How to select a distribution amplifier
The special features of the DA1-100-10

Introduction

Distribution Amplifiers (DistAmp) are used to deliver a centralised reference signal to multiple pieces of equipment.

The centralised reference signal is normally a highly accurate source such as a high quality oven controlled crystal oscillator, a rubidium or cesium atomic oscillator or a hydrogen maser. Typically, the frequency will be 5 or 10 MHz although could be anywhere in the range 1 to 100 MHz.

The separate pieces of equipment may be physically close to the reference source, or located hundreds of metres away.

There are many distribution amplifiers on the market and the end user may find it hard to make a decision on what unit is best for him.

This article will high-light the important attributes of a good distribution amplifier.

The features of the DA1-100-10, Precision Test Systems flagship distribution amplifier, are also noted in each section.

Basic Requirements of a Distribution Amplifier

The task of the DistAmp is basically two fold:

- To protect the reference source from the outside world
- To deliver multiple signals without adding any noise to the reference source

Protecting the Reference

It is essential that the reference oscillator is protected from any load impedances changes to its output or that noise cannot be accidentally added to the output.

For example, the reference may be a crystal oscillator that only has a simple buffer amplifier on it. Any drastic load impedance changes or shorts may cause the oscillator to go off frequency. It could take several hours for the crystal oscillator to stabilise after the short is removed.

A good DistAmp will have adequate output to input isolation or “reverse” isolation. A good figure to go for is at least 90 dB of isolation with preferably > 130 dB of isolation. This means any noise accidentally added to a DistAmp output will be attenuated 130 dB before it is fed back to the reference.

Also channel to channel isolation is important. This is so any load change or short circuit applied to one output channel should not interfere with or change any other outputs. A figure > 70 dB is an ideal target for channel to channel isolation.

The DA1-100-10 has > 90 dB channel to channel isolation and > 130 dB of reverse isolation.

No Addition of Noise to the Reference

The DistAmp must not add any noise to the reference. This noise can be in many forms such as:

- Phase Noise
- AM noise.
- FM Noise
- Frequency Stability

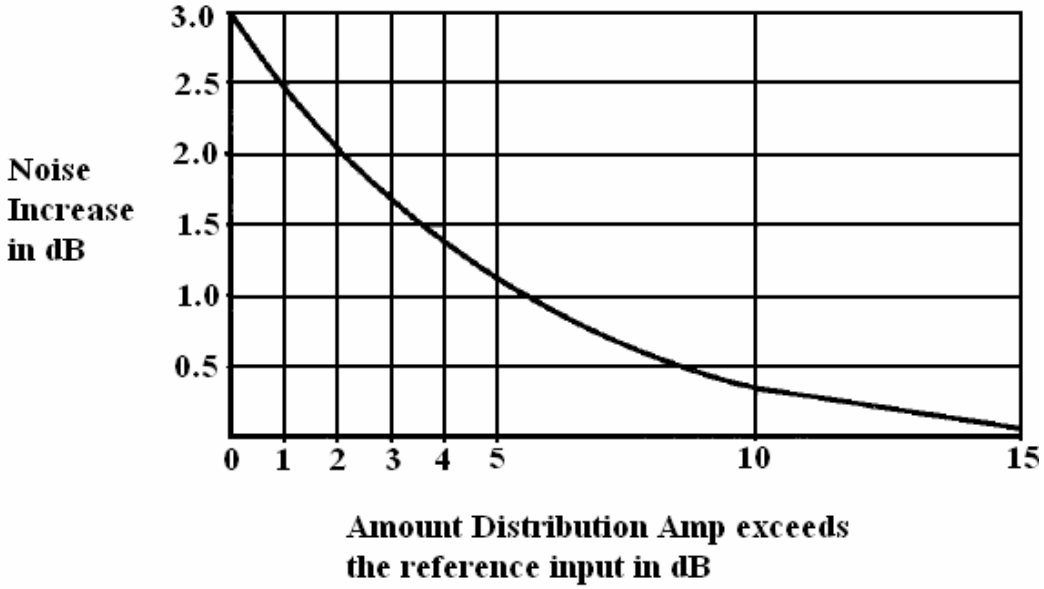
Phase Noise

Phase noise is often overlooked but is one of the most important features of a DistAmp. Many of today's crystal oscillators have excellent phase noise, and a DistAmp must preserve the signal integrity.

