AR241030

CLF24H4LS300P, 2.4-2.5GHz

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AMPLEON

Application Report

Document information	
Status	General Publication
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Abstract	Measurement results of 2.4-2.5GHz line-up with the CLF24H4LS300P and CLP24H4S30P driver

1. Revision History

Table 1: Report revisions

Revision	Date	Description	Author
1.0	2024.03.05	Initial document	Naser H.R Miveroud

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5. Description

This report presents measurement results of Ampleon's 2.4-2.5GHz 300W GaN-based two stages amplifier. The power device used is CLF24H4LS300P, and the driver is CLP24H4S30P, both 50V GaN HEMT transistors. The amplifier integrates a surface mount circulator and a directional coupler for the power monitor. Moreover, the board contains an analog temperature sensor close to the driver amplifier for temperature read-out. The presented demo is operating at full 2.4-2.5GHz ISM band. Results are presented for a typical application. However, the demo can be tuned for different efficiency/power tradeoffs.
The amplifier has very small size and utilizes proper treatment of the harmonic impedances to deliver high efficiency and yields excellent harmonic suppression.

For further details and conditions, customers can contact an Ampleon marketing/sales representative.

Table 2: Mechanical characteristics

Parameter	Description	Unit
L x W	105 x 33	mm
PCB assembly height	8	mm

Table 3: Board Specifications

Parameter	Value
Manufacturer	Rogers
Type	TC350
Dk	3.5 @ 10GHz
Df	0.002 @ 10GHz
Total PCB thickness	0.508 mm (20mil)
Copper thickness	35um (1 oz)
Board dimensions	105 x 33 mm

6. Demo Board

Figure 1 illustrates the demo board's top view. The PCB and the transistor are soldered to the copper base plate.

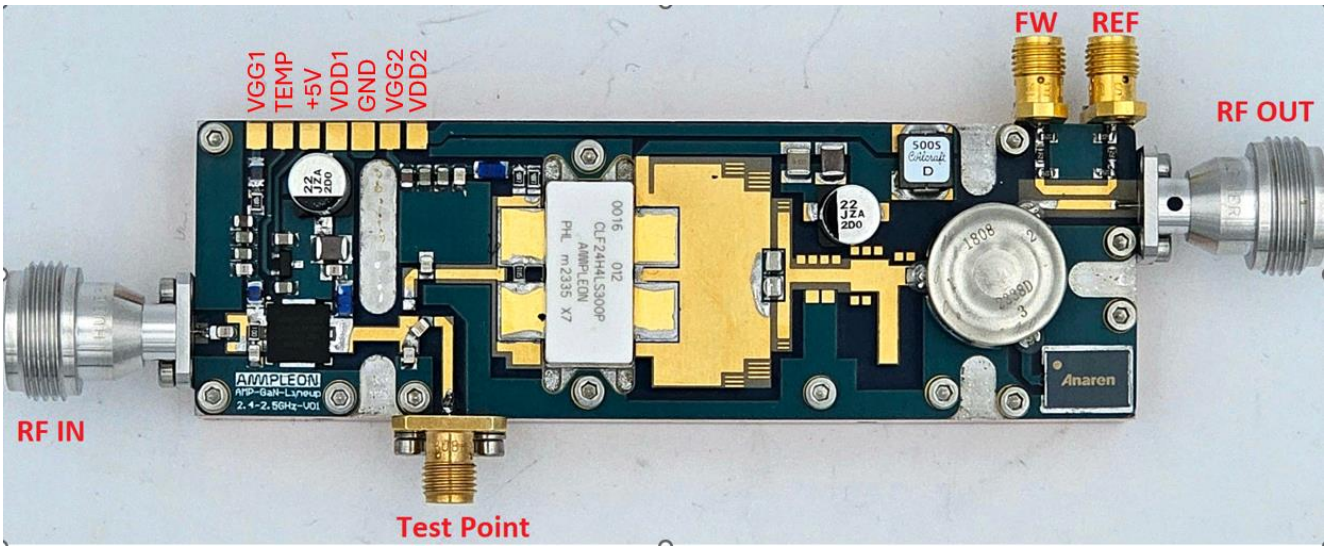

Figure 1 Demo board's top view

Table 4 summarizes the key parameters of the demo. Output power is 350W in CW mode. Measurement is done at the output connector (RF OUT) of the demo followed by a high power load and a 2.4-2.5 GHz circulator for accurate power and efficiency measurement.

