

AR191191

BLF989E, 470 to 700 Mhz

v0.2 — 16 January 2020

AMPLEON

Application Report

Document information

Status Company public

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Abstract Measurement results of an A-symmetric Ultra Wideband Doherty design with BLF989E for 470 to 700 Mhz

1. Revision History

Table 1: Report revisions

Revision	Date	Description	Author
0.0	20191218	Final version	Walter Sneijers

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5. General description

This report presents the measurement results of the A-symmetric Ultra Wideband Doherty demo AR191191. The device BLF989E used is 180Wavg DVB-T, 9th generation LDMOS in a SOT539 package. BLF989E lower section is the Main amplifier, the upper section is the Peak amplifier. The power ratio is 1:1.5 for optimum efficiency with DVB-T (and ATSC-3) signals. The presented demo was designed for the frequency band 470 to 700 Mhz (a relative bandwidth of 39%). AR191191 is the reference 470-700Mhz demonstrator.

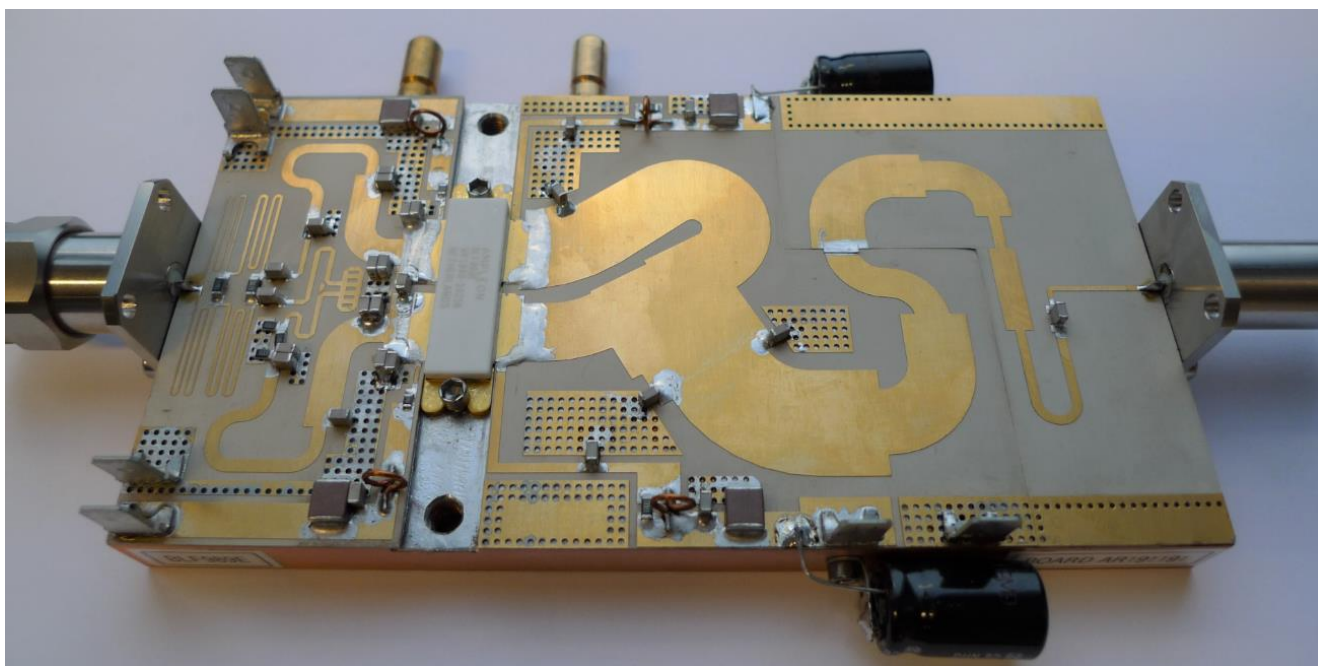


Figure 1 AR191191, 470-700Mhz demo top view

6. Biasing and practical aspects

The efficiencies presented are based on the currents of the drain feeds only. I.e. the biasing currents for the gate circuitry have not been included.

The biasing is as follows:

V_{DD_MAIN}	=	50V
V_{DD_PEAK}	=	50V
V_{GS_MAIN}	=	approx. 2.2V, leading to an $I_{DQ_MAIN}=600mA$
V_{GS_PEAK}	=	0.5V (range 0.25 – 0.7 V, can vary dependent on frequency and device)

The application is built on a copper heatsink and is water cooled.

The application is designed on 2 different (output) pcb materials to realise practical line widths near the transistor drains and 50Ω output.

Both transistor and pcb's are soldered on a baseplate to achieve optimum performance.

Special care is needed when the pcb's are not soldered on the baseplate to prevent bad grounding contact near the transistor and/or the transformer interface (connection of the 2 output pcb's).

Demo board designs:

AR191170 = 1st prototype 470-700Mhz board

AR191191 = reference demo 470-700Mhz board

AR191201 = 1st reproduction 470-700Mhz board (see fig. 13 + 14)

7. Performance Summary

Table 2: Performance summary, in band 470-700Mhz

Parameter	Condition-1	Condition-2	Unit	Pulsed CW	DVB-T
Power		Idq_m=0.6A Vgs_p=0.5V	W		180
Gain		Idq_m=0.6A Vgs_p=0.5V	dB		14.5 - 17
Drain Efficiency		Idq_m=0.6A Vgs_p=0.5V	%		46 - 54
P _{6dB}	100µs/10%	Idq_m=0.6A Vgs_p=0.5V	W	1000	-
PAR output signal	CCDF0.01%	Idq_m=0.6A Vgs_p=0.5V	dB		7 – 7.5
PAR output signal -c	Pre-corrected ^{1,2} CCDF0.01%	Idq_m=0.6A Vgs_p=0.5V	dB		> 7.5
Shoulder distance ^{1,2,3}		Idq_m=0.6A Vgs_p=0.5V	dBc		< -37.5
MER		Idq_m=0.6A Vgs_p=0.5V	dBc		> 34.5

Note 1: Input PAR DVB-T signal 9.5dB @ CCDF0.01%

Note 2: Pre-distorter: ProTelevision PT3000

Note 3: Shoulder distance ±4.3Mhz

The amplifier can deliver 180W average DVB-T power or pulsed CW 1000W (P6dB) over the whole bandwidth 470-700Mhz.

All RF measurements were performed with a 750Mhz LPF coupled towards the power meter. This avoids any harmonic content in the measured output power.

The wideband Klopfenstein transformer has 9 sections.

Note that the amplifier will not isolate mismatch impedances in the harmonic band.

Pre-correction:

The pre-corrected measurements were performed with a ProTelevision PT3000 exciter.

Idq/Vgs settings can be optimised for each channel. Note that some UHF channels need more correction on AM-AM (and AM-PM) distortion, which can be influenced by Vgs_p.

Vgs_p(eak) has a significant impact on efficiency. Best trade-off between (peak) power and efficiency was achieved at a Vgs_p of 0.5V. Different transistor batches can result in different Vgs settings dependent on transistor Vgs_threshold level.

