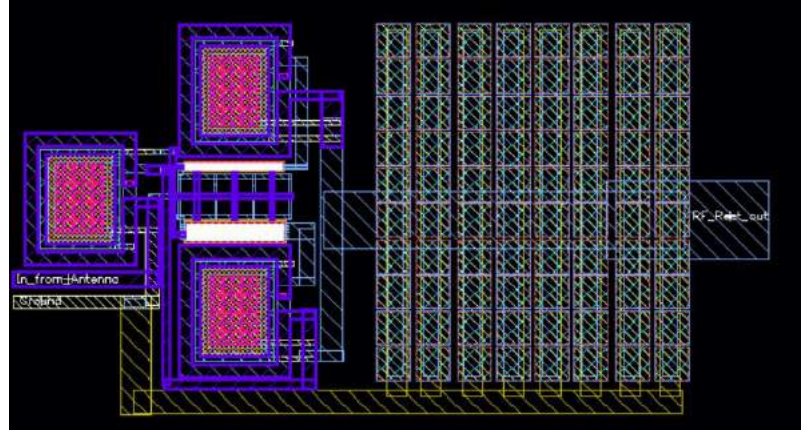




# Current **RF** CC-205IP Wideband CMOS RF Rectifier

**6Mhz to 5.8Ghz Frequency Range**  
**-18 to +33dBm Input Power Range**  
**40% to 90% Conversion Efficiency**  
**3.3V DC Output Voltage Range**  
**Wide Antenna Matching Impedance**  
**-40 dB S11 Input Return Loss**



## General Description

The CC-205IP Wideband CMOS RF Rectifier is a CMOS full wave rectifier with a 6Mhz to 5.8Ghz rectification frequency range capability, can rectify input power signals ranging from -18dBm to over +33dBm, while maintaining a 40% to 90% conversion efficiency. The CC-205IP, at maximum efficiency at 5.8Ghz, outputs a 3.3V DC voltage with a current capacity of 125mA, making it ideal for on chip RF Power Transfer and Broadcasting, and RFID transceivers. The CC-205IP can be interfaced to on and off chip supercapacitors, making the IP block ideal for RF Power Transfer Systems in burst mode operation. The CC-205IP has an aspect ratio of 140um X 140um making it an ideal choice for RFID chips and systems. The CC-205IP features wideband, adjustable Antenna matching capability, with the ability of directly interfacing to a given antenna impedance, avoiding the conversion losses incurred with an antenna to rectifier interface matching network. The rectifier block features a -40 dB S11 return loss, adding to it's overall conversion efficiency. The CC-205IP Wideband CMOS RF Rectifier is available on XFABs XT013 manufacturing process, and can be ported to any given RFCMOS process.

### Topology

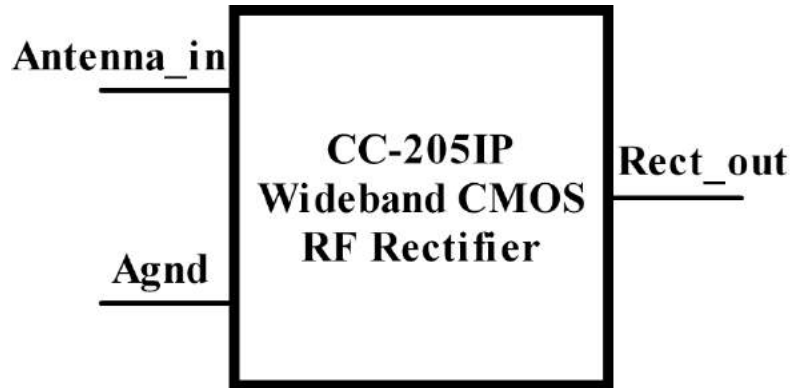
**WideBand CMOS Architecture**  
**Adjustable Antenna Matching**  
**Wide Input Power/Frequency Range**  
**Proprietary Topology**

### Features

**RFID Compatible**  
**RF Power Transmission Compatible**  
**RF Transceiver Compatible**  
**Up to 90% Conversion Efficiency**

## Functional Description

The CC-205IP Wideband CMOS Rectifier directly interfaces to any antenna with a given characteristic impedance (no matching network needed), can be set up for full wave or half wave rectification, and possesses a very low S11 return loss (-40db) for maximum transfer of power. The IP block is sensitive to -18dBm RF inputs and can handle a maximum input power of +36dBm.



**Figure 1: CC-205IP Top Level Block Pinout**

The block has 3 connections, shown in Figure 1, **Antenna\_in**, the direct to antenna input, **Agnd** for a ground reference, and **Rect\_out**, the DC output of the CC-205IP block.

## CC-205IP Wideband CMOS Rectifier Specifications (5.8Ghz Frequency Input)

| Parameter         | Description                | Min | Typ | Max | Unit  |
|-------------------|----------------------------|-----|-----|-----|-------|
| Active Rectifier  |                            |     |     |     |       |
| Frequency Input   | Input Frequency            |     | 5.8 |     | Ghz   |
| Power Level       | Input Power Level          | -18 |     | +36 | dBm   |
| Return Loss       | Input reflection S11       |     | -40 |     | dB    |
| "On" impedance    | Channel Impedance (5.8Ghz) |     | 50  |     | Ohms  |
| "Off" impedance   | Channel Impedance (5.8Ghz) |     | 100 |     | KOhms |
| Reverse Breakdown | Reverse Voltage Breakdown  |     |     | 17  | V     |

**Table 1: CC-205IP CMOS Rectifier 5.8Ghz Specifications**

## CC-205IP CMOS Rectifier 5.8Ghz Performance

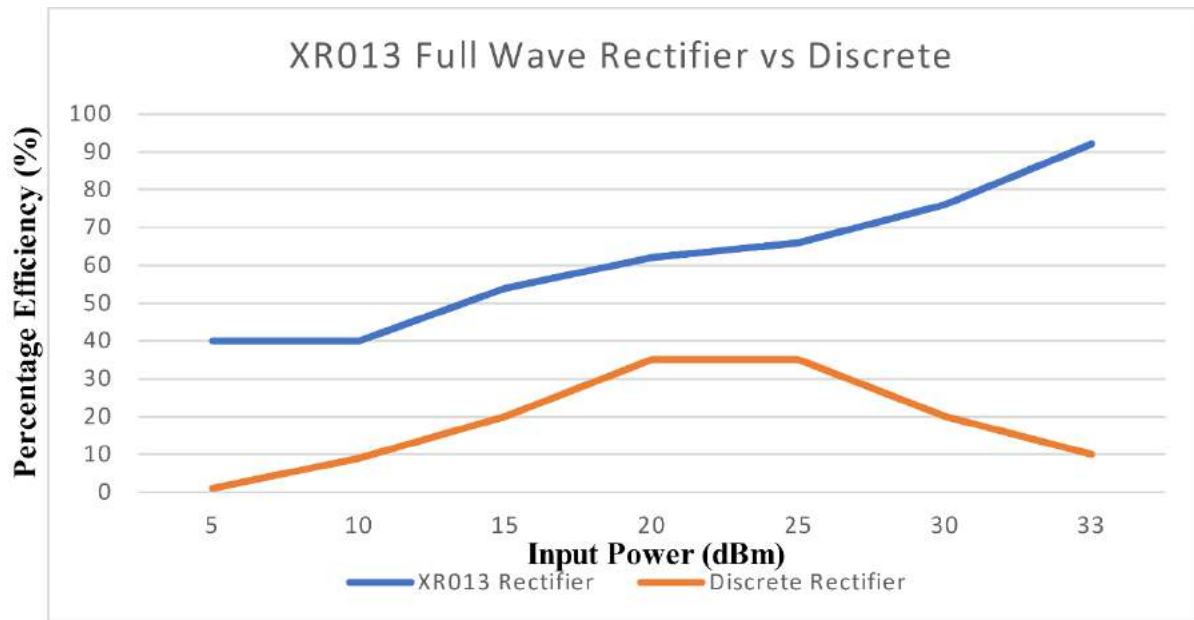


Figure 2: Full Wave Rectifier Efficiency Performance as Compared to Discrete Designs