Tables 5 and 6, and Figures 3 to 8 depict detailed values of the measurement for the demo.

Table 4: General Specifications, Base plate temperature = 25° C

Symbol	Parameter	Unit	Min	Typ	Max
F	Frequency of operation	MHz	2400	-	2500
V_{DD}	Drain voltage of GaN transistor	V	-	-	50
P_{OUT}	Output power[1]	W	-	350	-
η_{DRAIN}	Drain efficiency[2]	%	-	66	-
P_{DISS}	Dissipated power	W	-	180	-
H	Level of harmonics	dBc	-	-	- 60
IRL	Input return loss	dB	-	10	-

[1] *Typical output power of 350W is achieved with V_{DD} = 50V at 3dB compression point (P_{3dB}).*

[2] *Typical efficiency of 66% is achieved with V_{DD} = 50V at 3dB compression point (P_{3dB}).*

6.1 RF characteristics

Test signal: CW; VDD1 = VDD2 = 50V, VGG1[1] = -3.7V, VGG2 = -5V; T_{base} = 25ºC.

Table 5: RF characteristics in CW mode, VDD1 = VDD2 = 50V, VGG1 = -3.7V, VGG2 = -5V

Freq (MHz)	Gmax (dB)	P1dB (W)	P3dB (W)	Eff_P1dB (%)	Eff_P3dB (%)	Eff_max (%)	Pout @ Eff_max (W)
2400	31.9	393	**403**	66.1	65.8	**66.2**	**381**
2450	32.2	360	**366**	66.3	65.9	**66.4**	**356**
2500	32.8	296	**305**	65.5	65	**65.7**	**292**

