AR201097

ART2k0FE, 170 to 240 Mhz

v0.1 — 20 May 2020

AMPLEON

Application Report

Document information	
Status	Company Public
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Abstract	Measurement results of a Symmetric Ultra Wideband Doherty design with ART2k0FE for 170 to 240 Mhz

1. Revision History

Table 1: Report revisions

Revision	Date	Description	Author
0.0	20200520	Final version	Walter Sneijers

2. Contents

3. List of figures

4. List of tables

5. General description

This report presents the measurement results of the Symmetric Ultra Wideband Doherty demo AR201097. The device ART2k0FE used can deliver **250Wavg** DVB-T, in **A**dvanced **R**ugged **T**echnology (LDMOS) in a SOT539 package. The ART2k0 lower section is used as Main amplifier, the upper section is used as Peak amplifier. The power ratio is 1:1 which provides optimum bandwidth. The presented demo was designed for the frequency band 170 to 240 Mhz (a relative bandwidth of 34%). An extension of the band to 160Mhz is under investigation (this report shows measurements with 165Mhz as lowest freq).
AR201097 is a preliminary version, the final board will contain all layout optimisation measures.

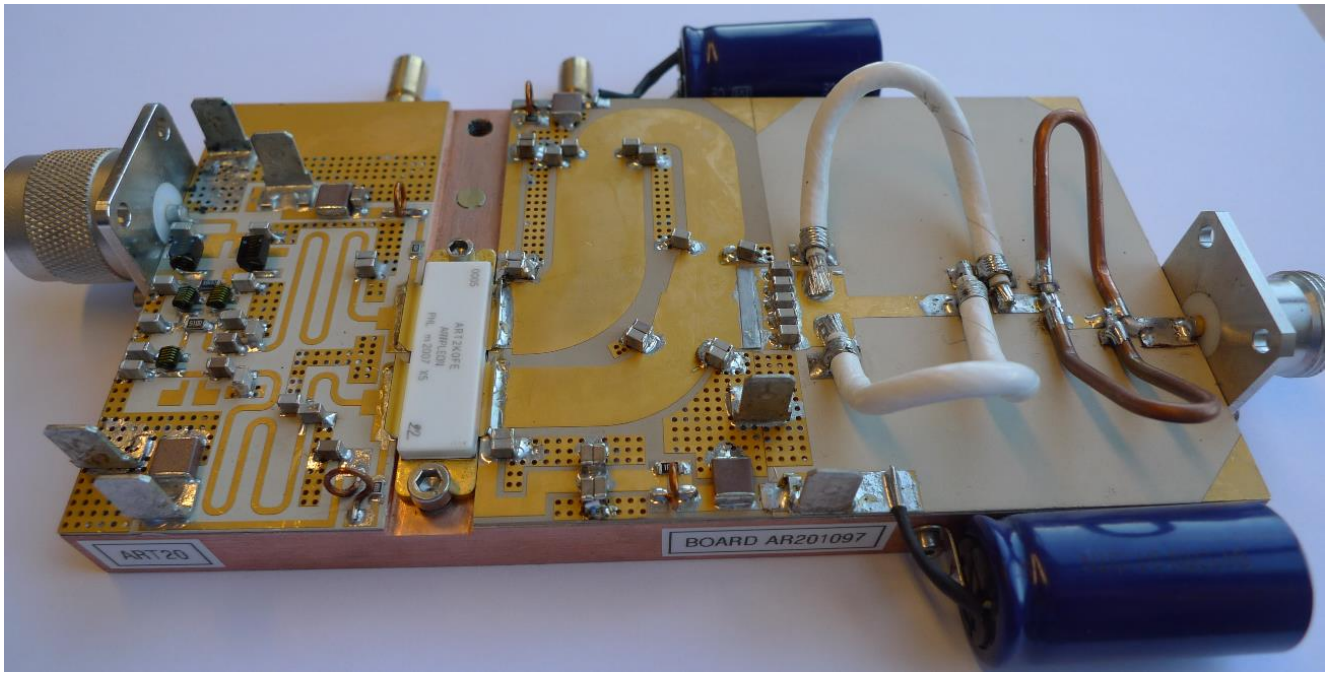

Figure 1 AR201097, 170-240Mhz demo board

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}	=	50-65V, 63V best trade-off for power/efficiency
V_{DD_PEAK}	=	50-65V, 63V best trade-off for power/efficiency
V_{GS_MAIN}	=	approx. 2V, leading to an I_{DQ_MAIN}=600mA
V_{GS_PEAK}	=	0.7V (range 0.4 – 1 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 a small design with practical line widths.
In the present application board the transistor is bolted down and pcb's are soldered.
Note that better performance can be achieved with a soldered transistor / pcb's.
Pcb's can also be bolted down with a careful design of the screw pressing points (especially near the transistor and connector).

Demo board designs:
AR201056 = 1st prototype 170-240 Mhz board
AR201083 = 2nd prototype 170-240 Mhz board
AR201097 = 3rd prototype 170-240 Mhz board

7. Performance Summary

Table 2: Performance summary, in band 170-240Mhz

Parameter	Condition-1	Condition-2	Unit	Pulsed CW	DVB-T
Power		Idq_m=0.6A Vgs_p=0.75V	W		250
Gain		Idq_m=0.6A Vgs_p=0.75V	dB		>21
Drain Efficiency		Idq_m=0.6A Vgs_p=0.75V	%		>47
P_{6dB}	100µs/10%	Idq_m=0.6A Vgs_p=0.75V	W	>1400	-
PAR output signal	CCDF0.01%	Idq_m=0.6A Vgs_p=0.75V	dB		7 – 7.5
PAR output signal -c	Pre-corrected[1,2] CCDF0.01%	Idq_m=0.6A Vgs_p=0.75V	dB		> 7.5
Shoulder distance[1,2,3]		Idq_m=0.6A Vgs_p=0.75V	dBc		< -37
MER		Idq_m=0.6A Vgs_p=0.75V	dBc		> 34

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 250W average DVB-T power or pulsed CW 1400W (P6dB) over the whole bandwidth 170-240Mhz.
All RF measurements were performed with a 300Mhz LPF coupled towards the power meter. This avoids harmonic content in the measured output power.
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 VHF channels need more correction on AM-AM (and AM-PM) distortion, which can be influenced by Vgs_p.

