

APPLICATION NOTE

# Apex and Paramount RF Generator Comparison



## Introduction

Advanced Energy (AE) offers a full lineup of RF plasma generators with many different features, mounts, sizes, and control methods. This application note is intended to provide a clearer picture of the AE RF generator options and highlight which is the best fit for various applications.

For this discussion, we will focus on the two most popular Advanced Energy 13.56 MHz generators: [Apex](#) and [Paramount](#). Both generators offer unparalleled stability, reliability, and precise process control. However, there are key differences that should be considered when selecting the appropriate product for your specific application.

## APEX AND PARAMOUNT RF GENERATOR COMPARISON

### Apex Fundamentals

The Apex product line was first introduced in 2000, but continued market demand drove Advanced Energy to begin a Refresh Initiative in 2015 to address parts obsolescence in order to continue manufacturing Apex. The refresh result is an Apex generator that retains its RF section but has an updated logic section, similar to the Paramount. The Apex Refresh consists of two main sections: the RF section and the logic section.

The RF section contains a three-phase rectifier, RF power amplifier, driver/exciter, and a RF measurement system. The three-phase rectifier creates the BUS voltages ( $\pm 150$  VDC) which are the direct drivers of the RF output voltage. The driver/exciter isolates the 13.56 MHz signal and the RF amplifier changes the RF output amplitude to meet the setpoint across the full output power range. The RF measurement system consists of a directional coupler which measures the output signal and completes the power feedback loop for the RF amplifier.

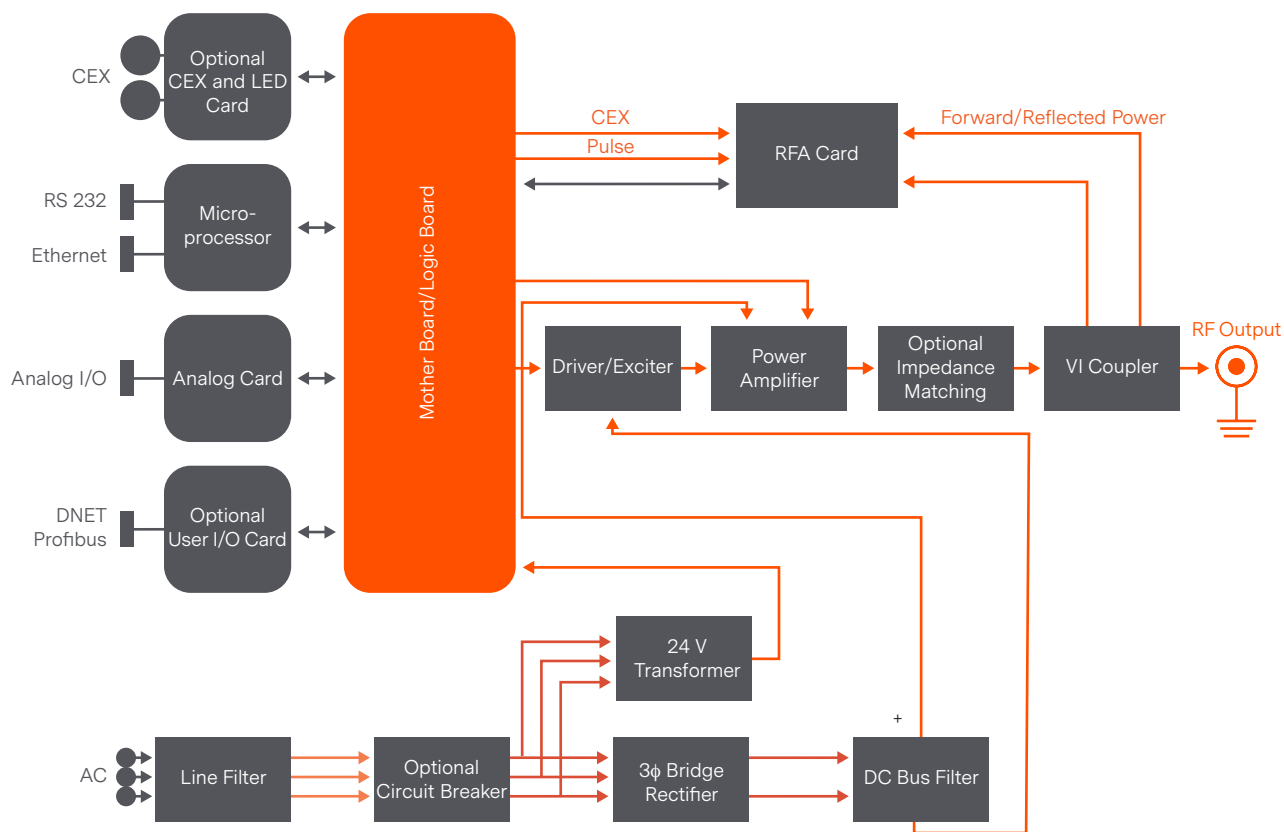


Figure 1. Apex Refresh block diagram

## Paramount Fundamentals

The Paramount product line was introduced in 2008. It was designed to be a more sophisticated RF generator, offering advancements in frequency tuning, arc management, CEX control, and other features. The Paramount consists of three sections: the DC section, the RF section, and the logic section.