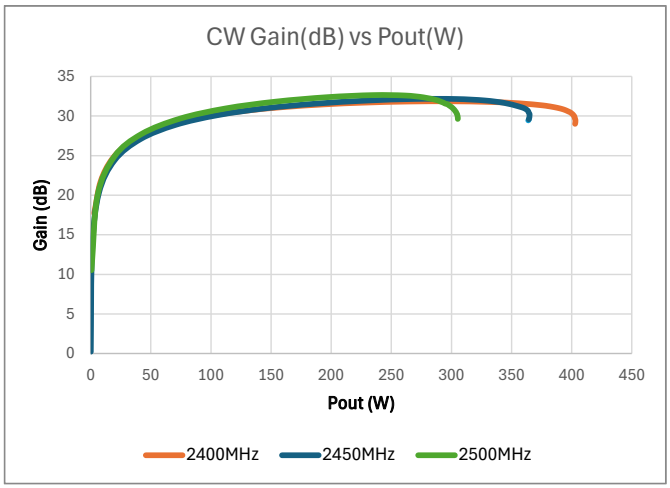

Figure 2 Gain (dB) over output power (W), CW signal

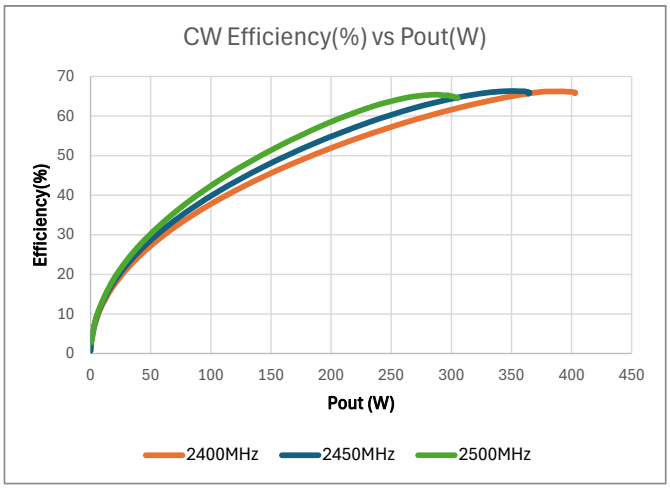

Figure 3 Efficiency (%) over output power (W), CW signal

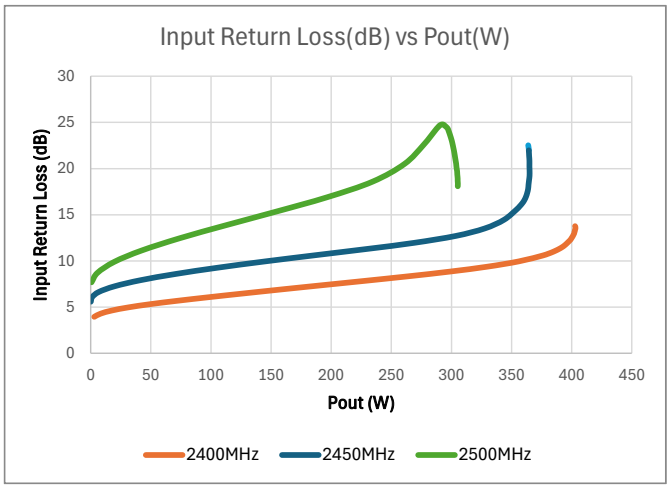

Figure 4 Input Return Loss (dB) over output power (W), CW signal

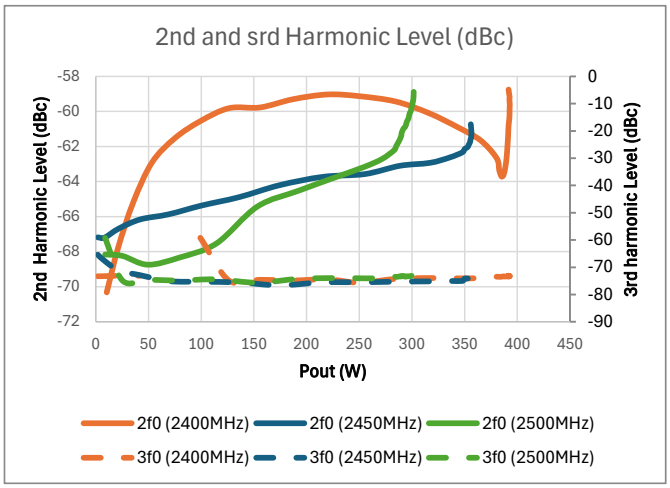

Figure 5 2nd and 3rd Harmonic level (dBc)