8. Performance Details

The amplifier was measured with a DVB-T 8K signal (8Mhz signal bandwidth) and with a pulsed CW signal. V_{gs_p} is (normally) fixed at 0.4V but can be varied at each channel, likewise I_{dq_main} or V_{dd} . The measured freq range is 450 – 714Mhz.

8.1 DVB-T measurement (no correction), $P_{avg}=180W$

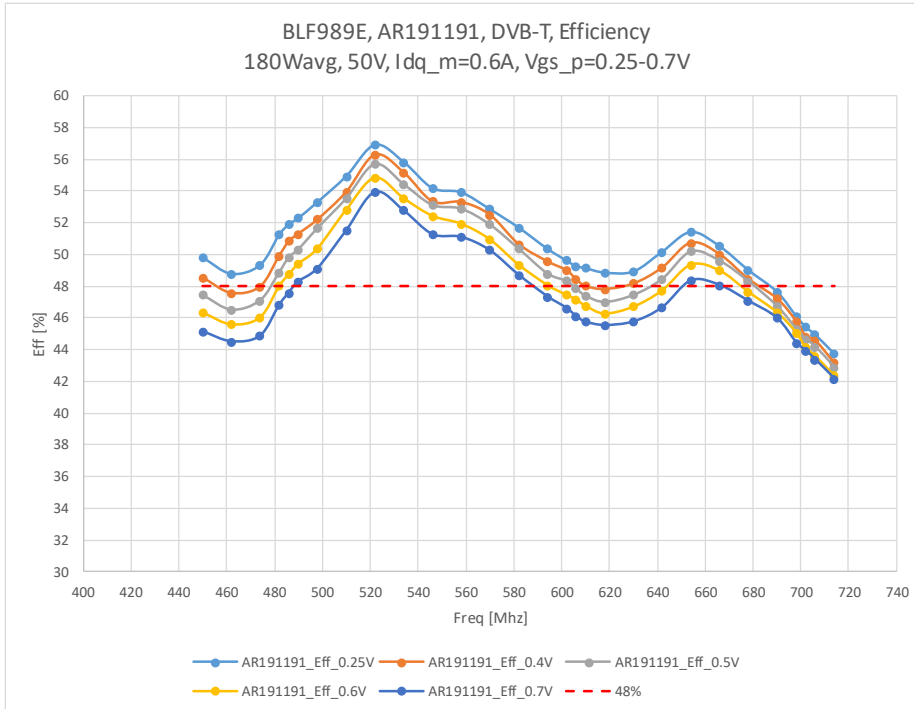


Figure 2 DVB-T, (Drain) efficiency (not corrected) $V_{gs_p}=0.25 - 0.7V$

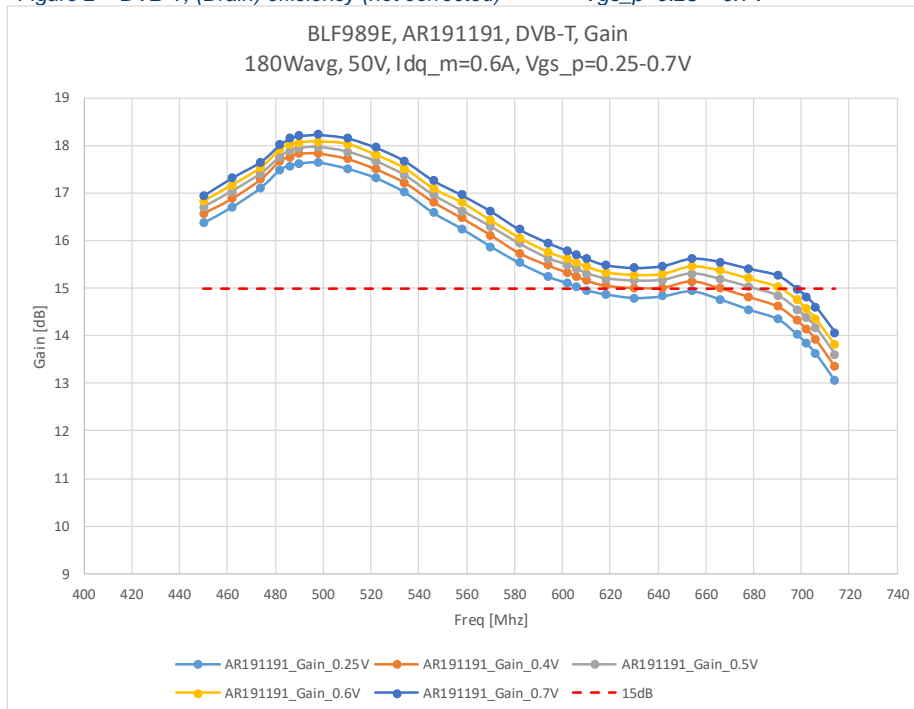


Figure 3 DVB-T, Gain (not corrected) $V_{gs_p}=0.25 - 0.7V$

8.2 DVB-T measurements with pre-correction, Pavg=180W

Pre-corrected data (ProTelevision PT3000).
The measured freq range is 474 – 690Mhz.

