RADIO FREQUENCY EXPOSURE REPORT

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RELEASE CONTROL RECORD

REVISION	REASON FOR CHANGE	DATE
1.00	Initial Release	09/06/2017
1.01	Updated FCCID and ICID for Report Updated EIRP calculation including 1.4dBi 802.11 antenna module gain.	11/01/2017

Table of Contents

1. DYNAPRO GO BACKGROUND 4
2. DEFINITION OF SPECIFIC ABSORPTION RATE (SAR) 4
3. RF EXPOSURE FCC LIMITS 5
   3.1. MAXIMUM PERMISSIBLE EXPOSURE ASSESSMENT METHOD 6
   3.2. SAR EXCLUSION LIMITS 7
   3.3. DYNAPRO GO's 802.11 MODULE DUTY CYCLE MEASURMENTS FOR TYPICAL TRANSACTION 8
   3.4. DYNAPRO GO 802.11 MODULE TRANSMISSION BURST ANALYSIS 14
   3.5. DYNAPRO GO COUNTRY SAR LIMIT EXCLUSIONS 16
4. REPORT FINAL CONCLUSIONS 17

ADDENDUM – SAR EXEMPTION LIMITS 18

1. DYNAPRO GO BACKGROUND

DynaPro Go hosts a Commercial-Off-The-Shelf (COTS) 802.11 module model ISM43362-M3G-L44-E, which is fully certified by Inventek Systems FCCID: O7P-362, and Industry Canada ID: 10147A-362. The antenna used in this 802.11 module does not exceed a gain of 2.15 dBi, which is the amount of focus applied by antenna with respect to an "Isotropic Radiator" which radiates energy equally in all directions onto an imaginary sphere surrounding the point source.

DynaPro Go's COTS certified 802.11 module has been integrated into the system where it will be re-certified for FCC, Industry Canada and other agencies to meet the market segments identified by MagTek.

2. DEFINITION OF SPECIFIC ABSORPTION RATE (SAR)

SAR is defined as the rate at which energy is absorbed per unit mass in an object exposed to a radio frequency field. SAR distribution in a biological body is complicated, and this testing is usually performed by experimental and/or numerical modeling in qualified laboratories, and test is mandatory for all cellphones, but not for "portable" or "mobile" devices. Such portable devices are sometimes exempt from SAR lab testing if their output power does not exceed a country's SAR exemption limits.

The formal definition of SAR is shown below

$$SAR = \frac{d}{dt}\left(\frac{dW}{dm}\right) = \frac{d}{dt}\left(\frac{dW}{\rho \cdot dV}\right) \ \text{Watts}/kg$$

$$SAR = \frac{P}{\rho} = \frac{\sigma E^2}{2\rho} = \frac{J^2}{2\rho\sigma} \ \text{Watts}/kg$$

$$SAR = \frac{\sigma |E|^2}{\rho} \ \text{Watts}/\text{kg}$$

where ***P*** is the power loss density, ***E*** is the electric field strength (V/m), ***J*** (A/m^2) is the current density, $\boldsymbol{\rho}\,(kg/m^3)$ is the density of the tissue or material, and $\boldsymbol{\sigma}(S/m)$ is the conductivity of the material typically averaged over a pre-defined mass.

Mass averaged SAR (typically 1g or 10g) is typically measured in a lab, and presently, the typical standards for mass average SAR are:

- US, Canada, Australia : 1.6W/kg averaged over 1g of tissue
- EU, Korea, Japan and Brazil: 2.0 W/kg averaged over 10g of tissue

3. RF EXPOSURE FCC LIMITS

DynaPro Go in this report was evaluated against FCC's KDB 447498 D01 "General RF Exposure Guidance v06" Appendix A, KDB Guidance publication and rule reference 47 C.F.R. §§ 2.1091 and 2.1093 dated January 14th, 2014. OET Bulletin 65 Supplement C Cross-reference.

Per the standard listed herein, it recommends observing two tier groups namely Occupational/Controlled Exposure, and General Population /Uncontrolled Exposures. The table below outlines the Maximum Permissible Exposure (MPE) limits.

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E\|^2$ $\|H\|^2$ or S (min)
(A) Limits for Occupational / Controlled Exposures				
0.3 – 3.0	614	1.63	$(100)^*$	6
3.0 – 30	$1824/f$	$4.89/f$	$(900/f^2)^*$	6
30 – 300	61.4	0.163	1.0	6
300 – 1500	--	--	$f/300$	6
1500 – 100,000	--	--	5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3 – 1.34	614	1.63	$(100)^*$	30
1.34 – 30	$824/f$	$2.19/f$	$(180/f^2)^*$	30
30 – 300	27.5	0.073	0.2	30
300 – 1500	--	--	$f/1500$	30
1500 – 100,000	--	--	1.0	30

f = frequency in MHz *Plane-wave equivalent power density

Table 1 FCC OET Bulletin 65 MPE Limits

- ***Occupational/Controlled*** limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational /controlled exposure also apply in situations when an individual is transient through a location through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.
- ***General Population/uncontrolled*** exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure.

