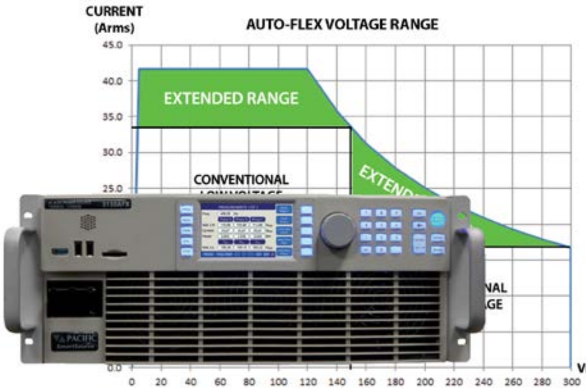
3150AFX CONSTANT POWER VOLTAGE RANGE EXPLAINED



Abstract

This application notes explains the differences between conventional AC power sources that provide two voltage ranges – high and low - to the 3150AFX power source that uses a single constant power mode voltage range instead.

Why is a Single Voltage Range Better?

A single voltage range as found in the AFX allows for a much larger operating area; as both high voltage, low current and low voltage, high current can be continuously applied to a unit under test, without the need to change voltage ranges. This is an important benefit as changing ranges on a conventional AC power source always requires the output to be turned off when the power source changes to the other output range. This means you no longer need to shut down the EUT when you use the 3150AFX to test full input voltage range operation.

This application note will provide some background information on why dual voltage ranges were used in the past and what types are commonly found. Then, several practical examples of EUT testing will be presented that illustrate the advantage of a single constant power voltage range. Often, a lower power AFX Series AC source with this capability can drive the same load as a higher power conventional power source.

Let's start with some technical background on conventional AC power sources.

Dual Voltage Range Power Sources.

The vast majority of programmable AC power sources come with two voltage ranges, a low range and a high range. Typical maximum set values for a low voltage range are either 135, 150 or 156 V rms. For the high voltage range, these values generally double to270, 300 or 312 V rms. The chart below (Figure 1) shows a typical model's low and high range voltage versus output current profile, for a 15 kVA, three phase output mode model. With 5000 VA available per phase, and on a 150 V range, 33.3 A rms maximum current is available. For the high voltage range, the current is cut in half as the voltage is double.

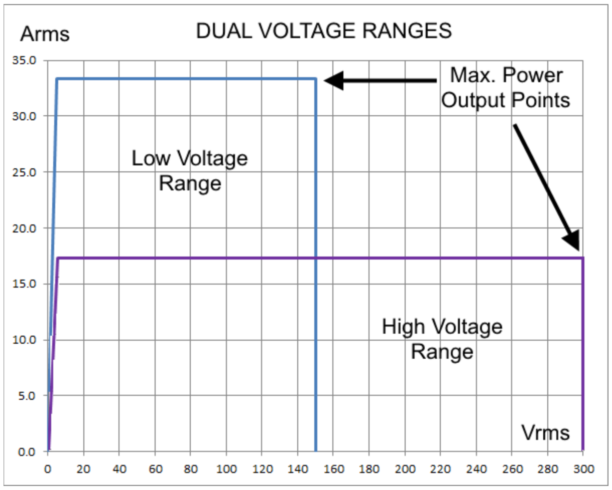


Figure 1: Conventional Dual Voltage Range V-I diagram

As can be seen in Figure 1, maximum output power, both VA and Watt, is available only at the maximum output voltage for each range. In most practical uses, the voltage will be less than the maximum setting as most EUT's operate on 115, 120, 220, 230 or 240 volt AC. That means this current limited, 15kVA rated power source can only deliver 3 x 115 x 33.3 = 11,500 VA or 76% of rated power. This is the most important reason why it is necessary to size an AC power source correctly when defining an application.