Trade-off:

Vgs_p(eak) has a significant impact on efficiency. Best trade-off between (peak) power and efficiency was achieved at a Vgs_p of 0.7V. Different transistor batches can result in different Vgs settings dependent on transistor Vgs_threshold level.
Vdd can be varied between 50 and 65V. In case of 65V the max power capability is achieved. The report contains comparison with measurements from demo board AR201056 and AR201083.

Important note:

AR201097 is not yet built with the final pcb design. This resulted in some capacitors which have an increased temperature during the DVB-T tests:
C3-C4: measurement show approx. 90° around 240Mhz. Solution is under investigation.

8. Performance Details

The amplifier was measured with a DVB-T 8K signal (8Mhz signal bandwidth) and with a pulsed CW signal. Vgs_p is (normally) fixed at 0.75V but can be varied at each channel, likewise Idq_main or Vdd. The measured freq range is 165 – 240Mhz.

8.1 DVB-T measurement (uncorrected), Pavg=250W

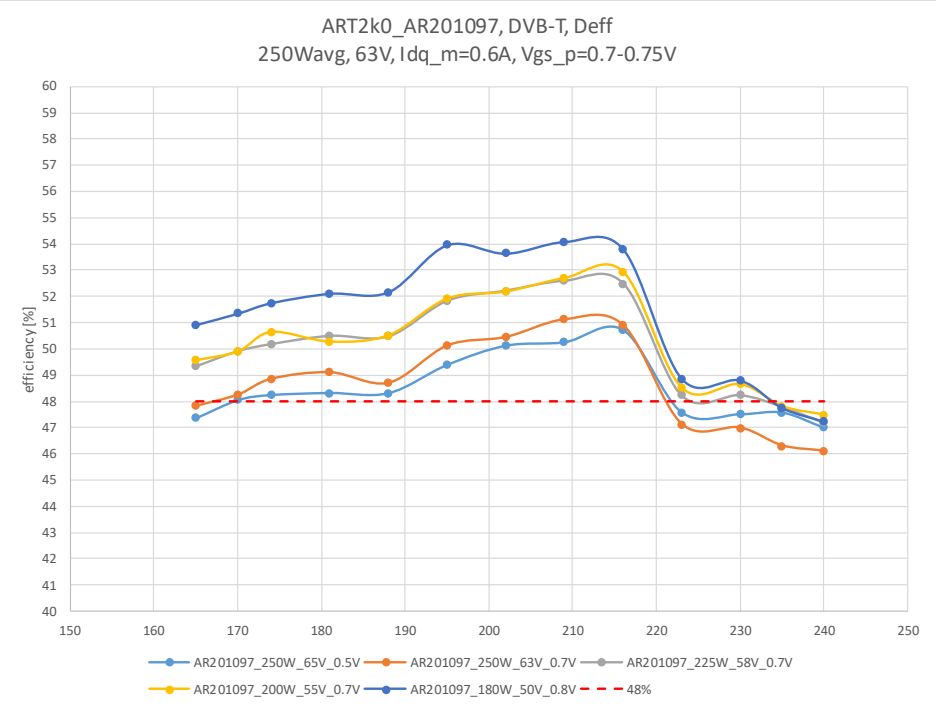

Figure 2 DVB-T, (Drain) efficiency (uncorrected) Vdd=50 – 65V

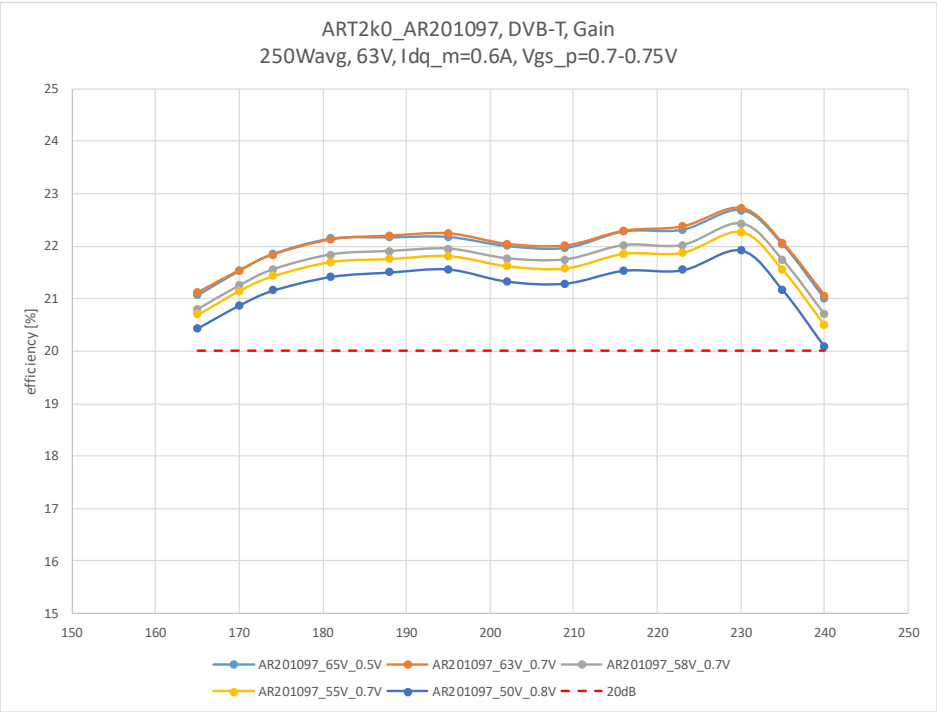

Figure 3 DVB-T, Gain (uncorrected) Vdd=50 - 65V

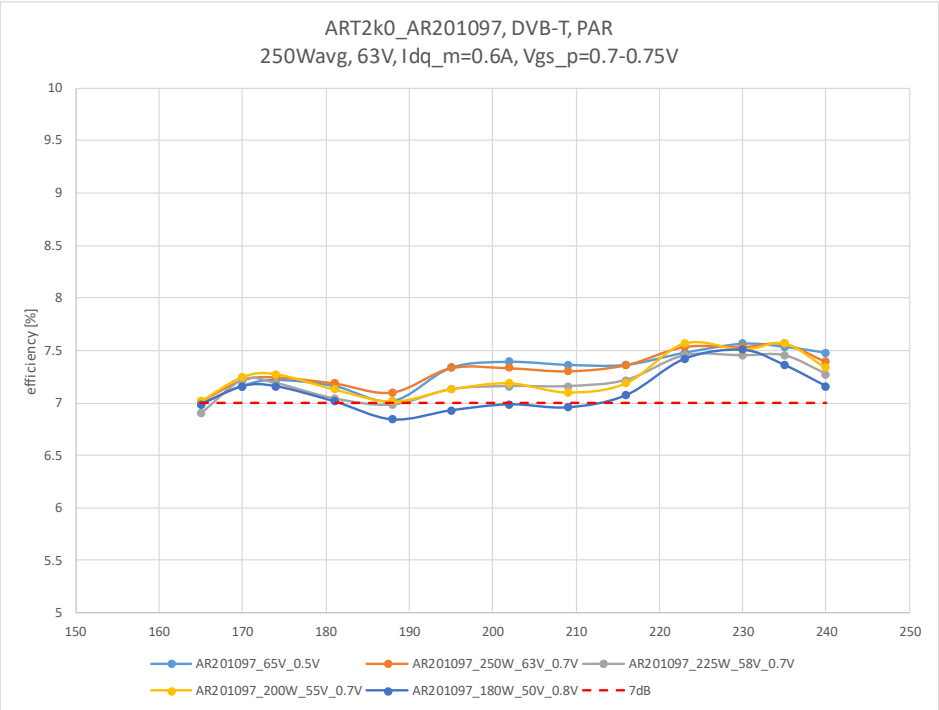

Figure 4 DVB-T, PAR (uncorrected) Vdd=50 – 65V

8.2 DVB-T measurements (corrected), Pavg=250W

Pre-corrected data (ProTelevision PT3000).
The measured freq range is 174 – 240Mhz.
No measurements with pre-corrector were performed with AR201097. Pre-corrected data is available from board AR201083, table summary is shown below.

AR201083																
Freq	Pout	Pout	Gain	Deff	PAE	Vdc	Id	Pdc	MER	SHLDR_4M3L	SHLDR_4M3H	Idq_m	Vgs_p	PAR	Ppeak	Ppeak
[Mhz]	[dBm]	[W]	[dB]	[%]	[%]	[V]	[A]	[W]	[dB]	[dB]	[dB]	[A]	[V]	[dB]	[dBm]	[W]
