AR211097

ART1K6FH, 160 to 240Mhz

v0.1 — 28 May 2021

AMPLEON

Application Report

Document information	
Status	Company Public
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Abstract	Measurement results of a Symmetric Ultra Wideband Doherty design with ART1K6FH for 160 to 240Mhz

1. Revision History

Table 1: Report revisions

Revision	Date	Description	Author
0.0	28 May 2021	Final version	Harrie Rahangmetan

2. Contents

3. List of figures

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5. General description

This report presents the measurement results of the Symmetric Ultra Wideband Doherty demo AR211097. The device ART1K6FH used can deliver **250Wavg** DVB-T, in **A**dvanced **R**ugged **T**echnology (LDMOS) in a SOT539 package. The ART1k6 device can work at supply voltages up to 50V.
The ART1K6FH upper section is used as Main amplifier, the lower 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 165 to 235 MHz (a relative bandwidth of 35%). The Doherty amplifier is built on TC350 pcb material. The output transformer is split in 2 sections: a 9:1 transformer with 11ohm coaxial cable and a 2.25:1 transformer with 25ohm coaxial cable.
The demo was designed for 185Wavg for best linearity and max. 225Wavg for best power/efficiency.

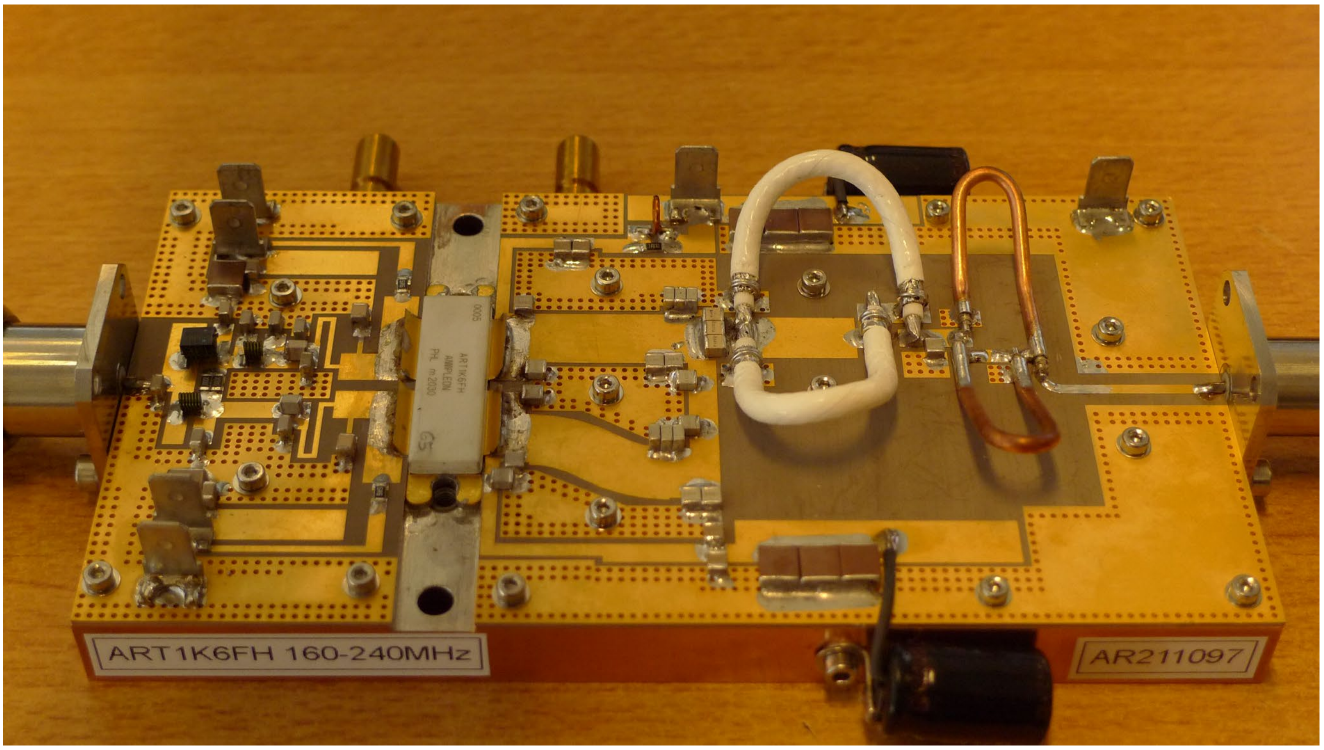

Figure 1 AR211097, 165-235Mhz demo board

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} = 50V
V_{DD_PEAK} = 50V
V_{GS_MAIN} = approx. 2V, leading to an I_{DQ_MAIN}=600mA
V_{GS_PEAK} = 0.7V (range 0.3 – 1 V, can vary dependent on frequency and device)

Main amplifier = upper section
Peak amplifier = lower section

The application is built on a standard copper heatsink and is water cooled. The actual design can be made on a smaller heatsink.
In the present application board, the transistor is soldered and PCB's are bolted down. The best RF performance is achieved with a soldered transistor. Under the pcb (the area under the coupling capacitors C18 – 20) thermal compound is used to lower the component/pcb temperature. Another option (best) is to solder the (output) pcb. The value of C22 can be changed (see Figure 6+7). In this demo circuit we choose for C22=0pF (means capacitor is not applied).

Note:
1. The final PCB layout (version v3) is available (dxf files: ART2k0_50V_pcb_input _TC350_30mil_v3, ART2k0_50V_output_TC350_30mil_v3).

7. Performance Summary

Table 2: Performance summary, in band 165-235Mhz

Parameter	Condition-1	Condition-2	Unit	Pulsed CW	DVB-T
Power		Idq_m=0.6A Vgs_p=0.7V	W		185-225
Gain		Idq_m=0.6A Vgs_p=0.7V	dB		>19
Drain Efficiency		Idq_m=0.6A Vgs_p=0.7V	%		>47
P_{6dB}	100µs/10%	Idq_m=0.6A Vgs_p=0.7V	W	>1200	-
PAR output signal[1]	CCDF0.01% 185W, 225W	Idq_m=0.6A Vgs_p=0.7V	dB		>7.5
Shoulder distance[2]	185W, 225W	Idq_m=0.6A Vgs_p=0.7V	dBc		<-22

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

Note 2: Shoulder distance ±4.3Mhz

The amplifier can deliver 185 - 225W average DVB-T power or pulsed CW 1200W (P6dB) over the hole bandwidth 165 - 235Mhz. Average power is dependent on linearity requirements. PAR (ccdf) and shoulder measurements were done with R&S FSV spectrum analyser.