3.1. MAXIMUM PERMISSIBLE EXPOSURE ASSESSMENT METHOD

A worst-case scenario is being considered to determine the maximum power density as shown in equation 1.

$$S = \frac{EIRP}{4\pi R^2}\left(mW/cm^2\right)$$

Equation 1 Power density definition

Where,

S = Power density in (mW/cm^2)

EIRP = Effective isotropically radiated power (mW)

R = Distance to the center of the antenna radiation (cm)

The worst-case distance from the antenna to the enclosure is 6.85 mm (0.27 in)

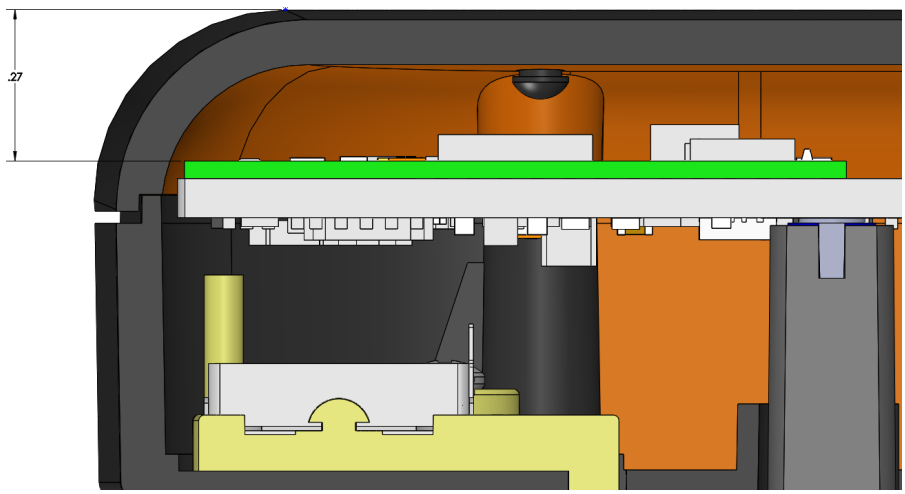


Figure 1 Worst case distance from 802.11 antenna to back side enclosure cover

From Table 1 using the General Uncontrolled Population MPE Limit of $1\,mW/cm^2$, we shall determine the DynaPro Go's maximum power density using 100% duty cycle conducted power at the 802.11 module's antenna.

$$S = \frac{97.7mW}{4\pi(0.6858cm)^2} = 16.53\left(mW/cm^2\right)$$

Equation 2 DynaPro Go's Maximum Power density at 100% duty cycle

MPE Power Density (mW/cm^2) Table1 (B)	DynaPro Go Maximum Power Density at 100% duty cycle (mW/cm^2)
1.0	16.53

Table 2 DynaPro Go's calculated maximum power density at 100% duty cycle

In section 3.3 DynaPro Go is tested further to measure the actual duty cycle and the measurement ahead demonstrate we meet SAR exclusion limits.

3.2. SAR EXCLUSION LIMITS

In accordance to KDB 447498 §4.3.1a, the 1-g and 10-g SAR test exclusion thresholds for devices whose frequency range is 100 MHz to 6 GHz at a separation distance of ≤ 50 mm are determined by the equation shown below:

$$\frac{\text{Max channel power, including tune - up tolerance (mW)}}{\text{Min test separation distance (mm)} \times \sqrt{\text{f (GHz)}}} \leq 3.0 \text{ for 1g SAR}$$

$$\frac{\text{Max channel power, including tune - up tolerance (mW)}}{\text{Min test separation distance (mm)} \times \sqrt{\text{f (GHz)}}} \leq 7.5 \text{ for 10g SAR}$$

Equation 3 SAR Exclusion Limit Equation

- Power and distance are rounded to nearest mW and mm before calculation
- The result is rounded to one decimal place for comparison
- The values of 3.0 and 7.5 are referred as *numeric thresholds*.

If the results in Equation 3 are less than or equal than the limit set forth, DynaPro Go is exempt from SAR testing in accordance to the exemption limits shown below.

SAR TEST CONFIGURATION	EXEMPTION LIMTS
1-g SAR	Result of Eq. 3 ≤ 3.0
10-g Extremity SAR	Results of Eq. 3 ≤ 7.5

3.3. DYNAPRO GO's 802.11 MODULE DUTY CYCLE MEASURMENTS FOR TYPICAL TRANSACTION

DynaPro Go was further tested to assess the average power in a typical smart card transaction. Each transaction is staged in at least three steps:

a) Host transaction initiation
b) Amount Approval by a customer
c) Customer's signature capture collection

A DynaPro Go device was instrumented to measure the time spent in each of the steps outlined above. For this measurement, the following equipment was utilized:

- Calibrated High Speed Oscilloscope Model CSA7404B
- DynaPro Go with latest Firmware Revision and 802.11 implementation Active to send data over the link. Device had a U.FL to SMA 6 GHz coax P/N: CAB.718 to monitor 802.11 activity
- Laptop computer with IPADSIM MagTek test software
- N300 Netgear Routed to provide connectivity from DynaPro Go to Laptop via Router.

