Radiated Emission From Handheld Devices with Touch-Screen LCD

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***Abstract*—Handheld communication devices fitted with touch-screen LCDs do emit some kind of electromagnetic radiation (EMR) even though they were not designed to do so. There is potential for the emission can be intercepted and reconstructed for eavesdropping or even intelligence purposes. Information leakage from hand-held devices can be valuable information for the intelligence communities. This paper presented discussions on how much unintentional emission is radiated from these devices. Comparison on the level of emission is made based on manufacturers and sizes of LCD.**

***Keywords*- RINT, compromising emanations, TEMPEST, information technology equipment (ITE)**

I. INTRODUCTION

It has become a trend nowadays for the handheld smartphones and tablets with touch-screen liquid crystal displays (LCD) to be manufactured and marketed in various sizes. All electronic devices which are fitted with LCDs emit some kinds of electromagnetic radiation (EMR) even though they were not designed to do so. The electromagnetic emission can be intercepted by a remote receiver system by virtue that EMR in free space can be intercepted. In [1], it has been proven that Video Display Units emitted electromagnetic radiation is similar to the radio waves and that they could be intercepted. The intercepted emission can be reconstructed into a coherent form so that it can be viewed from a remote location. The compromising emanation is exposed to be eavesdropped and the application is suitable for radiation intelligence (RINT).

RINT can be developed to intercept unintentional radiation for intelligence purposes. It has been reported that the display images on CRT display monitors can be reconstructed at remote location [1-5]. With the advent of technology, CRT monitors have been replaced by LCD monitors. Just like the CRTs, LCD monitors also emit unintentional radiation that can be intercepted for eavesdropping and intelligence purposes. A number of studies about the compromising emanations of information technology equipment (ITE) such as devices with LCD have been reported. In [6] and [7], flat panel and laptop displays with LCDs have been investigated with possible eavesdropping risks.

Some of the works have been experimenting the distance in which the emanation intercepted can be reconstructed and readable. In [8], study has been done on the maximum receivable distance for radiated emission from laptop at a distance of 10m. A much larger distance of 46m has been proven in [7] with eavesdropping on a 17" LCD monitor.

TEMPEST is indeed a big threat for information security. A number of works have also been reported on improving the resistance for RINT devices. The countermeasure techniques have been actively researched to prevent such information leakage [9-11].

Most of the work done involved in unintentional emanation from LCD devices that are either supplied by ac power or dc adapters i.e. laptop and flat panel monitors. In this work we have investigated the unintentional EMR from sample handheld Touch-Screen LCD devices. These devises are much smaller in LCD sizes as well as the level of power emitted. The investigation involved dealing with only the unintentional radiated emission from LCD devices, thus all communications and wireless tools have been disabled or turn off.

With almost everybody is having at least one smartphone or tablet nowadays, the information gathering for intelligence purposes is enormous. Thus, this area of research is promising to the intelligence communities for the military, police and other civil law enforcement agencies as the intelligence activities do not involve third parties especially the telcos and service providers.

II. INSTRUMENTATION

A. Material and Method

The level of electromagnetic emission from handheld LCD devices is expected to be much lower compared to the CRT or even LCD devices with ac powered i.e notebooks. Thus the measurement made based on touching distance so as to get almost accurate reading for all samples. Measurements were made using *EMFields Professional* by *Sensory Perspective Ltd UK* as shown in Fig. 1. This device measures *E* field in V/m and magnetic flux density *B* in µT. The level of radiation emitted by selected samples LCD devices were measured in open area free from other sources of EM fields.

Fig. 1. EMFields Meter

B. LCD Sample

Samples of ITE with touch-screen LCD have been chosen for the measurement were based on availability either borrowed or owned. Manufacturers selected as sample

are from Nokia, Huawei, Apple, Blackberry, Samsung, and HTC with devices ranging from smartphones and tablets.

Measurements were made based on various types of LCD devices, from different manufacturers and with different LCD sizes (ranging from 4.0 in – 7 in). For the purpose of comparisons, all measurements were made during battery or dc operated only and not during ac charging. In order to get pure unintentional radiation all intended communication connections such as Bluetooth, wi-fi, internet etc. are either disabled or switched off prior to measurements. The distance between measurement device and DUT is put to the minimum since the radiated emission of handheld devices is much lower compared to notebook or other ac supplied LCD devices. Besides, the meter did not detect any EMR from the samples at a distance of 1 m.

