonlinear phenomenon, such as intermodulation effects and harmonic generation. These effects are evident in spurious products present at the output. In the case of the single-tone condition, the spurious signals are the harmonics of the fundamental input signal. In the case of the two-tone condition, the spurious signals are a product of mixing two input signals at the frequencies f_1 and the other at f_2. The most common are the second order and the third order two-tone spurs.



INTERMODULATION SPURIOUS FREQUENCY SPECTRUM

Second order two-tone spurs are the sum and difference product of the fundamental input frequencies, i.e.,

$$f_{SPUR} = f_1 \pm f_2$$

These spurious signals are only of concern when the band is greater than one octave. If the frequency range is less than one octave, the two-tone second order spurs will be out of band.

These spurious signals are characterized with respect to the input signal by means of a theoretical tool called an intercept point. These points are defined as the point where the linear curve of input vs. output power of the fundamental would intersect with the linear curve of the spurious signal if saturation effects would not limit the output levels of these signals. Since it is known that the second order spurious products have a slope of 2:1 with respect to the fundamental input power, the value of the spurs can be estimated if the input signal power (P_{IN}) and the output second order intercept point (OIP_2) are known. The relationship is as follows:

$$\text{Two-tone second order spurious suppression} = OIP_2 - (P_{IN} + G)$$

$$\text{Two-tone second order spurious level} = 2\,(P_{IN} + G) - OIP_2$$

Third order spurious products result from combinations of the fundamental signal and the second harmonics.

$$f_{SPUR} = |2f_1 \pm f_2| \pm |f_1 \pm 2f_2|$$

The slope of third order spurious signal is 3:1 with respect to the fundamental input power, and again the value of the spurs can be estimated if the input signal power (P_{IN}) and the output third order intercept point (OIP_3) are known. The relationship is as follows:

$$\text{Two-tone third order spurious suppression} = 2\,\{OIP_3 - (P_{IN} + G)\}$$

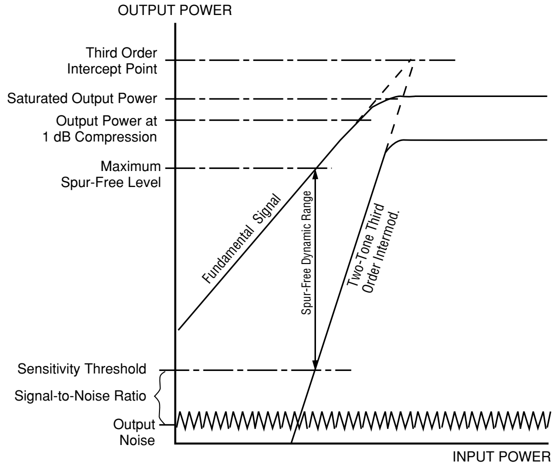
$$\text{Two-tone third order spurious level} = 3\,(P_{IN} + G) - 2\,OIP_3$$

DYNAMIC RANGE

Dynamic range can be defined in several ways. The two classical methods are to define the linear dynamic range and the spurious free dynamic range.

The linear dynamic range defines the difference between the Minimum Detectable Signal (MDS), referred to the input of the amplifier or receiver and the maximum signal level at which the amplifier remains linear. This is typically defined by the input 1 dB compression point (P_{IN} 1 dB). The minimum detectable signal is defined by system constraints, such as noise figure, bandwidth and predetection signal-to-noise ratio.

Spurious free dynamic range is defined as the difference between the minimum detectable signal and the point at which the intermodulation signals generated from two equal tones would either equal this MDS or some other acceptable level. The dynamic range can



DYNAMIC RANGE AND INTERCEPT POINT

be easily derived by the following relationship:

$$\text{Two-tone spurious free dynamic range} = (2/3)\,(\text{IP}^3_{\text{INPUT}} - \text{MDS})$$

$$\text{MDS (dBm)} = -114 + 10\,\text{Log}_{10}\,(\text{BW in MHz}) + \text{N.F.} + \text{SNR}$$

REVERSE ISOLATION

Reverse isolation simply defines the isolation between the input and output of an amplifier. It is tested by injecting a signal into the output port and measuring its level at the input. Typically, reverse isolation is twice the gain.

PHASE LINEARITY

The phase of a signal versus frequency will be distorted due to the nonlinear phase elements within the amplifier. This distortion is called phase linearity and is measured by means of a vector network analyzer across the operating frequency range.

PHASE MATCHING

Phase matching, in the strict sense, is defined as the difference in insertion phase between any two or more units. This parameter is usually defined across the operating frequency band, however, in some cases it is defined over frequency segments (ΔF) within the overall operating band.