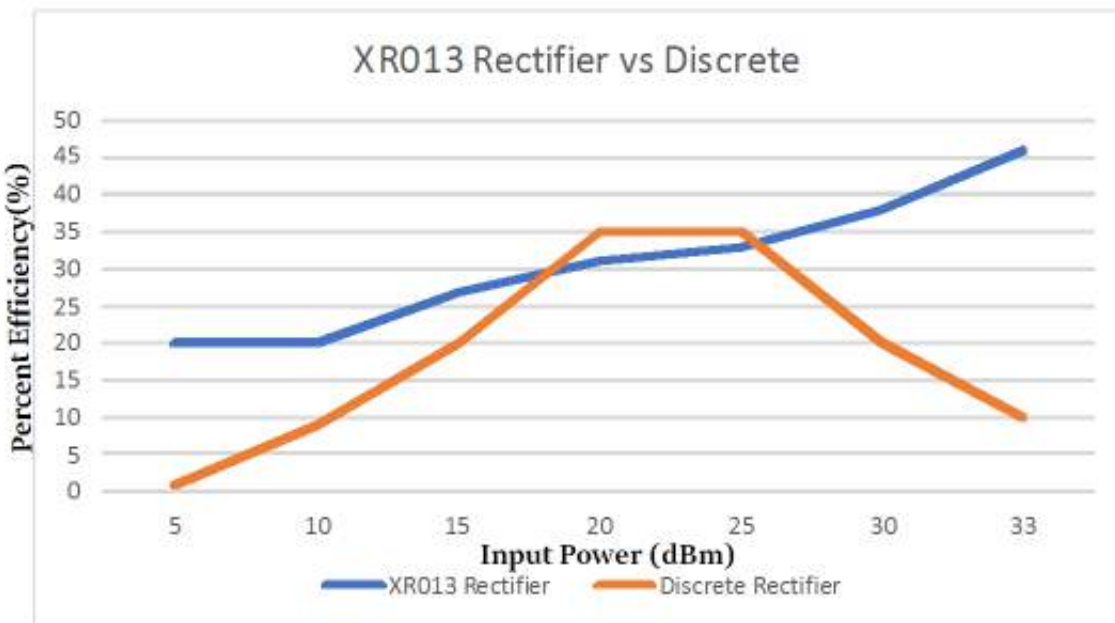
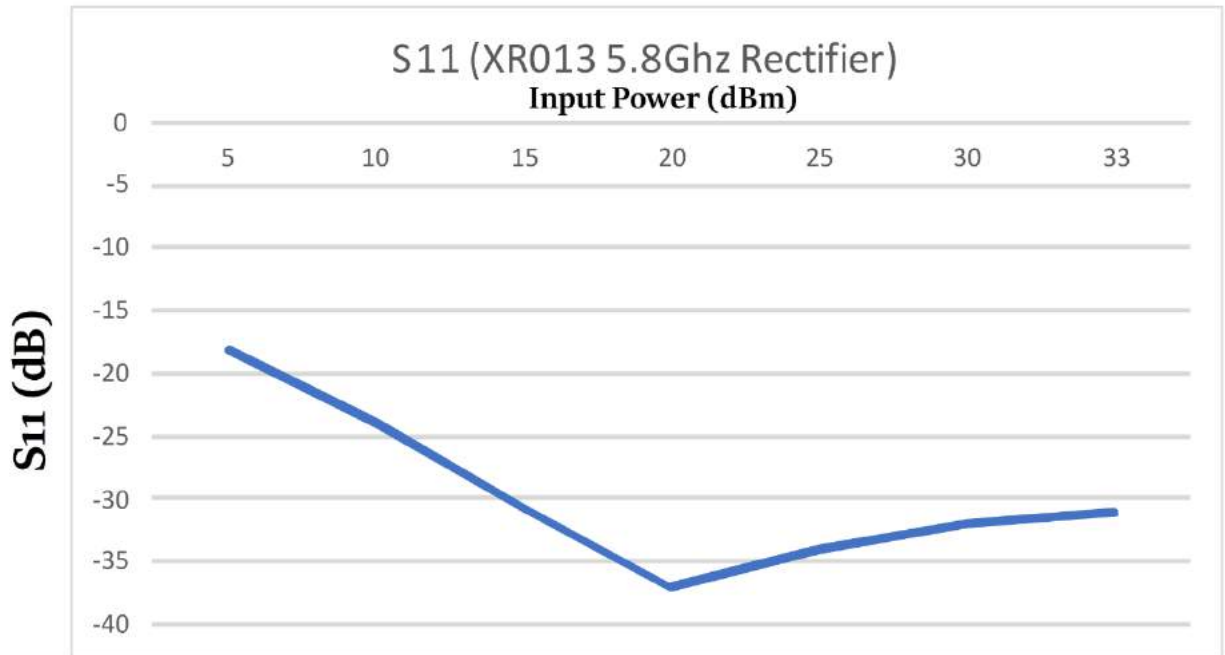
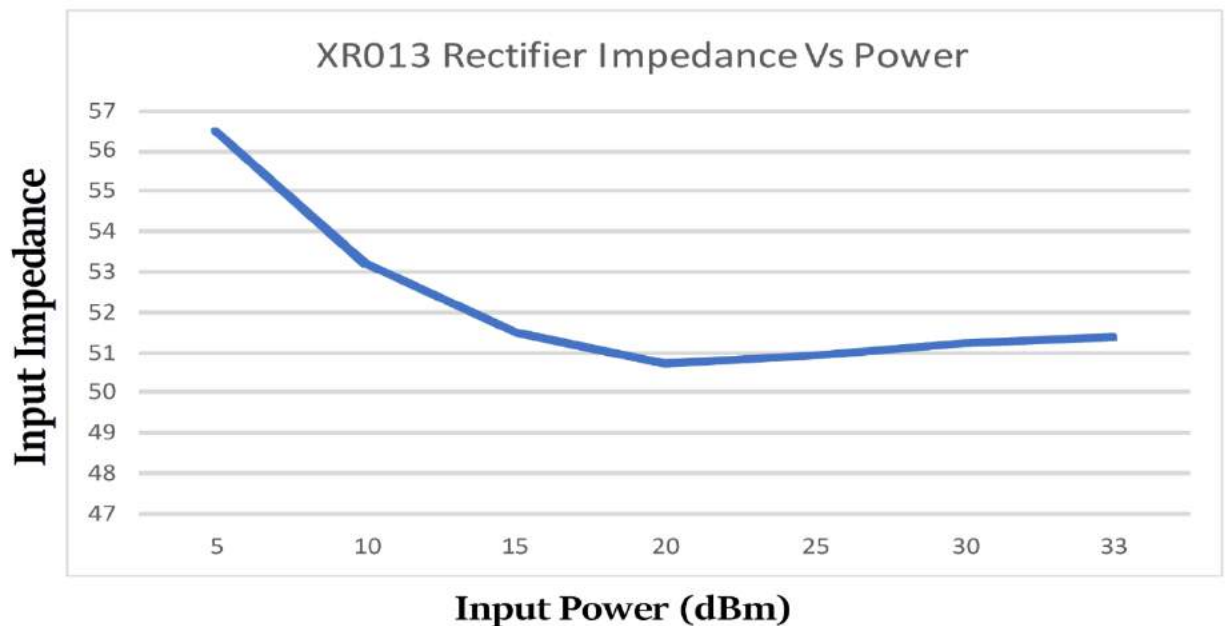


Figure 3: Half Wave Rectifier Efficiency Performance as Compared to Discrete Designs