Constant Power Mode

A refinement to this conventional approach is to allow more the current at less than full voltage on each voltage range. This means the current de-rates along a constant power curve as the voltage is reduced from the maximum 150 or 300 V rms. Of course doing so all the way to zero volts would require infinite current so at some point the current cannot continue to increase. Furthermore, power devices, board traces, wire harnesses, contactors and terminal blocks used in the power source's design all have maximum current ratings that cannot be exceeded, thus defining a practical limit on the amount of current delivered. For most AC power source, the limit is allowed to increase down to the commonly used voltage set points of 115 and 230 V rms. This approach is illustrated for both low and high voltage ranges in Figure 2. The additional operating area obtained by using a constant power voltage range is highlighted.

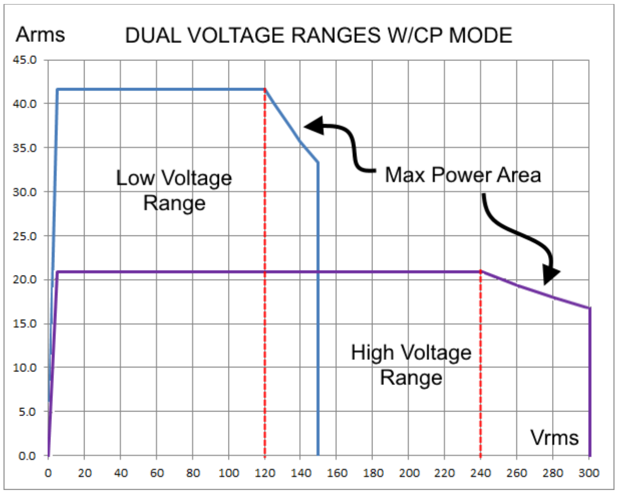


Figure 2: Dual Range AC Source with Constant Power Mode

Dual Range Topology

How do these power sources create these two voltage ranges? There are two methods than can be used:

1. Transformer coupled output stage
2. Dual Amplifier Configuration

Transformer Coupling

The first method is the simplest to implement as it only requires an output transformer with two identical windows that are switched between parallel or series connections to accomplish both ranges. See Figure 3. When in parallel, the output provides a low voltage range with two times the current. When in series, the output provided twice

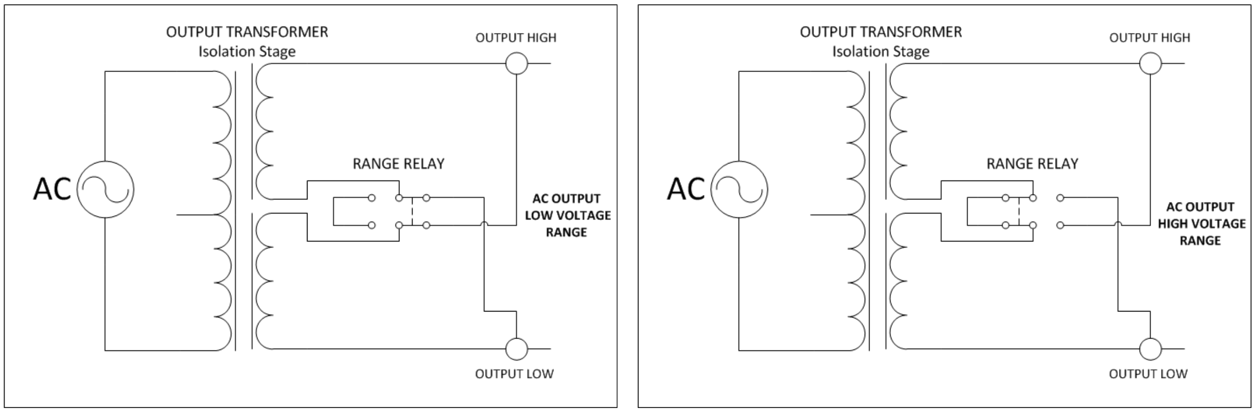


Figure 3: Transformer Coupled Output Ranges - Low (parallel) and High (Series)

the voltage at half the current. Again, power output is the same in either range. A set of output replay is generally used to accomplish this range configuration selection.