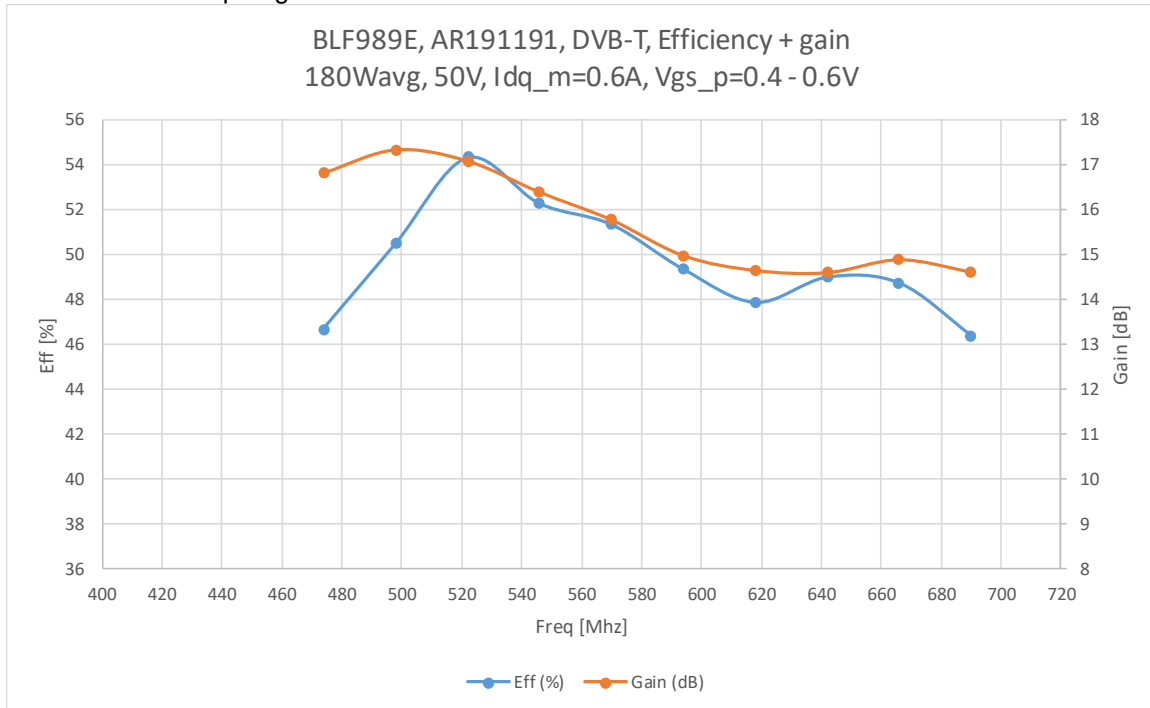


Figure 4 DVB-T, (Drain) efficiency + Gain Pre-corrected values

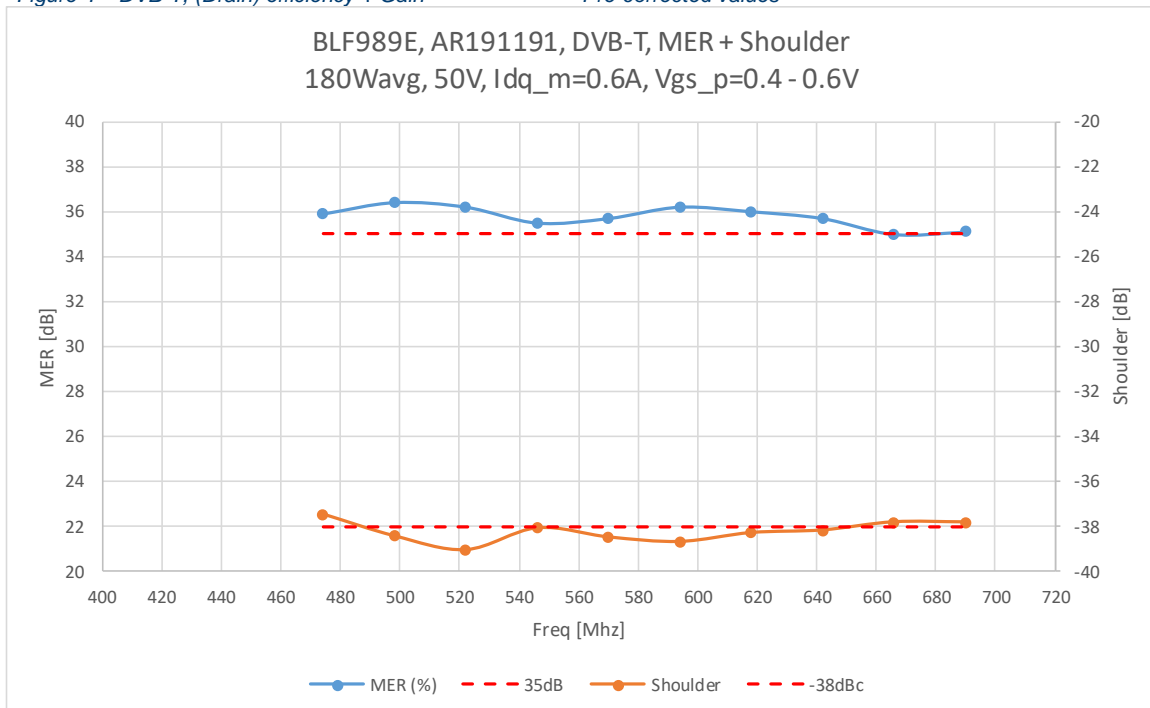


Figure 5 DVB-T, MER + Shoulder (4.3Mhz distance) Pre-corrected values

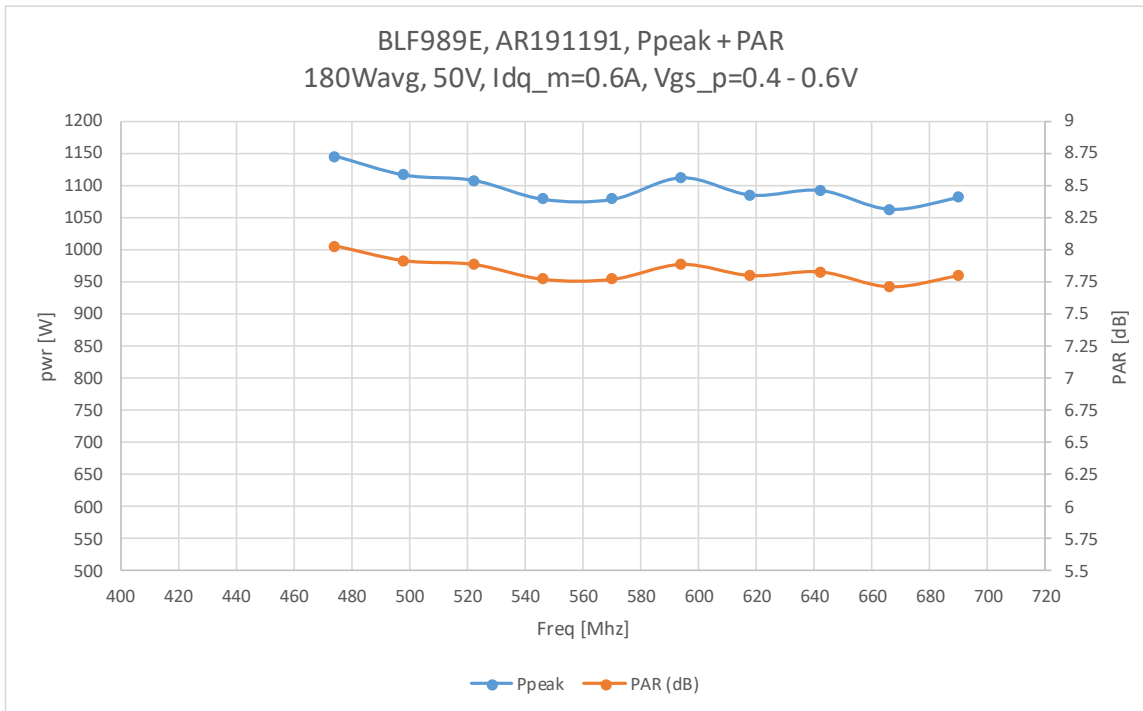


Figure 6 DVB-T, Ppeak + PAR Pre-corrected values

AR191191											
Freq	Idq_main	Vgs_peak	Gain (dB)	Eff (%)	PAE (%)	PAR (dB)	Pavg	Ppeak	MER (%)	ACPR4M3L (dBc)	PR4M3H (dBc)
474	0.6	0.5	16.80	46.67	45.70	8.03	180.37	1145.69	35.9	-37.48	-38.74
498	0.6	0.5	17.32	50.47	49.54	7.91	180.50	1116.28	36.4	-38.44	-39.24
522	0.6	0.5	17.08	54.32	53.26	7.88	180.35	1107.97	36.2	-39.06	-39.20
546	0.6	0.5	16.38	52.28	51.08	7.77	180.33	1078.63	35.5	-38.09	-38.79
570	0.6	0.5	15.77	51.34	49.98	7.77	180.31	1078.52	35.7	-38.49	-38.52
594	0.6	0.4	14.97	49.34	47.77	7.88	181.01	1112.02	36.2	-38.69	-39.38
618	0.6	0.4	14.64	47.85	46.21	7.80	180.21	1085.16	36	-38.30	-38.80
642	0.6	0.4	14.59	48.98	47.28	7.83	180.22	1092.49	35.7	-38.18	-39.14
666	0.6	0.6	14.88	48.72	47.13	7.71	180.14	1063.25	35	-37.82	-37.82
690	0.6	0.6	14.61	46.37	44.77	7.80	179.57	1081.27	35.1	-37.83	-37.85

Table 3: AR191191, Pre-corrected data 474Mhz (ch21) - 690Mhz (ch48)

The top table shows the pre-corrected measurements at 180Wavg. A minimum MER of 35dB with a shoulder distance of 38dBc was achieved over the band 474-690Mhz.