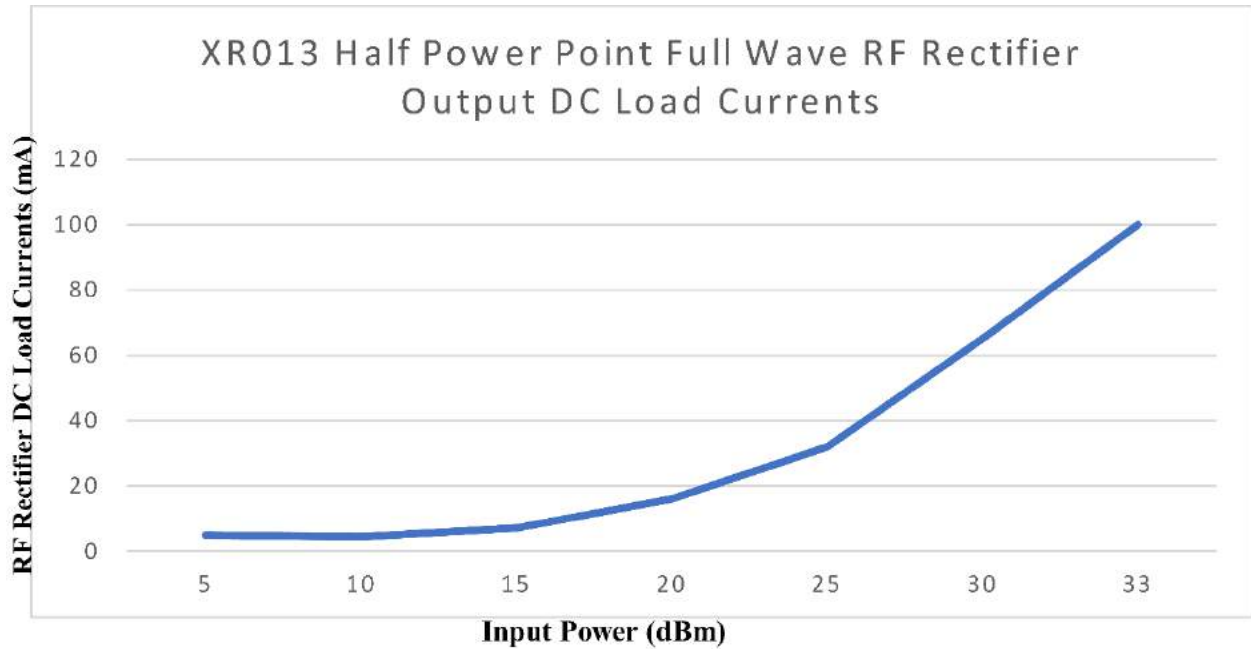


**Figure 4: CC-205IP RF Rectifier S11 Performance**

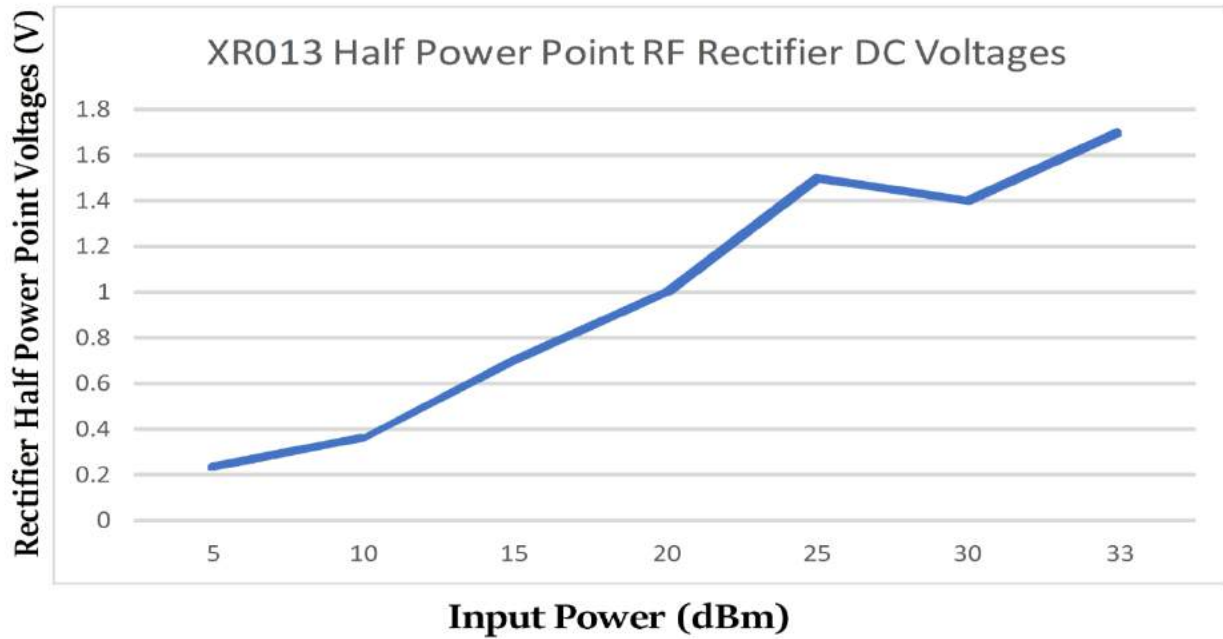
Figures 2 and 3 shows the CC-205IP Rectifier performance vs typical rectifier diodes used in a voltage doubler configuration. Because of the unique architecture of the CC-205IP RF Rectifier, the reflection is minimal across all power input levels (see Figure 4), and the Rectifier input impedance does not significantly vary as power is applied to the rectifier (see Figure 5).



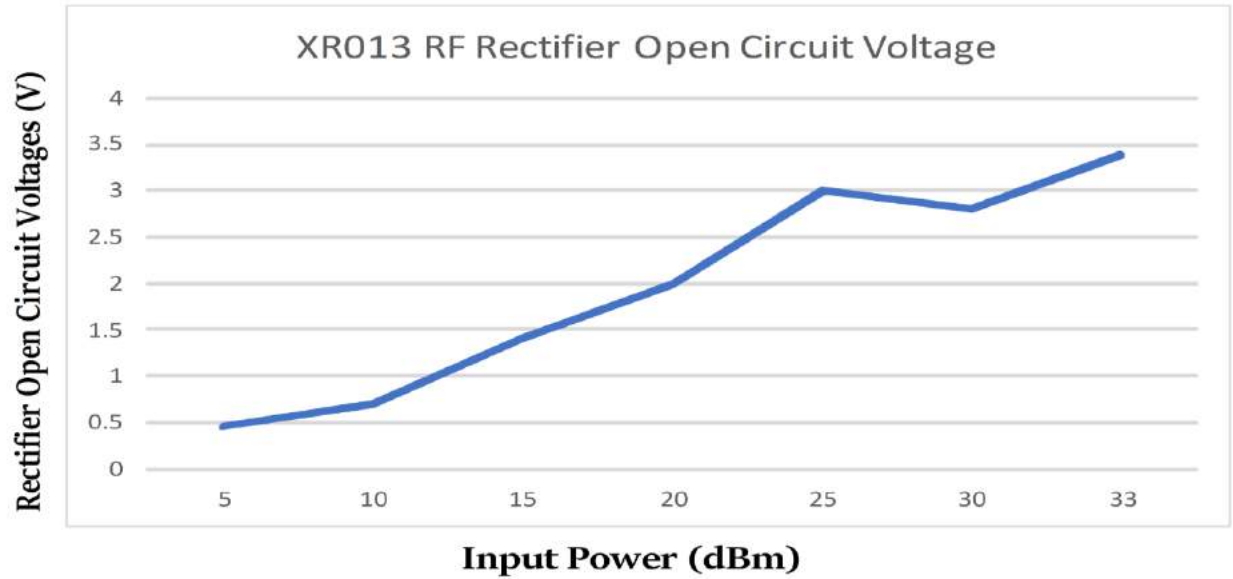
**Figure 5: CC-205IP Input Impedance Change with Input Power at 5.8Ghz (50 Ohms Nominal)**



**Figure 6: CC-205IP RF Rectifier Half Power Point Load Currents (Resistive Load)**



**Figure 7: CC-205IP RF Rectifier Half Power Point Voltages (Resistive Load)**



**Figure 8: CC-205IP RF Rectifier Open Circuit Voltages (No Resistive Load)**

Figures 6 through 8 show details of the CC-205IP Rectifier performance with respect to Half Power Point performance in reference to Full Wave design loading currents (Figure 6), Half Power Point loaded voltages (Figure 7), and Rectifier Open Circuit Voltage Output (Figure 8).