III. EMR AND POWER DENSITY RADIATED

The real instantaneous forms of the electric field as mathematical representations are written as [12]:

$$E_x(z,t) = |E_{x0}|\cos[\omega t - k_0 z + \phi_1] + |E'_{x0}|[wt + k_0 z + \phi_2] \quad (1)$$

where the first and second expression represent forward z travel and backward z travel respectively, k_0 is the wavenumber in free space (spatial frequency) with unit rad/m defined as

$$k_0 \equiv \frac{\omega}{c} \quad (2)$$

where ω is the radian time frequency and c is the speed of light. The unit of V/m of the electric field strength E can be converted into the unit of dBμ V/m as the electric field strength $E(dB\mu\ V/m)$ by the following equation [8]:

$$E(dB\mu V/m) = 20 \log (E) + 120 \quad (3)$$

Since the measurement device only measured the magnetic flux density (μT), the magnetic field strength H (A/m) can be obtained from,

$$B = \mu_0 H \quad (4)$$

where μ_0 represents the permeability of free space ($4\pi \times 10^{-7}$ H/m). The instantaneous power density vector associated with the emission at a given point is given by

$$S = \frac{E^2}{120\pi} \quad (5)$$

where 120π is the intrinsic impedance of free space. This is measured as the electrical power (watts) passing through a plane one meter square. The power density radiated (in dB) per squared meter is obtained from

$$dBW/m^2 = 10 \log (V/m - A/m) \quad (6)$$

IV. RESULTS

A. EMR Measurements

The measurements of the EMR from selected sample LCD devices are tabulated in Table 1 below. Measurements were made for radiated electric field and magnetic flux density during active and standby modes with all intended communication facilities disabled.

TABLE I. EMR MEASUREMENT FOR SELECTED LCD DEVICES

Type & Manufacturer	LCD Size (in)	**E** V/m		**B** μTesla	
		Active	Standby	Active	Standby
Nokia E7	4	13	13	0.03	0.03
I Phone 4S	4	9	5	0.02	0.02
Blackberry Torch 9800	4.8	5	3	0.03	0.04
Huawei Honor	4.8	11	4	0.01	0.01
Samsung Galaxy S2	5.3	15	12	0.02	0.02
HTC Desire HD	5.3	12	7	0.03	0.03
Samsung Galaxy Note	5.8	4	1	0.02	0.02
Samsung Galaxy Tab 7.0	7.7	6	3	0.03	0.01

B. Level of Radiations

The level of unintentional radiated emission varies from types, manufacturers and modes of operations. The level of emission also differs during active and standby modes. As shown in Fig. 2, during active mode the power densities ranging from 6-11 dBW/m^2 while in standby-mode the level proportionately reduced to 0 – 6 dBW/m^2. As expected the field density is higher during active mode than standby mode where in active mode LCD can be as high as 6 dBW/m^2 than standby.

Compromising emanations are at risk normally available during active mode. Obviously no information can be gathered during standby-mode anyway. The worst case (lowest level) of emission during active mode is 6 dBW/m^2 or E field of 4 V/m. This level of radiation theoretically can be intercepted by the eavesdropper or by RINT devices. However, the interception is subject to the distance and the sensitivity of the receiver and the antenna system used.

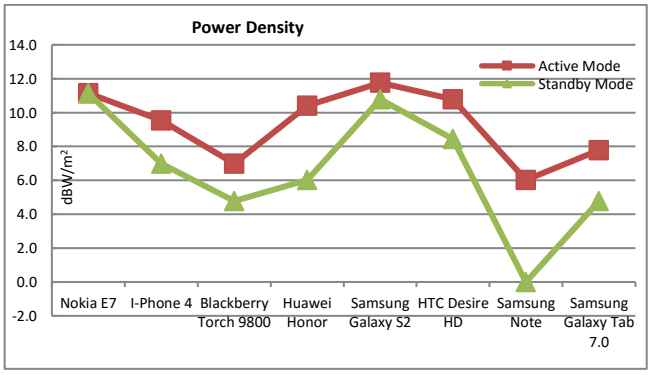

Fig. 2. Power density for selected LCD samples

The magnetic field intensity measured for the samples are shown in Fig. 3 below. As mentioned earlier, the electric field is higher in active mode than in standby mode but the condition is not the same for the magnetic field. Though the level of magnetic field strength varies with manufacturers of LCDs (0.5 mA/m – 3 mA/m), the magnetic field is pretty much the same during active and standby modes. Most of the samples have equal magnetic field intensity whether during active mode or standby mode.