Below are some images showing the setup.

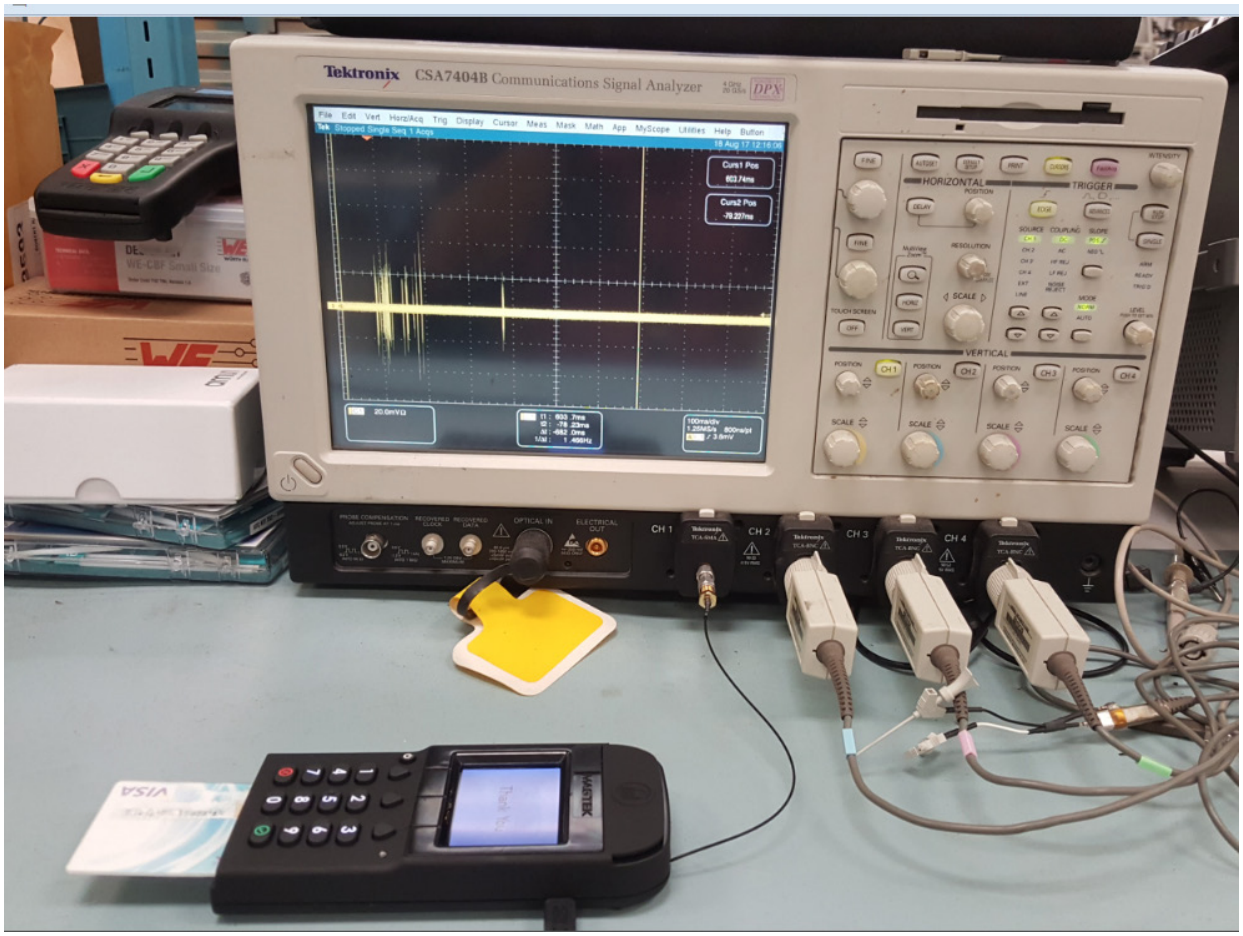


Figure 2 DynaPro Go Test Setup with HS Oscilloscope

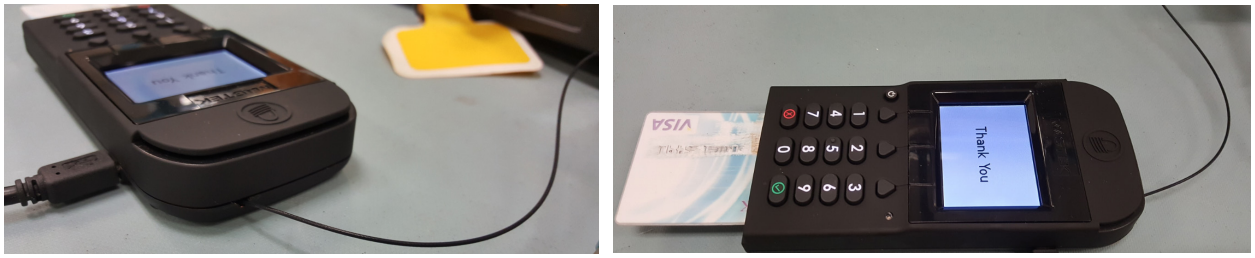


Figure 3 DynaPro Go coaxial and card interface views

For each step above the output at the U.FL connector on the 802.11 module was monitored in order to collect the 802.11 module's transmission time spent at each step.