For example a signal generator may have a very low phase noise specification. It probably gets its low phase noise by using an internal very low phase noise crystal oscillator. If now an external reference is used in substitution of the internal reference, the external signal must have equally low phase noise.

However, it isn't simply good enough for the DistAmp to have similar phase noise to the reference input. The DistAmp must have much lower phase noise than the reference, ideally 15 dB or better than the reference.

Refer to the diagram below



The DistAmp must ideally exceed the reference sources phase noise by at least 10 dB. Referring to the above graph, 10 dB (on the X axis) corresponds to 0.4 on the Y axis.

So, if the DistAmp's phase noise is 10 dB better than the reference, and the reference is connected to this DistAmp, the DistAmp will add 0.4 dB to the references phase noise. Thus ideally the DistAmp must be 15 dB better than the reference phase noise.

The DA1-100-10 has a typical phase noise of -135 dBc/Hz at one hertz offset. This is about 20 dB better than the best oscillators available on the market today.

Increasing the number of Outputs

Most DistAmps have between 5 and 30 outputs. However there is often a need for a greater number of outputs, maybe 100's of them.

This means units need to be connected in series. Every time two DistAmps are put in series the phase noise will increase, typically by 3 dB.

So once again low phase noise is of paramount important.

Up to three DA1-100-10's can be put in series, producing up to 1000 outputs from one reference input. Even with three units in series the DA1-100-10's phase noise is still better than -130 dBc/Hz and a 1 Hz offset.

AM Noise

The DistAmp must not have residual amplitude modulation otherwise this can also cause phase jitter.

The DA1-100-10 has very low AM noise.

FM Noise and Allan Variance

The output frequency of the unit must obviously be exactly the same as the reference input. However, with cesium and hydrogen masers having stabilities in the 10E-14 range, the DistAmp must have excellent Allan Variance. This is closely linked with phase noise, since phase noise is basically frequency variations on the output signal.

The DA1-100-10 has an Allan Variance of $< 5 \times 10^{-14}$ (1 sec).

Automatic Gain Control (AGC) and Gain.

One important feature of the DistAmp is that is should have AGC. This means that if the input level to the input of the DistAmp varies, the output should remain constant. Variation in output level can cause phase changes in the equipment being synchronized.

For AGC to operate effectively the DistAmp must have some gain, preferably at least 5 dB. Many DistAmp's only have a unity gain (gain = 1). The reason manufacturers don't add gain is that gain adds to the phase noise. However with a gain of 1, there is no headroom for the AGC circuit to work.

The DA1-100-10 has 7 dB of gain allowing the AGC circuit to operate effectively. Despite this gain, the phase noise is still very low as already described. This 7 dB gain figure can be optionally increased, if needed, by the customer.

Wideband Frequency Range

Most frequency standards are either 5 or 10 MHz. However other frequencies are used such as 2.048 MHz, 10.23 MHz, 15 MHz and 100 MHz.

Usually this means separate units need to be ordered. However a DistAmp with a wideband frequency response means one unit can be used in different applications. Also the wideband frequency range helps with phase stability.

The DA1-100-10 has a frequency range of 1 to 100 MHz, although versions are available with narrow band frequency responses as well.

Variable Output Level and High Output Level

It is essential that the output level of each output channel be variable over a 10 dB range. This is because different types of equipment have different requirements for frequency reference inputs.