The DC section contains the AC input and DC module assemblies. The DC module converts the AC input power to two DC signals which are supplied to the RF module: 150 VDC to the driver/exciter and variable 0 to 200 VDC which is used to regulate the RF output signal.

The RF section consists of a driver/exciter and power amplifier. The driver/exciter uses a stable frequency source from the control section to create the 13.56MHz output signal. This is then amplified by the power amplifier. Similar to the Apex Refresh, a directional coupler is used to measure the output signal and feed it back to the control section.

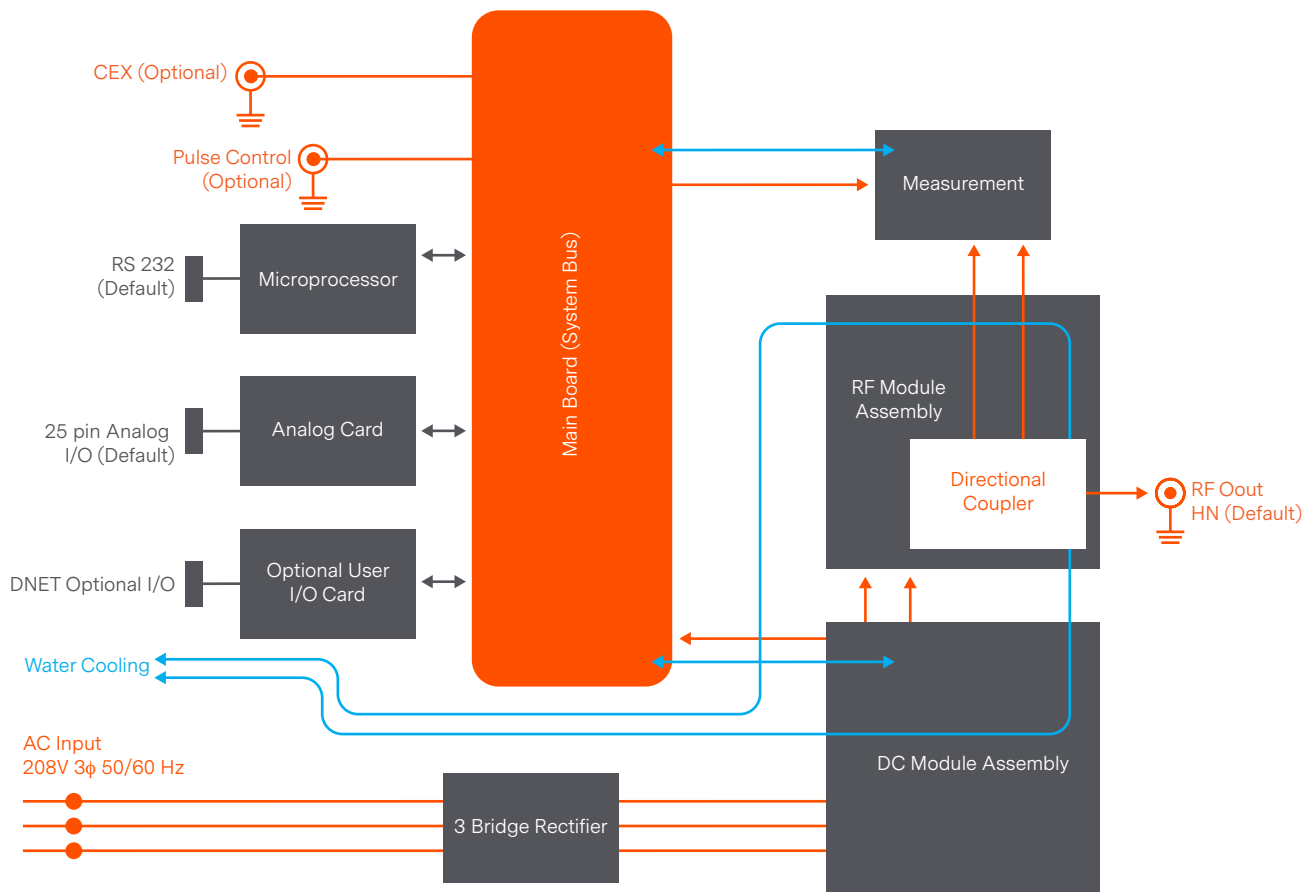


Figure 2: Paramount Block Diagram

## APEX AND PARAMOUNT RF GENERATOR COMPARISON

### Topology Differences

The topologies of the two units create some key operating differences. One primary change is the addition of the DC section in the Paramount. This section provides regulated DC signals to the RF section, which give optimal stabilization over varying input power levels. The Apex Refresh, however, is susceptible to changing input power levels since the RF section uses a BUS voltage directly derived from the AC line. This can cause shifting process performance, if the site sees variances in the AC line voltage.