The power sources controller must be designed to operate in both ranges which will require its sensing and measurement circuits to be scaled between ranges. A simpler approach is to design voltage and current read back circuits for the highest available voltage and current but this is at the expense of losing some resolution and accuracy as at all time, one or the other will not be in its optimal range.

There are other, more significant drawbacks to this design. They are:

- Increased size, weight and cost of the product due to one transformer for each output phase.
- No possibility of providing DC output or DC offset as the output transformer block any DC.
- Need for interleaved winding – expensive – transformer construction to support frequencies higher than 60 Hz.
- Poor load regulation caused by additional output resistance and inductance of the transformer.
- Reduced peak output current capability due to transformer impedance.
- Difficulty supporting low output frequencies as this would result in output transformer saturation. These designs are typically limits to no less than 45 Hz output or de-rate the available output voltage below 45 Hz.
- Reduced efficiency due to transformer core and winding losses.

Dual Amplifier Configuration

The other approach is to use two sets of amplifiers for each phase and configure them in series or parallel with their drive signals in phase or 180° out of phase. This accomplished dual voltage ranges as well as the two output are either in parallel (in phase) or in series (out of phase). See Figure 4. In these designs, often two half H-bridge output stages are used rather than two full H-bridges to cut cost. The DC busses for such designs have to be carefully isolated which ads complexity and cost as well.

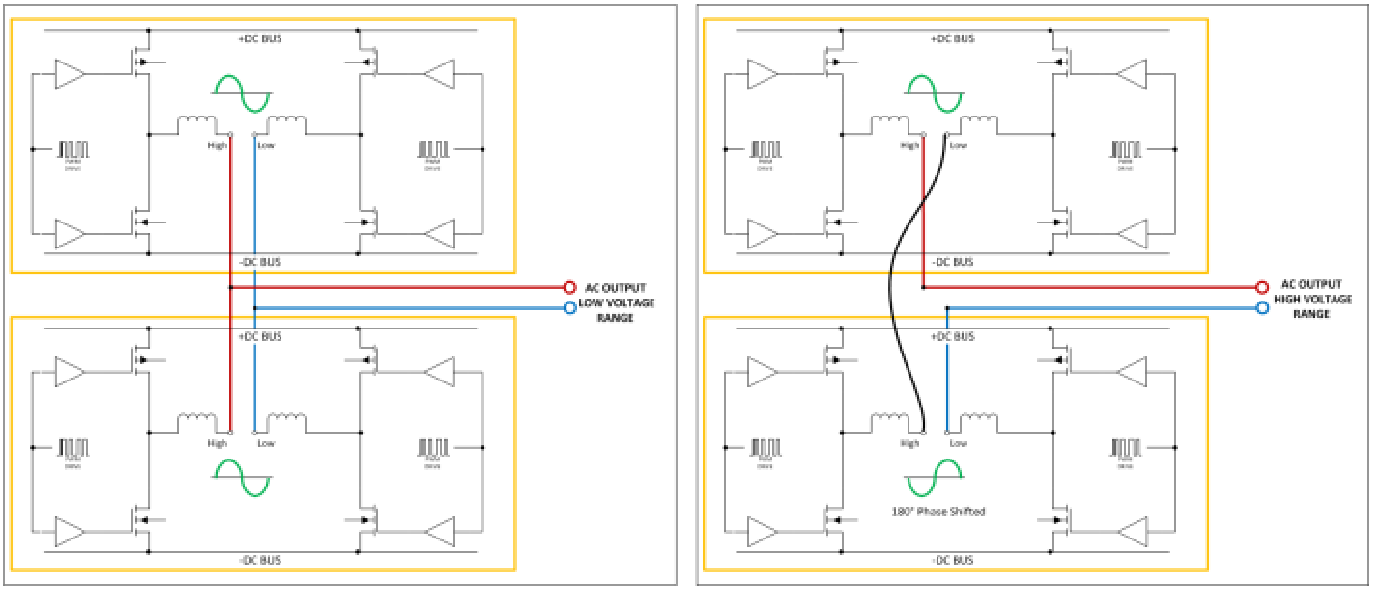


Figure 4: Dual Inverter Output Ranges - Low (parallel) and High (Series)

