

SAR Analysis Report

(Based upon upper bound transmission duty factor)

Electronic Display Device

FCC ID: 2A4DH-4832

IC number: 24273-4832

Amazon.com Services LLC

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Rev. A

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1. Product Description

- a. Radio Capabilities
 - i. WLAN portion: 802.11 a/b/g/n/ac ii. BT5.0 including EDR/LE
- b. External connector:
 - i. USB port
- c. The primary use of this device is to download the eBook and periodical offering from the content provider. The wireless radios are only used to send and receive data (electronic article) for this Electronic Display Device and does not support wireless file transfer to/from other devices.

The UBTF for this Electronic Display Device is filing with FCC ID: 2A4DH-4832 , IC number: 24273-4832

2. Network Connection on a typical eBook purchase RX-TX sequence

- a. Step #1 Initial wireless power-up and pairing request

When a customer switches on the Electronic Display Device, a link of 1kB data size is sent to the content provider website via carrier towers in conjunction with a proprietary Data network. This is also called a pairing request for connections, as defined in the Data network terminology.

There is an uplink activity. Its uplink duration is 0.5 seconds. Entire process will take 30 seconds based upon the most conservative estimate (shortest).

- b. Step #2 Launch store application: this is download activity only. Application will be launched about 30 seconds based upon the most conservative estimate (shortest).
- c. Step #3 Search for content: Majority time spent in this process is during browsing the store content in making the decision on which category of electronic article and specific title to be purchased. The duration of event can be varied from one user to the other. The most conservative estimate is based upon the shortest browsing time of 40 seconds and entering multiple selections by the end user (transmitting) of 8 seconds.
- d. Step #4 Review search result: This is receiving activity only. Before making the final decision on download the electronic article, estimating the end user will take time in reviewing the content summary before making the purchasing decision. The most conservative estimate that the end user will take about 150 seconds in reviewing the search result.
- e. Step #5 New search and review result: To anticipate the end user will be making multiple selections (to purchase multiple books) at the same time but less time will be spent in browsing the contents and reviewing the selections. The most conservative duration is 90 seconds with less selections entered by the end user of 7 seconds.(transmitting).
- f. Step #6 Over-the-air book purchase request

The customer then browses the Electronic Display Device and sends a purchase request to the content provider website through the carrier tower through Data network. The data size of this request is approximately 1kB. The data contains the customer's credit card information and the book information.

There is an uplink activity. The uplink duration is 0.5 second. The duration of time for the end user in entering the credit card information is estimating of 30 seconds (shortest).

- g. Step #7 Over-the-air book purchase confirmation including download information exchange.

The content provider sends a purchase confirmation to the Electronic Display Device. The data size of this confirmation is approximately 1kB. The purchase confirmation #, the credit card authorization/receipt, and the delivery confirmation are contained this purchase confirmation. This confirmation is preceded by the wireless delivery of the ordered item to the Electronic Display Device.

There is an uplink activity. The uplink duration is 0.5 seconds and the duration of time takes about 20 seconds.

h. Step #8 Over-the-air book delivery

The content provider sends the ordered book to the requesting device through carrier network via Data network. The data size of this delivery is typically 500kB based on the book purchased.

- i. For magazine or newspaper subscription delivery, it will consist of 1 and 8 steps described above
- j. Proprietary Notes:
- Data network controls the signal transmission.
 - The Data network is a proprietary “cloud “that handles all traffic between this Electronic Display Device and the contend provider who implemented Data network. It handles handshakes, authentication, purchase transmission, book download. It also provides a books management system whereby a customer can keep their place or content across Electronic Display Device hardware and other mobile device.

3. Referenced FCC Guideline

- a. “ Information requirements for FCC consideration of relevant upper bound transmission duty factor to qualify e-book devices/e-reader for SAR test exclusions” Dated Jan 07, 2010
- b. “RF Exposure procedure review : e-Reader – estimating a conservative transmission duty factor”
- c. TCB council workshop presentation dated April 28, 2010 c. “Greater than 10 MB using HSPA” Dated June 17, 2010
- d. KDB 447498 D01v06 General RF Exposure Guidance

4. Conservative Approach in Upper Bound Transmission Duty Factor

Our calculation of RF exposure for the purpose of SAR analysis is based on conservative product or network usage.