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.

8. Performance Details

The amplifier was measured with a DVB-T 8K signal (8Mhz signal bandwidth) and with a Pulsed CW signal. Normally, Vgs_peak is fixed at 0.7V and Idq_main at 0.6A. The measured freq range is 160 – 240Mhz.

8.1 DVB-T measurement, Pavg=185W, Vgs_p variation

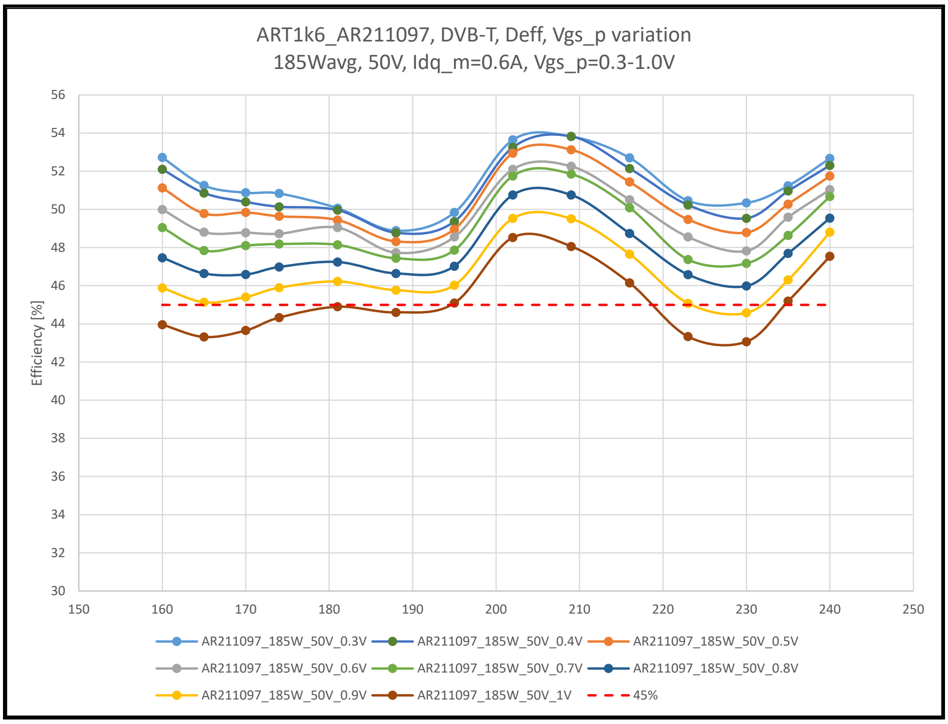

Figure 2 DVB-T, (Drain) efficiency Vgs_p = 0.3 – 1V

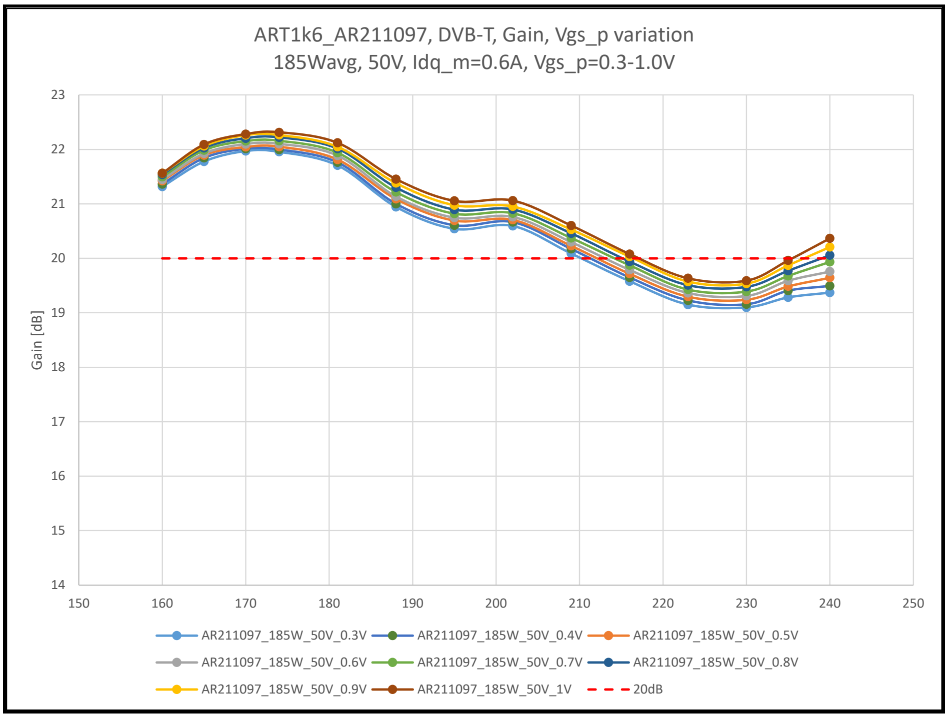

Figure 3 DVB-T, Gain Vgs_p = 0.3 – 1V

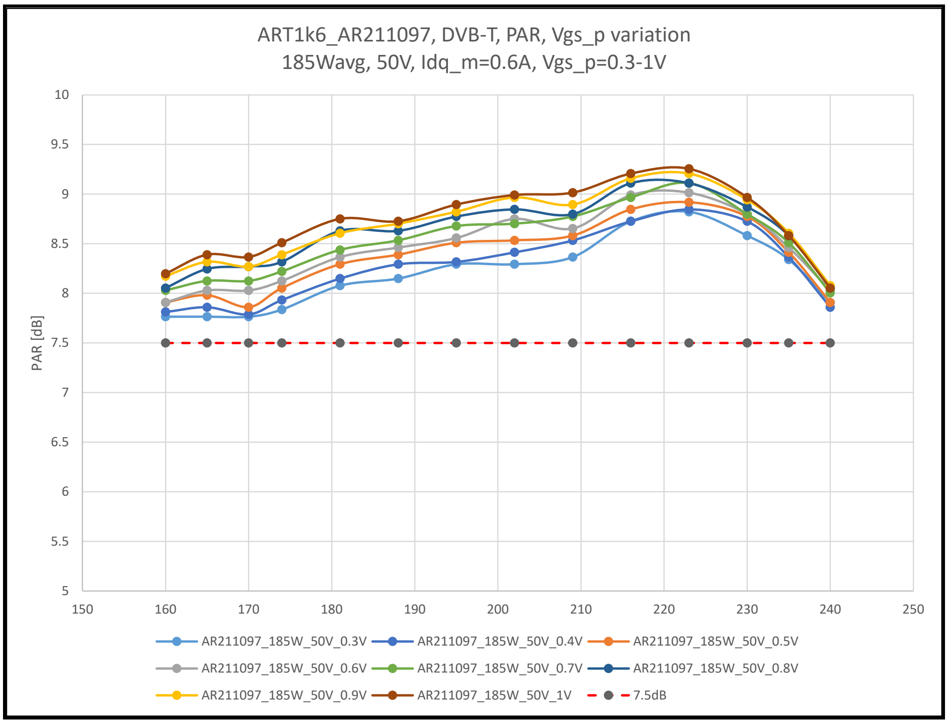

Figure 4 DVB-T, PAR Vgs_p = 0.3 – 1V

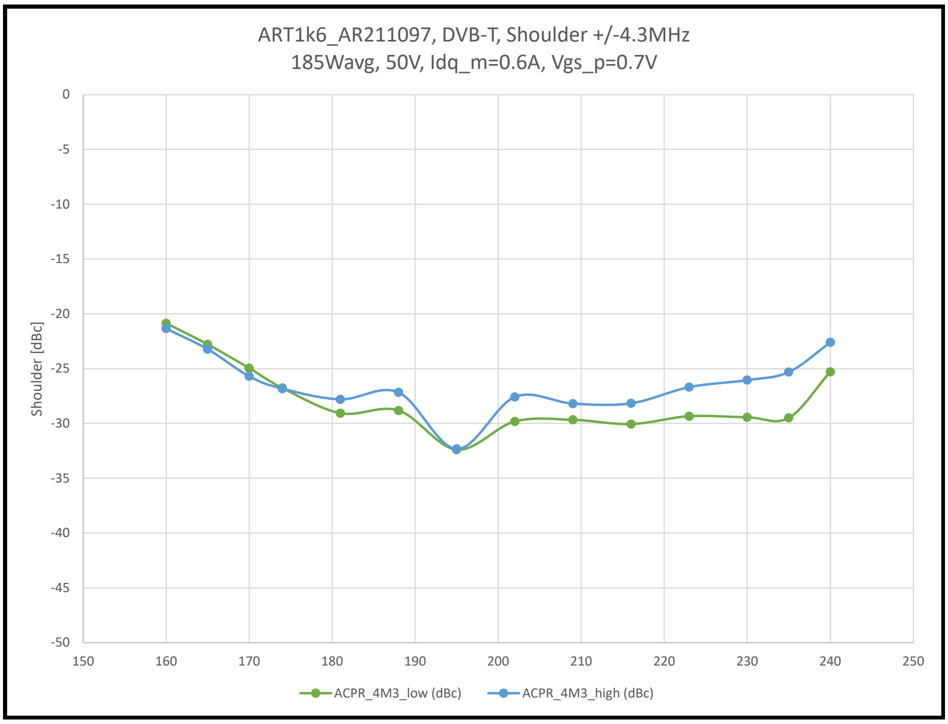

Figure 5 DVB-T, Shoulder [dB] Vgs_p=0.7V