STEP1 – Initiate a Transaction

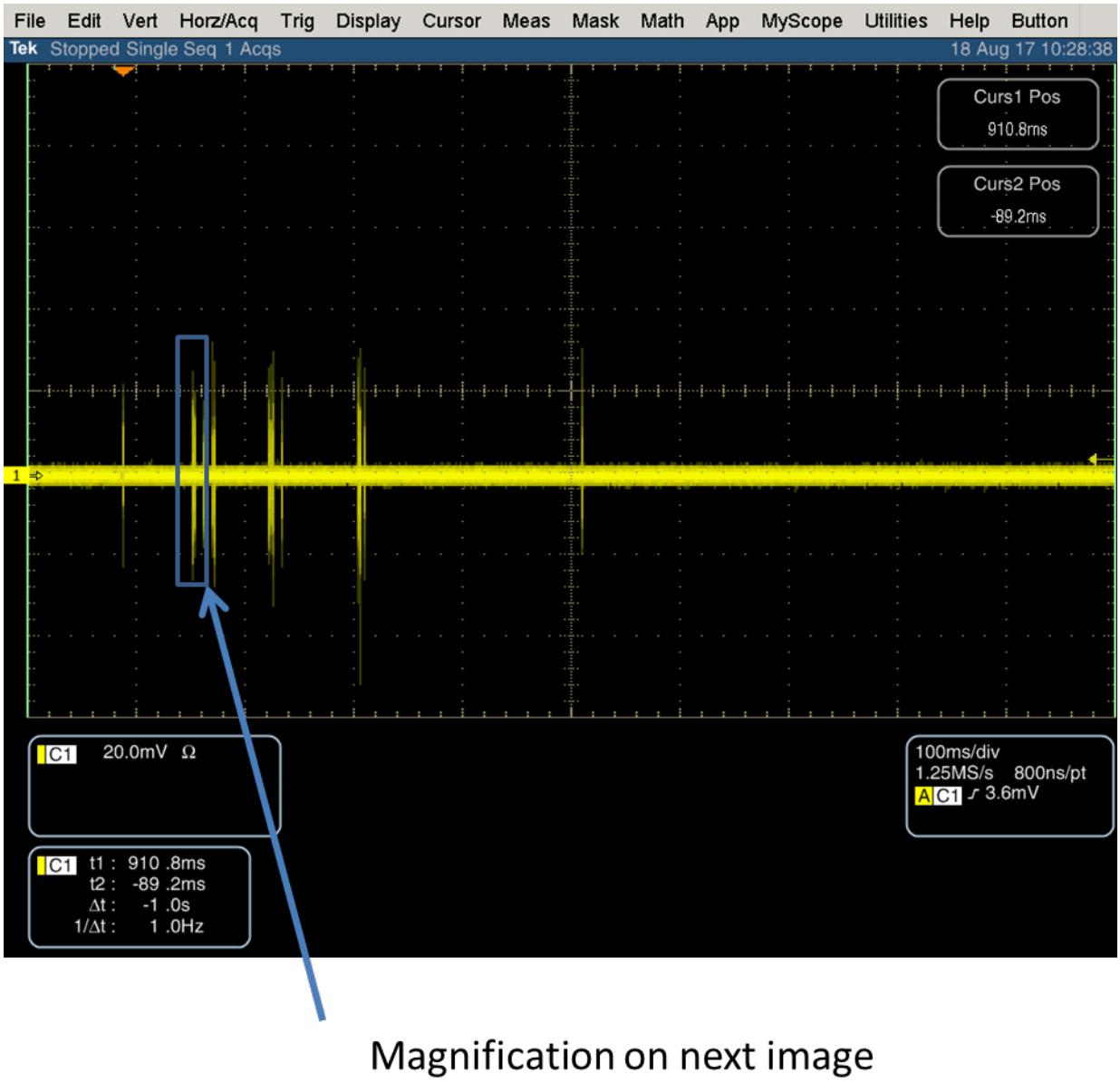
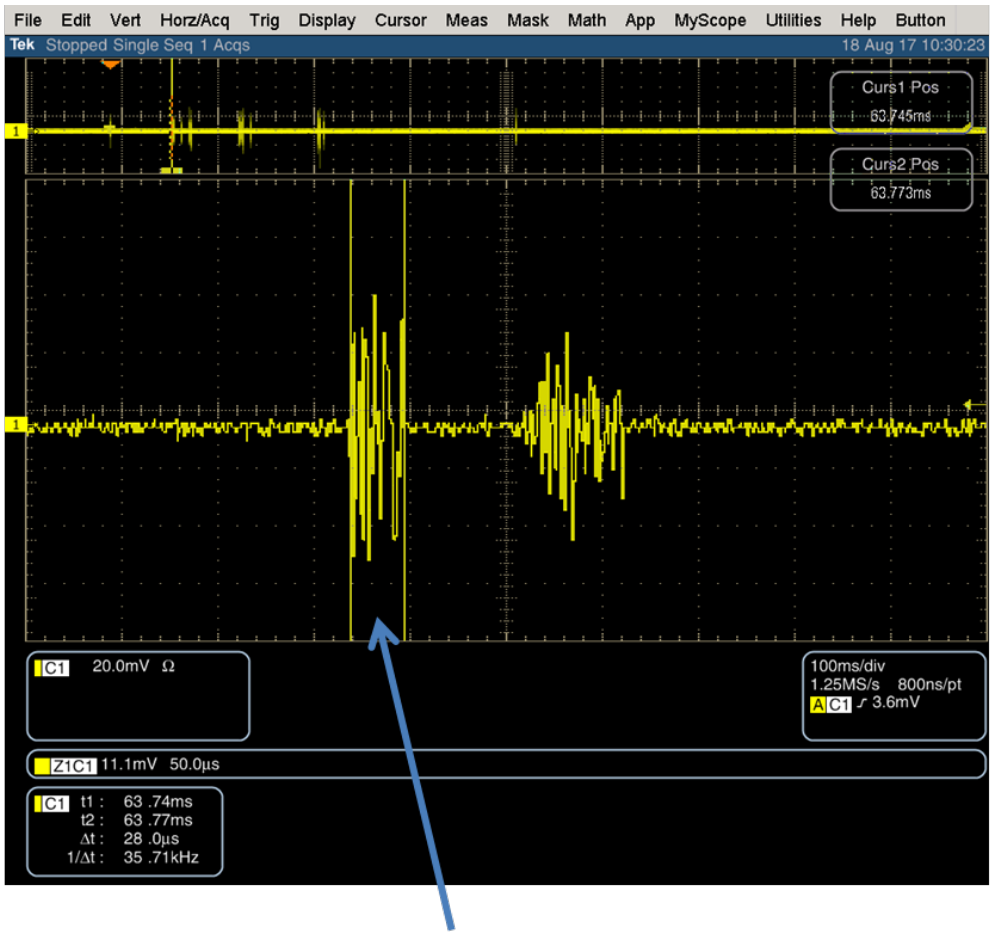