[1] VGG1 = -3.7V yields Idq1 = 5mA

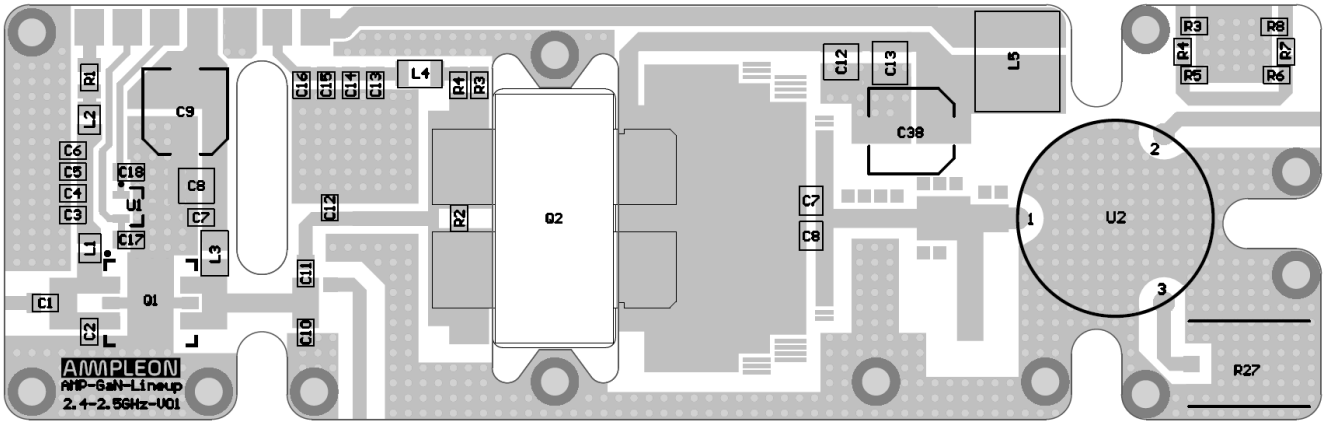

Figure 6 PCB and component layout

6.1 Bill of materials

Table 6: Bill of Materials

Designator	Group	Value	Tolerance	Name	Manufacturer	Quantity
C1, C3, C7, C13	Capacitor	100pF	±5%	ATC600F101JW250XT	ATC	4
C2	Capacitor	1.2pF	±0.1pF	ATC600F1R2BW250XT	ATC	1
C4, C5, C14, C15, C17	Capacitor	100nF	±5%	GRM21B71H104A01L	ATC	5
C6, C16, C18	Capacitor	4.7uF	±10%	C2012X7R1H475K	TDK	3
C7, C8	Capacitor	1.2pF	±0.1pF	ATC800R1R2BW500T	ATC	2
C8, C12	Capacitor	1nF	±0.1pF	ATC800B102JW50XT	TDK	2
C9, C38	Capacitor	22µF/63V	±10%	Aluminium Polymer Capacitor D6 x H8	ATC	2
C10, C11	Capacitor	1.4pF	±0.1pF	ATC600F1R4BW250XT	ATC	2
C12	Capacitor	1.1pF	±0.1pF	ATC600F1R1JW250XT	ATC	1
C13	Capacitor	10uF/100V	±10%	C3225X7R2A106K	TDK	1
L1	Inductor	12nH	±10%	0805HP -120XJRB	Coilcraft	1
L2	Inductor	220nH	±5%	0805HP -221XJRB	Coilcraft	1
L3	Inductor	6.8nH	±5%	0805HP -6R8XJRB	Coilcraft	1
L4	Inductor	12nH	±5%	1206CS-120XJRB	Coilcraft	1
L5	Inductor	50nH 40A			Coilcraft	1
Q1	Transistor			CLP24H4S30P	Ampleon	1
Q2	Transistor			CLF24H4LS300P		1
R1, R3, R4	0805R Chip Resistor	50R		Various		3
R2	0805R Chip Resistor	5R1		Various		1
R3, R5, R6, R8	0603R Chip Resistor	62R		Various		4
R4, R7	0603R Chip Resistor	240R		Various		2
R27	50R Termination, DC - 2.2 GHz, 200W, 2538 size	50R 200W		Anaren	Anaren	1
U1	Tempreture Sensor			LM50	Texas Instruments	1
U2	SMD Ferrite Circulator			SKYFR-001808	Trans-Tech	1

6.2 Thermal Characteristics

Figures 7 to 9 show thermal image of the demo while the amplifier is working at compression at 2.4GHz, 2.45GHz, and 2.5GHz respectively under CW signal.