174	54.00931	251.73	21.17236	49.95716	49.57578	63.29546	7.960341	503.8874	36.2	-39.939888	-39.01583099	0.6	0.7	7.913043	61.92236	1556.81
181	54.01016	251.78	20.97069	47.67779	47.29651	63.30767	8.340939	528.08	35.1	-38.6158371	-38.09345245	0.6	0.7	7.710145	61.7203	1486.04
188	53.99578	250.94	21.40821	50.31512	49.95131	63.2919	7.879371	498.7462	36	-38.79697418	-38.1424675	0.6	0.7	7.681159	61.67694	1471.276
195	53.99439	250.86	21.34251	50.56024	50.18908	63.32299	7.834523	496.1691	35.8	-38.2076683	-38.50523376	0.6	0.7	7.623188	61.61758	1451.302
202	53.99606	250.96	21.27109	50.58843	50.21091	63.31339	7.834378	496.0834	35.6	-39.21773911	-38.64955139	0.6	0.7	7.623188	61.61925	1451.86
209	53.99352	250.81	21.60984	49.79671	49.45299	64.29397	7.8338	503.6759	35.6	-38.64488983	-38.74090576	0.6	0.75	7.73913	61.73265	1490.27
216	53.98059	250.07	21.80491	47.57291	47.25896	64.31088	8.173712	525.6533	35.3	-37.06954956	-39.05715942	0.6	0.75	7.826087	61.80668	1515.89
223	54.03287	253.10	22.47993	49.13043	48.85287	63.30746	8.137035	515.1534	36.5	-40.46313095	-39.25386047	0.6	0.75	7.942029	61.9749	1575.76
230	53.99736	251.04	22.19019	48.23991	47.94857	63.33303	8.216067	520.3907	36.5	-39.36010742	-39.77692795	0.6	0.7	8.057971	62.05533	1605.215
240	53.98601	250.38	21.13629	49.02947	48.65205	64.34103	7.935938	510.6742	35.5	-38.52497101	-38.85124969	0.6	0.75	8.057971	62.04398	1601.026

Table 3: AR201083, Pre-corrected data 174Mhz - 240Mhz

The top table shows the pre-corrected measurements at 180Wavg. A minimum MER of 35dB with a shoulder distance of 37dBc was achieved over the band174-240Mhz.
The trade-off between higher power and lower efficiency/higher gain was made via Vdd/Vgs_p.