Figure 4 Step1: Initiate a Transaction



Each transmit section was measured. This section was .028 msec

Figure 5 Zoomed in View to observe the burst time duration - In this case, it was measured as 28usec

STEP2 – After Amount on DynaPro Go was approved or OK'ed

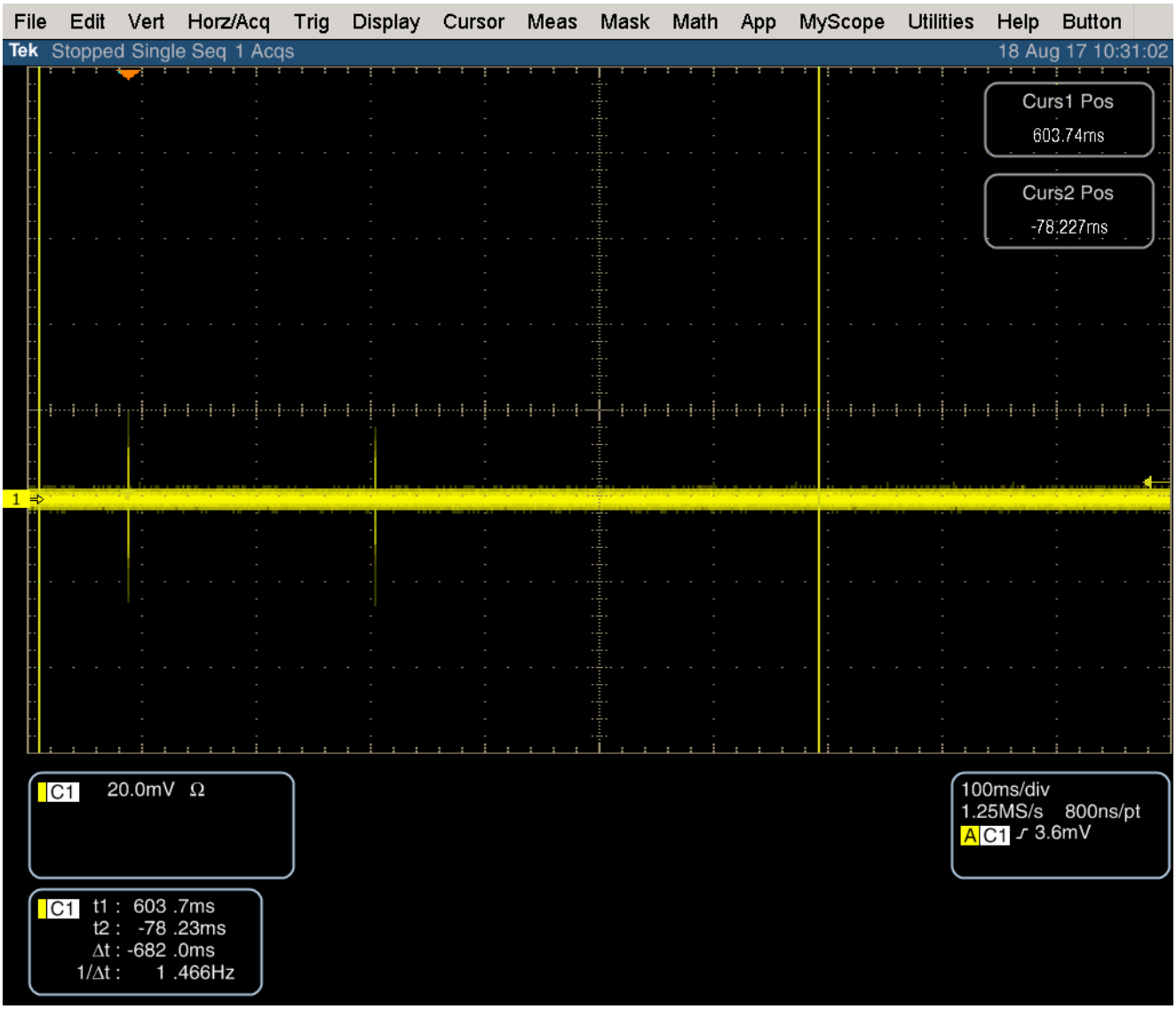


Figure 6 Step2 802.11 module data transmission after amount was approved