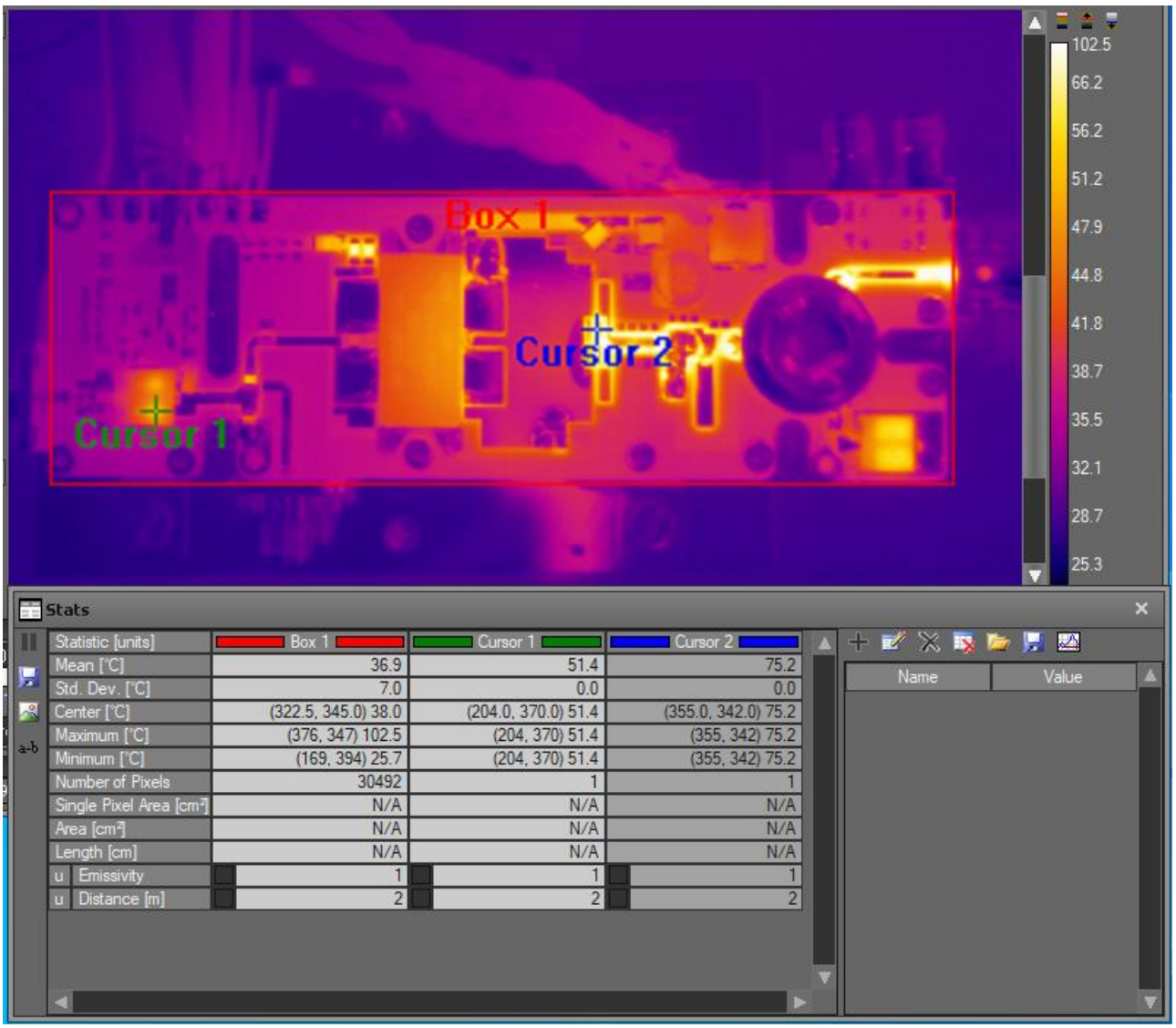

Figure 7 IR Image of the demo under CW signal at 2.4GHz, Output power = 395W, Tbase = 25ºC