8.3 Pulsed CW measurements

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

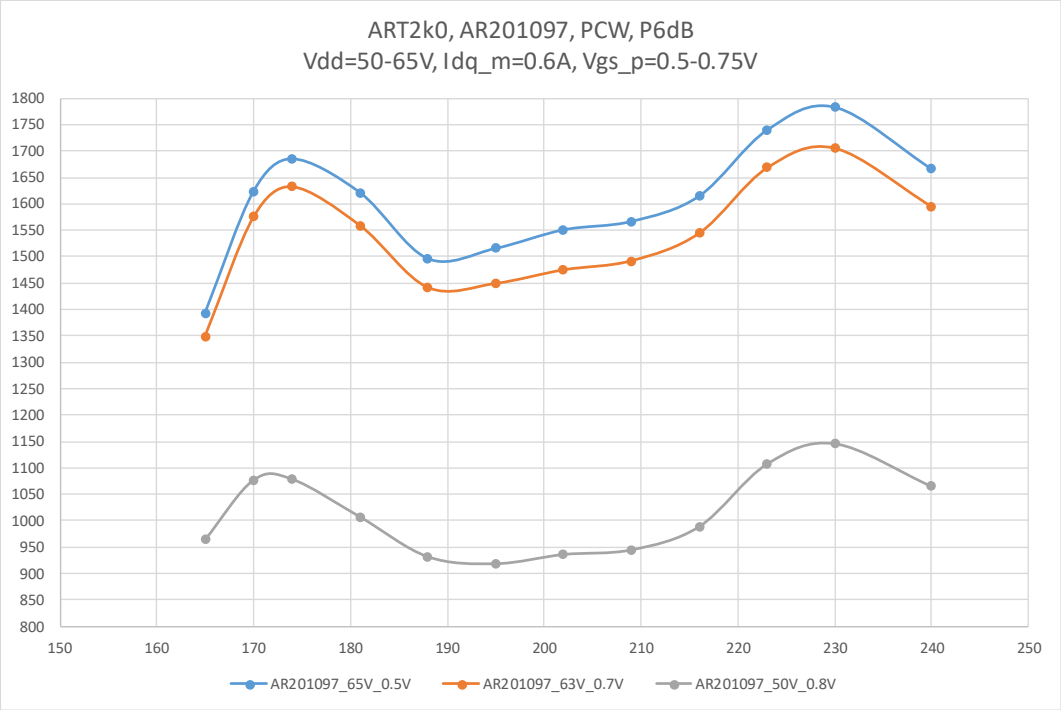

Figure 5 Pulsed CW, P6dB [W] Vdd = 50 – 65V

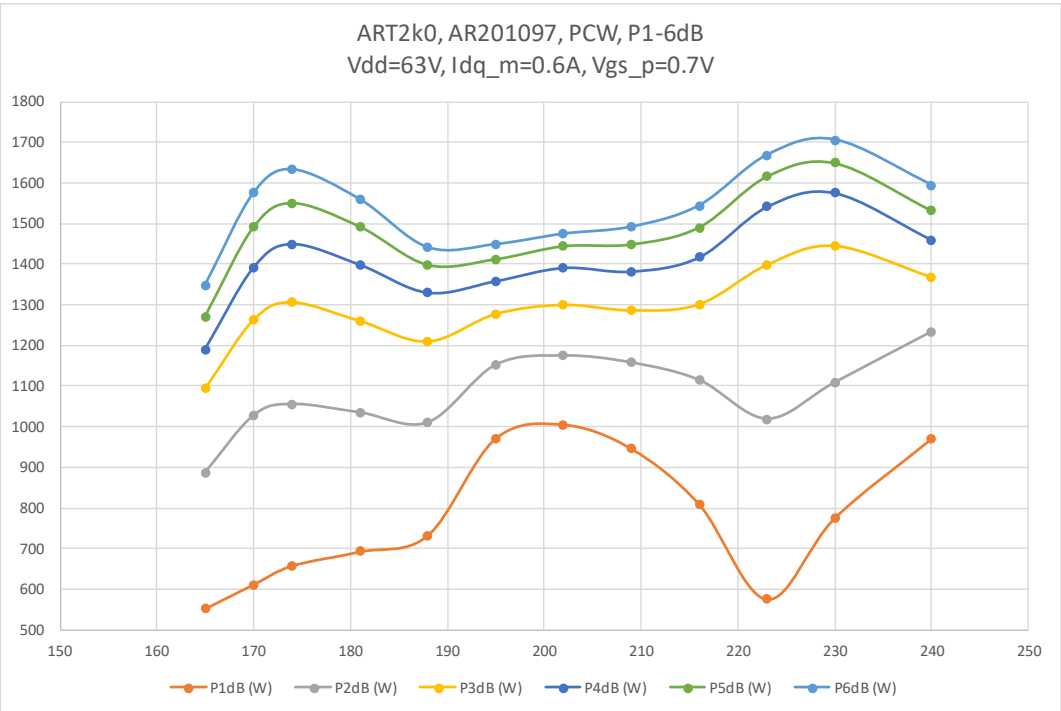

Figure 6 Pulsed CW, PxdB [W] Vdd = 50 – 65V

8.4 Pulsed CW power sweeps

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

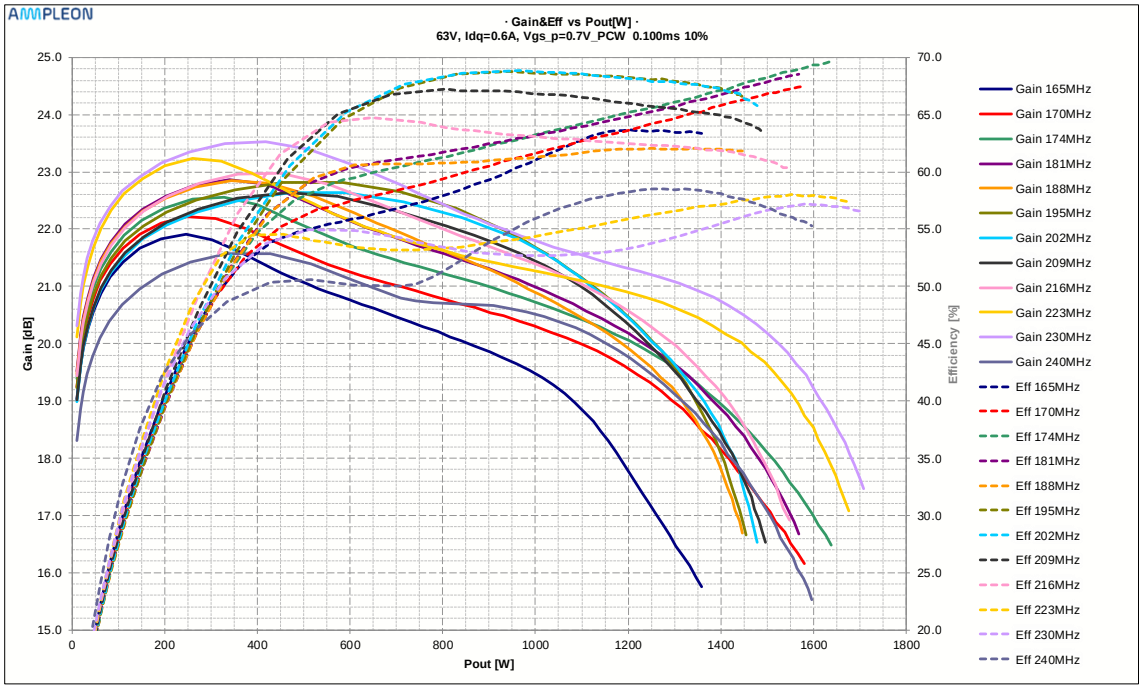

Figure 7 Pulsed CW, Gain [dB] + Deff [%] as function of Pout [W] Vdd=63V, Vgs_p=0.7V