The trade-off between higher power and lower efficiency/higher gain was made via Vgs_p.

8.3 Pulsed CW measurements

Pulse condition: 100µs/10%. P6dB gives the best indication of the peak power capability.

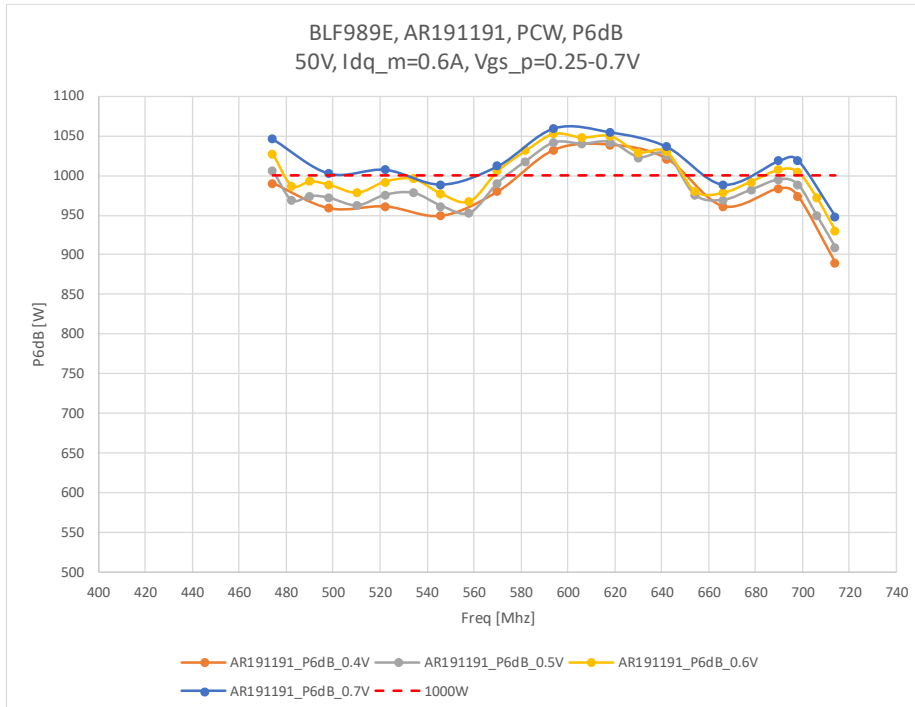


Figure 7 Pulsed CW, P6dB [W] Vgs_p = 0.4 ÷ 0.7V

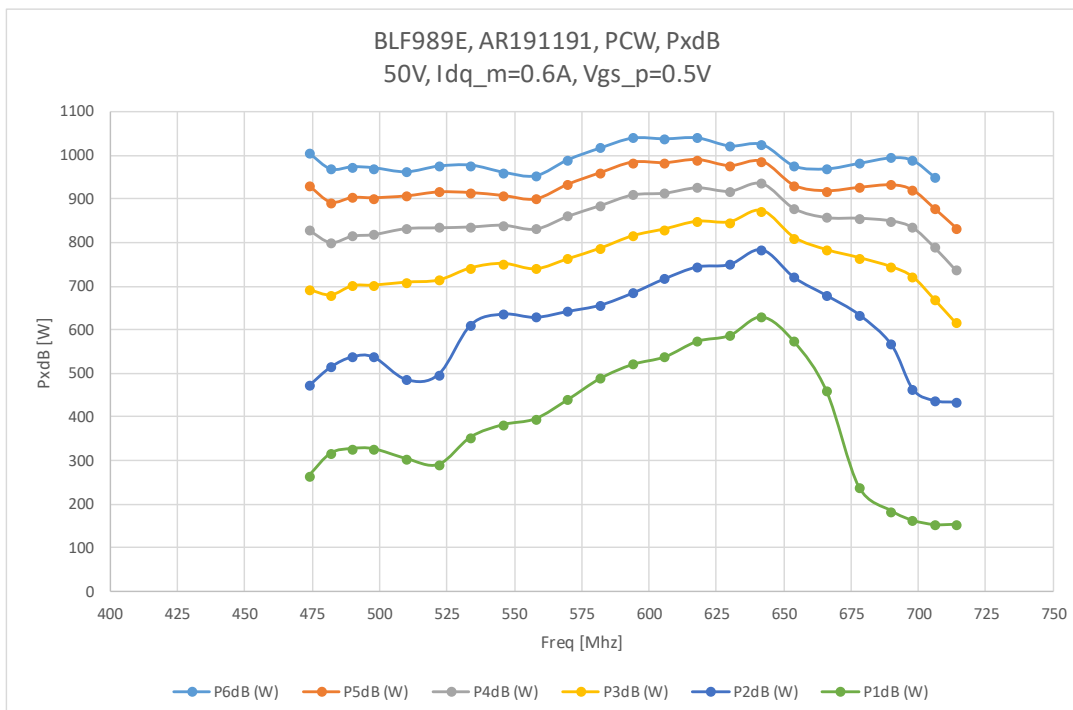


Figure 8 Pulsed CW, PxdB Vgs_p=0.5V

8.4 Pulsed CW power sweeps

Pulse condition: 100µs/10%. Vgs_p=0.6V

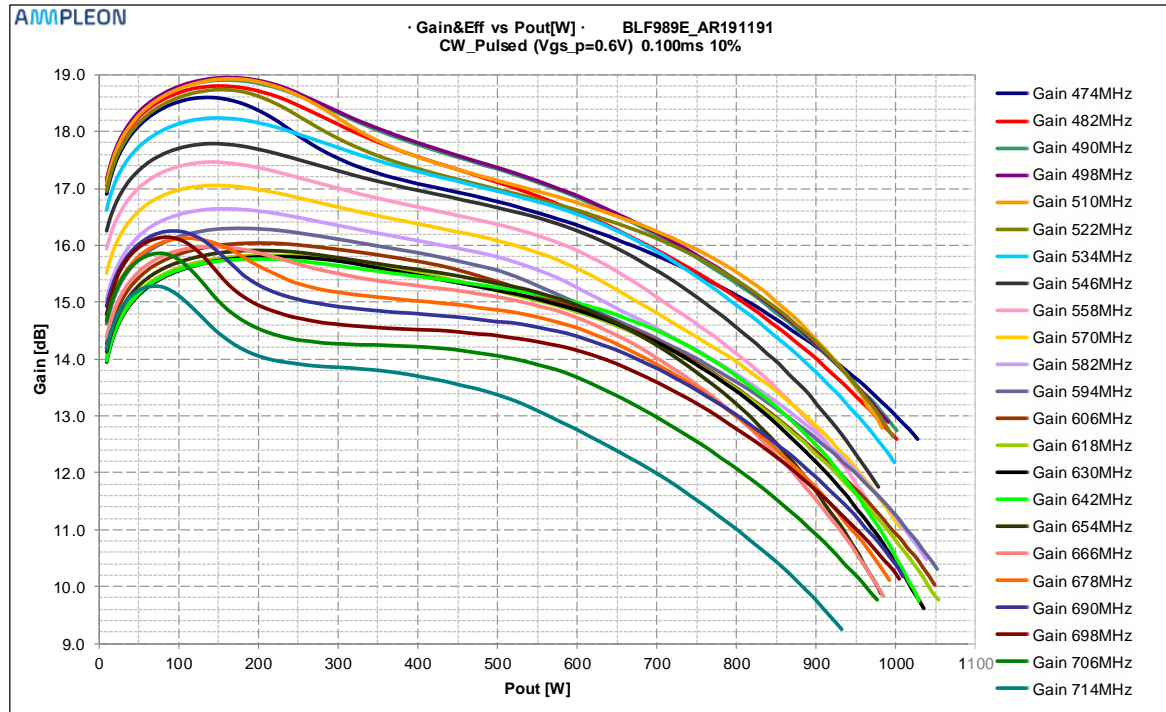