In the case of the definition over the entire band, the insertion phase is measured by means of a vector network analyzer, stepped across the band. The values at each frequency for two amplifiers are subtracted to provide a delta plot across frequency. Since each system has its own peculiarities, there are a wide variety of variations of this definition. Therefore, if your system requirements are such that this definition does not accurately meet your needs, or if this level of definition exceeds your real need and results in higher cost, you should contact MITEQ's engineering staff to discuss the most cost effective options.

PHASE TRACKING

Phase tracking is very similar to phase matching. However, an arbitrary fixed offset exists between the amplifiers that can usually be compensated by the system software. The offset, sometimes referred to as the DC component (because all that remains is the phase versus frequency ripple and slope), is calculated at each temperature based upon an average over the band. As with phase matching, there are many variations on this theme that also should be discussed with MITEQ's engineering before committing to a final specification.

AMPLITUDE MATCHING

Same as phase matching, except substitute gain for phase.

AMPLITUDE TRACKING

Same as phase tracking, except substitute gain for phase.

AM TO PM CONVERSION

This specification parameter defines the change in phase at any fixed frequency within the operating band relative to the input signal power. It is usually defined in terms of degrees per dB (°/dB) over a specified input dynamic range. Most GaAs FET amplifiers exhibit well-behaved AM/PM conversion (less than 1°/dB) up to a few dB below the 1 dB compression point. Beyond the 1 dB compression point, the variation can be quite large, depending on the devices and biasing conditions used.

PULSE CONDITIONS

A variety of pulse conditions can be specified for an amplifier, including amplitude or phase overshoot and ringing, amplitude or phase settling time, recovery time, etc. As with the matching and tracking specifications, they are typically system dependent and rarely fall into a standard definition. Therefore, it is best to contact MITEQ's engineering staff when attempting to define the operation of an amplifier in the presence of pulsed signals.

MAXIMUM INPUT POWER

Most low noise figure amplifiers will withstand an input level of 13 dBm CW. In the event that you require a higher input level, an input limiter can be added to the front end of the amplifier in order to protect it. The problem with the addition of the limiter is that its insertion loss is directly additive when calculating the overall noise figure.

THERMAL CONSIDERATIONS

The following information can be used as a guide relative to the changes in performance of an amplifier as a function of temperature.

GAIN

The gain of a typical amplifier, that is not temperature compensated, tends to decrease as the operating temperature of the device increases. Since most low-noise amplifiers have their specifications defined at 23°C, the difference in the gain caused by temperature is approximately 0.01 dB/°C/stage for driver stages and 0.015 dB/°C/stage for power stages. By temperature compensating the amplifiers, improvements of 1/4 to 1/2 of the uncompensated gain change can be realized depending on the frequency bandwidth, gain, power, and temperature extremes.

1 dB COMPRESSION POINT

The 1 dB compression point of a low-noise amplifier varies inversely proportional to the operating temperature. As the temperature increases over room temperature (23°C), the 1 dB compression point will typically decrease up to 0.01 dB/°C.

NOISE FIGURE

The noise figure of a typical amplifier will increase as the operating temperature of the device increases over room temperature (23°C). This rise in noise figure is typically 0.01 dB/°C. Thus, if the noise figure of an amplifier is defined by the manufacturer as 0.9 dB, and the unit has to operate at 85°C, the expected noise figure will be approximately:

$$[85^\circ - 23^\circ\text{C}]\,[0.01\ \text{dB}/^\circ\text{C}] + 0.9\ \text{dB} = 1.52\ \text{dB}$$

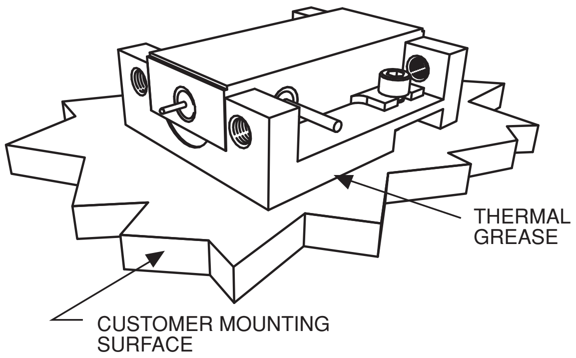
Similarly, for cold temperatures, the noise figure decreases at the same rate.

HEATSINKING

All of MITEQ's amplifiers utilize active components that generate heat when bias is applied. As such, proper mounting must be achieved to maintain the junction temperatures of the devices and ensure specification compliant operation. This is done via conduction cooling of the amplifier case to a base plate or mounting surface. It is recommended that the mounting surface is smooth and clear of any foreign substances, so that there is a clear thermal path between the base plate of the amplifier and that of the mounting surface. We also recommend that thermal grease be used wherever possible to enhance the conductivity of the thermal path.