The frequency and duration of transmission time are based on nominal use, and the transmission time reported in this waiver request is done in seconds.

In addition, Electronic Display Device uses the following techniques for conservative approach in assessing RF exposure impact

- 1) For WiFi mode of operation, since there is little or no transmission during the download, the analysis is based on the shortest downlink data rate of 2000 kbps. We schedule delivery of subscriptions at times we expect that users will be less likely to be holding the device.

5. Available Content for Electronic Display Device Download

Table 1	
Publication Category	% of total download
Books	30
Newspapers	30
Magazines	20
Internet Content	20

Table 1 presents the data of content distribution in each of category based upon data gathered with expected future content distributions in the most conservative way to ensure continued compliance.

6. File Size Distribution for Each Content Type

Table 2 / Monthly Download Metric				
A	B	C	D	E
File Size (Mbyte)	Books % Distribution	Newspapers % Distribution	Magazine % Distribution	Internet Content % Distribution
< 0.5MB	52.8	10	22	45
0.5 - 1	29.3	9	7	30
1 - 5	15.2	59	47	20

5 - 10	1.1	19	19	4
10 - 20	0.7	3	5	0
20 - 30	0.4	0	0	0
30 - 40	0.2	0	0	1
40 - 50	0.3	0	0	0

Table 2 presents download metrics based upon available store content download file size in each category and future expectations provided by the content store for the device. This usage/content was updated in June 2013 and was re-evaluated recently in Jan. 2019 to be the same.

7. Rationale in calculating Upper Bound Transmission Duty Factor

- a. Step 1: Define the percentage of distribution based upon category defined.
 - i. Table 1: Based upon the category defined in content download store and data center database structure. Four content categories have been defined as eBook, Newspaper, Magazine and internet content.
- b. Step 2: Grouping the file size and provide the percentage for each group of file size in each category. For file size larger than 10 MB, the increment of grouping should not be less than 5 MB or greater than 20 MB (June 17, 2000 FCC guidance).
 - i. Table 2: The max. file size is 50 MB,
- c. Step 3: Category type download duration for each file size grouping for each mode of operation
 - i. WiFi & Bluetooth Analysis
 - 1. Event Process Durations and UBTDF percentage (Table 13)
- d. Step 4: Based upon RF conducted output power and antenna-to-user separation distance in calculating the SAR test Exclusion threshold.
- e. Step 5: Adjusted RF conducted output with UBTDF Vs. SAR test exclusion threshold.

8. WLAN & Bluetooth Analysis

Within the WiFi network, this client device (Electronic Display Device) shall establish the network connection and authenticated with master device (hot spot). The step timeline is similar to GPRS. EDGE and WCDMA, the transaction duration is similar to HSDPA. During the download process, the client device is constantly sending the acknowledgement back to master device to check the number of packet received.

Within the WiFi network, the UBTF is max. when the download data rate is the slowest in term to have longest transmitting –on time. A 0.5 MB file size is used in the calculation due to 0.5 MB size has higher download percentage across all four categories and 2MBPs data rate is used.

Sample calculation:

$$\text{For 2.4GHz case: } (0.5 \text{ MB} * (8\text{bits/byte}) * (1024\text{Kbytes/MB})) / 2000\text{kbps} = 2.048 \text{ seconds}$$

Table 13/ Upper bound transmission duty factor based upon weighted composite download			
A	B	C	D
Step	Event	Event Duration (in sec)	Transmission on- time(in sec)
1	Power up & register on network	30	0.5
2	Launch store application	30	0
3	Search for content	40	8
4	Review search results	150	0
5	New search and review result	90	7
6	Over-the-air purchase request	30	0.5
7	Over-the-air purchase confirmation	20	2.5
8	Download archived content (0.5MB)	2.048	2.048
9	Purchase completed (Modem inactive)	5.0	0
Totals		397.05	20.55
Duty Factor		5.18%	

Bluetooth operation supports audio streaming. The UBTDF is max. when the packet transmission extend to 5 slots combined with 1 receiving slot. The max. duty factor for Bluetooth is 5/6 = 83.3%.