8.2 DVB-T measurement, Pavg=185W, C22 variation

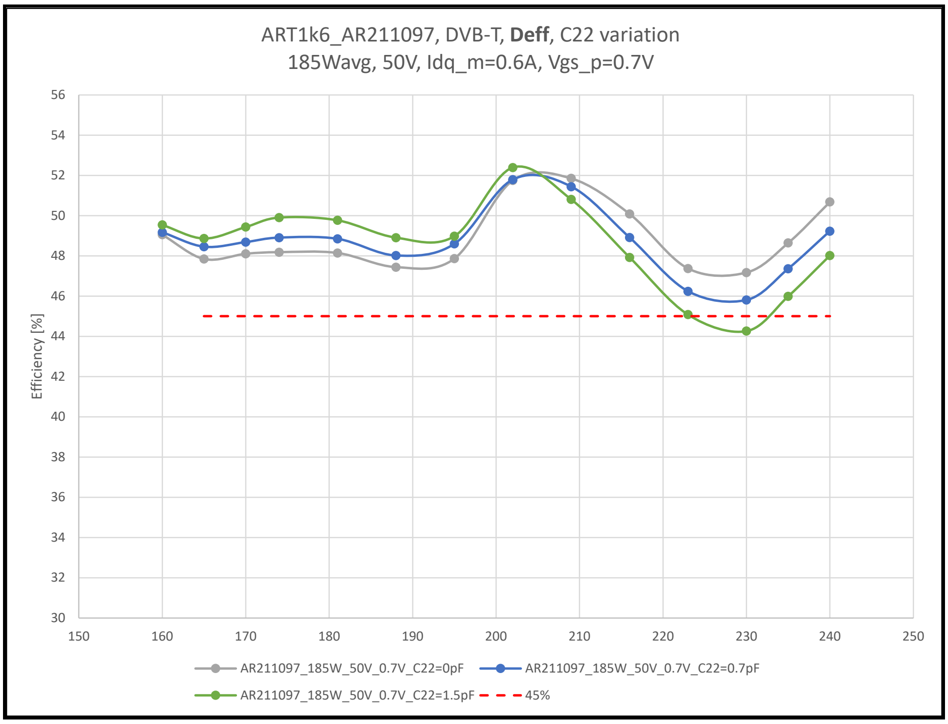

Figure 6 DVB-T, (Drain) efficiency C22=0-0.7-1.5pF, Vgs_p = 0.7V

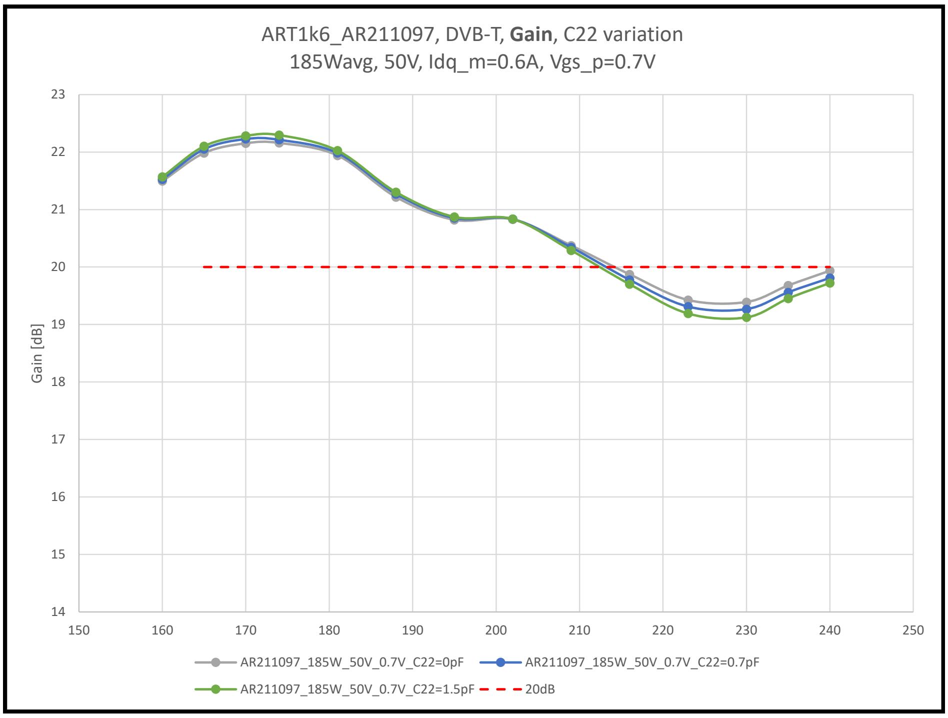

Figure 7 DVB-T, Gain C22=0-0.7-1.5pF, Vgs_p = 0.7V

8.3 DVB-T measurement, Pavg=225W, Vgs_p variation

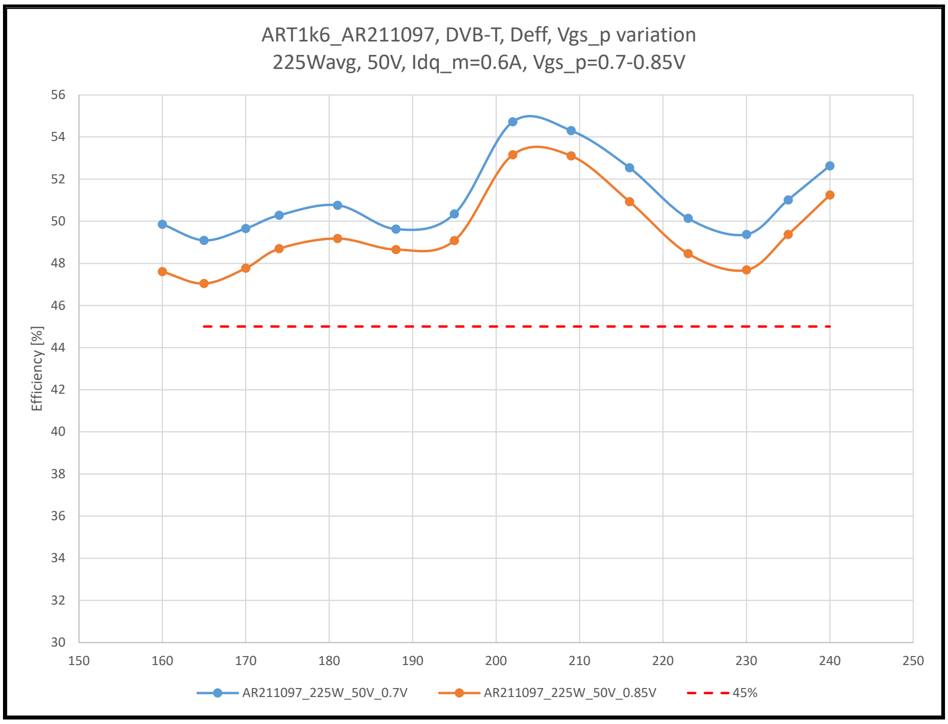

