

# BLF989 Doherty

BLF989 X 2 470-500MHz.

V1.0 — 8 July 2018

AMPLEON

Test Report

## Document information

Info	Content
Status	Company Public
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Abstract	Measurement results of a Symmetrical Inverted Doherty design for the 470-500 MHz.band with 2 X BLF989 devices combined.

## 1 Revision History

Table 1. Report revisions

Revision No.	Date	Description	Author
1.0	20180706	Initial document	Bob Bartola

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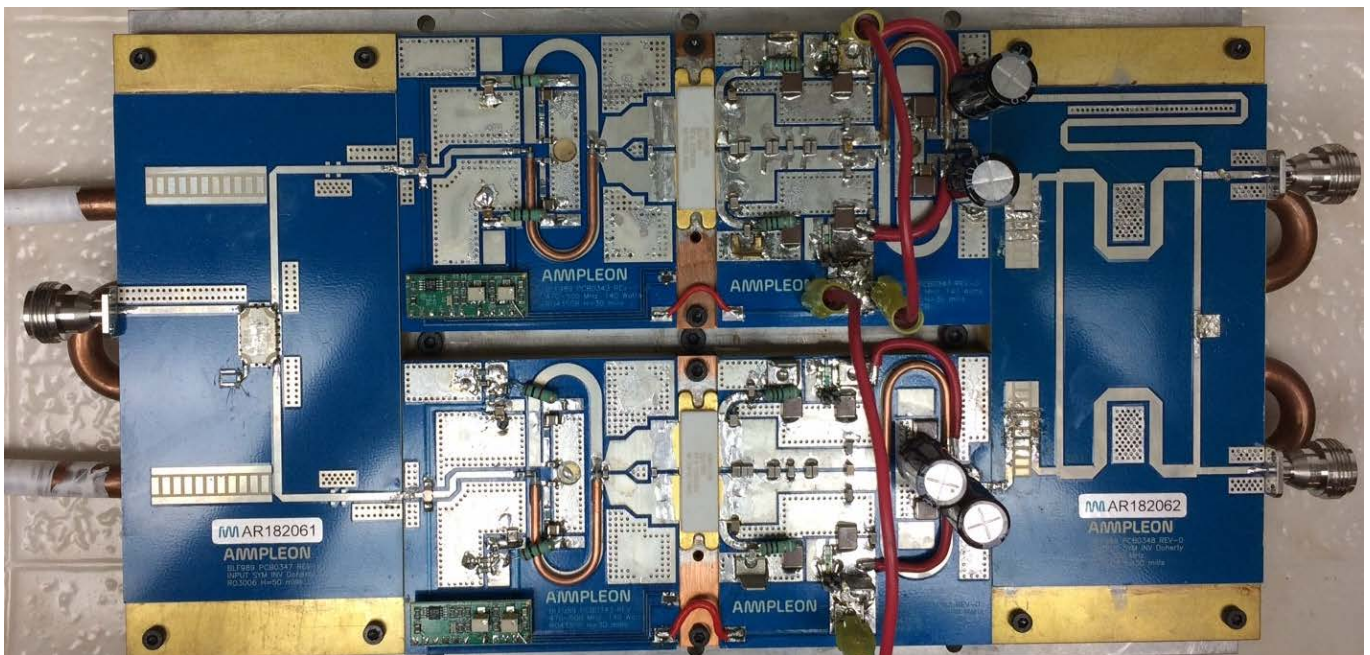
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## 5 General Description

This document contains measurement results of two Ampleon Gen9 BLF989 Symmetrical devices in an inverted symmetrical Doherty application circuit designed for the 470-500 MHz UHF band. Although this narrowband Doherty concept can be used to cover a narrow portion of the UHF band this application board was optimized for approximately 30 MHz bandwidth to improve efficiency, linearity, and harmonic rejection. The application board was tested with an 8MHz DVB-T signal using a Pro-TV exciter with bias levels of  $V_{ds}=50V$ ,  $I_{dq}(\text{main})=1200mA$ . and  $V_{gs}(\text{peak})=400mV$  and an output power of 300W average and approx..2KW pulsed Pload @ P-6dB.

Figure 1. Assembled Symmetrical Inverted Doherty DVB-T amplifier



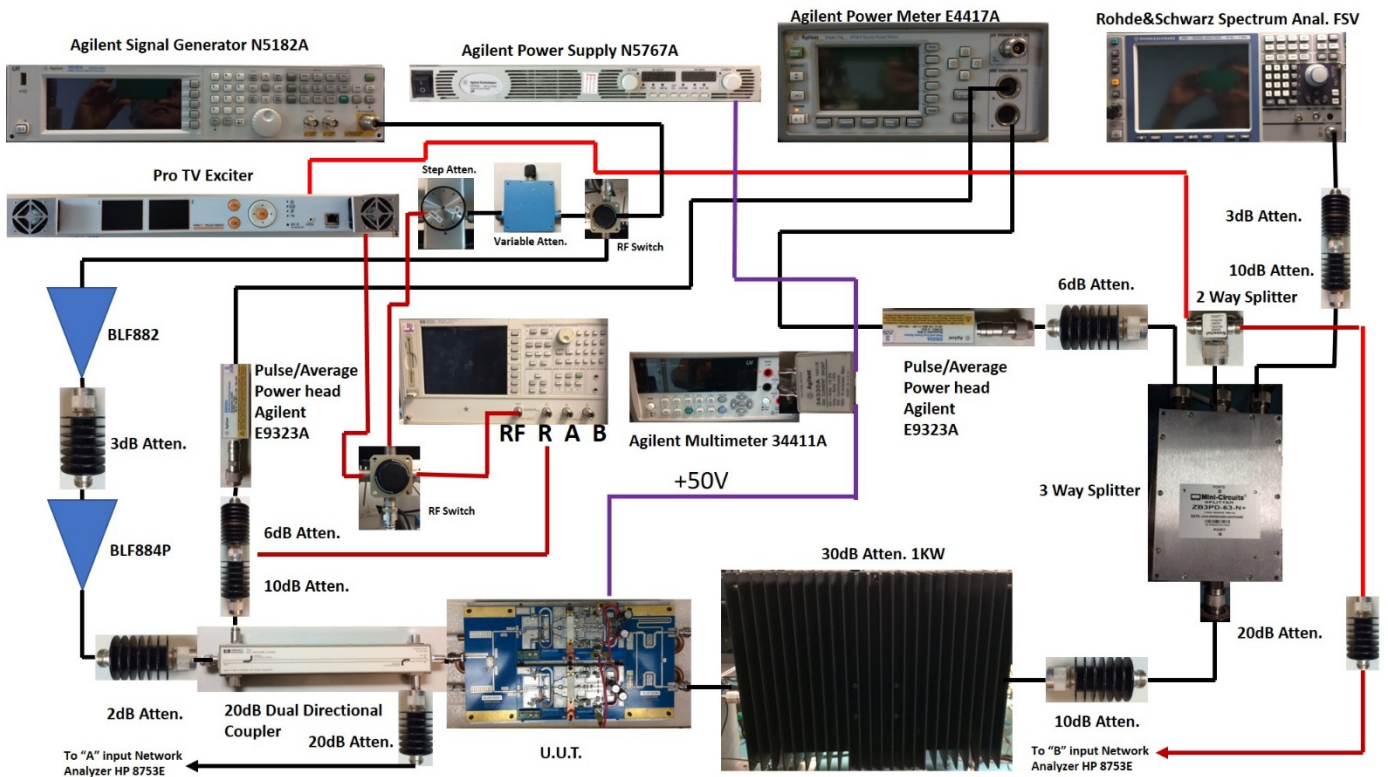
## 6 Biasing

### 6.1 Inverted Symmetrical Doherty Demo Bias Levels

The efficiencies presented are based on the currents of the drain feeds only. I.E. the biasing currents for the gate circuitry has not been included. The biasing is as follows:

- Vds(main) = 50V
- Vds(peak) = 50V
- Idq. (main)= 1200mA.
- Vgs(peak) = 400mV.