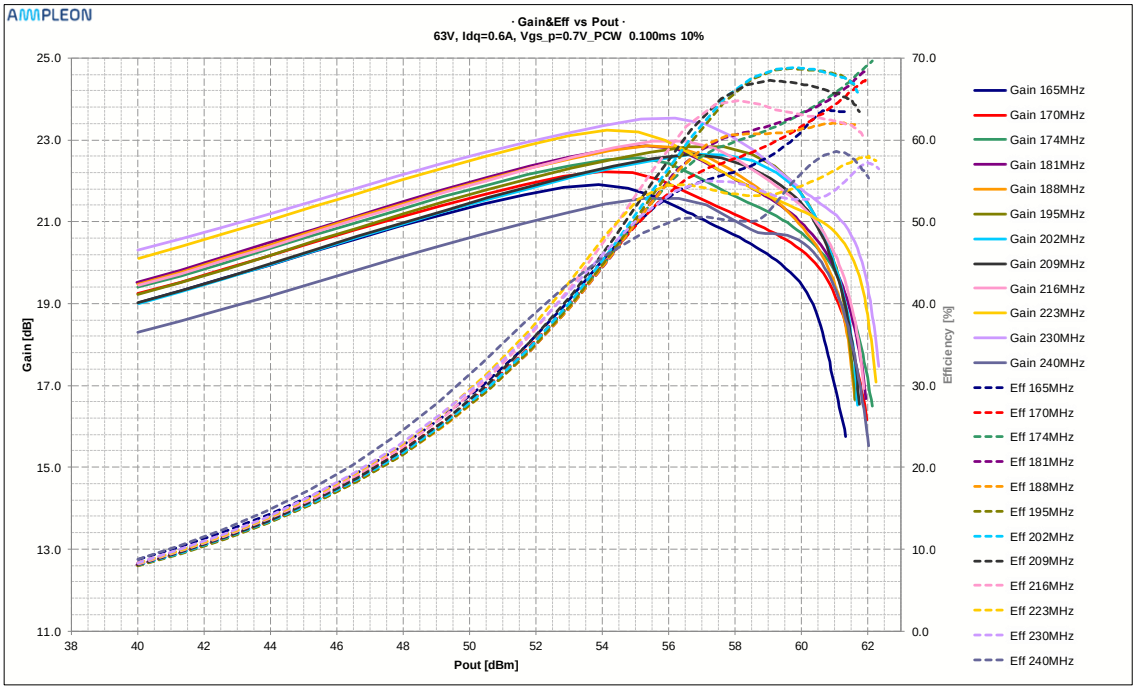

Figure 8 Pulsed CW, Gain [dB] + Deff [%] as function of Pout [dBm] Vdd=63V, Vgs_p=0.7V

8.5 Comparison demo boards

AR201097 is not yet built with the final pcb layout. Therefore, the tuning of the board can be slightly different from earlier built boards AR201056 and AR201083. A comparison between these boards is given in the picture below.