Figure 8 DVB-T, (Drain) Efficiency Vgs_p = 0.7 – 0.85V

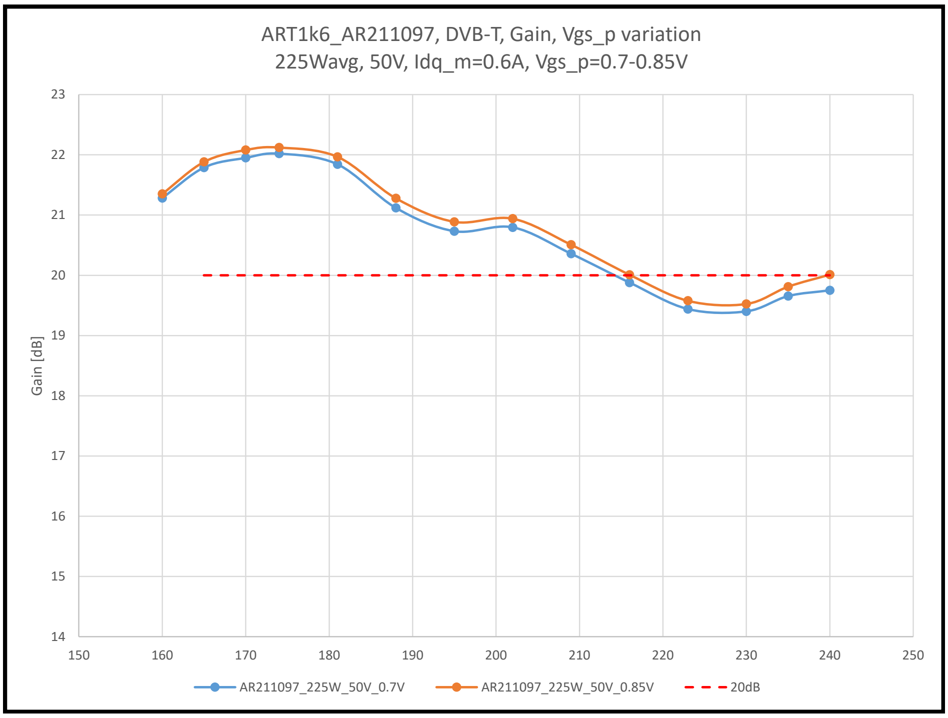

Figure 9 DVB-T, Gain Vgs_p = 0.7 – 0.85V

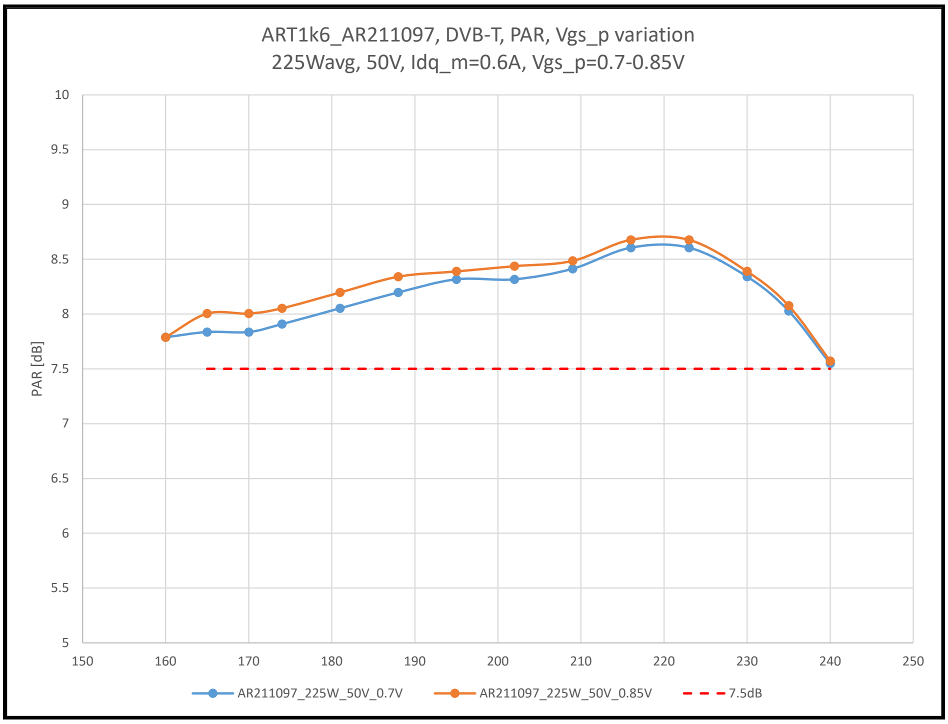

Figure 10 DVB-T, PAR Vgs_p = 0.7, 0.85V

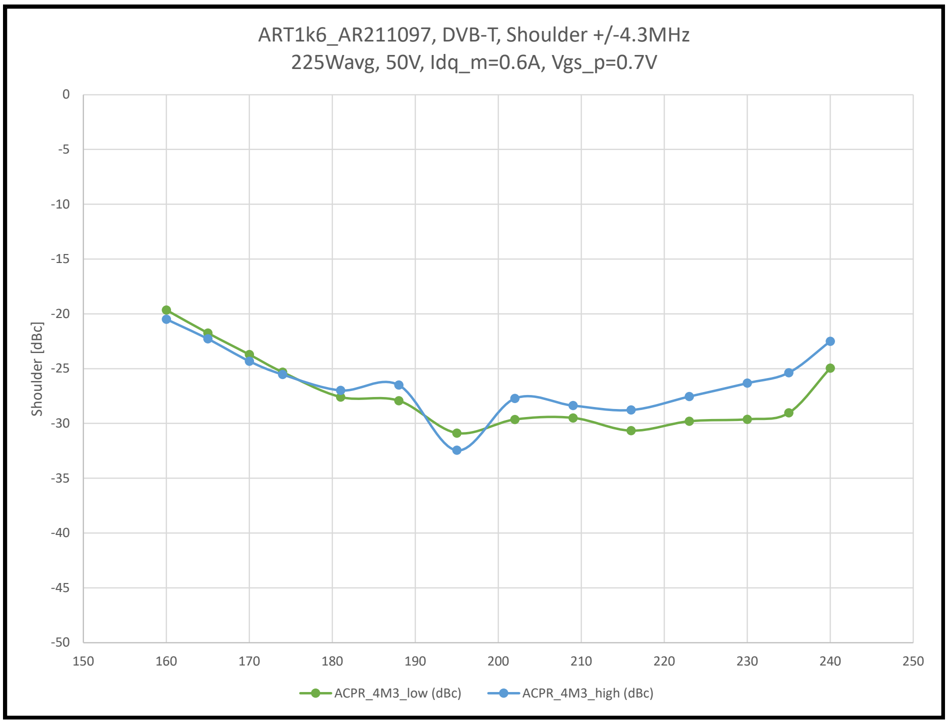

Figure 11 DVB-T, Shoulder [dBc] Vgs_p = 0.7V

8.4 Pulsed CW power sweeps