Since the amplifiers are sealed, there is no way to remove the heat other than by conduction, even if the ambient temperature is significantly below that of the base plate. For higher power models, heatsinks are required. Please consult the factory for details.

In order to increase the efficiency and reduce the thermal stress on the components in our amplifiers, MITEQ has done extensive research on the thermal effects of the heat generating devices in our amplifier designs. Most of our designs use either aluminum, copper/tungsten, or Kovar for the chassis, and aluminum for the mounting fixture, as shown below.



TYPICAL AFS AMPLIFIER MOUNTING

TYPICAL MEDIUM POWER AMPLIFIER CONFIGURATION

It is important for the user to understand that in addition to the thermal resistance of the chassis metal, every interface, starting with the mounting of the FET into the amplifier package, results in a thermal gradient. As such, one should try to minimize these various interfaces by directly soldering the unit wherever possible.

In order to minimize the amount of heat dissipated, MITEQ either eutectically bonds or epoxies the FETs directly to the housing. Since most of the FETs are less than 20 x 20 x 5 mils and the mounting posts are large, there is a good thermal path between the FET and the chassis. Typical power dissipation for the FETs in a two-stage low-noise amplifier is in the order of 100 mW. For a medium power FET with a gate-to-gate spacing of 56 µm and a gate finger width of 200 µm (two fingers/FET), the maximum channel temperature can be calculated to be 135°C, for a base plate temperature of 85°C. The equation is as follows:

$$T_J = T_{\text{case}} + (V_{DS})(I_{DS})(R\,\Theta_{JC})$$

To further guarantee a good thermal path, the base of

THERMAL CONSIDERATIONS (CONT.)

TYPICAL GaAs FET SPECIFICATIONS

CHARACTERISTICS	MEDIUM POWER	HIGHER POWER
Dimension (inches)	0.022 x 0.014 x 0.004	0.019 x 0.014 x 0.004
Gate finger width	200 µm	100 µm
Gate-to-gate spacing	56 µm	25 µm
# FETs	2	2
# Gate fingers/FET	2	5
Power dissipation (W)	0.16	0.16
Total periphery	0.8 mm	1.0 mm
Q ccb (C/W)	80	86
ΔT (C)	12.8	13.8

TYPICAL THERMAL CONDUCTIVE EPOXIES

TYPE	THERMAL CONDUCTIVITY BTU/in./ft. 2hr. °F	MAXIMUM OPERATING TEMP. CONTINUOUS °C
H20E	11.5	125
H31D	11.5	150
H35-175MP	11	175

both the amplifier and mounting fixture should be machined to very fine tolerance (i.e., 0.001”/inch). This equates to a contact conductance of approximately 550 BTU/hr-ft^2-F.

QUALITY ASSURANCE

QUALITY ASSURANCE

MITEQ believes that quality must be built into all of the products that we manufacture. As such, we take extreme care in maintaining a complete and detailed product assurance program. Our product quality is structured to and operates within the precepts of ISO 9001 and to MIL-I-45208. This, in turn, allows us to meet the rigorous requirements generated by our customers in the aerospace, military, and commercial sectors. Internal procedures are used to relate all functions affecting quality, from initial design through final acceptance. These procedures detail the responsibilities and functions necessary to maintain effective controls and to provide a means for evaluating quality disciplines during all phases of a job’s performance.

Beginning with the audit of the customer’s contract, our Quality Assurance Department will review and evaluate the contract and all of the specifications applicable to the job. Quality requirements and characteristics are highlighted and adequate plans are implemented to ensure the incorporation of all aspects pertaining to overall product quality. Quality assurance activities will be coordinated with engineering, manufacturing, and procurement during all phases of an order to ensure the transmittal of complete quality information to all manufacturing centers and inspection stations in a manner consistent with schedule requirements.

MITEQ, through our Quality Assurance and Purchasing Departments, is responsible for the quality of all purchased items. Procurement sources will be selected and approved, based upon the supplier’s quality history records, facility and quality system surveys, or coordinated industry records. Approved sources will be required to maintain a quality program that is commensurate with the requirements of the items being purchased and in compliance with the contract.

Copies of MITEQ’s Quality Manual and Workmanship Standard, that define the methods used for both quality and process control, are available upon request.

TEST EQUIPMENT

MITEQ maintains a complete inventory of the latest state-of-the-art mechanical, electrical, and manufacturing test equipment. Equipment calibration and maintenance is performed and is traceable to the requirements of MIL-STD-45662A.