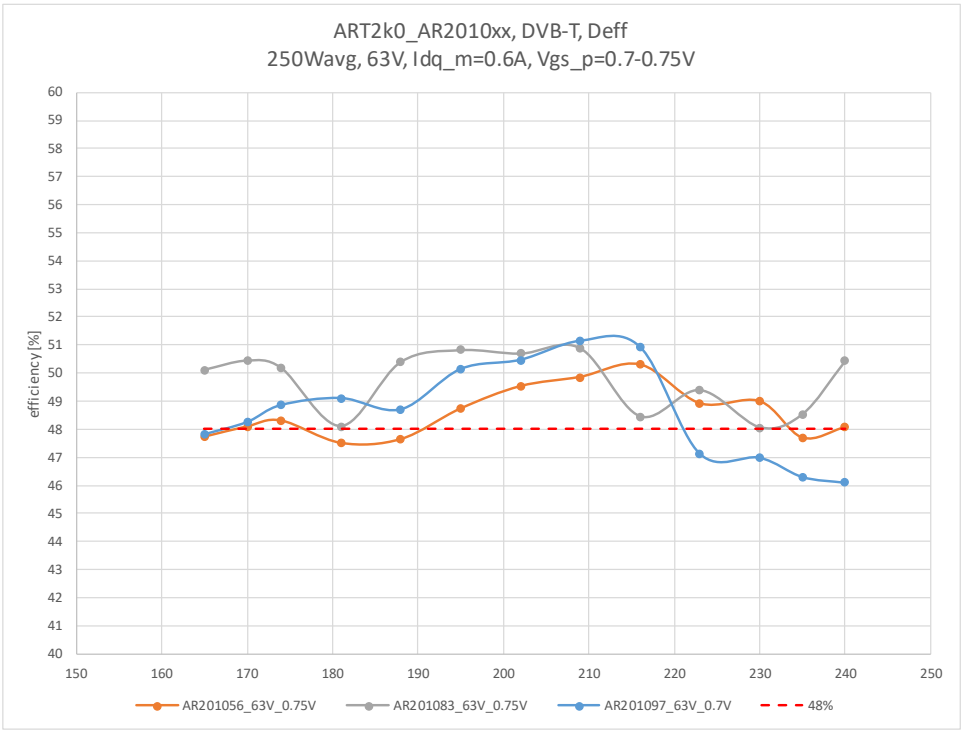

Figure 9 AR2010xx, DVB-T, Deff [%] Vdd=63V, Vgs_p=0.7 - 0.75V

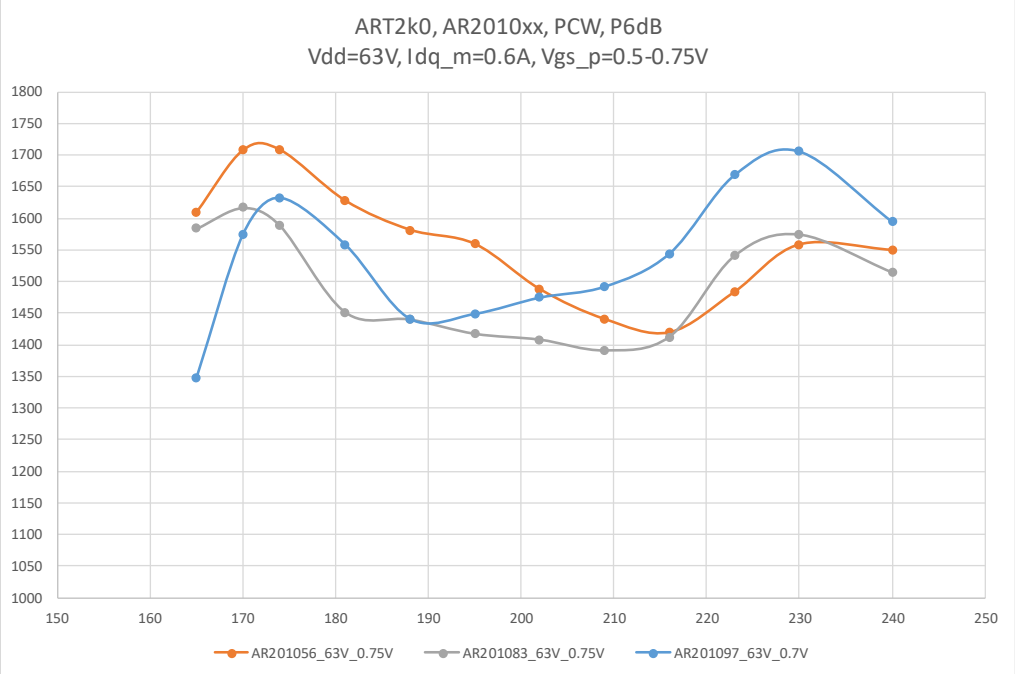

Figure 10 AR2010xx, PCW, P6dB Vdd=63V, Vgs_p=0.7 – 0.75V

9. Hardware

9.1 Board Image

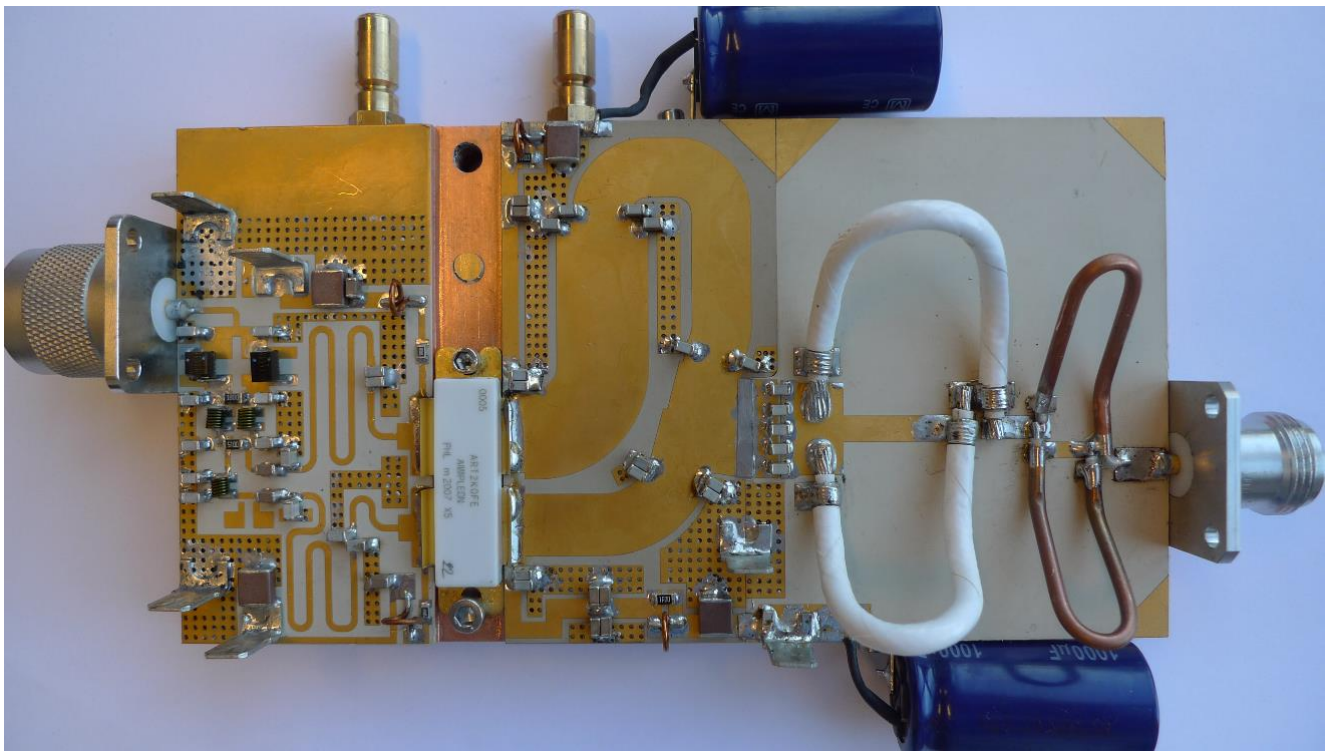

Figure 11 Picture of AR201097, 170-240Mhz demo board (top view)