### 6.2 Bench Test Set Up



6.3 BLF989 Symmetrical Inverted Doherty Demo Block Diagram

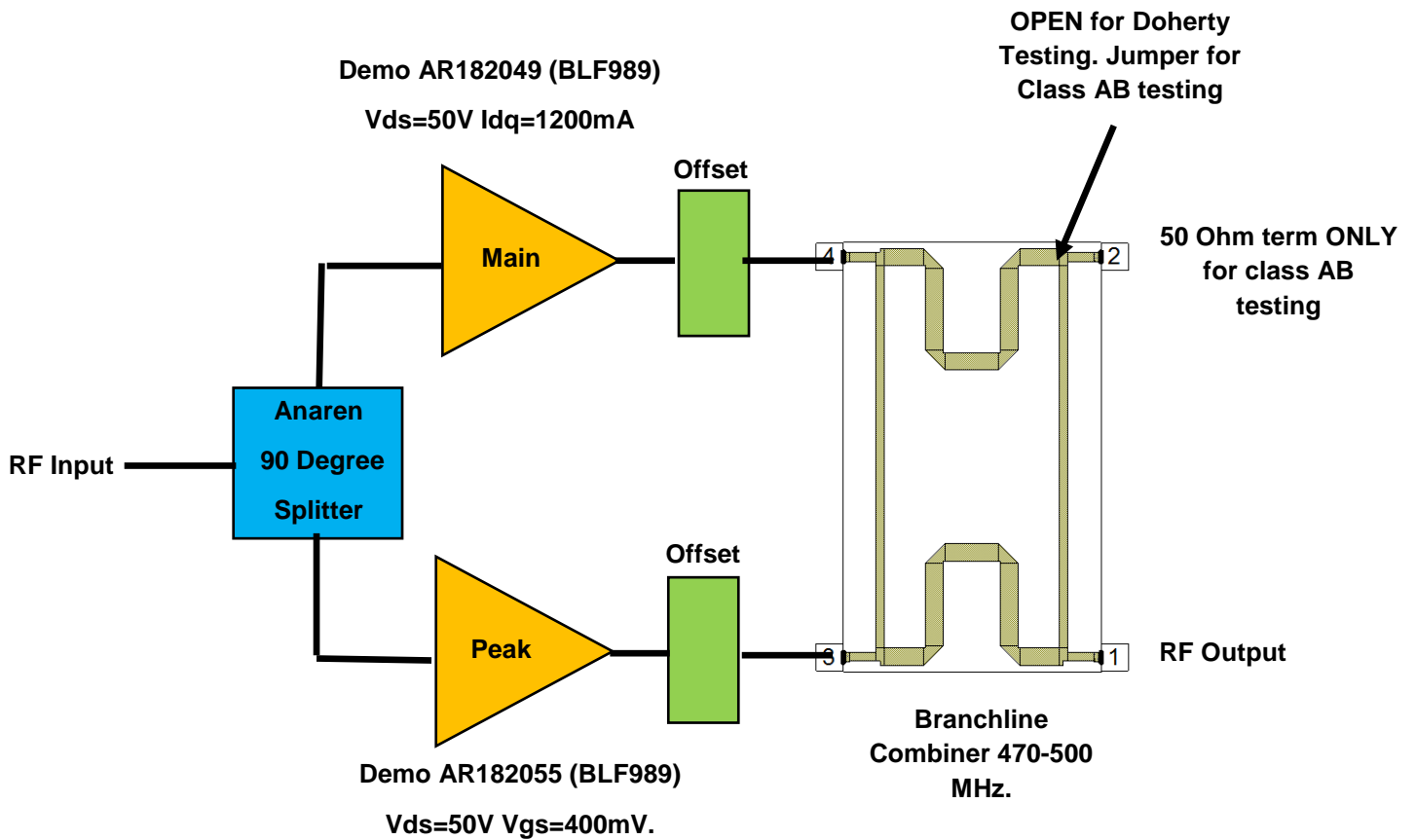


Figure 2. BLF989 X 2 Inverted Symmetrical Doherty and Class AB Block Diagram Test Platform

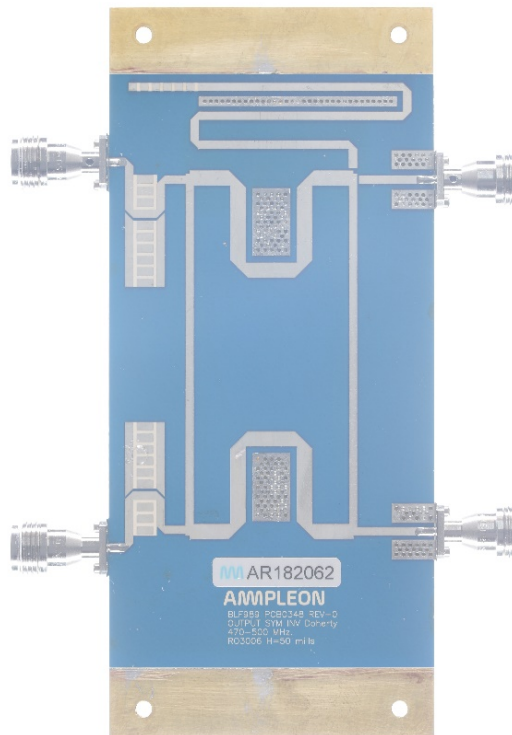


Figure 3. Output Branchline Combiner (470-500 MHz.)