Pulse condition: 100µs/10%. Vds=50V, Idq_m=600mA, Vgs_p=0.7V

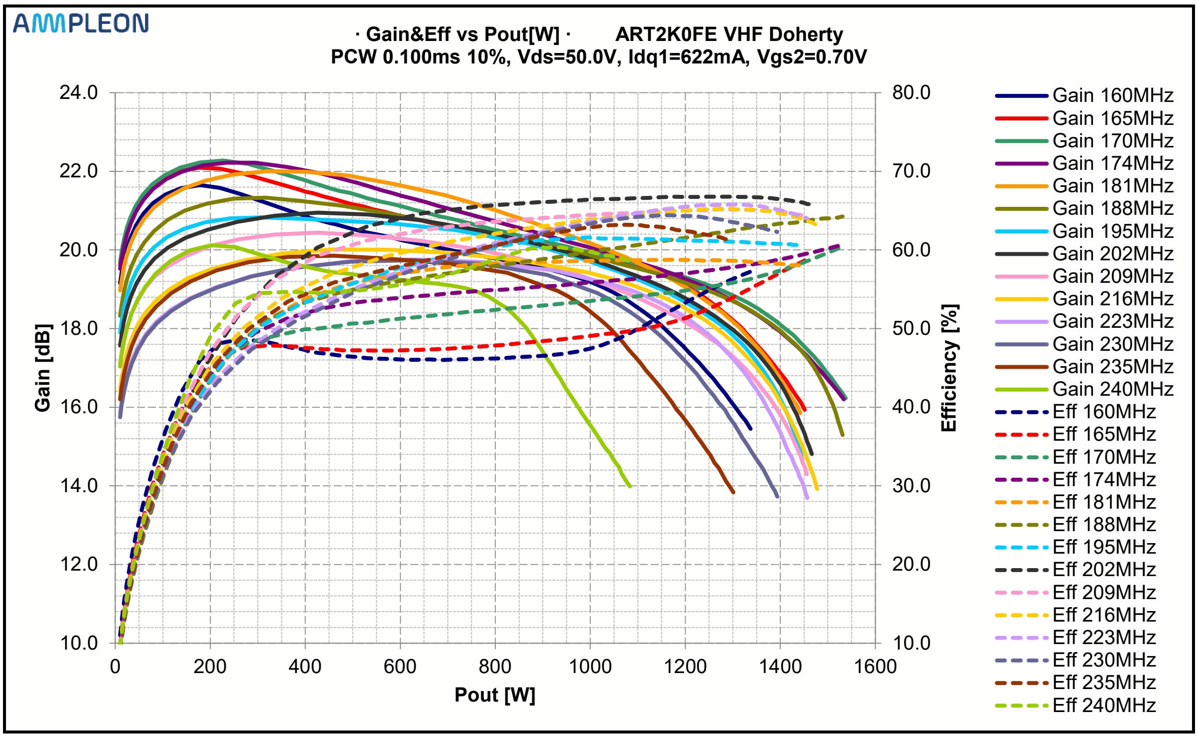

Figure 12 Pulsed CW, Gain [dB] + Deff [%] as function of Pout [W] Vdd=50V, Vgs_p=0.7V

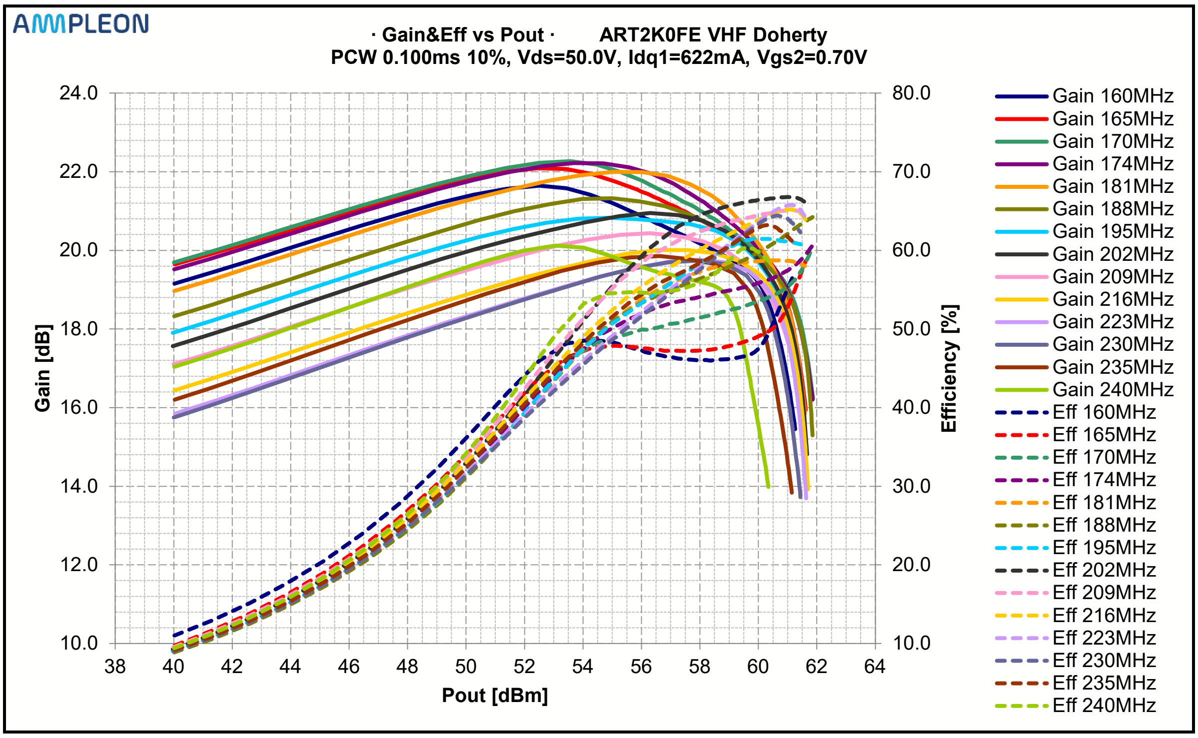

Figure 13 Pulsed CW, Gain [dB] + Deff [%] as function of Pout [dBm] Vdd=50V, Vgs_p=0.7V