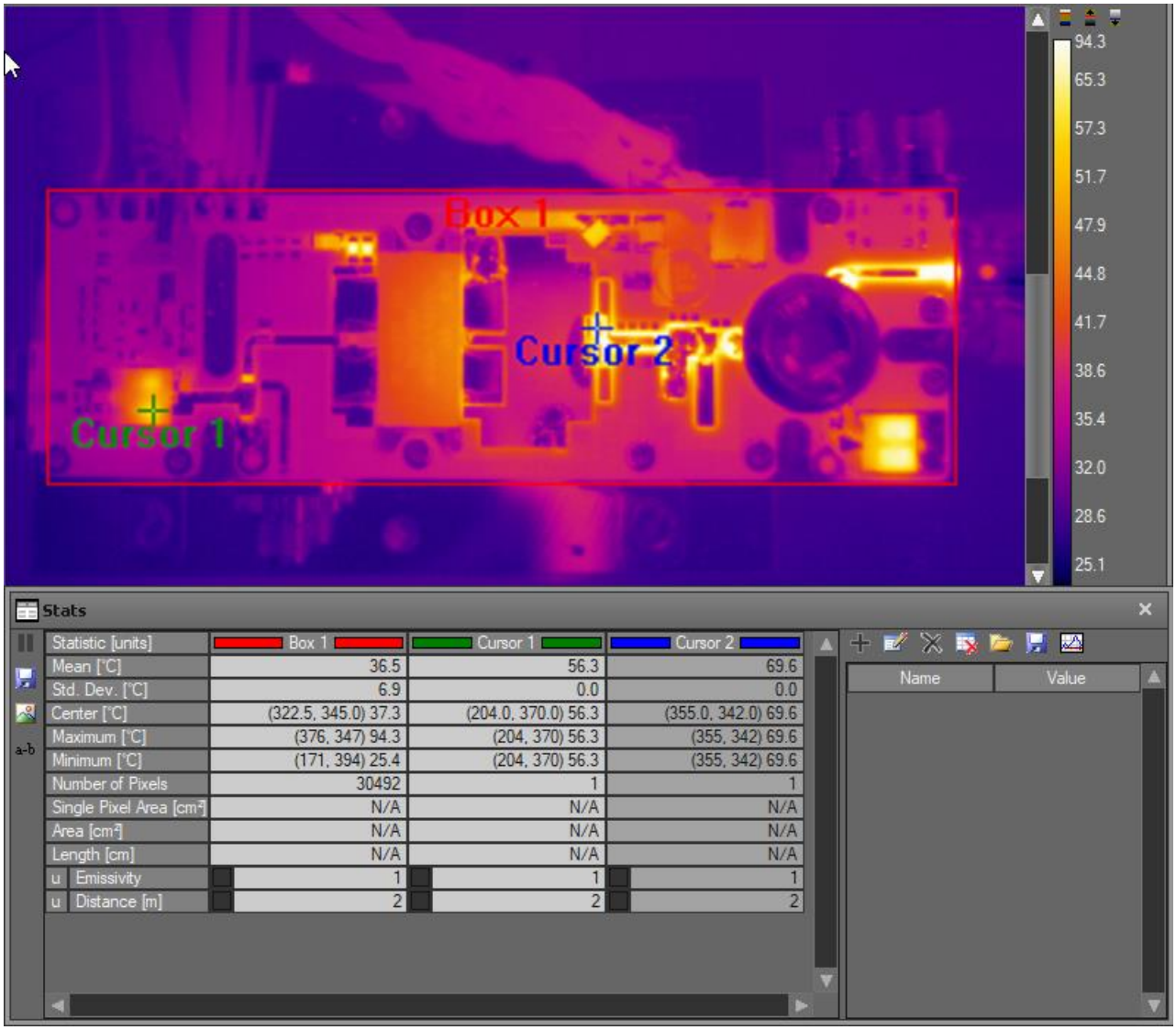

Figure 8 IR Image of the demo under CW signal at 2.45GHz, Output power = 355W, Tbase = 25ºC