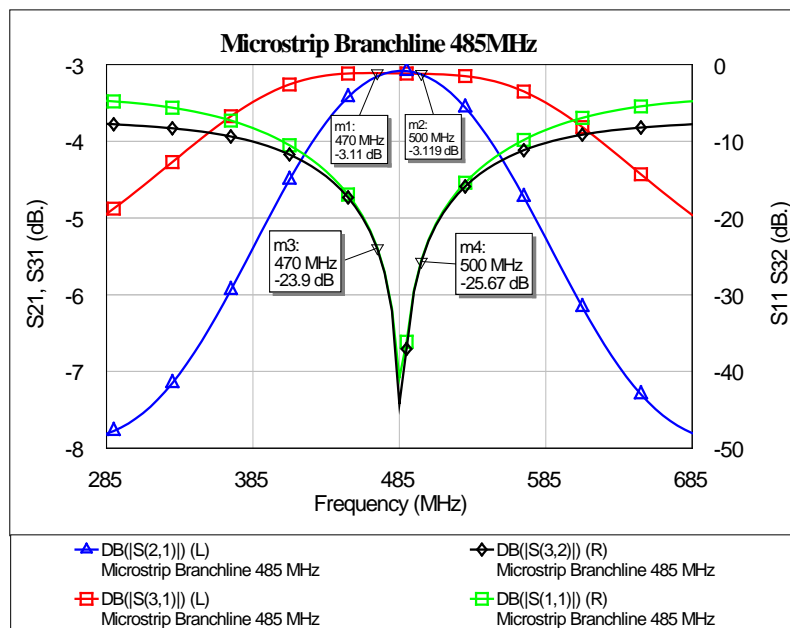


Figure 4. Output branchline S11, S21, S31, and S32



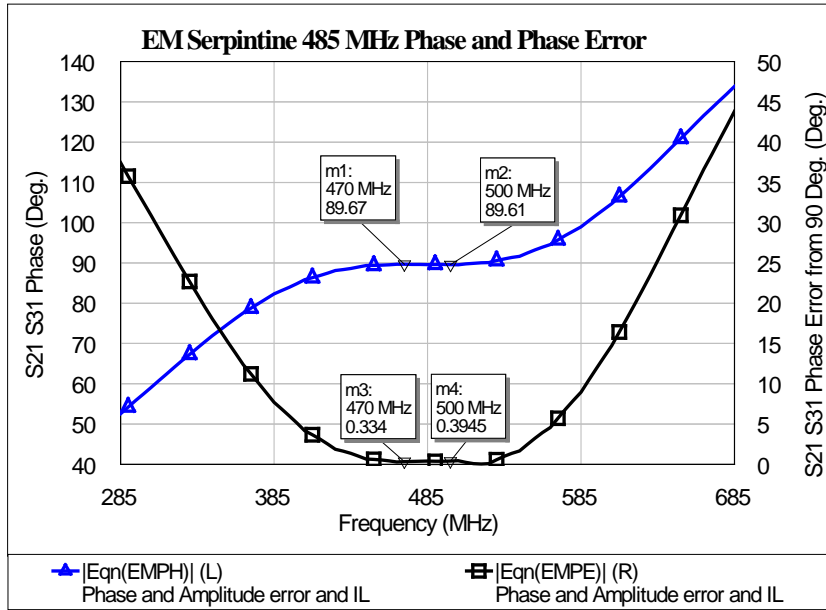


Figure 5. Branchline Phase and Phase Error from 90 degrees

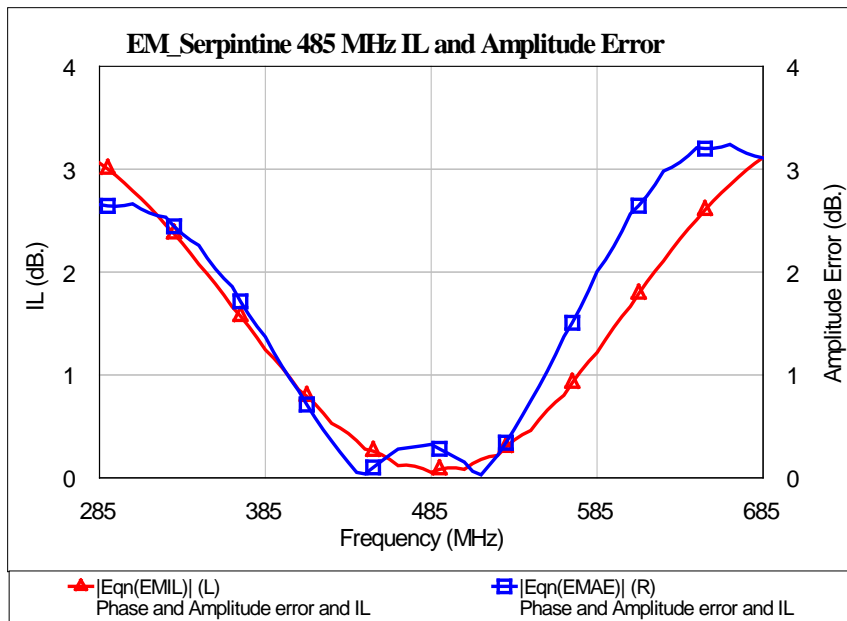
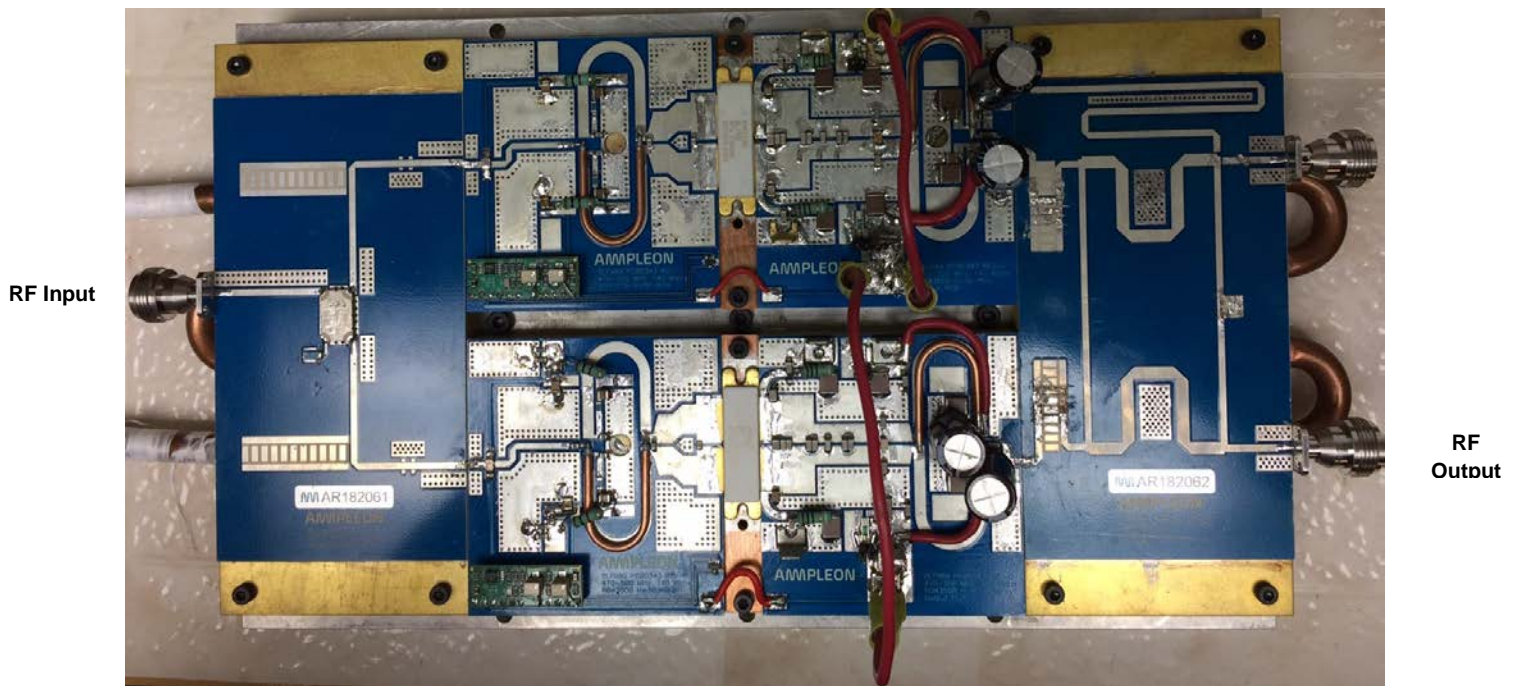


Figure 6. Branchline Insertion Loss and Amplitude Error

## 6.4 BLF989 X 2 Symmetrical Inverted Doherty Demo

AR182049 Main Amplifier



AR182055 Peak Amplifier

## 7 Performance Indicators

Table 2. Demo Bias conditions:  $V_{ds}=50V$   $I_{dq}$ . (main)=1200mA.  $V_{gs}$  (peak)=400mV.

Parameter	Condition	Unit	Demo "as-is"
Vds	470-500 MHz	V	50
Small Signal S11	470-500 MHz Small signal	RTN-L dB.	>25
Small Signal S21	470-500 MHz Small signal	Gain dB.	>16
AM-PM	Max @ 300W CW	Deg.	< 5
Corrected Shoulder Attenuation	280W Average	dBc.	-37 max.
CW Efficiency	300W Pload	%	>49
DVB-T Efficiency	300W Ave. Pload	%	>50
Gain @ 300W	CW 470-500 MHz.	dB.	>18.5

## 8 Test Object details

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Transistor (Main amplifier) type: BLF989

Transistor (Peak amplifier) type: BLF989

Production code (Main amplifier): RFA D180389

Production code (Peak amplifier): RFA D180389

PCB Boards:

Input Splitter PCB: PCB0347 REV-0 Rogers RO3006 H=50 mills

Output Splitter PCB: PCB0348 REV-0 Rogers RO3006 H=50 mills

Main Amplifier (AR182049) PCB: PCB0343 REV-0 Rogers RO4350 H=30 mills

Peak Amplifier (AR182055) PCB: PCB0343 REV-0 Rogers RO4350 H=30 mills

**9 Performance Details**

**9.1 Uncorrected and Corrected Inverted Symmetrical Doherty Performance Tables**

DVB-T Average Pload (Watts)	Offset Frequency (MHz.)				CW AM/PM (Deg.)
	-8.6	-4.3	+4.3	+8.6	
50	-39	-33	-33	-39	+1
100	-38	-32	-32	-38	+1.5
150	-35	-29	-29	-35	+1.8
200	-33	-26	-26	-33	+2.5
250	-32	-24	-24	-32	+3.0
300	-30	-23	-23	-30	+3.6