STEP3 – After DynaPro Go collected the user's signature

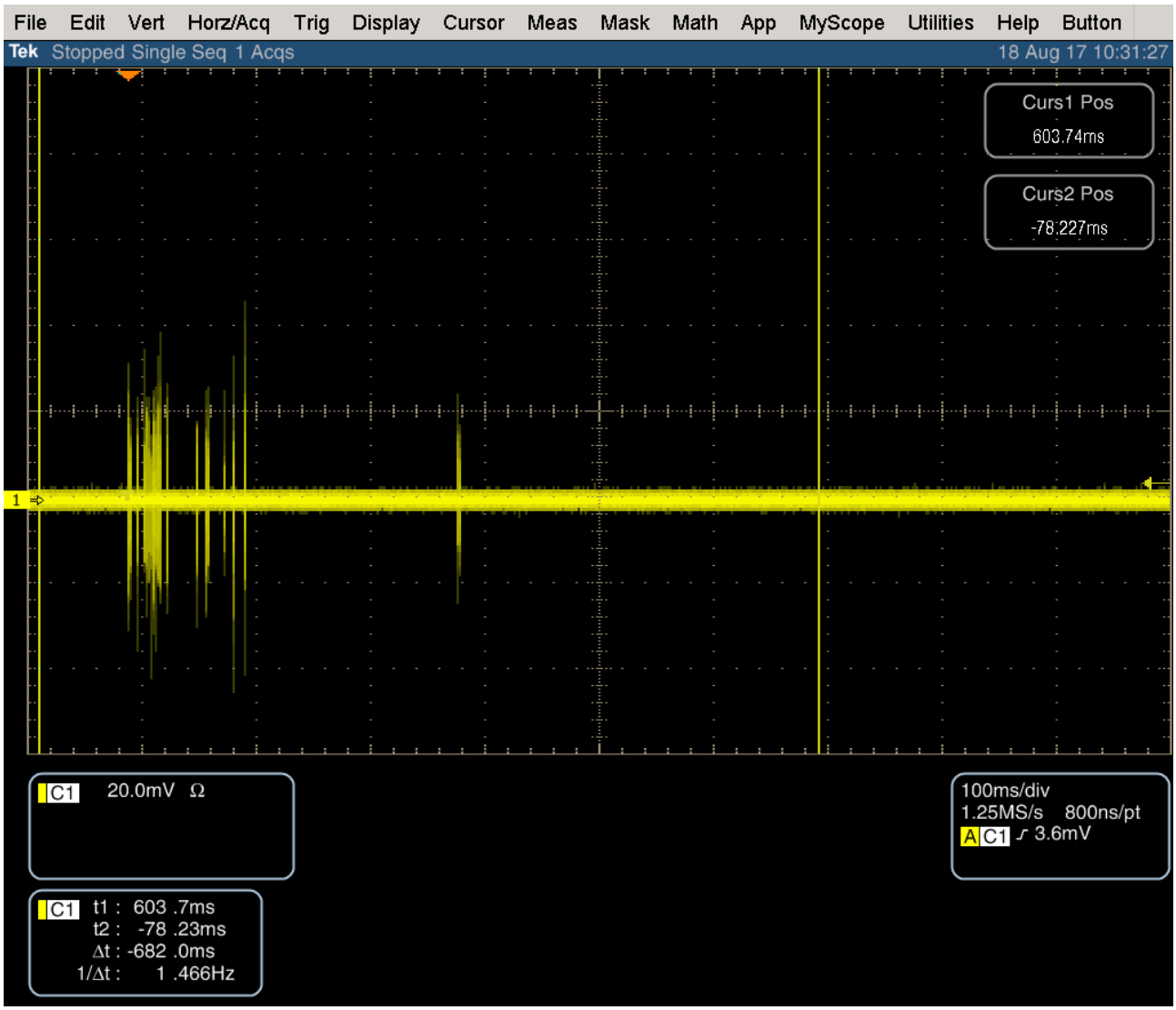


Figure 7 Data burst after DynaPro Go collected the user's signature

3.4. DYNAPRO GO 802.11 MODULE TRANSMISSION BURST ANALYSIS

In order to identify a typical transactions duty cycle, the 802.11 module data transmission burst's time was tabulated and analyzed as shown in Table 3.