For 5GHz case: $(0.5 \text{ MB} * (8\text{bits/byte}) * (1024\text{Kbytes/MB})) / 6000\text{kbps} = 0.68 \text{ seconds}$

Table 13/ Upper bound transmission duty factor based upon weighted composite download			
A	B	C	D
Step	Event	Event Duration (in sec)	Transmission on-time(in sec)
1	Power up & register on network	30	0.5
2	Launch store application	30	0
3	Search for content	40	8
4	Review search results	150	0
5	New search and review result	90	7
6	Over-the-air purchase request	30	0.5
7	Over-the-air purchase confirmation	20	2.5
8	Download archived content (0.5MB)	0.68	0.68
9	Purchase completed (Modem inactive)	5.0	0
Totals		395.68	19.18
Duty Factor		4.84%	

9. RF Conducted Power

Max. Target average Power Based upon Tune up Procedure

The maximum output power, including tune up tolerances +0 dB / -2 dB are detailed in the tables below. Measurement data included in the application filing are within the tune-up nominal power and tolerances described in the tune up procedure documentation.

BT BLE

Mode	Channel	Frequency (MHz)	Average power (dBm)		
			1Mbps	2Mbps	3Mbps
BR / EDR	CH 00	2402	4.70	4.30	4.30
	CH 39	2441	4.90	4.60	4.60
	CH 78	2480	4.80	4.50	4.50
Tune-up Limit			6	6	6

Mode	Channel	Frequency (MHz)	Average power (dBm)	
			1Mbps	2Mbps
LE	CH 00	2402	-1.50	-1.40
	CH 19	2440	-1.30	-1.20
	CH 39	2480	-1.30	-1.20
Tune-up Limit			0	0

<2.4GHz WLAN>

2.4GHz WLAN	Mode	Channel	Frequency (MHz)	Average power (dBm)	Tune-Up Limit	Duty Cycle %
	802.11b 1Mbps		1	2412	16.10	17.00
6			2437	16.00	17.00	
11			2462	16.00	17.00	
12			2467	16.10	17.00	
13			2472	15.60	17.00	
802.11g 6Mbps		1	2412	14.70	15.50	96.97
		6	2437	14.70	15.50	
		11	2462	14.60	15.50	
		12	2467	13.30	14.00	
		13	2472	9.90	11.00	
802.11n-HT20 MCS0		1	2412	14.60	15.50	96.77
		6	2437	14.50	15.50	
		11	2462	14.50	15.50	
		12	2467	12.30	13.00	
		13	2472	8.00	9.00	

<5GHz WLAN>

	Mode	Channel	Frequency (MHz)	Average power (dBm)	Tune-Up Limit	Duty Cycle %
5.2GHz WLAN	802.11a 6Mbps	36	5180	14.68	15.50	96.97
		40	5200	14.65	15.50	
		44	5220	14.67	15.50	
		48	5240	14.58	15.50	
	802.11n-HT20 MCS0	36	5180	14.52	15.50	96.23
		40	5200	14.55	15.50	
		44	5220	14.65	15.50	
		48	5240	14.59	15.50	
	802.11n-HT40 MCS0	38	5190	13.64	15.00	93.73
		46	5230	13.70	15.00	
	802.11ac-VHT20 MCS0	36	5180	14.43	15.50	96.79
		40	5200	14.46	15.50	
44		5220	14.56	15.50		
48		5240	14.50	15.50		
802.11ac-VHT40 MCS0	38	5190	13.60	15.00	93.75	
	46	5230	13.66	15.00		
802.11ac-VHT80 MCS0	42	5210	13.54	14.50	87.79	

	Mode	Channel	Frequency (MHz)	Average power (dBm)	Tune-Up Limit	Duty Cycle %
5.3GHz WLAN	802.11a 6Mbps	52	5260	14.54	15.50	96.97
		56	5280	14.64	15.50	
		60	5300	14.66	15.50	
		64	5320	14.71	15.50	
	802.11n-HT20 MCS0	52	5260	14.70	15.50	96.23
		56	5280	14.53	15.50	
		60	5300	14.78	15.50	
		64	5320	14.73	15.50	
	802.11n-HT40 MCS0	54	5270	13.72	15.00	93.73
		62	5310	13.61	15.00	
	802.11ac-VHT20 MCS0	52	5260	14.61	15.50	96.79
		56	5280	14.45	15.50	
		60	5300	14.70	15.50	
		64	5320	14.63	15.50	
	802.11ac-VHT40 MCS0	54	5270	13.68	15.00	93.75
		62	5310	13.57	15.00	
802.11ac-VHT80 MCS0	58	5290	12.99	13.50	87.79	