The benefit of this approach over the use of output transformers is that DC output is possible. However, there are also significant drawbacks:

- More complex DC bus design needed to support series operation of two half H-Bridge output stages.
- Need to reconfigure and switch outputs of both amplifiers.
- Somewhat increased size, cost and weight over single amplifier per phase design.
- Potential for unwanted DC offset in AC output mode of operation.
- Same need to scale feedback and measurement circuits as with output transformer based design.

Despite these trade-offs, direct coupled dual amplifiers per phase design have been the most common in recent years.

Single Constant Power Voltage Range

A better approach than either of the two conventional designs discussed was used during the development of the new AFX Series programmable AC and DC power source. By combining a direct coupled, single amplifier per phase design with an extreme constant power mode 300V rms single range output, all switching and reconfiguration has been eliminated. The resulting available current as a function of output voltage is shown in Figure 5.

The additional operating areas are clearly visible if we overlay the two V-I profiles as in Figure 6. The additional operating area allows for full power operation over the widest possible voltage range.

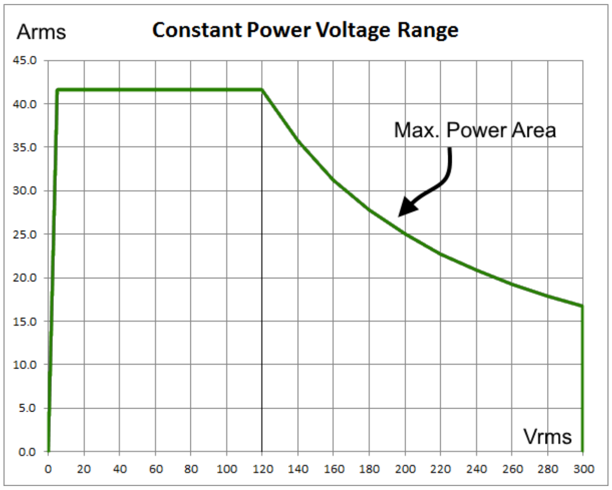


Figure 5: Wide constant power voltage range

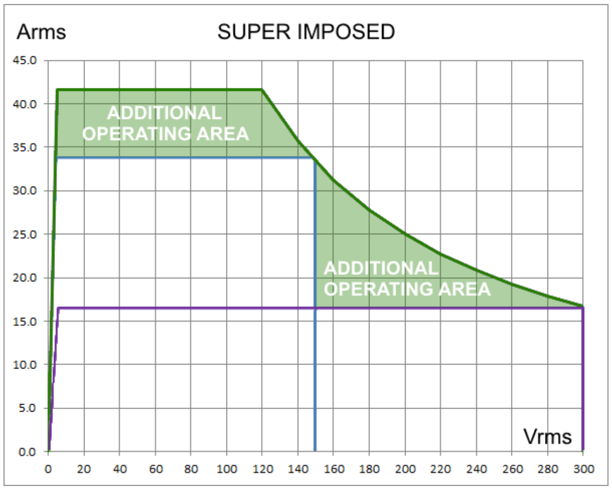


Figure 6: Additional Operating Area of an AFX Series

Practical Applications

The greatly expanding operating range of the AFX Series programmable power source has important implications for a number of applications. When switching a conventional power source from its low 0-150 voltage range to its high 0-300 voltage range, two things happen that are bad:

1. The available max. RMS current is cut in half. This means that the power source may no longer be able to deliver enough current to perform the required test needed.
2. The output will drop out for some period of time as the power source is reconfigured from

low voltage to high voltage range operation or vice versa. On some AC sources designs, this range change can take several seconds, but at the very least, it will take 100's of msec. Either way, this means the EUT will shut down. If the EUT needs some time to restart when power is reapplied, even more test time is lost.