Step 1	time in ms		Step 2	time in ms		Step 3	time in ms
	0.15			0.16			1
	0.08			0.036			0.7
	0.17						0.9
	0.05						0.5
	0.36						0.7
	0.28						0.1
	0.68						0.05
	0.034						0.18
	0.034						0.08
	0.066						0.32
	0.036						0.56
	0.032						0.032
	0.036						0.18
	0.06						
	0.036						
	0.032						
	0.032						
	0.056						
	0.036						
	0.056						
	0.036						
	0.06						
	0.032						
	0.044						
Total broadcat time for each step	2.488			0.196			5.302
Total Time (ms)	510			200			340
Total Transaction broadcast time	7.986						
Total Transaction time	1050						
total broadcast time/total time	0.00760571						
	0.76057143	%					

Table 3 DynaPro Go 802.11 Module Data burst time capture for a typical Smart card transaction

These calculations assume a transaction time of one second. We can compute the duty cycle as:

$$D = \frac{ACTIVE_DATA_BURST_TIME}{TOTAL_TRANSACTION_TIME} \times 100 = 0.7605\%$$

Equation 4 DynaPro Go 802.11 Module Data Duty Cycle

Manufacturer states that the antenna gain shall not exceed 2.15dBi. According to the antenna plots on the Manufacturer datasheet shows 1.4dBi antenna gain.

EIRP = ERP + 1.4 dBi = 19.89 dBm + 1.4 dBi = 21.29 dBm = 134.58 mW

Given this measured duty cycle and we know the maximum power ***EIRP*** of 134.58 mW (21.29 dBm). We can then conclude the average power for a typical transaction is given by:

$$P_{Ave_Transaction} = (D \times EIRP) = 0.00760571 \times 134.58mW = 1.02mW \text{ or } 0.08\,\text{dBm}$$

Equation 5 DynaPro Go Average Power calculation as a function of transmission duty cycle

The time averaged power shown in equation 5 is based on a typical transaction, and it is demonstrated to be very low, and below the limits set forth by the countries in which this product is going to be sold. It is also worth pointing out that the 802.11 module ***does not transmit any data*** during any idle time between the tree steps in the transaction as shown by the oscilloscope images. Thus, during idle times, the 802.11 module do not transmit any RF energy out.

DUTY CYCLE TEST RESULTS SUMMARY

TRANSACTION TOTAL TIME (msec)	TOTAL DATA BROADCAST TIME (msec)	ACTIVE TRANSACTION DUTY CYCLE	AVERAGE POWER FOR TYPICAL TRANSACTION (mW)	AVERAGE POWER FOR TYPICAL TRANSACTION (dBm)
1050	7.986	0.7605%	1.02	0.08

Table 4 DynaPro Go Measured Duty Cycle

Table 6 below outlines a summary demonstrating that since DynaPro Go does not remain active 100% of the time, the SAR limits for 1-g body, and 10-g extremity limits are met with significant margin. Furthermore, Table 5 shows the power density reduction by the measured duty cycle.

100% Duty Cycle Power Density (mW/cm^2) @ 0.68cm distance from limbs	DynaPro Go Power Density 0.76% Duty Cycle applied (mW/cm^2) < 1.00 (mW/cm^2)
16.53	0.126

Table 5 DynaPro Go Power Density comparison between 100% duty cycle and 0.76% duty cycle

Ch	Frequency (GHz)	Maximum Source-based conducted output power including tune-up tolerance (mW)	Minimum Separation Distance (mm)	Result of Eq.3 No Duty Cycle Applied	0.76% Duty Cycle Applied to Max Power Result Eq. 3	Limit for 1-g Body SAR	Limit for 10-g Extremity SAR	VERDICT
1	2.412	97.7	6.85	9.17	**0.07**	3	7.5	*Exempt from SAR*
3	2.422	97.7	6.85	9.15	**0.07**	3	7.5	*Exempt from SAR*
6	2.437	97.7	6.85	9.13	**0.07**	3	7.5	*Exempt from SAR*
11	2.462	97.7	6.85	9.08	**0.07**	3	7.5	*Exempt from SAR*
14	2.484	97.7	6.85	9.04	**0.07**	3	7.5	*Exempt from SAR*

Table 6 DynaPro Go duty cycle included in Maximum P in the calculation and compared against Body and Extremity limits

3.5. DYNAPRO GO COUNTRY SAR LIMIT EXCLUSIONS

DynaPro Go has a target market segment in the following countries: USA, Canada, United Kingdom, New Zealand, and Australia. Below are some references for the standards found publicly on the internet. Furthermore, some of the limits used for Australia, New Zealand and UK were obtained from Jay Moulton RF Exposure Laboratory in San Marcos, CA.