**Table 3. Uncorrected ACPR and CW AM/PM performance at 470 Mhz.**

DVB-T Average Pload (Watts)	Offset Frequency (MHz.)				Efficiency (%)
	-8.6	-4.3	+4.3	+8.6	
200	-45	-41	-41	-45	42
250	-42	-38	-38	-42	47
300	-41	-36.5	-38	-41	50.5

**Table 4. Corrected ACPR and CW AM/PM performance at 470 Mhz.**

DVB-T Average Pload (Watts)	Offset Frequency (MHz.)				CW AM/PM (Deg.)
	-8.6	-4.3	+4.3	+8.6	
50	-38	-33	-33	-38	+1.0
100	-39	-34	-34	-39	+1.2
150	-38	-33	-33	-38	+1.4
200	-37	-31	-31	-37	+1.9
250	-35	-29	-29	-35	+2.3
300	-33	-26	-26	-33	+2.5

**Table 5. Uncorrected ACPR and CW AM/PM performance at 485 Mhz.**

DVB-T Average Pload (Watts)	Offset Frequency (MHz.)				Efficiency (%)
	-8.6	-4.3	+4.3	+8.6	
200	-45	-41	-41	-45	44
250	-44	-40	-40	-44	48
300	-42	-38	-38	-42	50.8

**Table 6. Corrected ACPR and CW AM/PM performance at 485 Mhz.**

DVB-T Average Pload (Watts)	Offset Frequency (MHz.)				CW AM/PM (Deg.)
	-8.6	-4.3	+4.3	+8.6	
50	-37	-30	-30	-37	+1.1
100	-38	-32	-32	-38	+1.4
150	-37	-32	-32	-37	+1.6
200	-36	-30	-30	-36	+3.5
250	-35	-28	-28	-35	+3.6
300	-33	-24	-24	-34	+3.9

Table 7. Uncorrected ACPR and CW AM/PM performance at 500 Mhz.

DVB-T Average Pload (Watts)	Offset Frequency (MHz.)				Efficiency (%)
	-8.6	-4.3	+4.3	+8.6	
200	-44	-40	-40	-44	44.4
250	-42	-38	-38	-42	48.5
300	-40	-36	-36	-40	51

Table 8. Corrected ACPR and CW AM/PM performance at 500 Mhz.

Frequency (MHz.)	-8.6 MHz.	-4.3 MHz.	+4.3 MHz.	+8.6 MHz.	Efficiency @300W (%)	CW AM/PM @300W (Deg.)	CW Pulsed (PW=100uS. DF=10%) Pload @ P-6dB. (WATTS)
470	-41	-36.5	-38	-41	50.5	+3.6	<b>1914</b>
485	-42	-38	-38	-42	50.8	+2.5	<b>2032</b>
500	-40	-36	-36	-40	51	+3.9	<b>1990</b>

Table 9. Pro-TV Exciter Corrected DVB-T @ 300W Average Measurements

## 9.2 Performance Data (Graphs)

Figure 7. Class AB Pulsed Gain and Efficiency vs. Pload drive up to P-6dB. PW=100uS. DF=10%

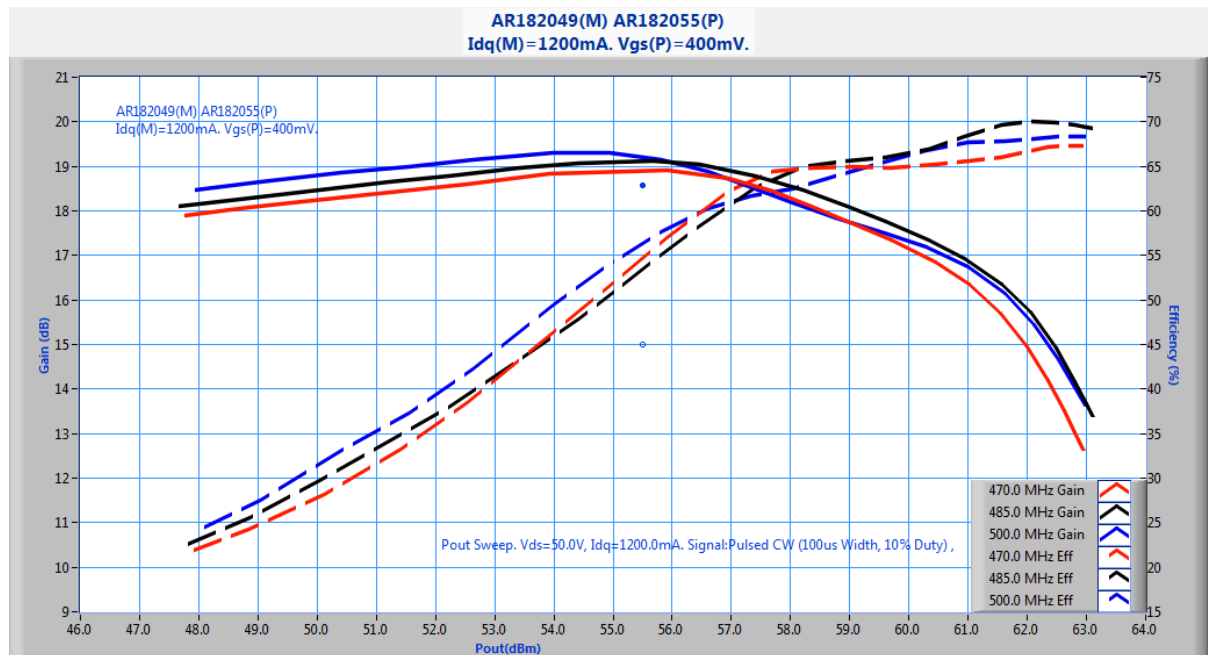
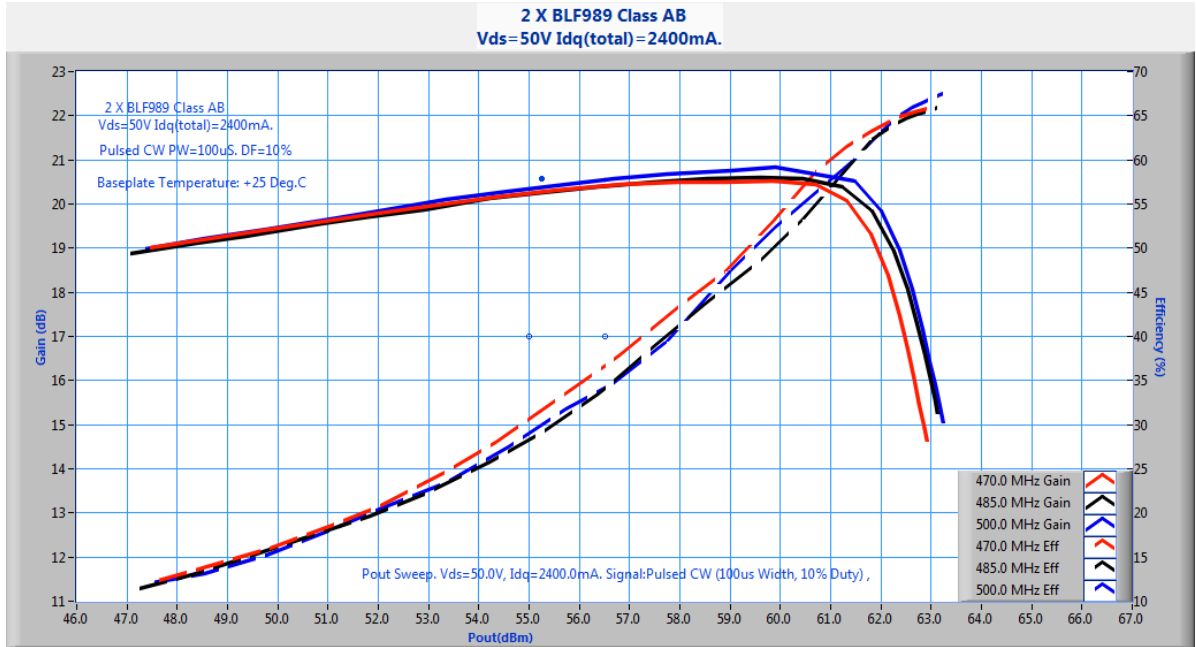