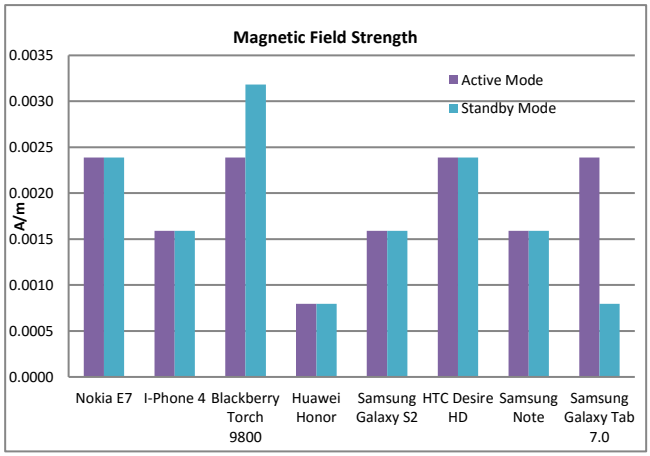

Fig. 3. Magnetic Field Strength

C. *Size of LCD*

The sizes of LCDs do not necessarily contribute to the level of radiation. As shown in Fig. 4, the level of unintentional radiation during active mode does not show the proportionality between sizes and level of radiation emitted. However, for LCD sizes of 5.8 in and larger, the proportionality is visible. Nonetheless, the level seems inversely proportional for Nokia E7, I-Phone 4 and Blackberry Torch 9800. Thus, no deduction can be made for the relationship between size and amount of radiation. The level of radiation is more dependent on the type and manufacturers of the LCDs.

By comparing the Blackberry Torch 9800 and Huawei Honor, it can be seen that both models possess the same size of LCD but the power density radiated is 6.99 dBW/m^2 and 10.41 dBW/m^2 respectively. This shows that LCD size does not significantly affecting the power density level but the manufacturer does.

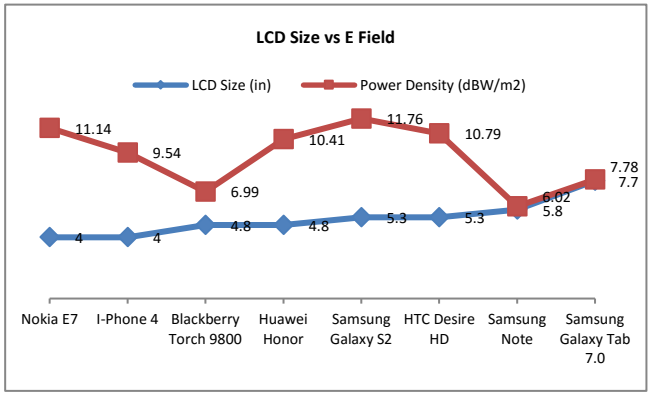

Fig. 4. Comparison between LCD size and Field Radiated

D. *Future work*

In the future, further analysis will be included by considering the interception of the emitted radiation from touch-screen LCD devices. It is expected that the handheld LCD devices can be eavesdropped just as it is possible for the notebook with flat-screen and LCD monitors and CRT displays. The low level of EMR from LCD devices may become the main challenge for the radiated signal interception. Besides, a high sensitivity receiver and a highly directional and high gain antenna would also be included in the experimental configurations.

V. CONCLUSION

It has been proven that all touch-screen LCD devices emit some kind of electromagnetic emission though the level is much lower compared to the laptop, flat panel or even CRT counterparts. The level of radiation varies from different LCD types, manufacturers and modes of operation. Active mode has higher level than standby mode. The size of the LCD does not matter in term of the amount of power density radiated but the manufacturer does. The level of radiation is not proportional to the size of LCD.

The intended research has some potentials to expand since the intelligence gathering where interception of radiated signal may potentially find applications in the monitoring and surveillance activities for the intelligence communities.

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