Figure 9 Pulsed CW, Gain [dB] as function of Pout [W] Vgs_p=0.6V

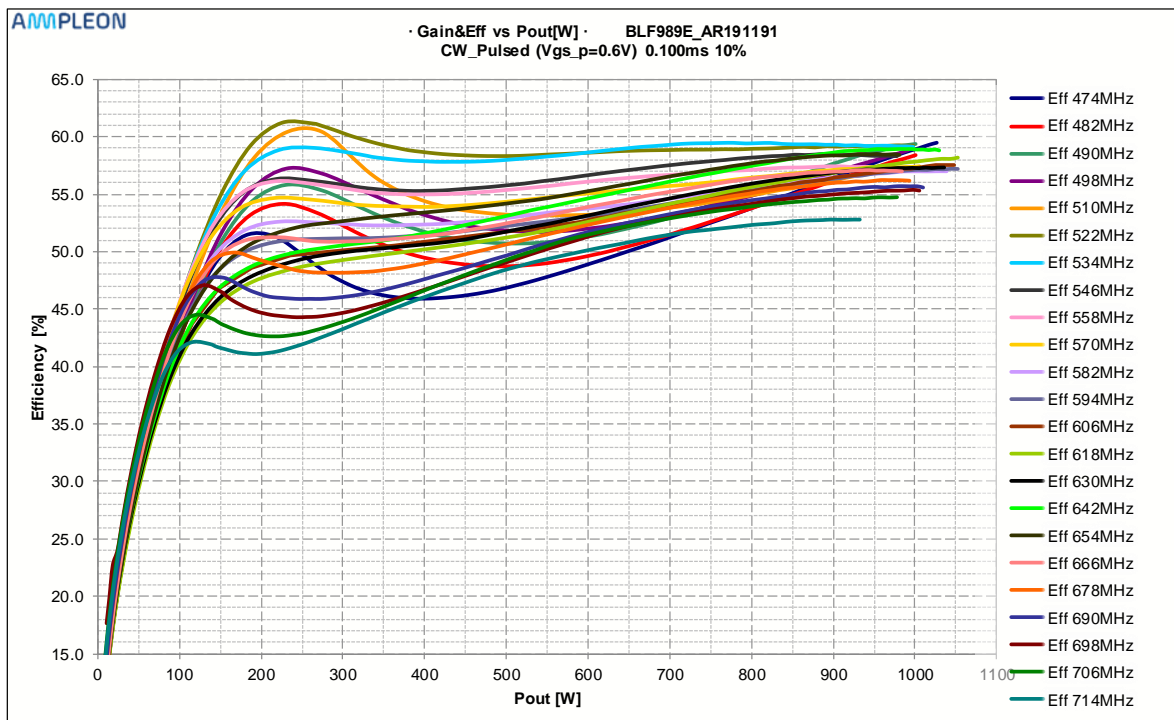


Figure 10 Pulsed CW, Efficiency [%] as function of Pout [W] Vgs_p=0.6V

Good pre-correction at 180Wavg (DVB-T) can be achieved when the pulsed CW power at P_{6dB} is approx. 1kW. This was achieved in the band 470-700Mhz. The Pre-corrected DVB-T data on page 7/8 confirm this.

8.5 Network analyzer (AM-AM and AM-PM)

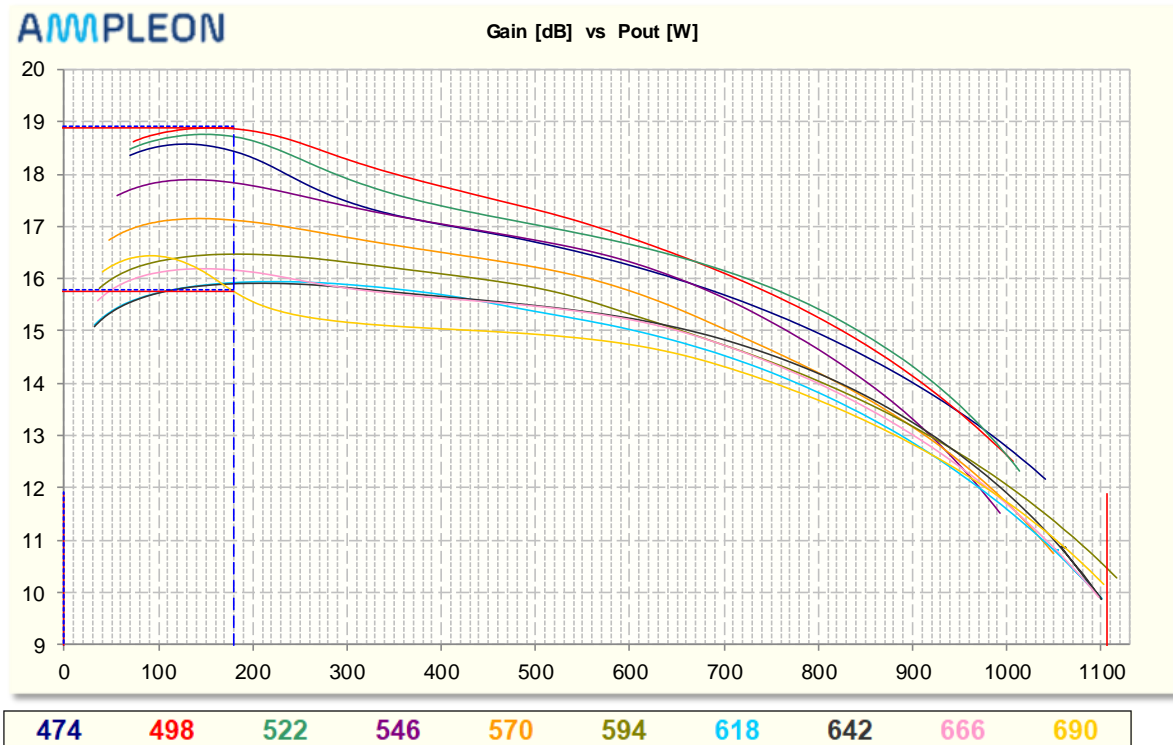


Figure 11 NA power sweep, Gain [dB]