5.5GHz WLAN	Mode	Channel	Frequency (MHz)	Average power (dBm)	Tune-Up Limit	Duty Cycle %
	802.11a 6Mbps	100	5500	14.51	15.50	96.97
		116	5580	14.33	15.50	
		124	5620	14.30	15.50	
		132	5660	14.28	15.50	
		140	5700	14.40	15.50	
		144	5720	14.42	15.50	
	802.11n-HT20 MCS0	100	5500	14.69	15.50	96.23
		116	5580	14.18	15.50	
		124	5620	14.15	15.50	
132		5660	14.17	15.50		
140		5700	13.59	15.50		
144		5720	14.30	15.50		
802.11n-HT40 MCS0	102	5510	13.53	15.00	93.73	
	110	5550	13.45	15.00		
	126	5630	13.28	15.00		
	134	5670	13.34	15.00		
	142	5710	13.70	15.00		
802.11ac-VHT20 MCS0	100	5500	14.59	15.50	96.79	
	116	5580	14.11	15.50		
	124	5620	14.11	15.50		
	132	5660	14.14	15.50		
	140	5700	13.52	15.50		
	144	5720	14.20	15.50		
802.11ac-VHT40 MCS0	102	5510	13.49	15.00	93.75	
	110	5550	13.41	15.00		
	126	5630	14.25	15.00		
	134	5670	13.31	15.00		
	142	5710	13.63	15.00		
802.11ac-VHT80 MCS0	106	5530	12.72	13.00	87.79	
	122	5610	13.35	14.50		
	138	5690	13.19	14.50		

5.8GHz WLAN	Mode	Channel	Frequency (MHz)	Average power (dBm)	Tune-Up Limit	Duty Cycle %
	802.11a 6Mbps	149	5745	14.45	15.50	96.97
		157	5785	14.34	15.50	
		165	5825	14.56	15.50	
	802.11n-HT20 MCS0	149	5745	14.38	15.50	96.23
		157	5785	14.35	15.50	
		165	5825	14.46	15.50	
	802.11n-HT40 MCS0	151	5755	13.40	15.00	93.73
		159	5795	13.90	15.00	
	802.11ac-VHT20 MCS0	149	5745	14.31	15.50	96.79
157		5785	14.27	15.50		
165		5825	14.39	15.50		
802.11ac-VHT40 MCS0	151	5755	13.37	15.00	93.75	
	159	5795	13.85	15.00		
802.11ac-VHT80 MCS0	155	5775	13.66	15.00	87.79	

10. SAR Analysis

a. SAR Exclusion Threshold: KDB 447498 Section 4.3.1

The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:

$[(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm})] \cdot [f(\text{GHz})] \leq 3.0$
for 1-g SAR.

- f(GHz) is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation • The result is rounded to one decimal place for comparison

The test exclusions are applicable only when the minimum test separation distance is ≤ 50 mm and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

For this Electronic Display Device, the test separation distance is 0mm therefore 5mm is used in the equation. For each of the technologies the maximum output power (nominal power plus tune-up tolerance), corrected for both source- based duty cycle and UBDF duty cycle calculated in this document, is used in the equation above to determine if SAR is excluded (value is 3.0 or less) or required (value exceeds 3.0). The table on the following page shows the results – thresholds with a green background meet the exclusion criteria, those in red do not.

ANT 1	Tx	Freq. (MHz)	UBDF Duty Cycle ^{Note1}	Output Power			Separation distance (mm) ^{Note 3}	Threshold Value ^{Note 4}
				dBm	mW	mW ^{Note2}		

WLAN	2.4GHz	2472	5.18%	17.5	56.2	2.9	5	0.9
WLAN	5GHz	5828	4.85%	16.5	44.7	2.2	5	1.0
BT	BR	2480	83.30%	8	6.3	5.3	5	1.7

Note 1: UBTDF duty factor calculation in this document.

