



# APPENDIX I RADIO FREQUENCY EXPOSURE

## LIMIT

According to §15.247(i), systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines. See § 1.1307(b)(1) of this chapter.

## EUT Specification

<b>EUT</b>	IP-STB
<b>Trade Name</b>	Roku
<b>Model Number</b>	2720X
<b>Frequency band (Operating)</b>	<input checked="" type="checkbox"/> 802.11b/g/n HT20: 2.412GHz ~ 2.462GHz <input checked="" type="checkbox"/> 802.11a/HT20: 5.150GHz ~ 5.250GHz <input checked="" type="checkbox"/> 802.11a/HT20: 5.745GHz ~ 5.825GHz <input type="checkbox"/> Others
<b>Device category</b>	<input type="checkbox"/> Portable (<20cm separation) <input checked="" type="checkbox"/> Mobile (>20cm separation) <input type="checkbox"/> Others
<b>Exposure classification</b>	<input type="checkbox"/> Occupational/Controlled exposure (S = 5mW/cm <sup>2</sup> ) <input checked="" type="checkbox"/> General Population/Uncontrolled exposure (S=1mW/cm <sup>2</sup> )
<b>Antenna Specification</b>	PIFA Antenna , Antenna 1: MSA-2509-25GC1-A3 Antenna Gain: 2.4GHZ: 3.52 dBi, (numeric gain is 2.25) 5.150GHz ~ 5.250GHz: 3.75 dBi, (numeric gain is 2.37) 5.745GHz ~ 5.825GHz: 4.54 dBi, (numeric gain is 2.84) Antenna 2: MSA-2509-25GC1-A4 Antenna Gain: 2.4GHZ: 1.27 dBi, (numeric gain is 1.34) 5.150GHz ~ 5.250GHz: 4.09 dBi, (numeric gain is 2.56) 5.745GHz ~ 5.825GHz: 3.05 dBi, (numeric gain is 2.02)
<b>Max. output power</b>	IEEE 802.11b : 14.84 dBm (30.479mW) IEEE 802.11g : 16.18 dBm (41.495mW) IEEE 802.11n HT20 : 18.46 dBm (70.146mW) IEEE 802.11a 5.150GHz ~ 5.250GHz : 14.59 dBm (28.774mW) IEEE 802.11a 5.745GHz ~ 5.825GHz : 15.51 dBm (35.563mW) IEEE 802.11a HT20 5.150GHz ~ 5.250GHz : 14.56 dBm (28.576mW) IEEE 802.11a HT20 5.745GHz ~ 5.825GHz : 17.78 dBm (59.980mW)
<b>Evaluation applied</b>	<input checked="" type="checkbox"/> MPE Evaluation* <input type="checkbox"/> SAR Evaluation <input type="checkbox"/> N/A
<b>Remark:</b> The maximum output power is <u>18.46dBm (70.146mW) at 2437MHz.</u>	



## **TEST RESULTS**

**No non-compliance noted.**

### **Calculation**

Given  $E = \frac{\sqrt{30 \times P \times G}}{d}$  &  $S = \frac{E^2}{377}$

Where  $E$  = Field strength in Volts / meter

$P$  = Power in Watts

$G$  = Numeric antenna gain

$d$  = Distance in meters

$S$  = Power density in milliwatts / square centimeter

Combining equations and re-arranging the terms to express the distance as a function of the remaining variables yields:

$$S = \frac{30 \times P \times G}{377d^2}$$

Changing to units of mW and cm, using:

$$P \text{ (mW)} = P \text{ (W)} / 1000 \text{ and}$$

$$d \text{ (cm)} = d \text{ (m)} / 100$$

Yields

$$S = \frac{30 \times (P/1000) \times G}{377 \times (d/100)^2} = 0.0796 \times \frac{P \times G}{d^2} \quad \text{Equation 1}$$

Where  $d$  = Distance in cm

$P$  = Power in mW

$G$  = Numeric antenna gain

$S$  = Power density in mW / cm<sup>2</sup>



**Maximum Permissible Exposure**

Substituting the MPE safe distance using  $d = 20$  cm into Equation 1:

$$S = 0.000199 \times P \times G$$

Where  $P =$  Power in mW

$G =$  Numeric antenna gain

$S =$  Power density in mW / cm<sup>2</sup>

**IEEE 802.11b mode:**

Ch.	Frq.(MHz)	P (mW)	Gain (num.)	D (cm)	Power density in mW / cm <sup>2</sup>	Limit (mW/cm <sup>2</sup> )
11	2462	30.479	2.25	20	0.0136	1

**IEEE 802.11g mode:**

Ch.	Frq.(MHz)	P (mW)	Gain (num.)	D (cm)	Power density in mW / cm <sup>2</sup>	Limit (mW/cm <sup>2</sup> )
6	2437	41.495	2.25	20	0.0186	1

**IEEE 802.11n HT20 mode:**

Ch.	Frq.(MHz)	P (mW)	Gain (num.)	D (cm)	Power density in mW / cm <sup>2</sup>	Limit (mW/cm <sup>2</sup> )
6	2437	70.146	2.25	20	0.0314	1

**IEEE 802.11a mode:**

Ch.	Frq.(MHz)	P (mW)	Gain (num.)	D (cm)	Power density in mW / cm <sup>2</sup>	Limit (mW/cm <sup>2</sup> )
48	5240	28.774	2.56	20	0.0147	1
Ch.	Frq.(MHz)	P (mW)	Gain (num.)	D (cm)	Power density in mW / cm <sup>2</sup>	Limit (mW/cm <sup>2</sup> )
165	5825	35.563	2.84	20	0.0201	1

**IEEE 802.11a HT20 mode:**

Ch.	Frq.(MHz)	P (mW)	Gain (num.)	D (cm)	Power density in mW / cm <sup>2</sup>	Limit (mW/cm <sup>2</sup> )
48	5240	28.576	2.56	20	0.0146	1
Ch.	Frq.(MHz)	P (mW)	Gain (num.)	D (cm)	Power density in mW / cm <sup>2</sup>	Limit (mW/cm <sup>2</sup> )
165	5825	59.980	2.84	20	0.0339	1