Vgs_p=0.6V

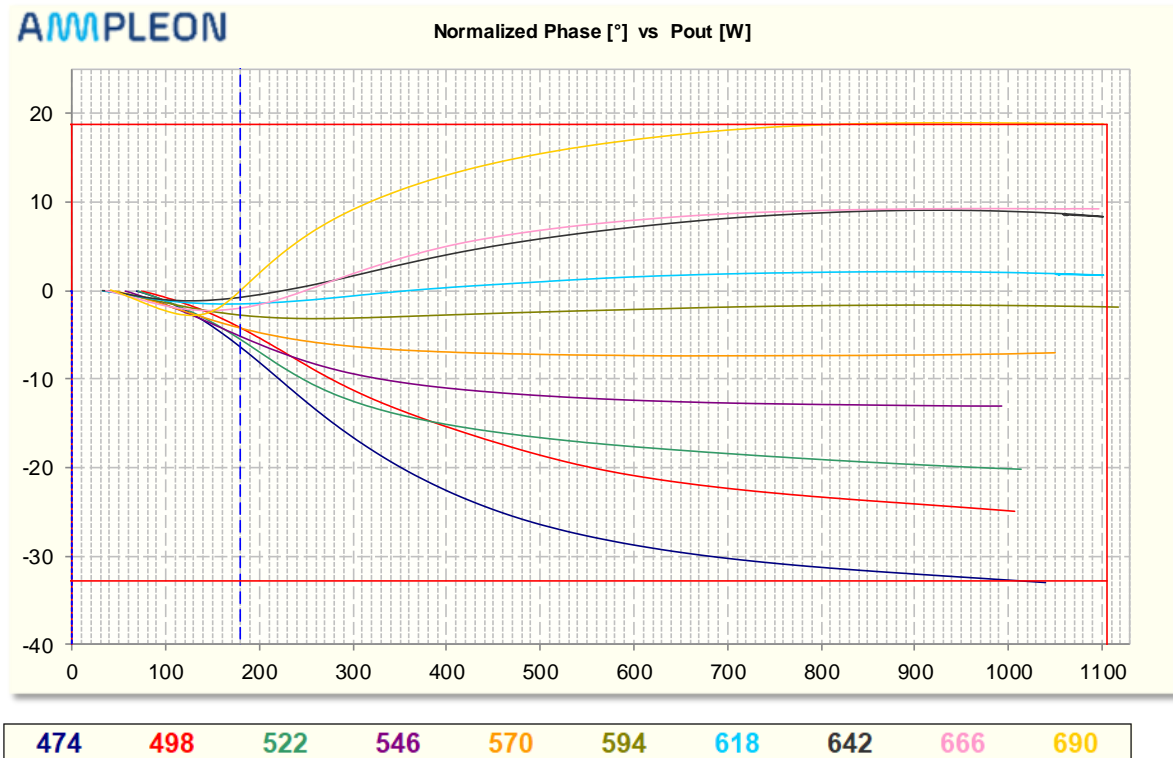


Figure 12 NA power sweep, normalised phase [°]

Vgs_p=0.6V

Frequency [MHz]	474	498	522	546	570	594	618	642	666	690
MaxGain [dB]	18.58	18.89	18.76	17.88	17.17	16.46	15.96	15.92	16.19	16.43
MaxEff [%]	58.44	58.46	62.26	58.92	57.98	59.29	59.71	61.43	62.19	59.77
MaxPout [dBm]	60.17	60.03	60.06	59.97	60.21	60.48	60.42	60.42	60.40	60.42
MaxPout [W]	1040.31	1005.95	1014.28	992.37	1050.05	1117.13	1101.04	1100.90	1097.05	1102.08
P6dB [dBm]	60.06	59.93	59.98	59.89	60.13	60.44	0.00	0.00	60.35	60.36
P6dB [W]	1012.87	983.22	994.44	975.99	1030.02	1106.16	0.00	0.00	1083.48	1087.15
Eff@6dB [%]	57.71	56.98	58.18	57.73	57.92	59.21	0.00	0.00	61.99	59.72
nPhase@6dB [°]	-32.78	-24.78	-20.20	-13.12	-7.12	-1.81	0.00	0.00	9.22	18.78
P1dB [dBm]	54.55	55.73	55.12	56.54	57.16	57.60	57.92	58.35	57.83	53.39
P1dB [W]	284.87	374.32	324.88	450.74	519.58	575.36	619.31	684.45	607.31	218.21
Eff@P1dB [%]	49.30	54.63	60.47	56.32	55.22	53.62	53.97	57.13	58.33	50.99
P6dB-P1dB [dB]	5.51	4.19	4.86	3.36	2.97	2.84	-57.92	-58.35	2.51	6.97
@Pwr [dBm] (=179.89W)	52.55	52.55	52.55	52.55	52.55	52.55	52.55	52.55	52.55	52.55
Gain@Pwr [dB]	18.44	18.87	18.72	17.82	17.13	16.46	15.94	15.91	16.16	15.75
Eff@Pwr [%]	53.01	56.16	60.04	57.77	56.41	53.07	51.04	52.69	56.29	51.87
Compression [dB]	6.43	6.39	6.43	6.36	6.42	6.20	5.15	5.05	6.29	6.27

Table 4: NA power sweep data Vgs_p=0.6V

The network analyzer (R&S ZVA) data shows slightly higher power levels compared to pulsed CW. Note that this data is generated via CW power sweeps which is different from pulse mode. Another reason could be small calibration differences between both methods.

8.6 Module spread

The graphs below show efficiency (not pre-corrected) and power (PCW) measurements on 2 prototype boards (AR191170, AR191181) and 5 boards with the final layout (AR191191, AR191201, AR191204, AR201001, AR201003). The reproductions show very similar performance.