# CC-205IP Baseline 5.8Ghz Rectifier Data

## +33dBm Input Performance

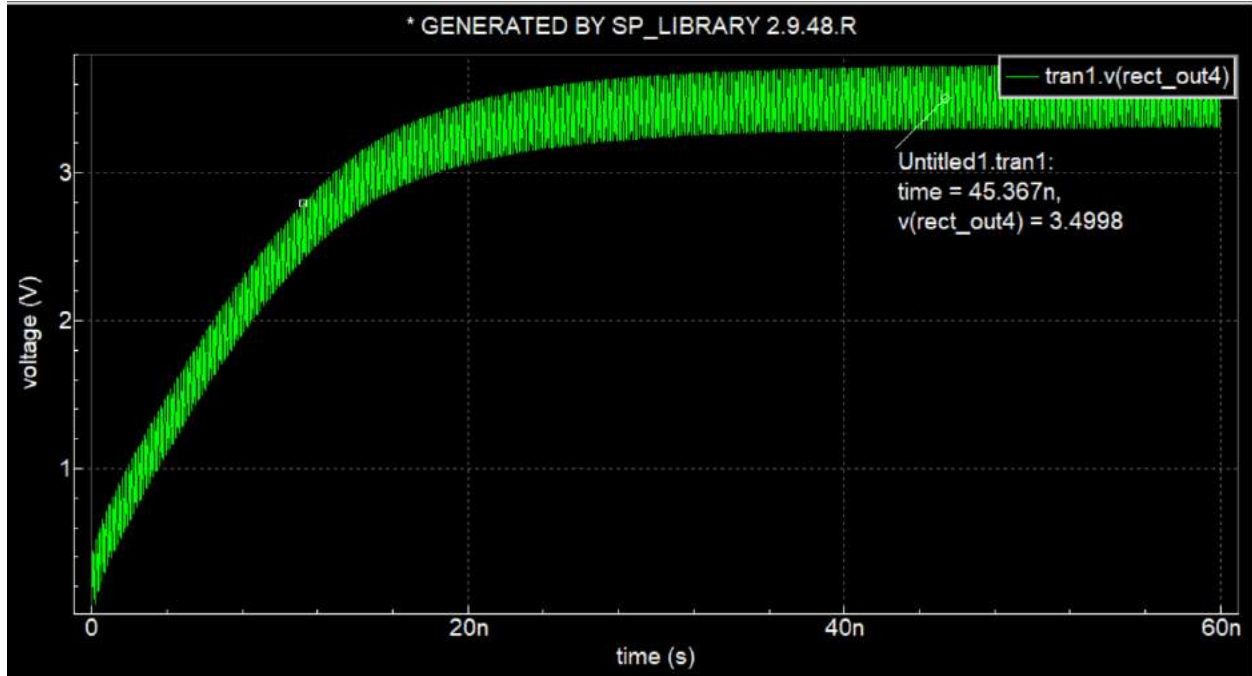


Figure 9: +33dBm unloaded— Showing Cold Start-up to full rectification



Figure 10: +33dBm Power Input at RF Rectifier Input

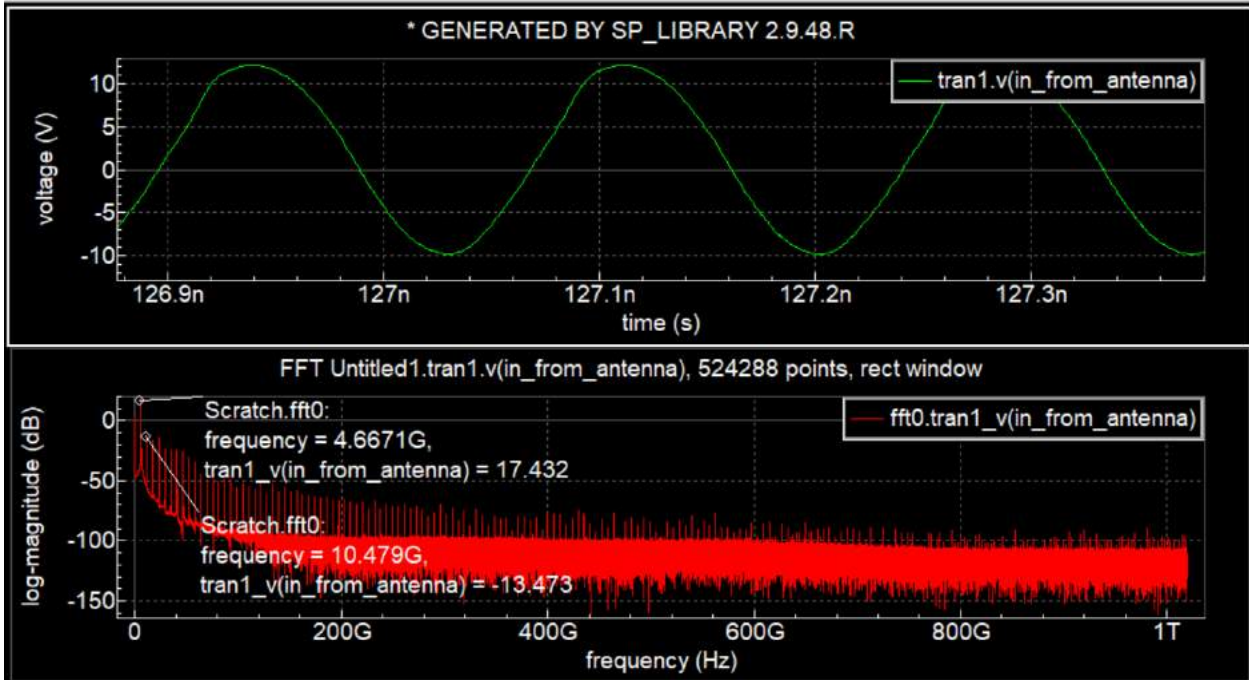


Figure 11: +33dBm input linearity—(30dB---low reflection---  $20 \log(1.5/51.5)=-31$  dB S11)

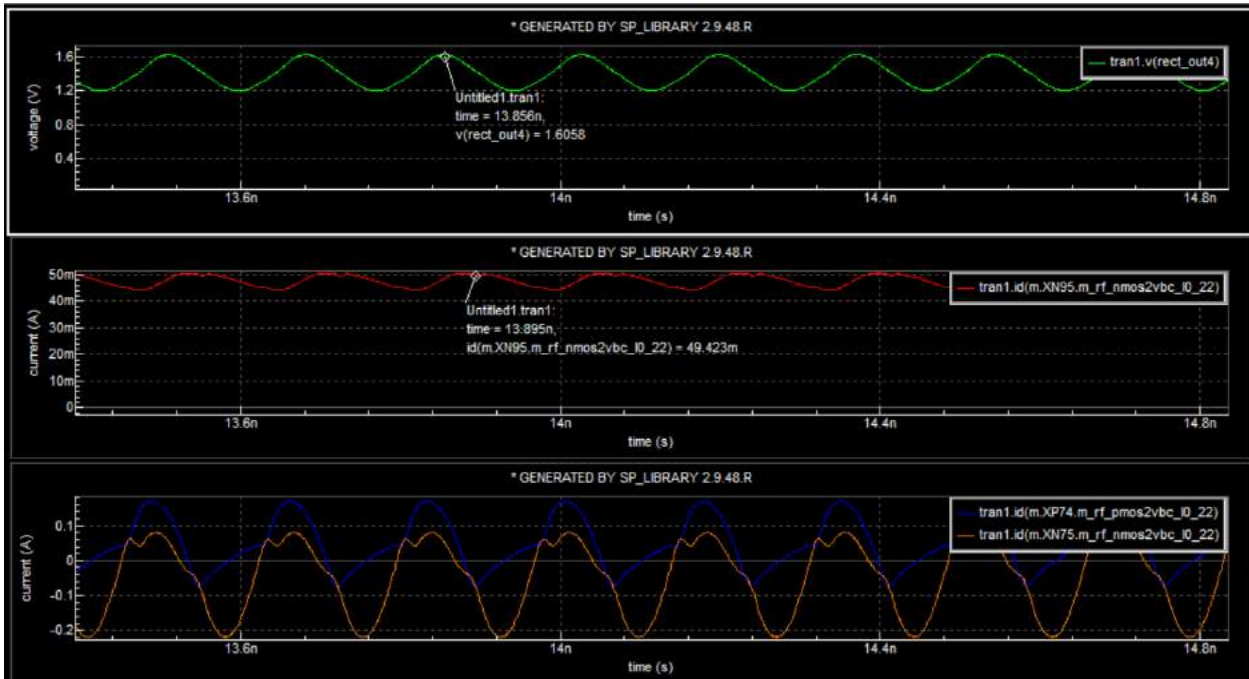


Figure 12: +33dBm Half Wave, Half Power Point Efficiency

150mA peak rectifier current \* .707=106mA RMS--  $(49\text{mA}/106\text{mA}) * 100 = 46.22\%$