Also equipment connected to the DistAmp output may be located 100's of meters away from the reference source. Thus, a high output level is needed to overcome any cable loss.

Every channel on the DA1-100-10 can be individually set over a 10 dB range from 0 dBm to 10 dBm, with options to > 15 dBm output.

Phase Stability or Phase Coherence of Outputs

Although not always an essential requirement, phase stability is still important in some situations. Phase stability means that the output frequency phase should not vary with time (in relation to the input phase). Normally, if the DistAmp incorporates tuned inductors in the output, the phase is likely to vary greatly with time and/or temperature.

The DA1-100-10 has excellent phase stability of 10 ps/°C or 0.036 ° / °C.

Spurious Outputs

The DistAmp must also not produce any spurious outputs that are not on the reference input. A good specification for this is that any generated spurs are at least 80 dB down. Spurious signals are often produced by the DistAmp's power supply.

The DA1-100-10 has a spurious specification of -120 dBc. So any spurious signals are at least 120 dB below the carrier output level.

Microphonics

A DistAmp must have low microphonics. This means the output frequency is not altered if there is mechanical vibration on or around the DistAmp. Vibration could be cause by cooling fans.

The DA1-100-10 exhibits excellent low microphonics.

Alarm Outputs

The DistAmp is often one part of a complete system. So it is often important that the DistAmp have alarm outputs. The alarm will be activated if there is a fault with the DistAmp, or a fault with the input or output.

The DA1-100-10 has individual alarms on every channel. The alarm threshold can be individually set for each channel output. The alarms on the DA1-100-10 not only monitor the power supplies of the DistAmp and the input reference level, but also for any shorts or poor VSWR applied to the output channels.

Isolated Inputs and Outputs

As mentioned before equipment connected to the DistAmp output may be located 100's of meters away from the reference source. This means equipment may be operated on different phases of an AC supply causing differences in the earth or ground potential of these supplies.

This can cause ground currents to flow causing noise on the output.

A good DistAmpwill have the option of isolated inputs or outputs. However, this should be an option, not a standard feature. Isolating the inputs and outputs can often cause noise rather than reduce it.

Therefore each individual situation must be evaluated to determine whether isolating inputs and/or outputs is recommended.

The DA1-100-10 has options to isolate any of its inputs or outputs

Back-up oscillator

One feature often needed in a DistAmp is the option of a back-up oscillator. A back-up oscillator is either incorporated inside the DistAmp or there is a second input allowing connection of an external back-up oscillator.

In either case the back-up oscillator should be automatically enabled should the main input fail.

The DA1-100-10 has options for an internal back-up oscillator or the option for a second back-up input connector. Normally outputs are derived from the main reference input. However, should this fail, the back-up source is automatically enabled to continue to provide the reference frequency outputs.

Redundancy

In critical systems that need high reliability it may be necessary to operate the DistAmp in a redundant mode.

In this mode two separate systems are duplicated. Should one system fail, the second system is switched in to continue to provide reference outputs.

A redundant system should ideally incorporate the following features:

- The two systems should monitor each other so if the main unit fails, the second unit automatically switches in.
- Both systems should be identical. This means either unit can operate as a master unit or either unit can operate as a slave unit. By doing this maintenance is easier. Only one spare unit needs to be kept as a spare, as one unit can replace a master unit or a slave unit.

The DA1-100-10 redundancy option satisfies the above requirements.

Options

Every customer's requirements are different. So it is important that any manufacturer be very flexible in its manufacturing process.

The DA1-100-10 has many options and Precision Test Systems will modify a unit to suit customer requirements with little increase in cost.

Summary

As has been shown, there are many considerations to chose from when buying a distribution amplifier.

The DA1-100-10 offers excellent features and is available on short delivery times at a cost-effective price.

Precision Test Systems also have a budget range of distribution amplifiers. While not offering all the features of the DA1-100-10, these budget models still offer excellent value for money.

Contact Precision Test Systems for more details.