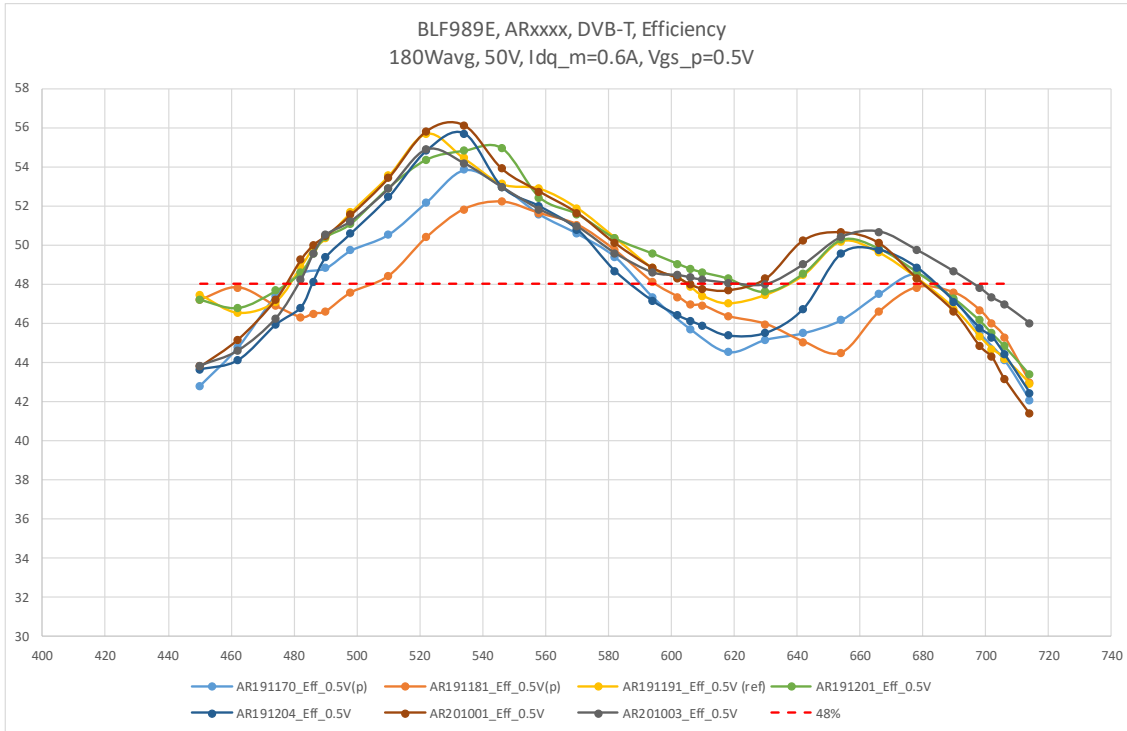


Figure 13 DVB-T Drain eff, module spread Vgs_p=0.5V

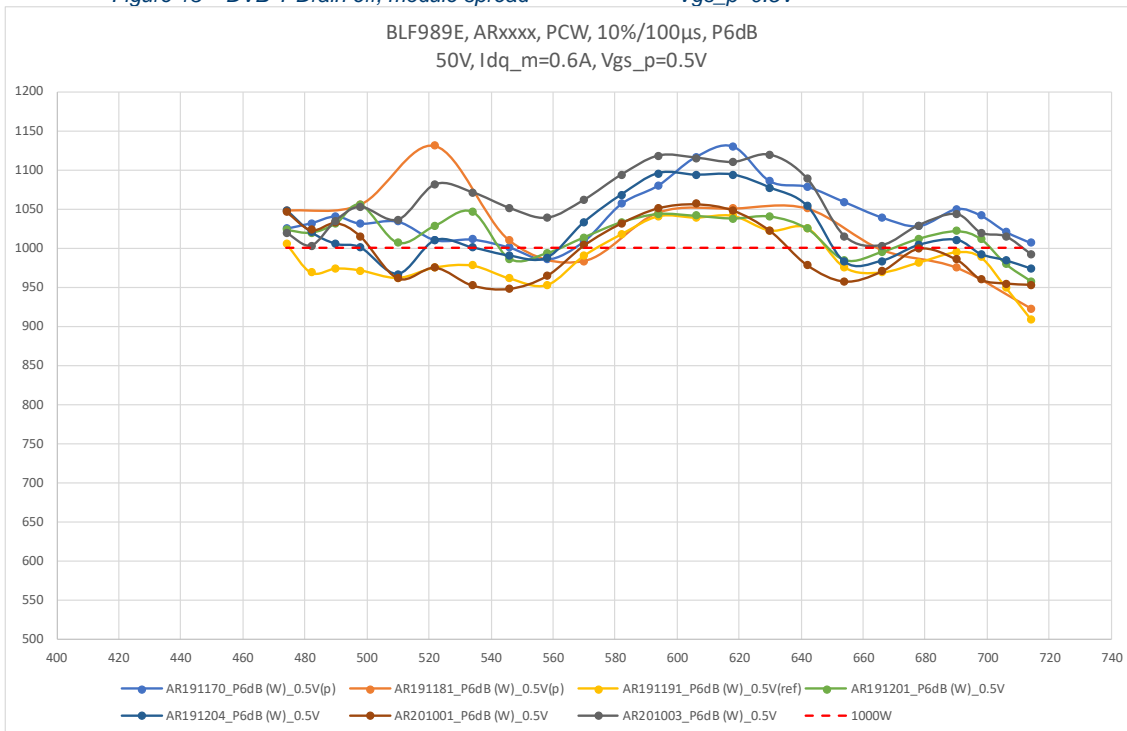


Figure 14 Pulsed CW 10%/100µs P6dB [W]