## +20 dBm Input Performance

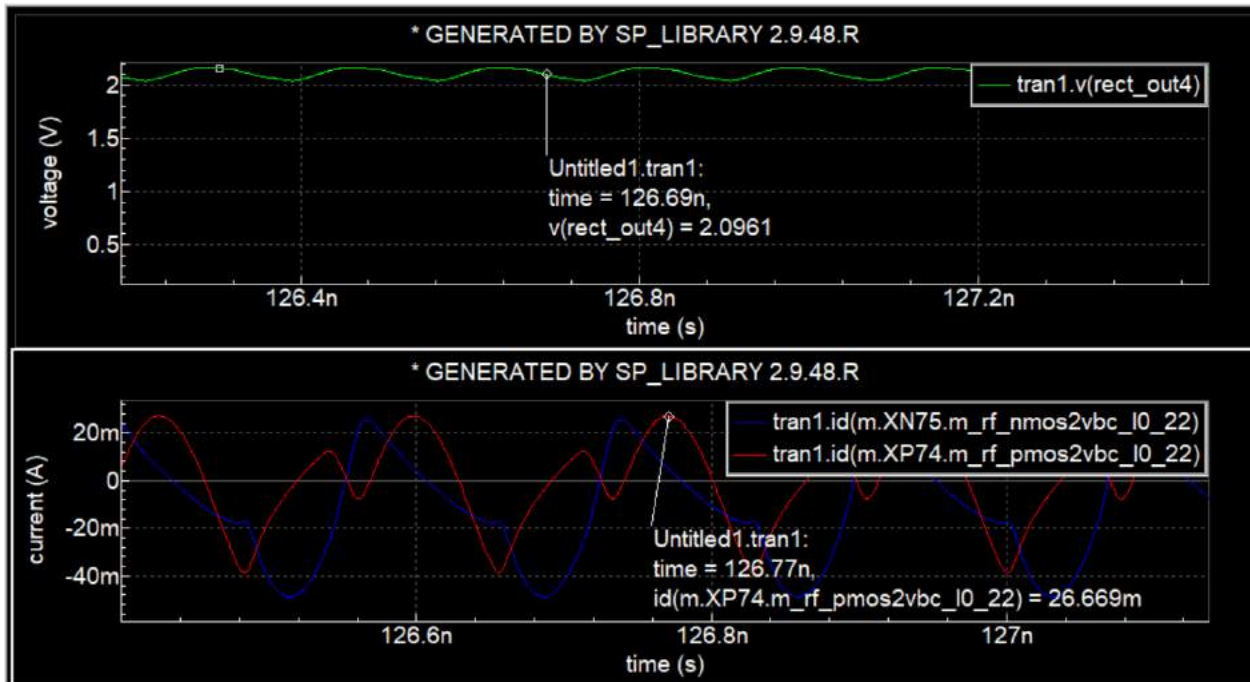


Figure 13: +20dBm unloaded 26.7mA peak rectifier current

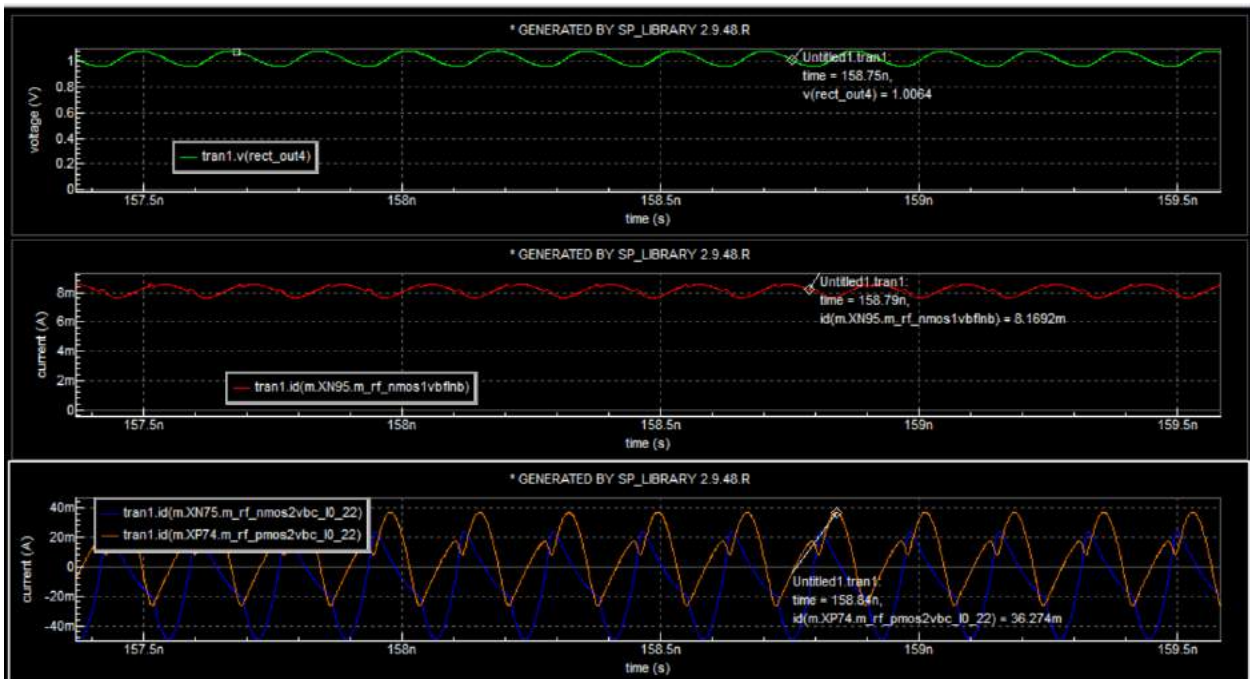


Figure 14: +20dBm Half Wave, Half Power Point Efficiency

36.2mA peak \* .707=25.6mA-- (8.1mA/25.6mA)\*100= **32%**

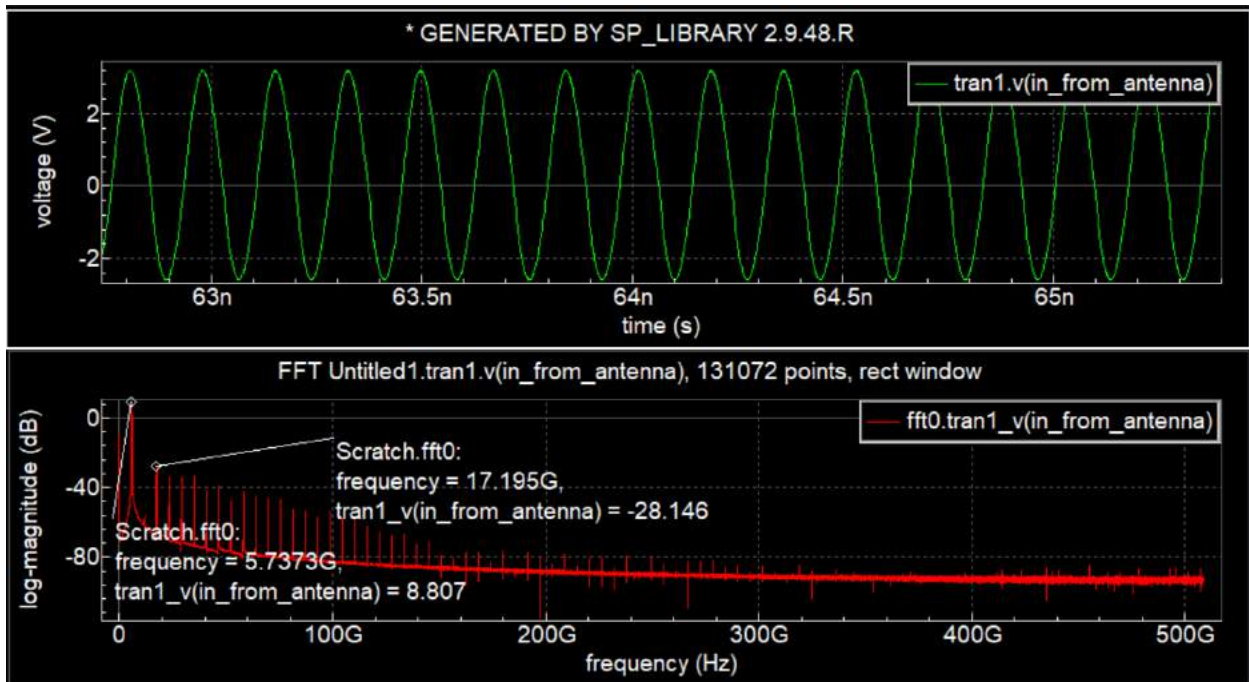


Figure 15: +20dBm input linearity—(36.8dB---low reflection--- $20 \log(.7/50.7)=-37\text{dB}$  S11)