Total board dimensions: 152 x 80mm

9.2 Copper Layout

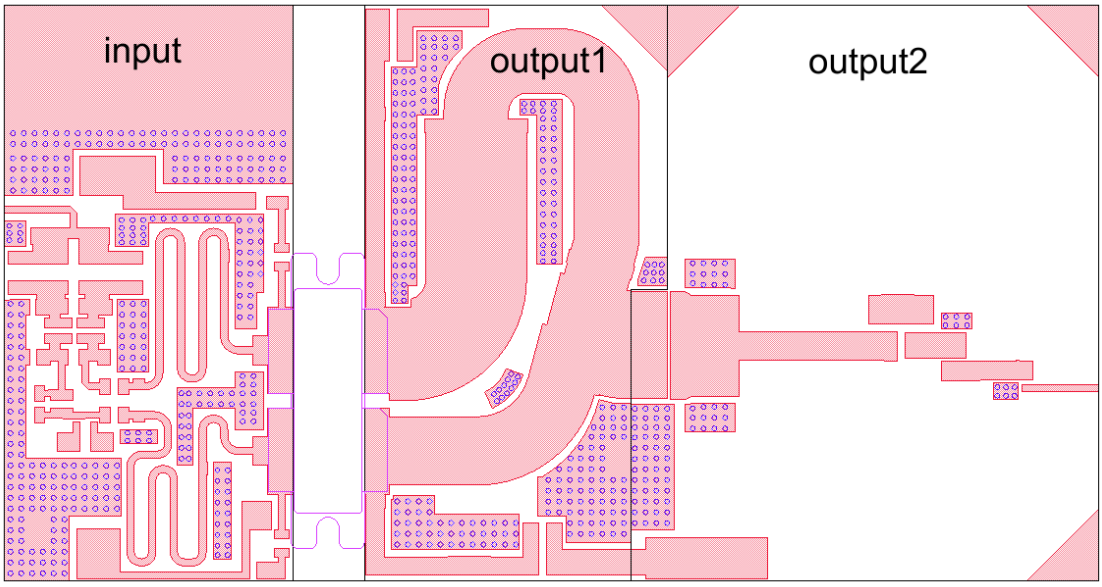

Figure 12 Layout drawing

9.3 Component Mapping

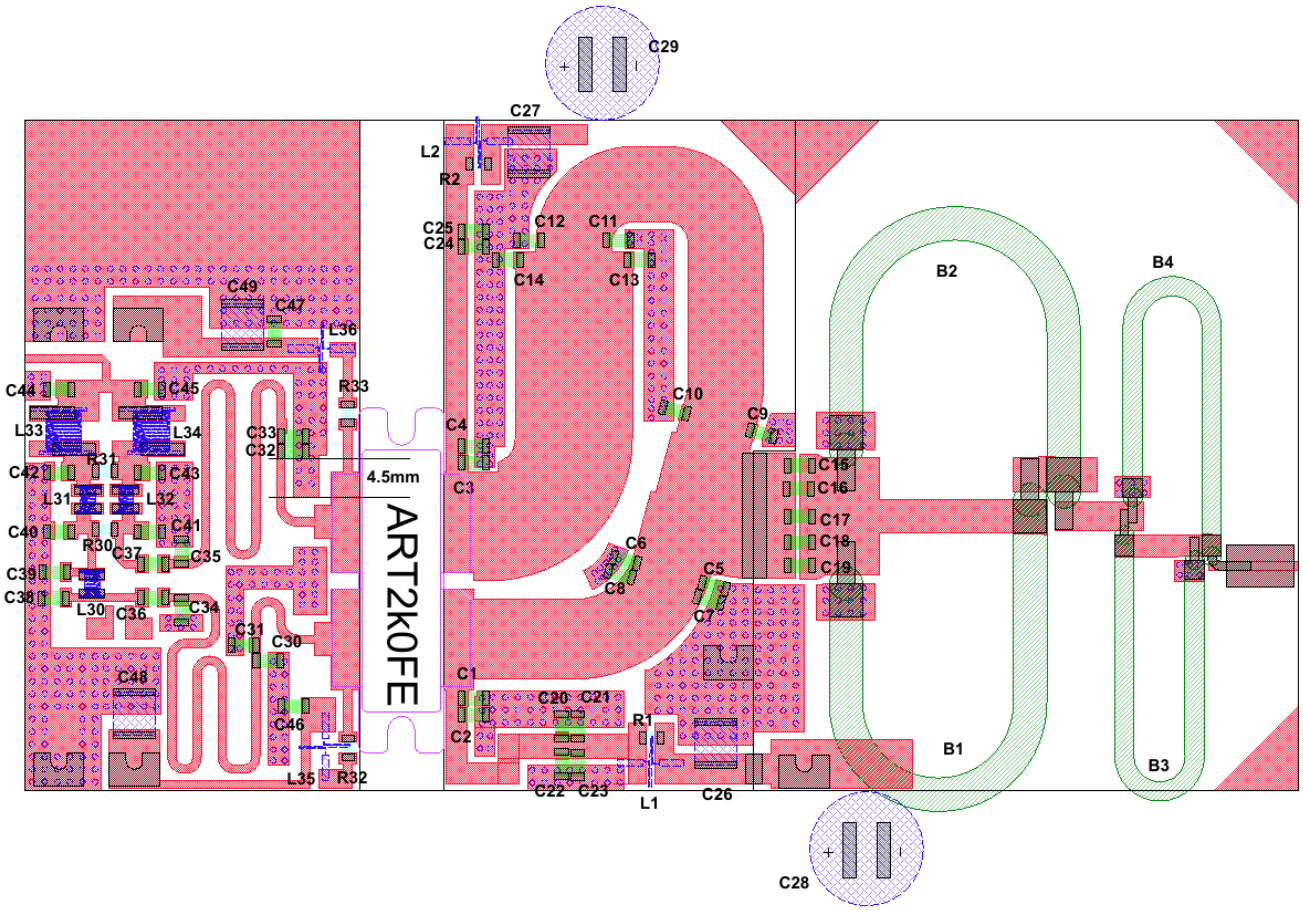

Figure 13 Component drawing

9.4 Bill of materials

Table 4: Bill of Materials

Description	Value	Case	Supplier	Remark
Output				
C1	43pF	ATC800B	ATC	
C2	39pF	ATC800B	ATC	
C3	82pF	ATC800B	ATC	
C4	39pF	ATC800B	ATC	
C5,C6	56pF	ATC800B	TDK	
C7,C8	20pF	ATC800B	ATC	
C9,C10,C11,C12	82pF	ATC800B	ATC	
C13,C14	56pF	ATC800B	ATC	
C15,C16,C17,C18,C19	47pF	ATC800B	ATC	
C20,C21,C22,C23,C24,C25	470pF	ATC800B	ATC	
C26,C27	4.7µF / 100V		TDK	
C28,C29	1000µF	ATC800B		
L1,L2				1 turn, 4-5mm diameter
R1,R2	1Ω			
B1,B2	12Ω / 73mm			TC12, flexible coaxial cable
B3,B4	25Ω / 63mm			UT-90C-25, semi rigid coaxial cable
Input				
C30,C31,C32,C33	68pF	ATC800B		
C34	24pF	ATC800B		
C35	22pF	ATC800B		
C36,C37	1000pF	ATC800B		
C38,C39	16pF	ATC800B		
C40	12pF	ATC800B		
C41	15pF	ATC800B		
C42	22pF	ATC800B		