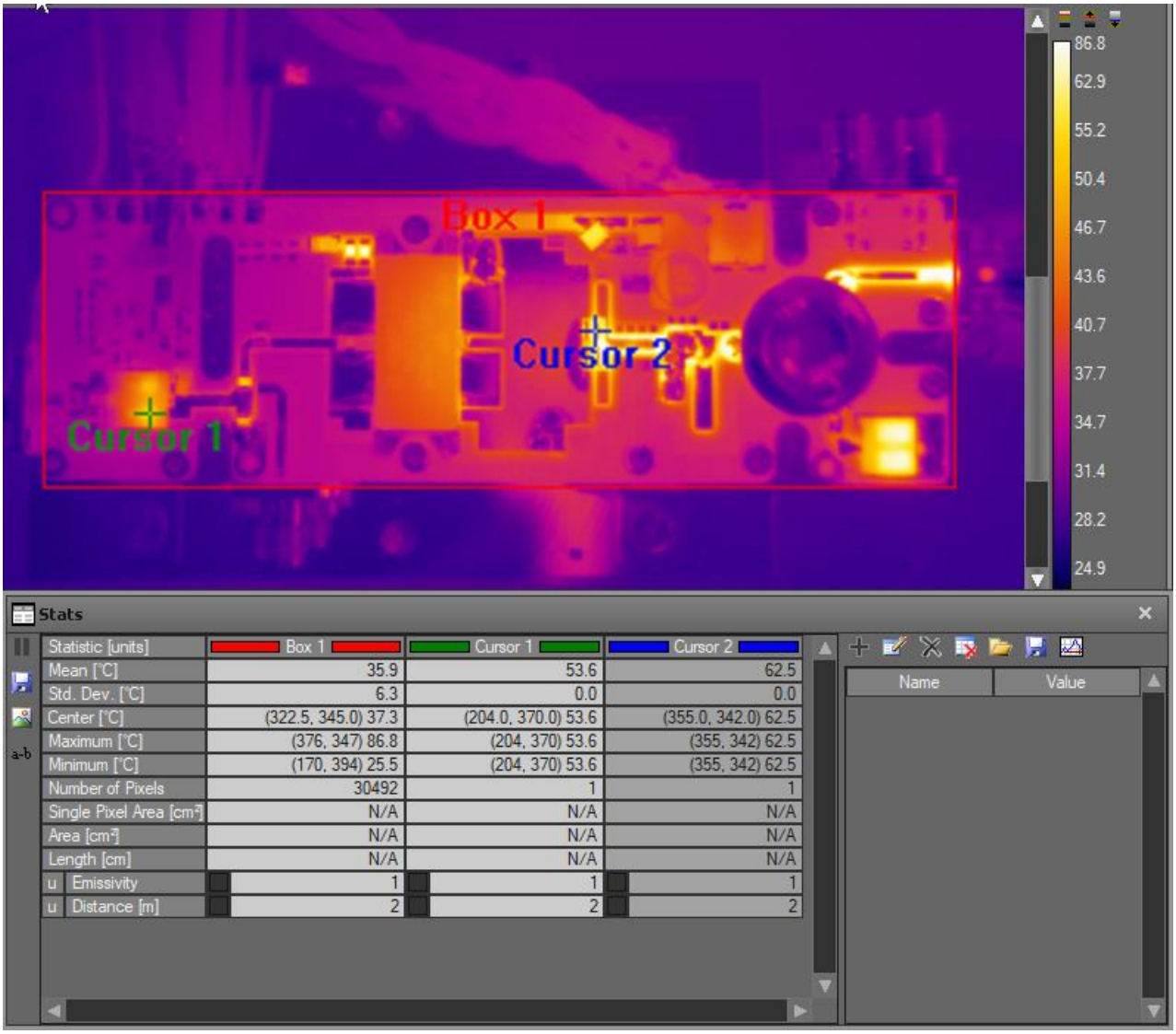

Figure 9 IR Image of the demo under CW signal at 2.5GHz, Output power = 300W, Tbase = 25ºC

6.3 Correct Power ON/OFF Sequence

Depletion mode transistors including GaN require proper sequence to power ON and OFF. If the correct procedure is not followed, the device can be damaged immediately or to be degraded.

To Turn the device ON:

1. Set VGG1 to -5V
2. Set VGG1 to -5V
3. Set VDD1 to 50V
4. Set VDD2 to 50V
5. slowly increase VGG1 until reaching desired Idq level (5mA as of this report)
6. Apply input RF signal

To Turn the device OFF:

1. Turn the input RF signal off
2. Reduce VGG1 to -5V

3. Reduce VDD1 and VDD2 to 0V (in case there is a big capacitor on the drain bias, give enough time to the capacitor to be discharged)
4. Turn the VGG1 and VGG2 off (VGG1=VGG2 =0V)

7. Abbreviations

Table 7: Abbreviations

Parameter	Description
F	Frequency
CW	Continuous Wave
Gmax	Maximum Gain
P1dB	1 dB Compression Point of the Gain
V_{DD}	Drain Voltage
VGS	Gate Voltage
η_{DRAIN}	Drain Efficiency
GaN	
VSWR	Voltage Standing Wave Ratio
δ	Duty Cycle
t_p	Pulse Width
RF	Radio Frequency
P_L	Power Delivered to 50Ω Load at RF OUT Connector
S21	Small Signal Gain (S-parameter measurement in 50Ω System)
Pin	Input Power to the Amplifier at RF IN Connector
Pout	Output Power of Amplifier at RF OUT Connector

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