Figure 8. Inverted Symmetrical Doherty Pulsed Gain and Efficiency vs. Pload drive up to P-6dB. PW=100uS. DF=10%



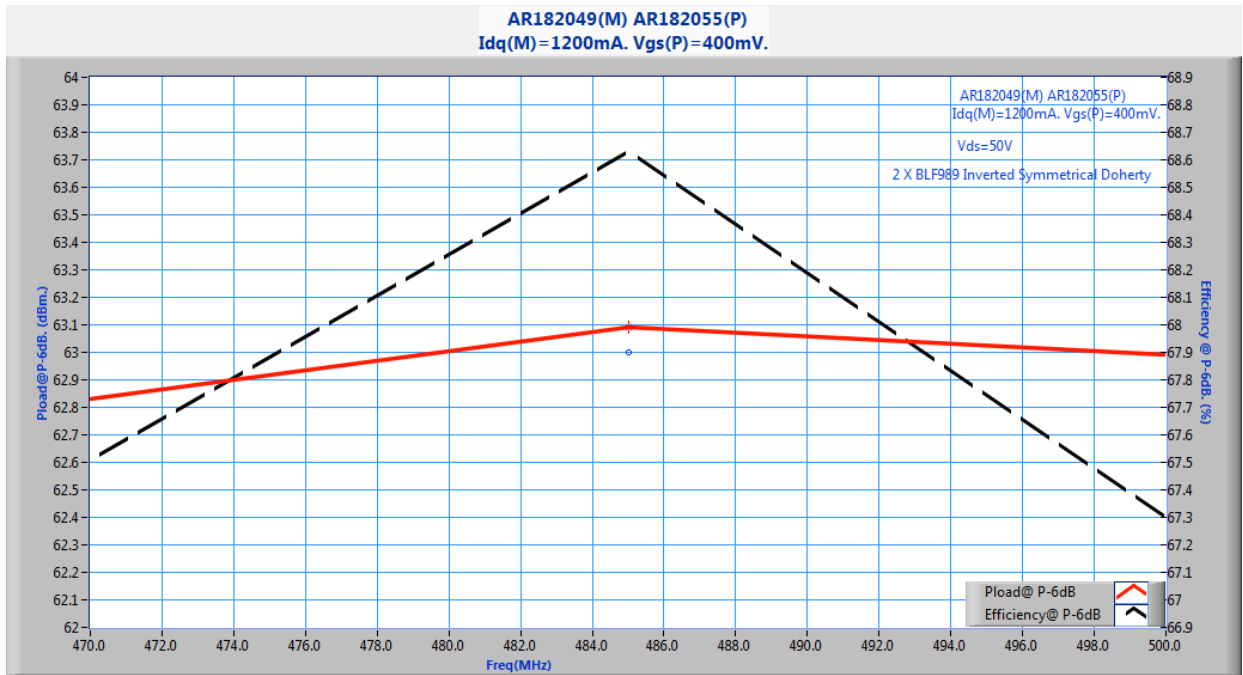


Figure 9. Pload and Efficiency (Pulsed CW 100uS 10%) vs. Frequency @ P-6dB.