C43	24pF	ATC800B		
C44,C45	10pF	ATC800B		
C46,C47	1000pF	ATC800B		
C48,C49	4.7µF / 50V		TDK	
R30	2x510Ω	1206		
R31	2x180Ω	1206		
R32,R33	5.6Ω	0805		
L30	39nH	1111SQ_39NJEB	Coilcraft	
L31	47nH	1111SQ_47NJEB	Coilcraft	
L32	43nH	1111SQ_43NJEB	Coilcraft	
L33	68nH	1812SMS_68NGLB	Coilcraft	
L34	56nH	1812SMS_56NGLB	Coilcraft	
L35,L36				1 turn, 4-5mm diameter

Note: C28,29 (1000µF capacitors) are needed for PCW measurements.

Note that the layout is not final, see Remark on page 5.

9.5 Board material

Table 5: Board specifications

Parameter	Value	thickness	metallisation
Manufacturer	Rogers		
Input pcb	RO3006	25 mil	35µ Cu, ground layer full Cu
Output-1 pcb	RO3010	25 mil	35µ 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: 42 x 80 mm

Output pcb 2: 65 x 80 mm

9.6 Device markings

Table 6: Device specifics

Parameter	Value
Manufacturer	Ampleon
Device	ART2k0FE
Marking	M2007-0005
Comments	

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