9. Hardware

9.1 Board Image

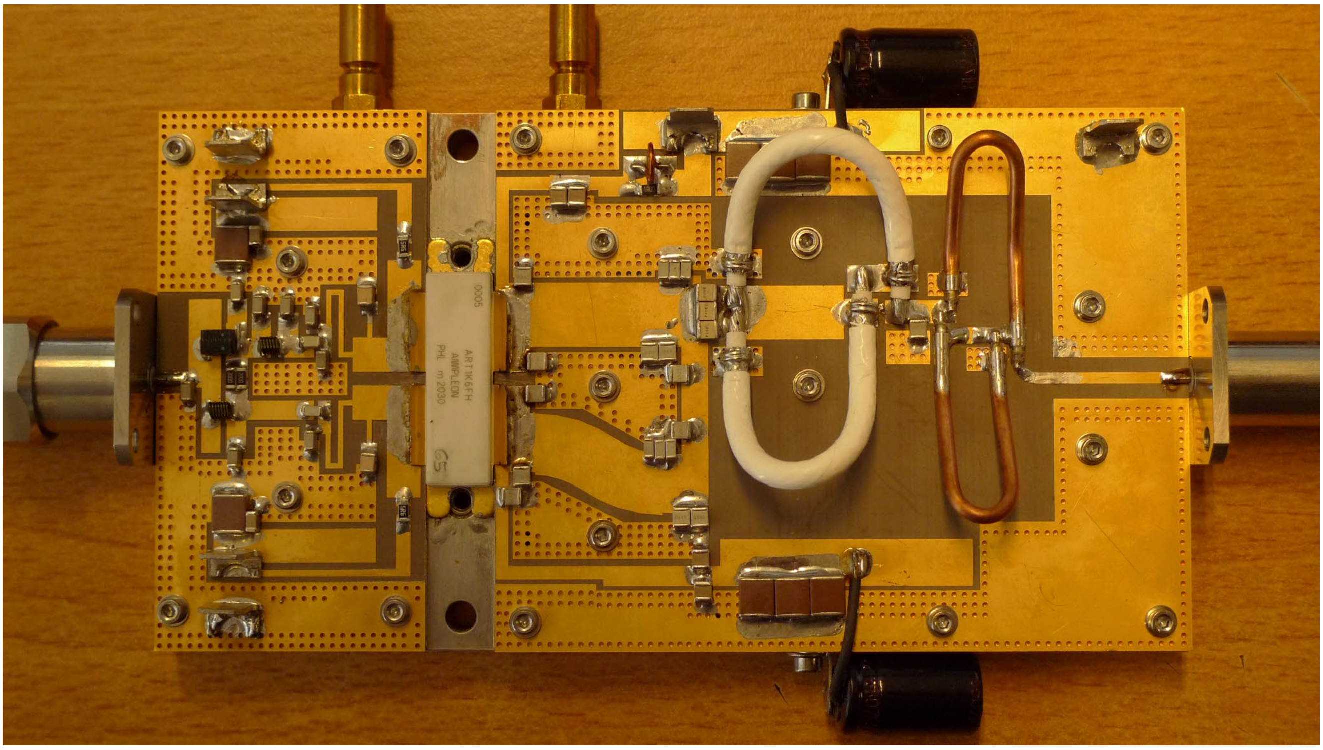

Figure 14 Picture of AR211097, 165-235Mhz demo board (top view)

Total board dimensions: 152 x 80mm

9.2 Copper Layout

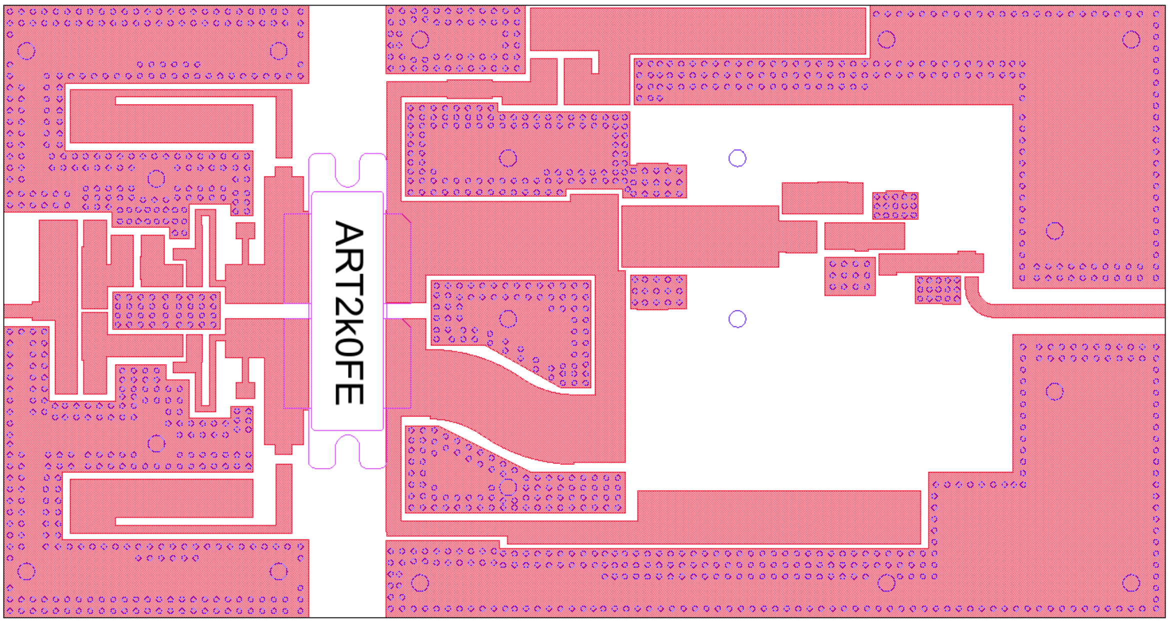

Figure 15 Layout drawing .