9. Hardware

9.1 Board Image

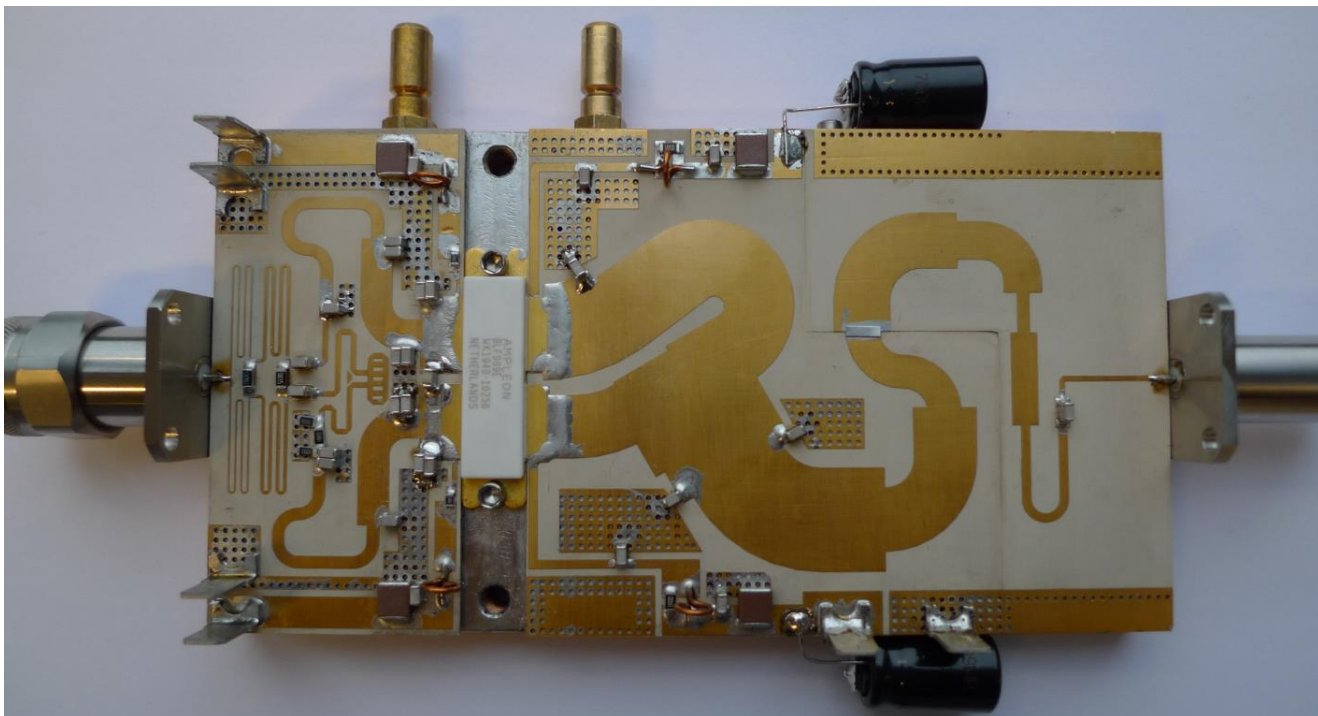


Figure 15 Picture of AR191191, 470-700Mhz board

Board "RF" Dimensions: 135 x 60mm

Total board dimensions: 152 x 80mm

9.2 Copper Layout

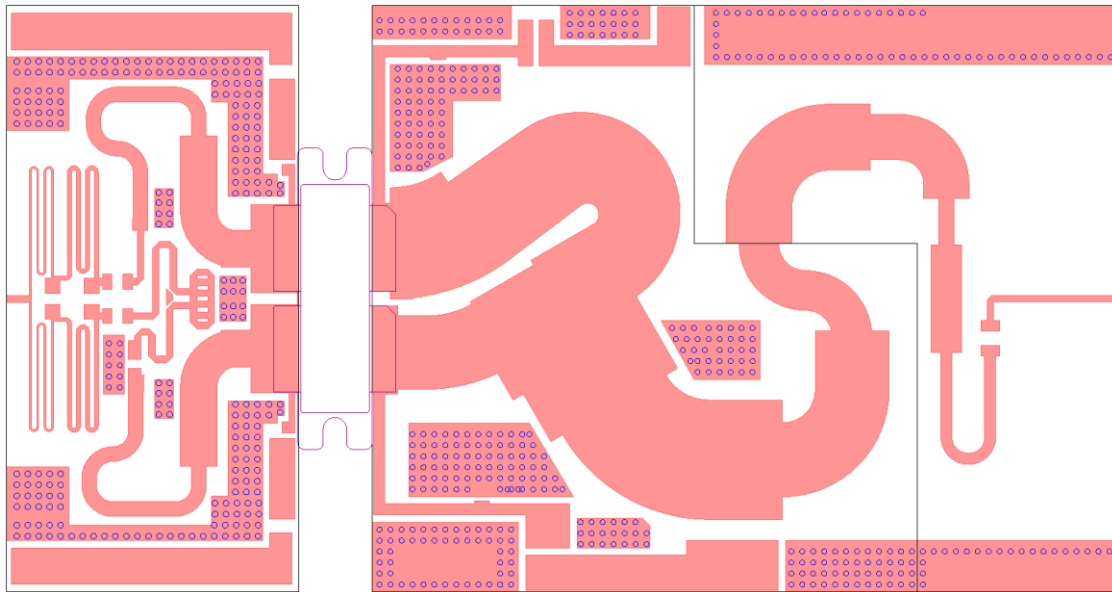


Figure 16 Layout drawing

9.3 Component Mapping

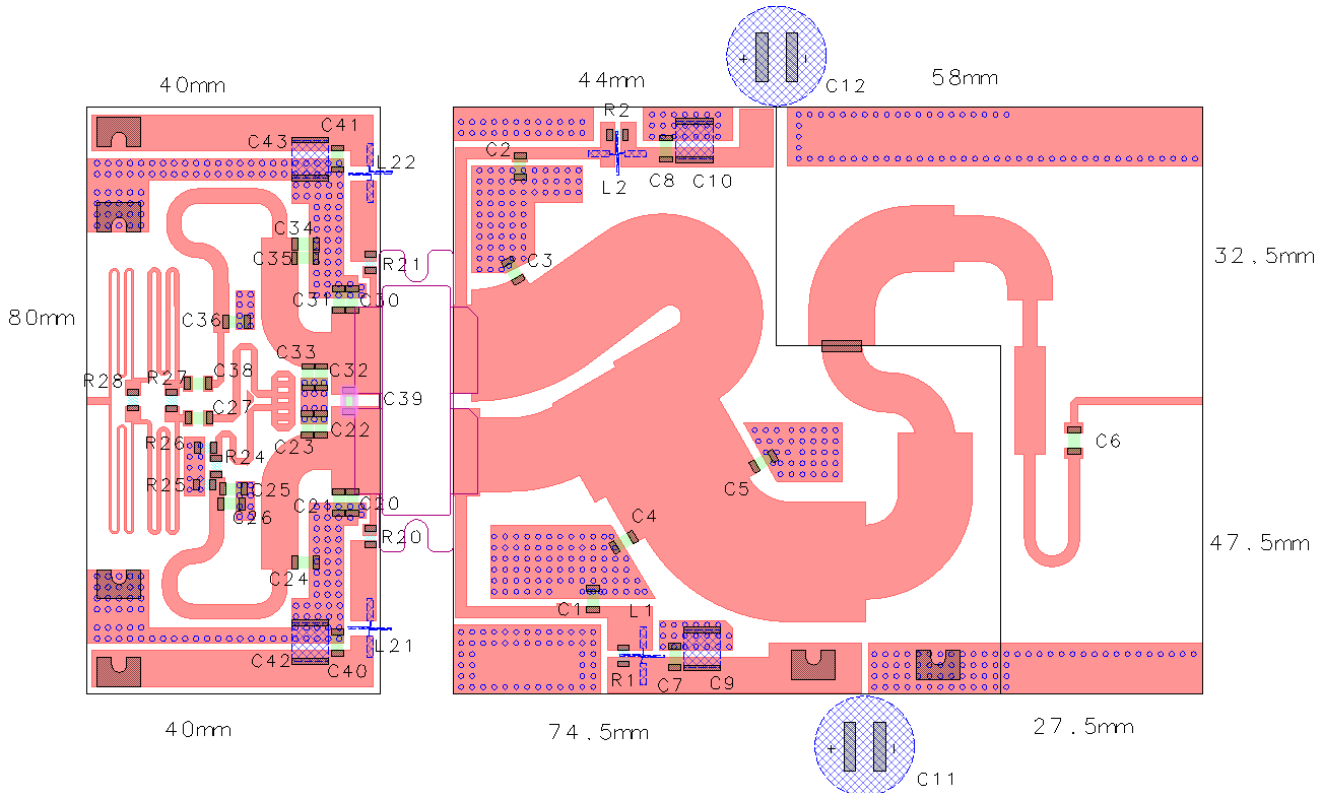


Figure 17 Component drawing

9.5 Board material

Table 6: Board specifications

Parameter	Value	thickness	metallisation
Manufacturer	Rogers		
Input pcb	RO3006	25 mil	35µ Cu, ground layer full Cu
Output-1 pcb	RO3010	10 mil	70µ Cu , ground layer full Cu
Output-2 pcb	RO3006	25 mil	35µ Cu, ground layer full Cu

Input pcb: 40 x 80 mm

Output pcb 1: 74.5 x 80 mm

Output pcb 2: 58 x 80 mm

9.6 Device markings

Table 7: Device specifics

Parameter	Value
Manufacturer	Ampleon
Device	BLF989E
Marking	wk1948-10256
Comments	

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