The design of the Apex Refresh makes it less susceptible to wavelength shifts caused by coaxial cable lengths. Because of this, it is better suited than the Paramount for installations requiring longer cable lengths. However, in general, short cable lengths (<6') should not be used with either Apex or Paramount. There are some applications where this length can be optimal, but typically the cable length for semiconductor processes needs to be optimized based on the wavelength of the application.

### Total Cost of Ownership Comparison

There are many considerations when comparing Total Cost of Ownership (TCO) between the Apex Refresh and the Paramount.

- The Paramount has a list price that is typically 20% lower than the Apex Refresh
- The Apex Refresh has a lower Annual Failure Rate (AFR):
  - Apex Refresh: < 0.5% AFR
  - Paramount: < 1.5% AFR<sup>1</sup>
- The Apex Refresh Flat Rate Repair (FRR) cost is approximately 7% lower than the Paramount
- The annual operating cost of Paramount is typically 4% lower than the Apex, due to the increased efficiency of the Paramount.

The higher upfront cost of the Apex Refresh may be made up for with the lower repair costs. All of these factors should be considered when choosing the right RF generator for your application

<sup>1</sup> The AFR provided is typical for the entire platform, but can vary over particular unit options.

## Other Specification Differences

Besides topological differences between the two products, the Apex Refresh and Paramount differ on some specifications as well. The table below highlights the similarities and differences, and when and why one may be more beneficial.

|                                  | Apex 3 K Refresh                                   | Paramount 3013  | Benefit   |
|----------------------------------|--|---|---|
| <b>Electrical Specifications</b> |  |   |   |
| AC Input Power                   | 208 VAC, 3ph                                       | 208 VAC, 3ph  |   |
| AC Input Current                 | 14.5 A per phase                                   | 13.2 A per phase  |   |
| AC Input Power Factor            | 0.96   | 0.95  |   |
| Sag Compliance                   | SEMI F47   | SEMI F47  |   |
| Output Power Range               | 30 to 3000 W                                       | 5 to 3000 W   | Paramount is better for High Accuracy Low Output (HALO) applications.   |
| Load Power into 2:1 VSWR         | 1980 W   | 2400 W  |   |
| Load Power into 3:1 VSWR         | 1500 W   | 1600 W  | Paramount has wider power profiles, supplying more power into mismatched loads (better for fixed match applications). |
| Reflected Power Limit            | 600 W  | 600 W   |   |
| Frequency                        | 13.56 MHz +/- .005%                                | 13.56 MHz +/- .005%                                     | Frequency tuning is available on the Paramount for fixed match applications.  |
| Harmonics                        | < -40 dBc into 50 ohms                             | < -50 dBc into 50 ohms                                  | Paramount has less RF noise.  |
| Spurious Noise                   | < -40 dBc  | < -50 dBc   | Paramount is less noisy.  |
| Dynamic Response                 | <10 ms (3.5 ms typical)                            | < 2 ms rise and fall times                              | Paramount typically has better plasma ignition, due to the fast rise time.  |
| AC to RF efficiency              | 60% typical @ 3 kW into 50 Ohms                    | >68% @ 3 kW into 50 Ohms                                | Paramount is more efficient, better for "green" initiative compliance.  |
| <b>Physical Specifications</b>   |  |   |   |
| Dimensions                       | 5.25" x 8.5" x 15" (133.35 mm x 215.9 mm x 381 mm) | 5.23" x 8.5" x 17.4" (133.35 mm x 215.9 mm x 441.96 mm) | Apex is more compact and has a very modular design which makes it ideal for chamber mounting.                         |
| Weight                           | 45 lb (20.4 kg)                                    | 35lb (16 kg)  | Apex is heavier.  |
| Coolant Type                     | Water Only   | Water/Air   | Apex is completely sealed and water cooled only. This makes it ideal for more rugged industrial applications.         |

In addition to the specifications listed above, both the Apex Refresh and Paramount offer a variety of features including CEX and pulsing. Both product lines offer Advanced Energy's unparalleled quality, performance, and global service options to meet your process needs and provide years of product reliability and excellence in system up-time. Advanced Energy can offer a variety of solutions to meet your specific needs. Please feel free to contact technical support for additional information about our full lineup of RF generators and matching networks.

For questions or feedback about this Application Note, please contact AE Technical Support at 1.800.446.9167 (option 2).