Compare this to using a single voltage range that can provide full power over a wide operating range like that found on the AFX. Since there is never a need to change voltage ranges, none of the above issues are a factor and testing is always smooth and continuous.

Universal AC Input Power Supply Testing

Many AC to DC power supplies on the market today have a wide AC input voltage range permitting the product to be used in many locales around the world. Such supplies generally allow operation from 85Vac to 264Vac. The values are based on a low nominal utility voltage of 100Vrms – 10% (90V) as found in Japan to a high of 240Vrms +10% (264V) as found in many European countries. When testing such a common power supply design, the AFX series can supply more than twice the current at 85Vac as it can at 264Vac, thus permitting testing across the entire AC input range. Other power sources with conventional voltage ranges would have to be sized larger to support the required current between 150V and 264V input operation.

Avionics Compliance Testing

Another good example of how this capability benefits testing in avionics power systems is the commonly required RTCA-DO160 Power Input compliance test. One of the tests requires AC power input voltage surges on a UUT that operates from nominal 115V L-N single phase or 200V L-L three phase nominal input voltage must be subjected to a 180V L-N or 311V L-L voltage surges lasting 100 msec. (Ref. Section 16, test no 16.5.2.3.1 – Abnormal Surge Voltage (AC).

Using a conventional dual voltage power source, we have one would have no choice but to switch to the 300V range. However, available output current is now half what is was on the low voltage range and may not be enough to power the UUT. Thus, the power source has to be oversized to support these test requirements.

Not so with the AFX. Using the same 5 kVA per phase rating, a 3150AXF can deliver 41.6A rms @ 115 V and 27.7A rms @ 180 V. The EUT likely draws less current at 180V input than it does at 115V so the same AC power source can be used for all these tests.

Similar examples can be found in other test standards like Boeing 787B3-047 and Airbus ABD0100.1.8 or ABD0100.1.8.1.

DC Applications

Note that the same benefits of a single high voltage range applies to DC applications. The AFX offers a 425Vdc range on each of its output phases. Full DC power is available from 212Vdc to 425Vdc

Simulated Low Voltage Range

Although the power source uses a constant power voltage range to allow operation with its single 300Vac/425Vdc voltage range, the user can simulate a low voltage range by setting the unit to low voltage range. Doing so limits programming of any output voltage to no more than 150Vac/212Vdc or half the available voltage range of the power source. This restricts operation to 150Vac/212Vdc output and can be used to avoid over voltage settings for lower voltage input EUTs. This effectively emulates a conventional dual voltage range model. The selection is made in the Voltage range field as shown in Figure 7.

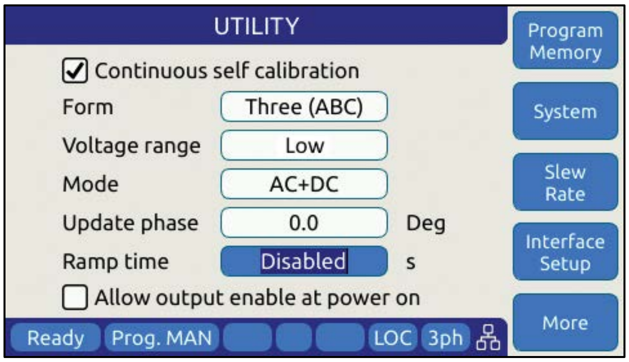


Figure 7: Low Voltage Range simulation

Conclusion

A single, constant power voltage range as found on the AFX Series of AC and DC power sources offers a significantly wider operating envelope compared to conventional AC power sources that rely of range switching between a low and a high voltage range. This not only allows a lower power rating AFX model to support the same EUT power levels as a high rated and thus more expensive conventional model, it also enables wide voltage input range products to be developed and tested with a continuous AC input.

AFX Series power sources are available in power levels ranging from 9 kVA to 60 kVA and can be operated in single, split or three phase mode as needed.

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