Note 2: Maximum power adjusted for UBTDF (see note 1) and rounded to closest mW as per KDB 447498 procedures.

Note 3: Minimum test separation distance between enclosure and person is 5mm per KDB 616217 D04 Tablet computer device test procedures.

Note 4: To exclude the device from SAR testing the threshold value must be less than 3.0.

11. Conclusion

In conclusion, WLAN and Bluetooth band has low power levels that are far below the low power threshold requirements by utilizing Upper Bound Transmission Duty Factor. Therefore, for this wireless mode, SAR testing is not required for RF exposure compliance for the Electronics Display Device.

12. IC SAR Analysis

SAR Exclusion Threshold: RSS102-Issue 5 Section 2.5.1

SAR evaluation is required if the separation distance between the user and/or bystander and the antenna and/or radiating element of the device is less than or equal to 20 cm, except when the device operates at or below the applicable output power level (adjusted for tune-up tolerance) for the specified separation distance defined in Table 1.

Table 1: SAR evaluation – Exemption limits for routine evaluation based on frequency and separation distance^{4,5}

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of ≤ 5 mm	At separation distance of 10 mm	At separation distance of 15 mm	At separation distance of 20 mm	At separation distance of 25 mm
≤ 300	71 mW	101 mW	132 mW	162 mW	193 mW
450	52 mW	70 mW	88 mW	106 mW	123 mW
835	17 mW	30 mW	42 mW	55 mW	67 mW
1900	7 mW	10 mW	18 mW	34 mW	60 mW
2450	4 mW	7 mW	15 mW	30 mW	52 mW
3500	2 mW	6 mW	16 mW	32 mW	55 mW
5800	1 mW	6 mW	15 mW	27 mW	41 mW

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of 30 mm	At separation distance of 35 mm	At separation distance of 40 mm	At separation distance of 45 mm	At separation distance of ≥ 50 mm
≤ 300	223 mW	254 mW	284 mW	315 mW	345 mW
450	141 mW	159 mW	177 mW	195 mW	213 mW
835	80 mW	92 mW	105 mW	117 mW	130 mW
1900	99 mW	153 mW	225 mW	316 mW	431 mW
2450	83 mW	123 mW	173 mW	235 mW	309 mW
3500	86 mW	124 mW	170 mW	225 mW	290 mW
5800	56 mW	71 mW	85 mW	97 mW	106 mW

Remark:

1. The exemption limits in Table 1 are based on measurements and simulations of half-wave dipole antennas at separation distances of 5 mm to 25 mm from a flat phantom
2. Output power level shall be the higher of the maximum conducted or equivalent isotropically radiated power (e.i.r.p.) source-based, time-averaged output power.
3. For test separation distance less than 5 mm, the exemption limits for a separation distance of 5 mm can be applied to determine if a routine evaluation is required.
4. For limb-worn devices where the 10 gram value applies, the exemption limits for routine evaluation in Table 1 are multiplied by a factor of 2.5

ANT 1	Tx	Freq. (MHz)	UBDTF Duty Cycle ^{Note 1}	Output power			Antenna Gain	Antenna Gain	EIRP	Exempt Level
				dBm	mW	mW ^{Note 2}	dBi ^{Note 3}	numeric ^{Note 3}	mW ^{Note 4}	mW
WLAN	2.4GHz	2472	5.18%	17.5	56.2	2.9	4	2.5	7.3	4
WLAN	5GHz	5825	4.85%	16.5	44.7	2.2	3.6	2.3	5.0	4
BT	EDR	2480	83.30%	8	6.3	5.3	4	2.5	13.2	4

Note 1: UBTDF duty factor calculated in this document.

Note 2: Maximum power adjusted for UBTDF (see note 1) and rounded to closest mW.

Note 3: Peak antenna gain.

Note 4: EIRP=Antenna gain * Maximum power adjusted for UBTDF

13. Conclusion

In conclusion, WLAN and Bluetooth band are with power levels (i.e. the higher of the conducted or radiated (e.i.r.p.) source-based, time-averaged output power) that is higher than the low power threshold requirements by utilizing Upper Bound Transmission Duty Factor. Therefore, for this wireless mode, SAR testing is required for RF exposure compliance for the Electronic Display Device.