## +5dBm Input Performance

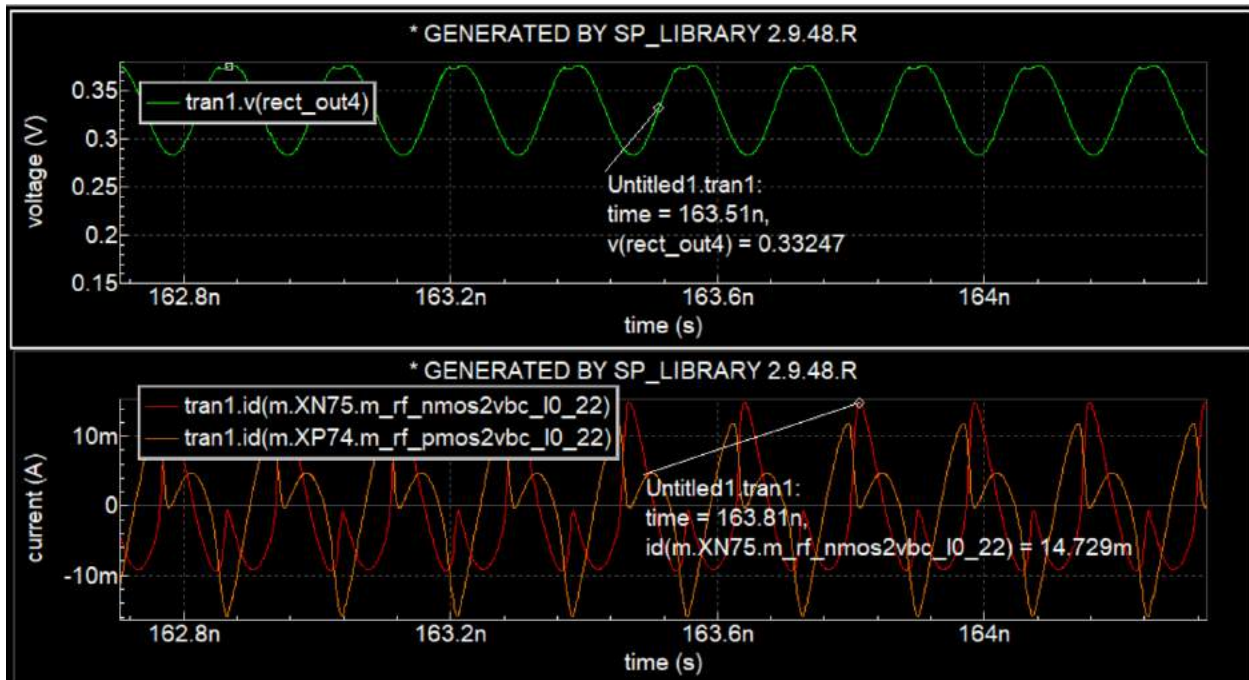


Figure 16: +5dBm input unloaded—14.27mA peak rectifier current

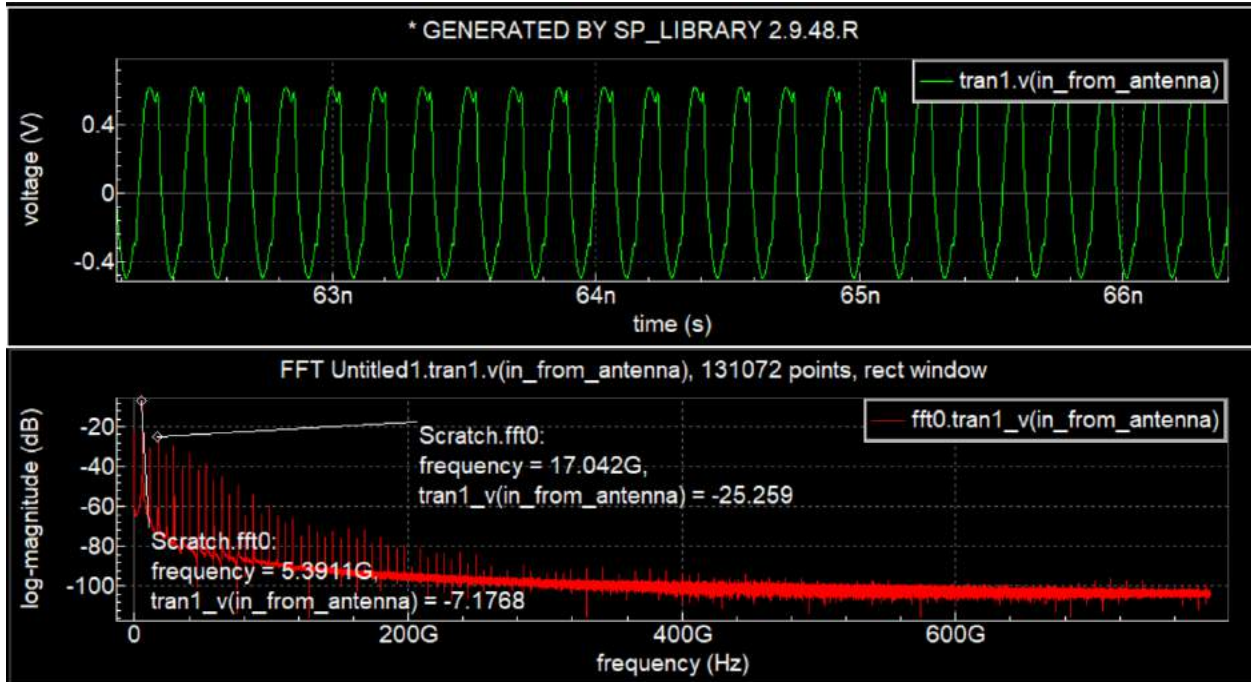


Figure 17: +5dBm input linearity (18db—moderate reflection---  $20\log(7/57)=-18.2\text{dB}$  S11)