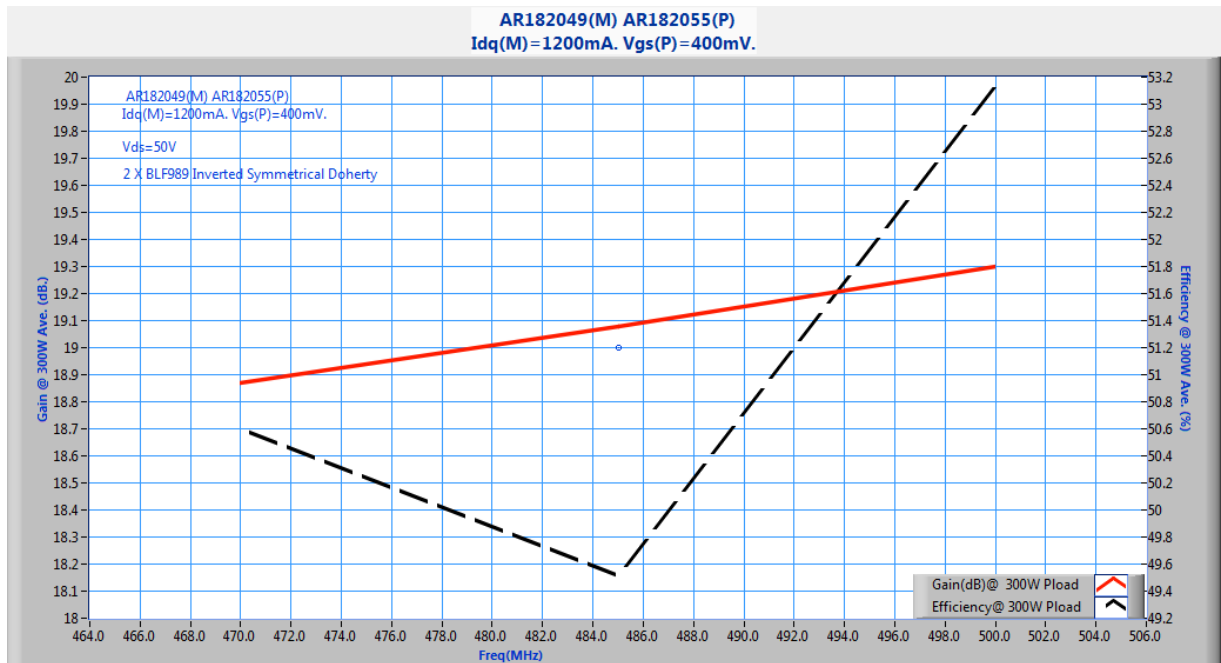


Figure 10. Pload and Efficiency CW vs. Frequency @ 300 Watts

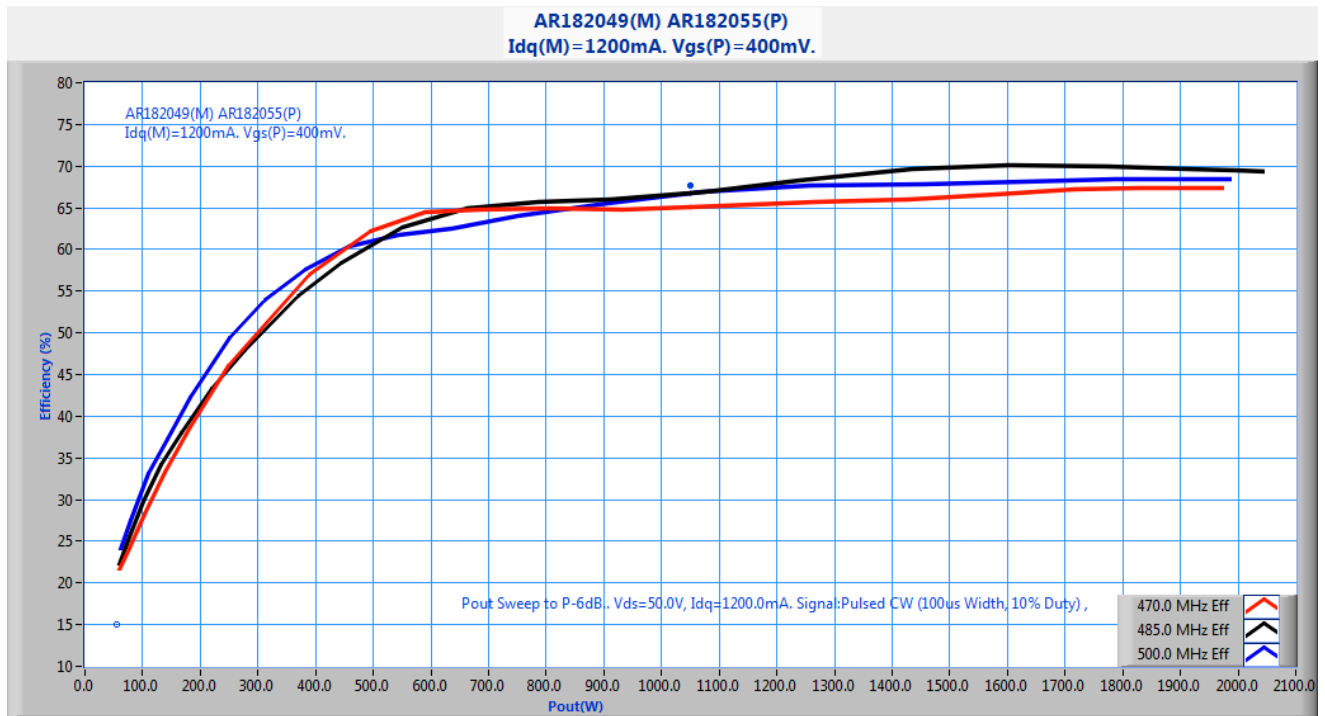


Figure 11. Efficiency vs Pload (Watts) Pulsed CW 100uS 10% RF Drive up to P-6dB.

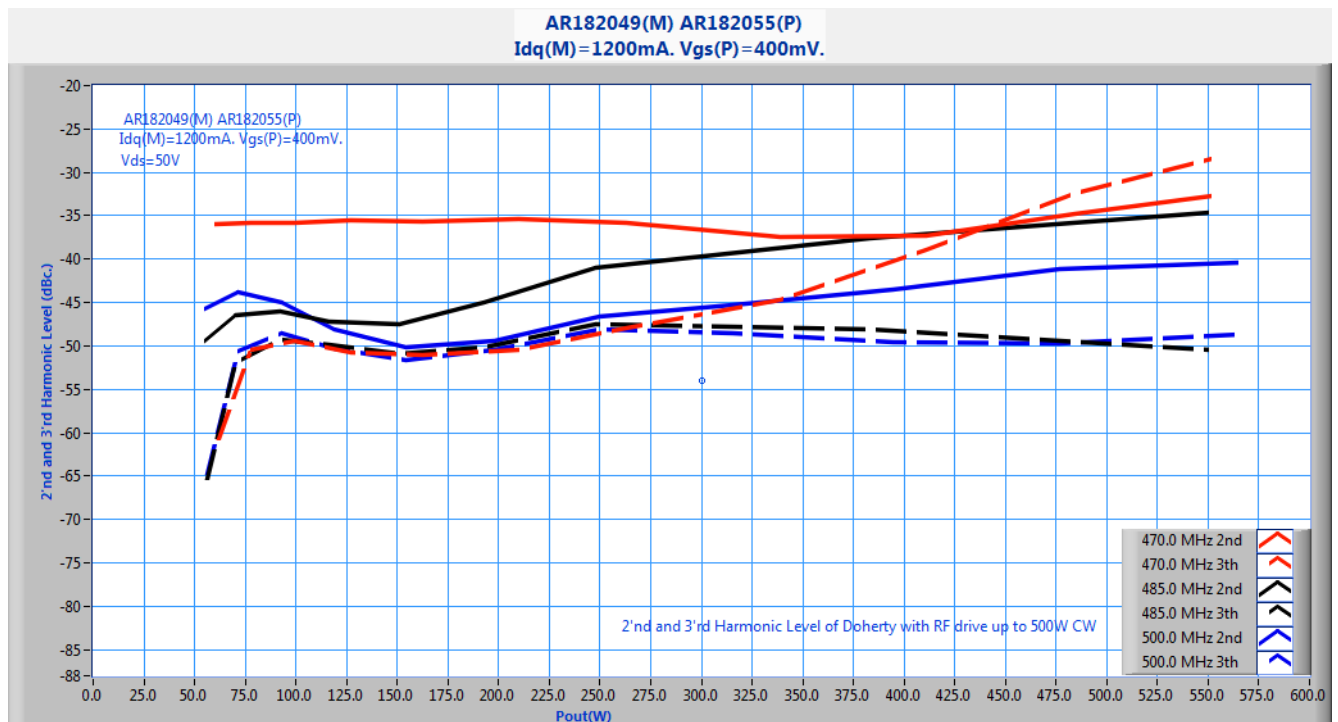
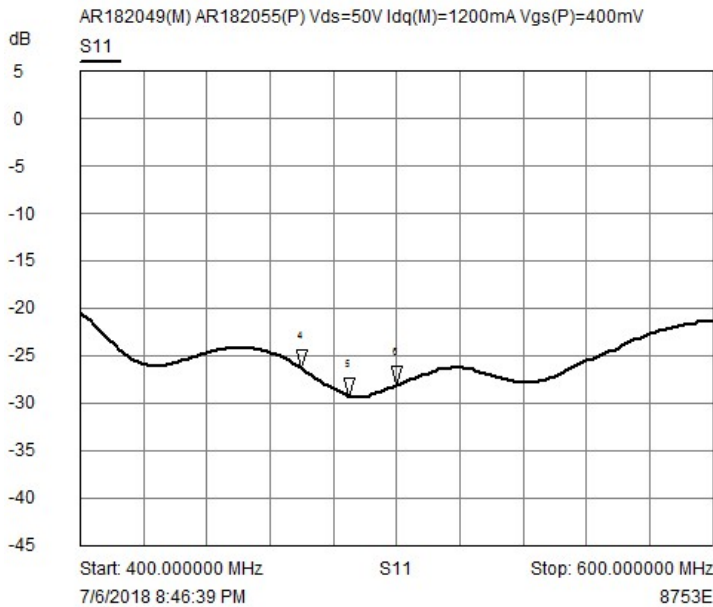


Figure 12. CW 2'nd and 3'rd Harmonic Level driven to 550 Watts

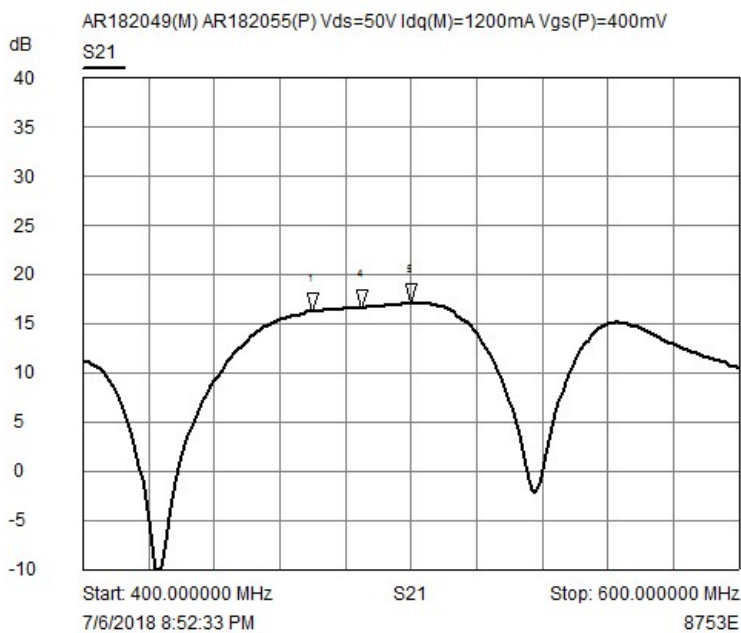
Figure 13. Small Signal S11 and S21 in Doherty mode



- 4 S11  
▽ 470.000000 MHz  
-26.3912 dB
- 5 S11  
▽ 485.000000 MHz  
-29.2593 dB
- 6 S11  
▽ 500.000000 MHz  
-28.1424 dB

S11 Vds=50V  
Idq. (Main)=1200mA.  
Vgs(Peak)=400mV.