- United State of America in accordance to KDB 447498 D01 v06 Appendix D
- CANADA – RSS-102 http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf01904.html#s2.5
- UK EN/IEC 62209-2:2010
- New Zealand NZS 2772.1:1999 - http://www.health.govt.nz/our-work/radiation-safety/non-ionising-radiation/radiofrequency-field-exposure-standard

- AUSTRALIA ARPANSA Radiation Protection Series No.3 §S5.2.2 Equipment with Mean power not exceeding 100mW updated 31 May 2016 - https://www.arpansa.gov.au/regulation-and-licensing/regulatory-publications/radiation-protection-series/codes-and-standards/rps3

COUNTRIES SAR TESTING EXCLUSION LIMITS

COUNTRY	Minimum Separation Distance (mm)	Power Level limit (dBm)	DynaPro Go Power limit with 0.76% Duty Cycle (dBm)	Frequency (MHz)	VERDICT
USA	5	10	0.08	2450	PASS
USA	30	17.56	0.08	2450	PASS
CANADA	5	6.02	0.08	2450	PASS
CANADA	30	19.19	0.08	2450	PASS
AUSTRALIA*		13	0.08		PASS
UK*		13	0.08		PASS
NEW ZEALAND*		13	0.08		PASS

**Limits obtained from technical discussion with RF Exposure Laboratory – Jay Moulton*

Table 7 DynaPro 802.11 Average power comparison to limits set forth by respective countries

4. REPORT FINAL CONCLUSIONS

DynaPro Go was analyzed using the maximum power EIRP of 134.58mW and minimum distance from the antenna to the user. A duty cycle was obtained via measurements for a smart card transaction to show the device has very minimum data transmission per transaction. Therefore, the SAR calculations are below the exclusion limits for the countries where this product will be sold. The complete study demonstrates that while the module ***uses a worst-case power EIRP setting, the time average power for DynaPro Go is very low to claim an SAR exclusion***.

ADDENDUM – SAR EXEMPTION LIMITS

Rev 0

SAR Exemption Limits

		Power (dBm)										Power (mW)									
IC Limits	d(mm)	5	10	15	20	25	30	35	40	45	50										
	300	18.5	20.0	21.2	22.1	22.9	23.5	24.0	24.5	25.0	25.4	71	101	132	162	193	223	254	284	315	345
	450	17.2	18.5	19.4	20.3	20.9	21.5	22.0	22.5	22.9	23.3	52	70	88	106	123	141	159	177	195	213
	835	12.3	14.8	16.2	17.4	18.3	19.0	19.6	20.2	20.7	21.1	17	30	42	55	67	80	92	105	117	130
	1900	8.5	10.0	12.6	15.3	17.8	20.0	21.8	23.5	25.0	26.3	7	10	18	34	60	99	153	225	316	431
	2450	6.0	8.5	11.8	14.8	17.2	19.2	20.9	22.4	23.7	24.9	4	7	15	30	52	83	123	173	235	309
	3500	3.0	7.8	12.0	15.1	17.4	19.3	20.9	22.3	23.5	24.6	2	6	16	32	55	86	124	170	225	290
	5800	0.0	7.8	11.8	14.3	16.1	17.5	18.5	19.3	19.9	20.3	1	6	15	27	41	56	71	85	97	106
FCC Limits																					
	100	16.8	19.8	21.5	22.8	23.8	24.5	25.2	25.8	26.3	26.8	47	95	142	190	237	285	332	379	427	474
	300	14.4	17.4	19.1	20.4	21.4	22.2	22.8	23.4	23.9	24.4	27	55	82	110	137	164	192	219	246	274
	450	13.5	16.5	18.3	19.5	20.5	21.3	21.9	22.5	23.0	23.5	22	45	67	89	112	134	157	179	201	224
	835	12.2	15.2	16.9	18.2	19.1	19.9	20.6	21.2	21.7	22.2	16	33	49	66	82	98	115	131	148	164
	1900	10.4	13.4	15.1	16.4	17.4	18.1	18.8	19.4	19.9	20.4	11	22	33	44	54	65	76	87	98	109
	2450	9.8	12.8	14.6	15.8	16.8	17.6	18.3	18.8	19.4	19.8	10	19	29	38	48	57	67	77	86	96
	3500	9.0	12.1	13.8	15.1	16.0	16.8	17.5	18.1	18.6	19.0	8	16	24	32	40	48	56	64	72	80
	5800	7.9	11.0	12.7	14.0	14.9	15.7	16.4	17.0	17.5	17.9	6	12	19	25	31	37	44	50	56	62
	Note: FCC exemption data extends beyond 50mm																				
EU Limits	100	13																			
	6000	13																			