9.3 Component Mapping

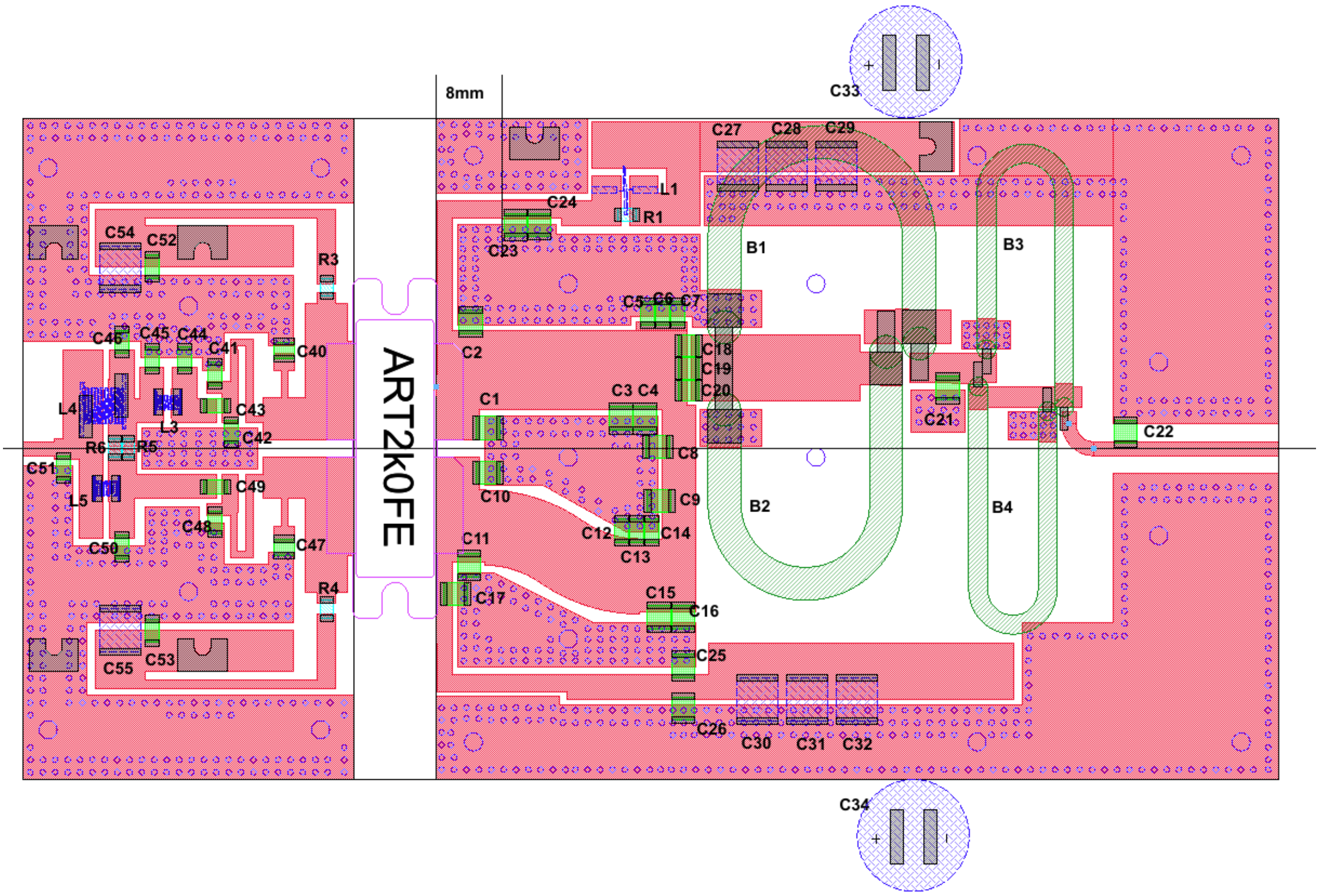

Figure 16 Component drawing .

Bill of materials

Table 3: Bill of Materials

Description	Value	Case	Supplier	Remark
Output				
C1, C2	68pF	ATC800B	ATC	
C3,C4,C5,C6,C7	91pF	ATC800B	ATC	
C8	62pF	ATC800B	ATC	
C9	20pF	ATC800B	ATC	
C10,C11	110pF	ATC800B	ATC	
C12	33pF	ATC800B	TDK	
C13,C14	56pF	ATC800B	ATC	
C15,C16,C17	68pF	ATC800B	ATC	
C18,C19,C20	330pF	ATC100B	ATC	
C21	39pF	ATC800B	ATC	
C22	NA	ATC800B	ATC	See figure 6+7
C23,C24,C25,C26	1000pF	ATC800B	ATC	
C27,C28,C29,C30,C31,C32	4.7µF / 100V		TDK	
C33,C34	470µF	ATC800B		
L1				1 turn, 4-5mm diameter
R1	1Ω			
B1,B2	12Ω / 60mm			TC12, flexible coaxial cable
B3,B4	25Ω / 60mm			UT-90C-25, semi rigid coaxial cable
Input				
C40	910pF	ATC100B		
C41,C48	51pF	ATC800B		
C42	1.5pF	ATC800B		
C43	100pF	ATC800B		
C44,C45	15pF	ATC800B		
C46	7.5pF	ATC800B		
C47	1000pF	ATC100B		
C49	160pF	ATC800B		
C50	12pF	ATC800B		
C51	22pF	ATC800B		
C52,C53	1000pF	ATC800B		
C54,C55	4.7µF / 50V		TDK	
R3,R4	5.6Ω	0805		
R5,R6	200Ω	1206		In parallel
L3	39nH	1111SQ_39NJEB	Coilcraft	
L4	68nH	1812SMS_68NGLB	Coilcraft	
L5	47nH	1111SQ_47NJEB	Coilcraft	

9.4 Board material

Table 4: Board specifications

Parameter	Value	thickness	metallisation
Manufacturer	Rogers		
Input pcb	TC350	30 mil	35µ Cu, ground layer full Cu
Output pcb	TC350	30 mil	35µ Cu, ground layer full Cu

Input pcb: 40 x 80 mm, file (dxf) name = ART2k0_50V_pcb_input_TC350_30mil_v3

Output pcb: 102 x 80 mm, file (dxf) name = ART2k0_50V_pcb_output_TC350_30mil_v3

9.5 Device markings

Table 5: Device specifics

Parameter	Value
Manufacturer	Ampleon
Device	ART1K6FH
Marking	M2030-0005
Comments	

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