2 X BLF989 Small Signal Doherty Mode



- 1 S21  
▽ 470.000000 MHz  
16.1785 dB
- 4 S21  
▽ 485.000000 MHz  
16.5652 dB
- 5 S21  
▽ 500.000000 MHz  
17.0020 dB

S21 Vds=50V  
Idq. (Main)=1200mA.  
Vgs(Peak)=400mV.

2 X BLF989 Small Signal Doherty Mode

## 10 BLF989 Doherty PCB Layouts

Figure 14. PCB Layout for Class AB Biasing (AR182049)

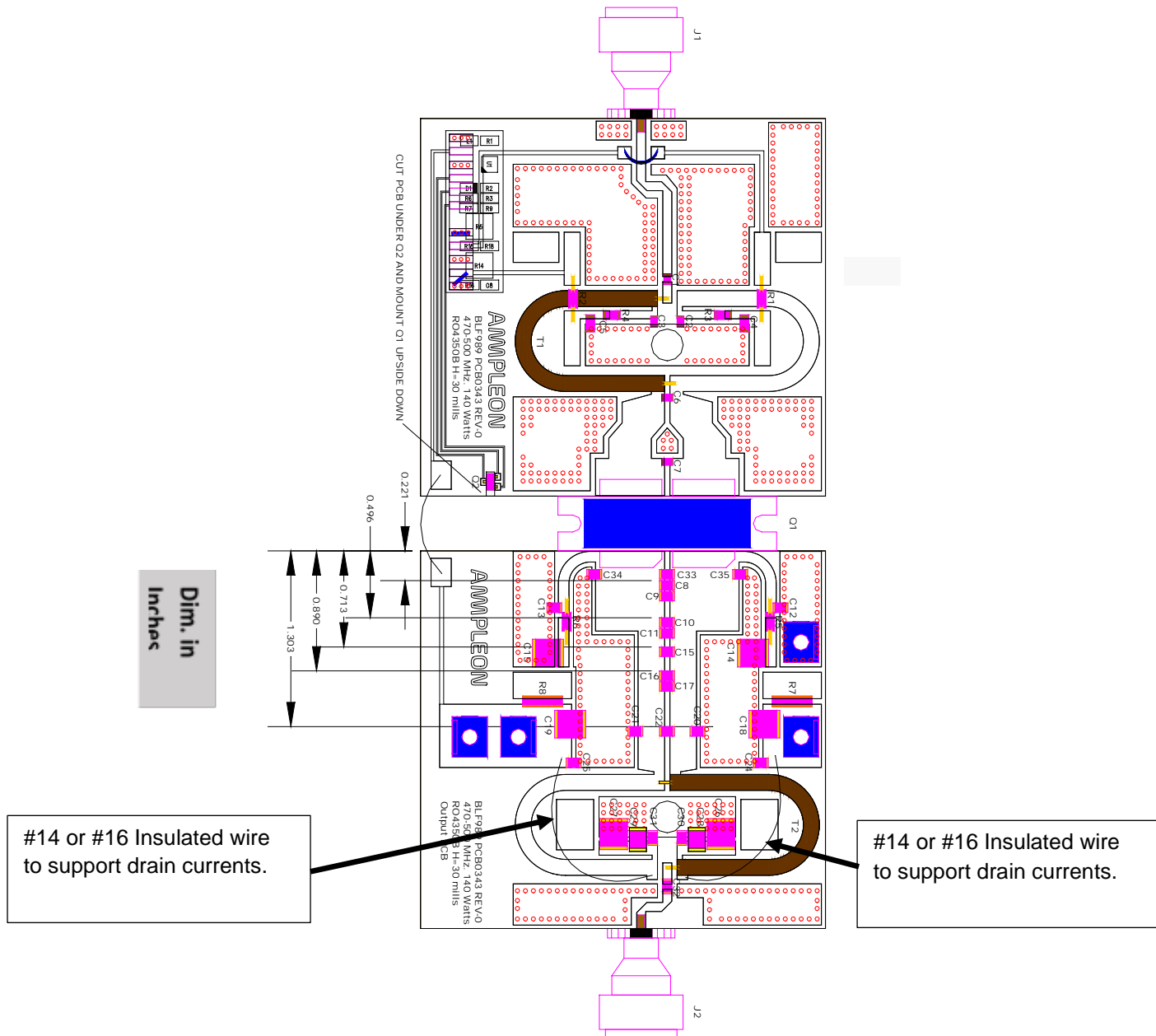


Figure 15. PCB Layout for Class C Biasing (AR182055)