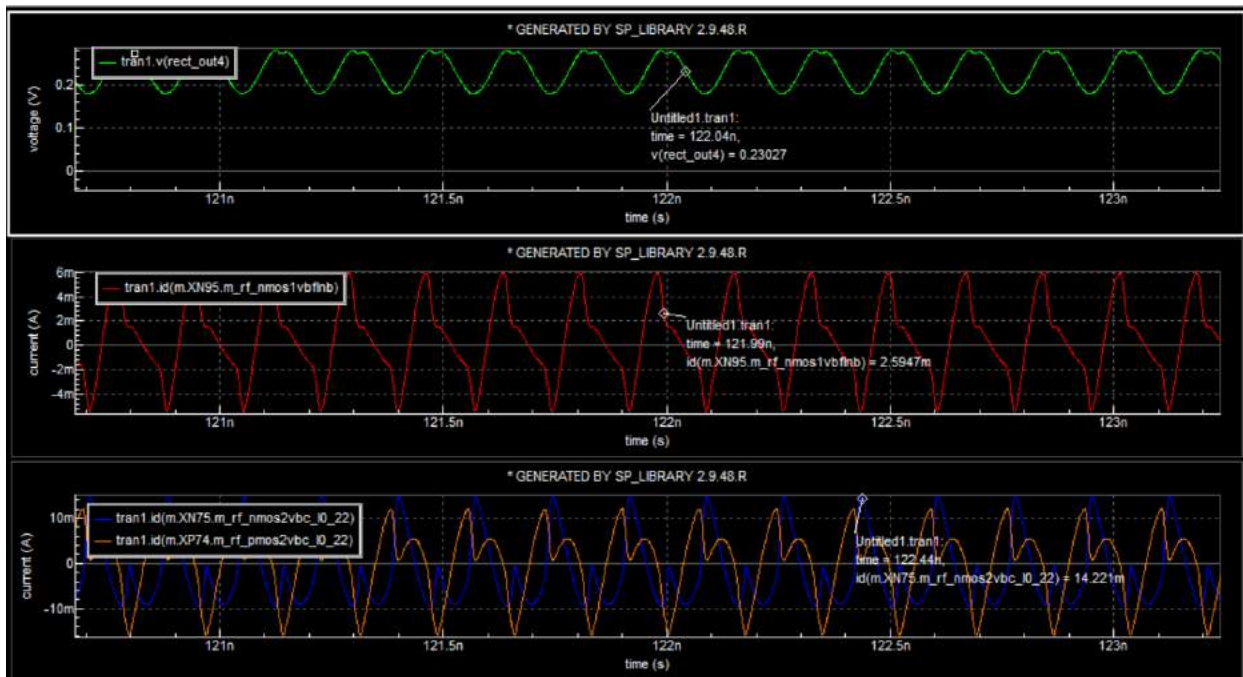


Figure 18: +5dBm Half Wave, Half Power point efficiency

14mA peak rectifier current \* .707=9.8mA RMS--  $(2.59\text{mA}/9.8\text{mA}) * 100 = 26\%$

Figures 9 to 18 show excerpts of simulation data taken on the CC-205IP RF rectifier that support the plots shown in Figures 3 through 8. Plots 9 to 18 are snapshots of rectifier performance at representative points in the power performance continuum.

## Cold Start Performance

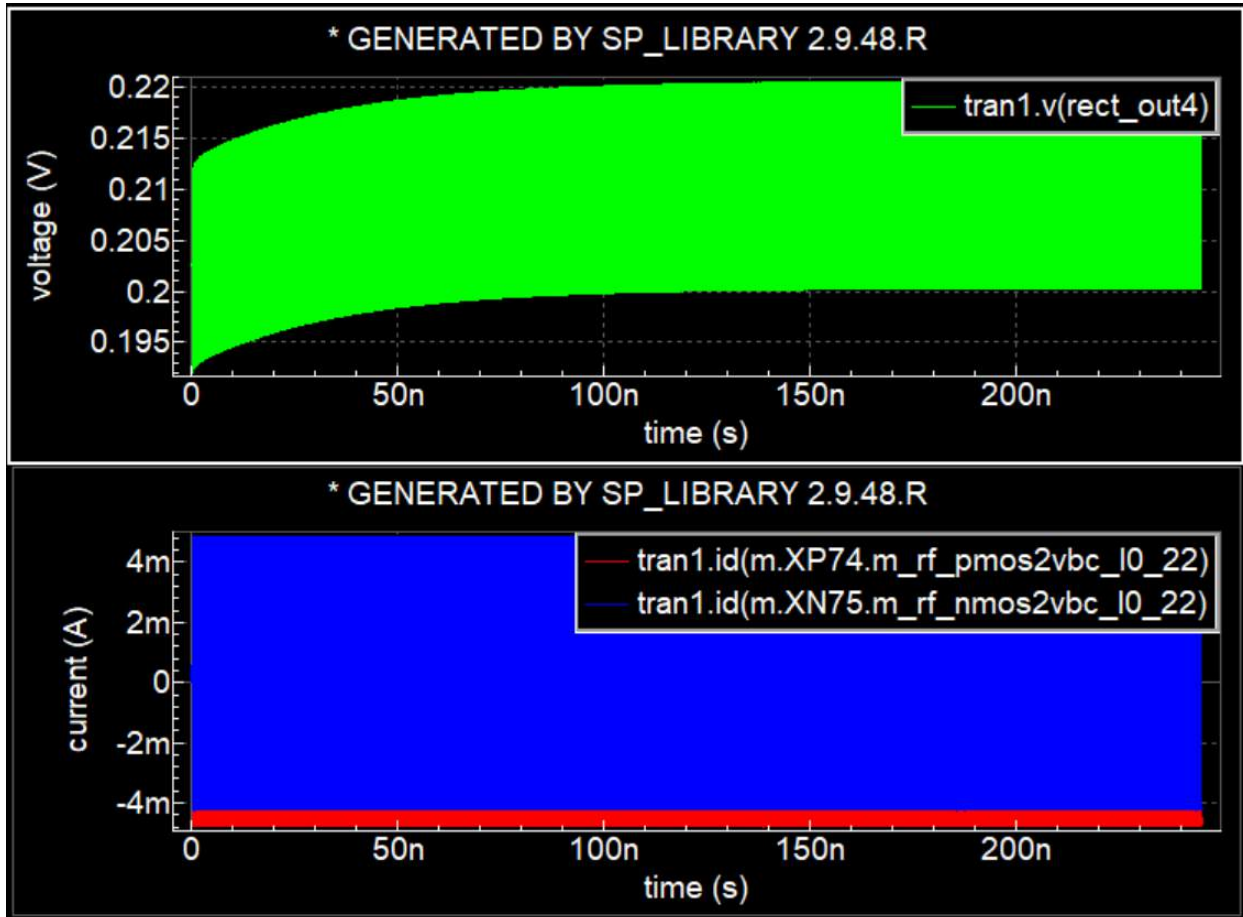


Figure 19: -.5dBm Performance—RF Rectifier Cold Start

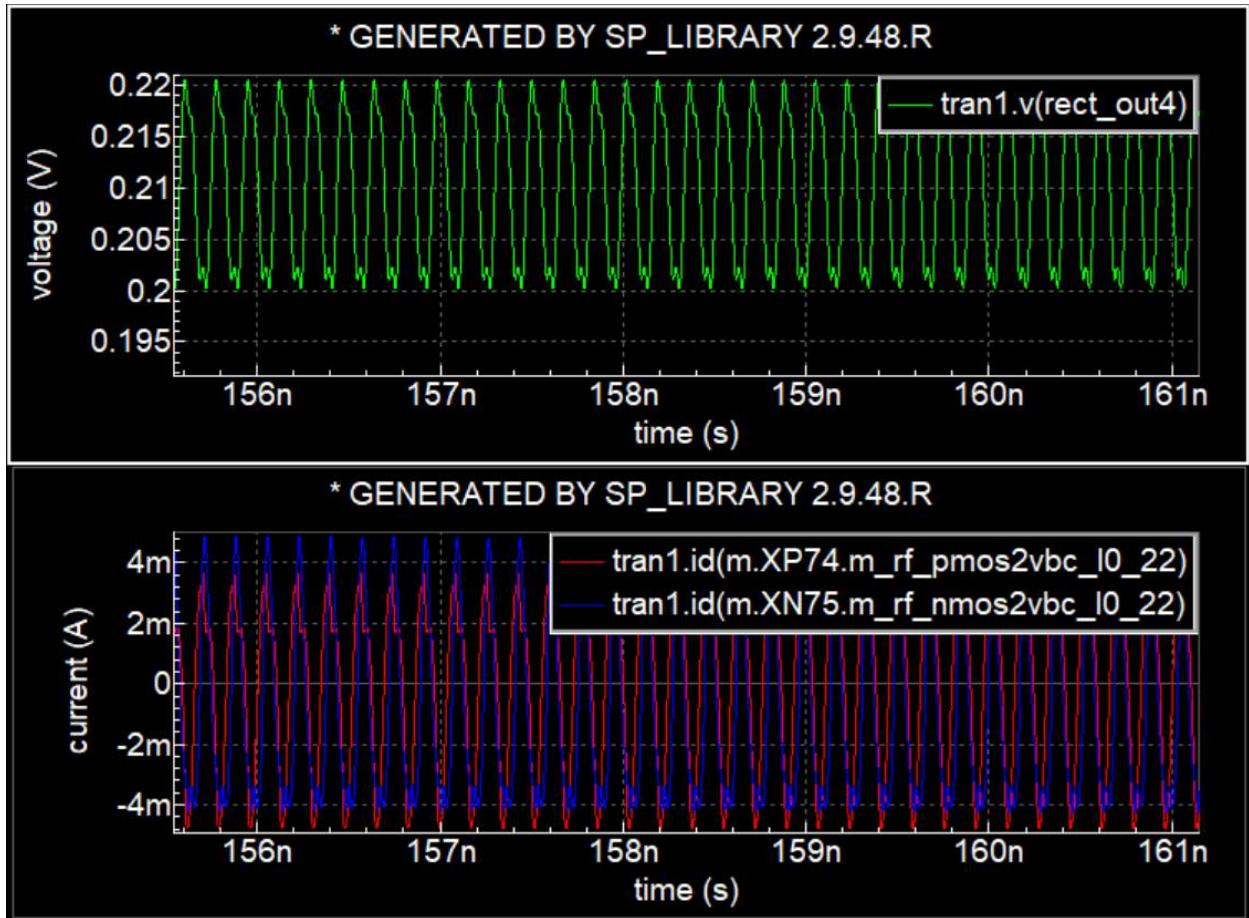
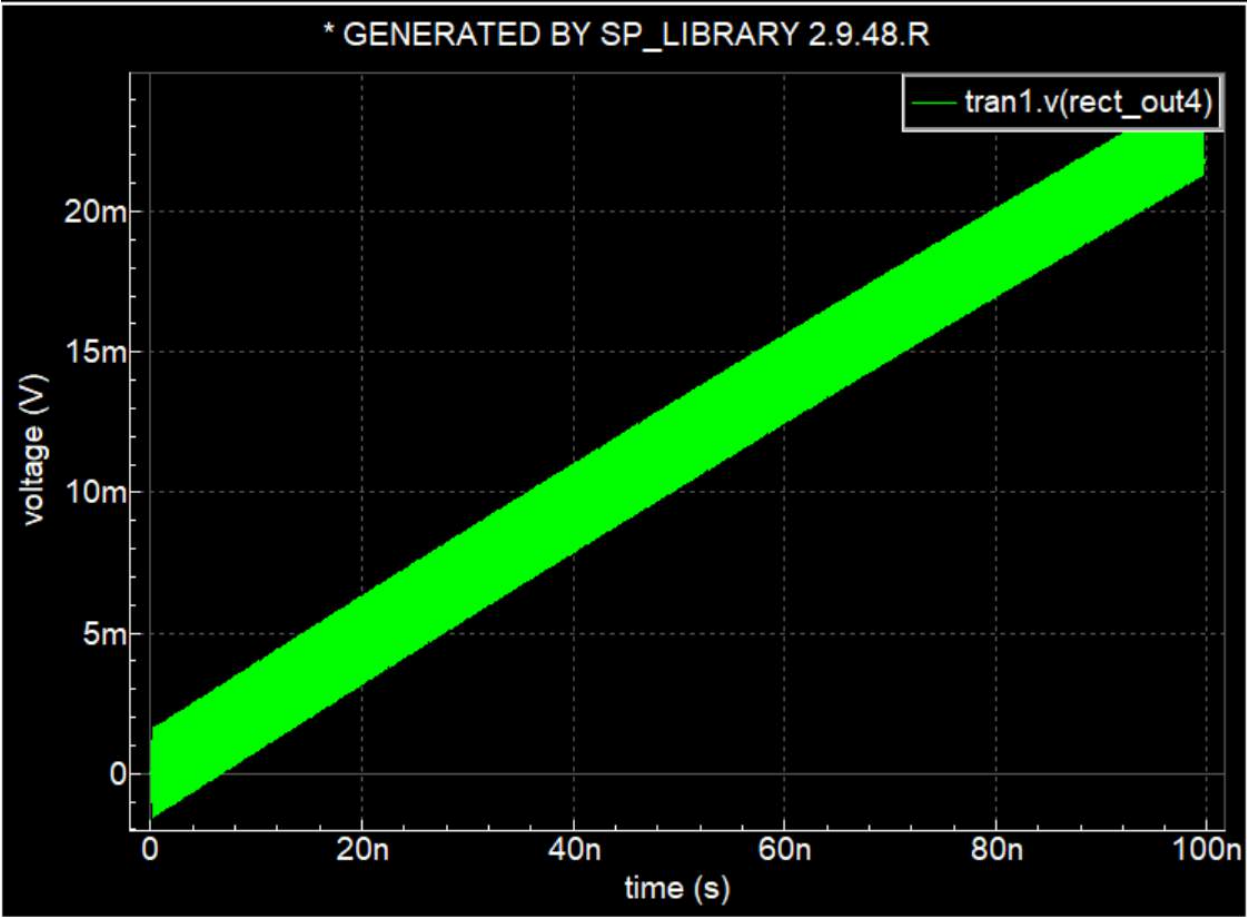
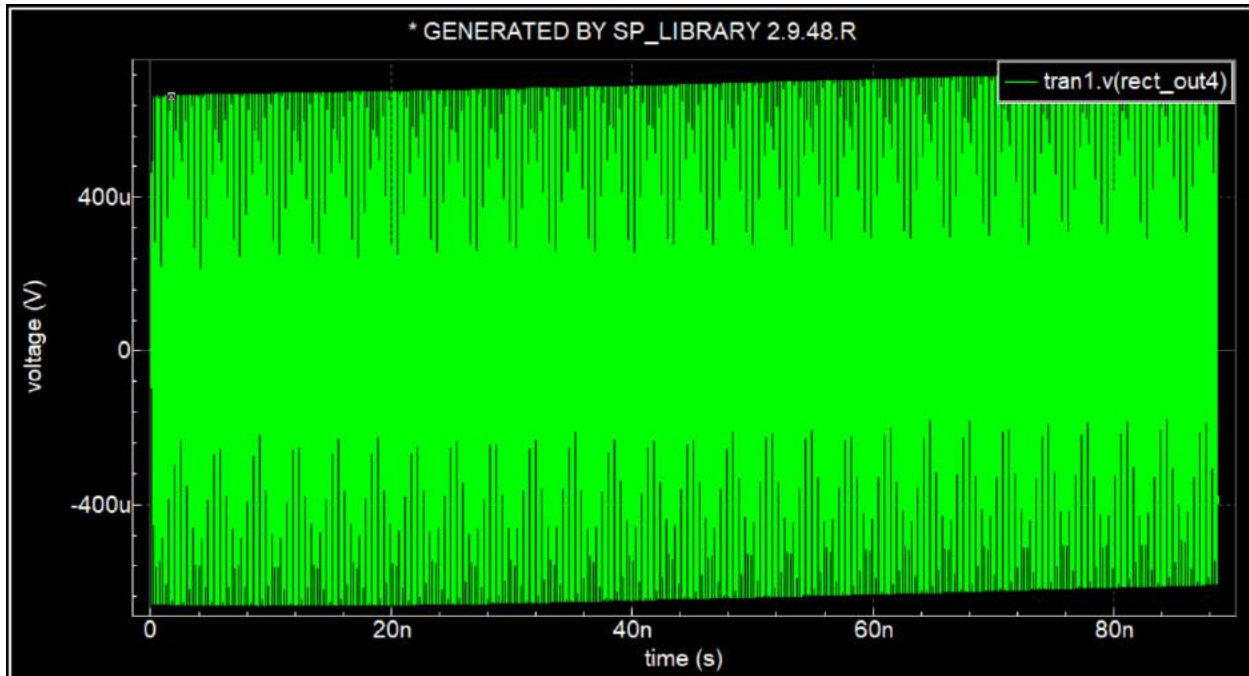


Figure 20: -.5dBm CC-205IP RF Rectifier Performance



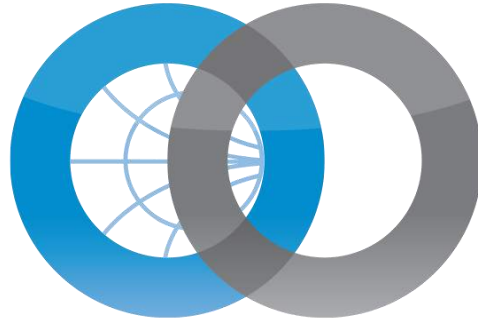
**Figure 21: RF Rectifier Cold Start -8dBm 125mVpp input**



**Figure 22: RF Rectifier Ultimate Cold Start -16dBm 50mVpp input**

Figures 19 to 22 show various input power conditions for cold start. Figure 9 also shows the cold start and DC rise under +33dBm conditions. The CC-205IP rectifier shows significant rectification current through the Block at -5dBm (Figure 20) and even shows an incremental DC rise at -8dBm and -16dBm input power conditions (Figures 21 and 22).

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