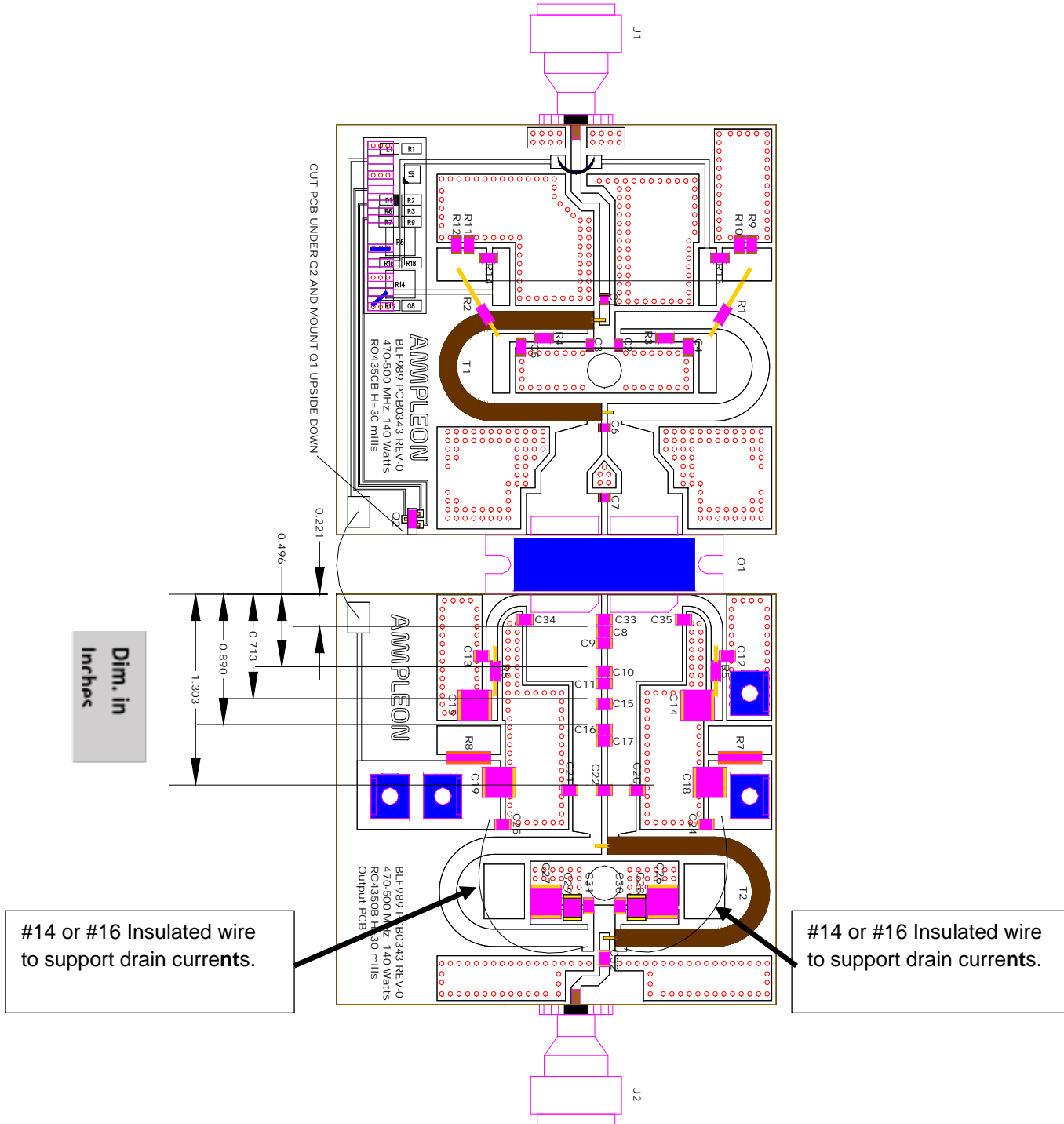
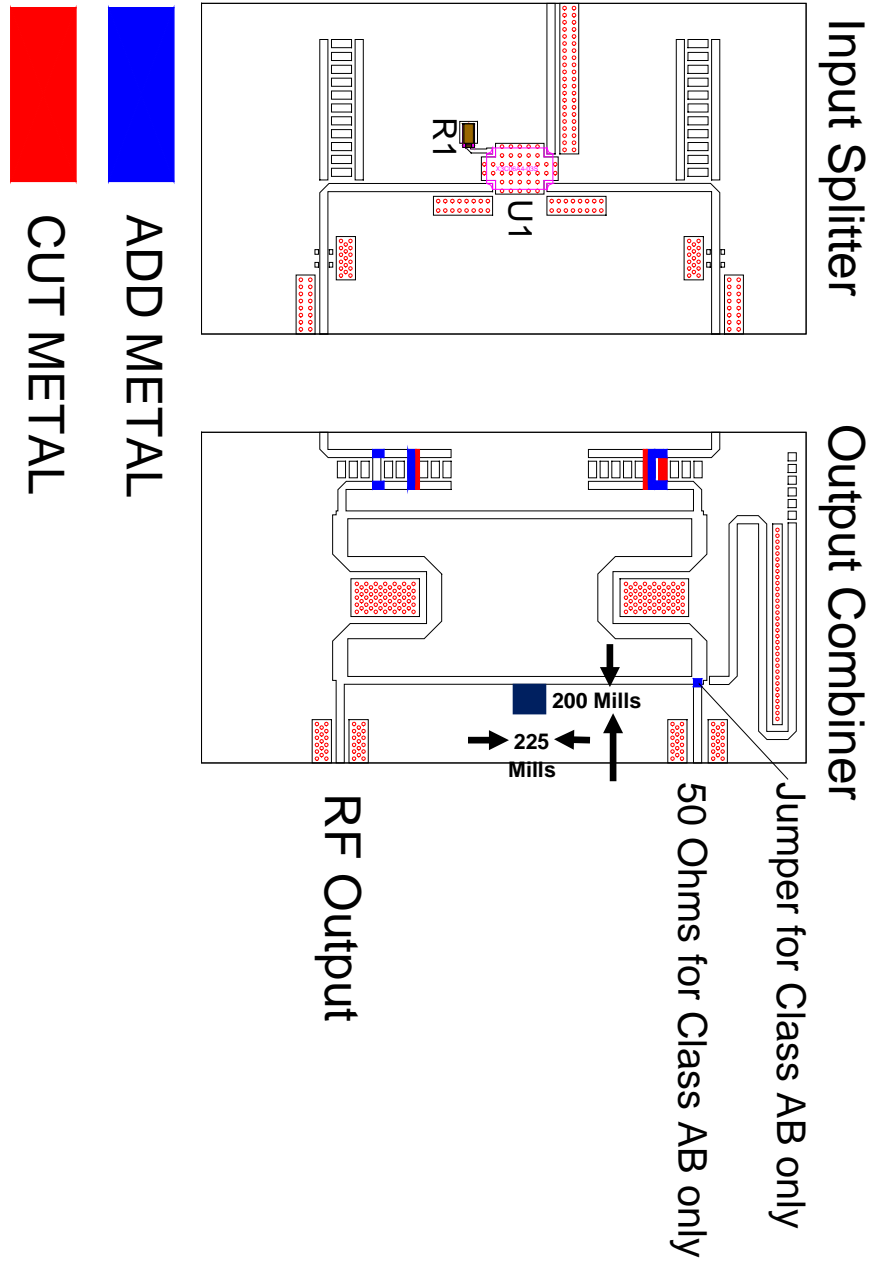


Figure 16. Input Splitter and Output Combiner



## 11 BLF989 Class AB and Doherty amplifier and Splitter/Combine BOM

Table 10. BLF989 Class AB and C Amplifier portion BOM

Designator	Description	Manufacturer	Part#
PCB Input PCB	Input PCB, 30 mil thk. RO4350B	Avanti Circuits	PCB0343 Rev.0
PCB Output PCB	Input PCB, 30 mil thk. RO4350B	Avanti Circuits	PCB0343 Rev.0
Input Base Plate	Input Brass Carrier 2.8" X 3"	Jones Machine	SMI0018 4350 Input
Output Base Plate	Output Brass Carrier 2.8" X 3"	Jones Machine	SMI0019 4350 Output
	Dual LDMOS Bias Board	Ampleon	
C1, C2, C3	100 pf. 0805 case (A2)	Passive Plus	0805N101JW251X
C4, C5	4.7 uF,50V SMT 1210 case	TDK	C3216X5R1H475M160AB
C6	12 pf. 0805 case (C1)	Passive Plus	0805N120JW251X
C7	18 pf. 0805 case (G1)	Passive Plus	0805N180JW251X
C8, C34, C35*Vert. Mount	12 pf. N1111 case	Passive Plus	1111N120JW501X
C9, C10, C11, C15, C16 *Vert. Mount	8.2 pf. N1111 case	Passive Plus	1111N8R2BW501X
C17*Vert. Mount	2.2 pf. N1111 case	Passive Plus	1111N2R2BW501X
C22*Vert. Mount	6.2 pf. N1111 case	Passive Plus	1111N6R2BW501X
C23*Vert. Mount	OMIT for 470-500 MHz		
C20, C21, C33 *Vert. Mount	10 pf. N1111 case	Passive Plus	1111N100JW501X
C12, C13, C24, C25, C30, C31, C32 *Vert. Mount	100 pf. N1111 case	Passive Plus	1111N101JW501X
C14, C15, C18, C19, C26, C27	4.7 uF, 100V SMT XR7 2220 case	TDK	C5750X7R2A475K230KA
C28, C29	0.01uf. 500V 1812 case	Vishay	VJ1812Y103KXEAT5Z
C36, C37	470MFD. 63V Tubular	Nichicon	Not on assy. Dwg. Solder in parallel with C30 and C31 on +50V line
Q1	LDMOS	Ampleon	BLF989
Q2 Mount Upside Down	2N2222 NPN transistor	Fairchild	MMBT2222
R1, R2	100-ohm wire wound axial	Ohmite	Order from Digii-Key
R3, R4	5.6-ohm 1206 case	Panasonic or equiv.	
R5, R6	10-ohm wire wound axial		Ordered from Mouser
R7, R8	0.005-ohm, 1% (3008 case)	Susumu	RL7520WT-R005-F
R9, R10, R11, R12	332-ohm 1206 case	Panasonic or equiv.	Class C Biasing
R13, R14	562-ohm 1206 case	Panasonic or equiv.	Class C Biasing

T1, T2	60mm. (2.36" long outer shield) 25-ohm Balun	E Z Form Cable	Semi Rigid Coax EZ 90-25 (copper jacket) or EZ 90-25-TP (tin plated copper jacket)
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Input and Output N connectors: Huber+Suhner Part #: 22641166 Type: 23 N-50-0-16

**Table 11. Input Splitter and Output Combiner BOM**

Designator	Description	Manufacturer	Part#
PCB Input PCB	Input PCB, 50 mil thk. RO3006	Avanti Circuits	PCB0347 Rev.0
PCB Output PCB	Output PCB, 50 mil thk. RO3006	Avanti Circuits	PCB0348 Rev.0
R1	50 Ohms 20W	EMC Technology Inc.	SMT2010TALN
U1	90 Degree Quad	Anaren	X3C060A4-035



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