XeThru Sensor Emissions

An Exploration of Safety Regulations

XeThru Application Note **By Novelda AS**

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Summary

The Novelda XeThru sensor measures distance to objects with high sensitivity and accuracy. This is done by emitting very low energy impulses and measuring the time of flight. The amount of energy allowed to send is defined by regulatory agencies around the world. This application note explores the regulatory safety limits and compares the XeThru technology with other technologies. The evaluated XeThru sensor is found to emit 486 times less energy than the regulations allow and a sensor at 0.4 meters corresponds to a 5 GHz WIFI transmitter at 44 meters.

1 Introduction

The heart and soul of the XeThru technology is the Ultra Wide Band (UWB) radar SoC. Unlike traditional radars, the energy level transmitted from the XeThru sensor is less than any electronic device is allowed to transmit unintentionally. This application note explores electromagnetic safety regulations and guidelines, and compares the XeThru technology to other more recognized electromagnetic transmitters such as WIFI and Bluetooth.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) released guidelines on electromagnetic safety in 1998 [1] and reconfirmed the document in 2012. The European Council Recommendation 1999/519/EC acknowledges the guidelines, which specify the SAR limits in Europe. ICNIRP's guidelines are used to evaluate the electromagnetic safety of the XeThru technology.

2 Transmission Power Regulations

The Federal Communications Commission (FCC) in USA and the European Telecommunications Standards Institute (ETSI) in Europe regulate the use of UWB devices. The maximum allowed mean equivalent isotropically radiated power (EIRP) spectral density is -41.3 dBm/MHz in the range of 6.0-8.5 GHz for ETSI [3] and 3.1 – 10.6 for FCC [4].

2.1 UWB Masks

The ETSI and FCC spectrum boundary masks regulates the maximum transmitted power from a UWB device. The maximum total transmitted power for a theoretical device utilizing the FCC mask is given by

(1)
$$\begin{aligned} BW_{FCC} &= 7500\,\mathrm{MHz} \\ EIRP_{FCC} &= -41.3\,\mathrm{dBm/MHz} \\ &= 74.13\,\mathrm{nW/MHz} \\ &= 556.0\,\mu\mathrm{W} \end{aligned}$$

where BW denotes the spectrum mask bandwidth. Similar calculation for the ETSI mask gives:

(2)
$$\begin{aligned} BW_{ETSI} &= 2500\,\mathrm{MHz} \\ EIRP_{ETSI} &= -41.3\,\mathrm{dBm/MHz} \\ &= 74.13\,\mathrm{nW/MHz} \\ &= 185.3\,\mu\mathrm{W} \end{aligned}$$

2.2 XeThru Sensor, X2M03

Measurements on the XeThru X2M03 sensor show ETSI compliance for Pulse Repetition Frequencies (PRF) up to 30 MHz. Fig. 1 shows the preliminary ETSI EIRP measurements of the X2M03 sensor. The sensor transmits short pulses and the measured power is averaged over 1 ms.

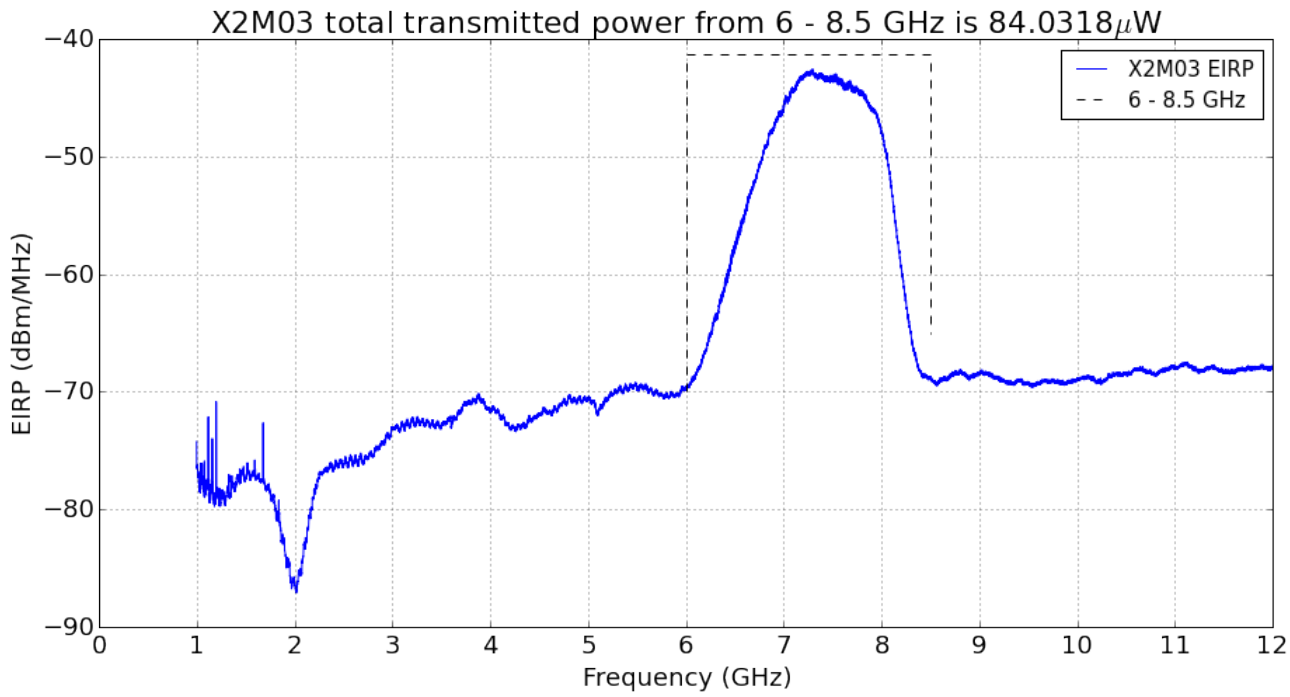

Fig. 1. X2M03 EIRP measurement.

The pulse duration is needed to calculate the peak power during pulse transmission. A pulse and the corresponding pulse width are plotted in Fig. 2. The envelope of the pulse was calculated to determine the half power points.

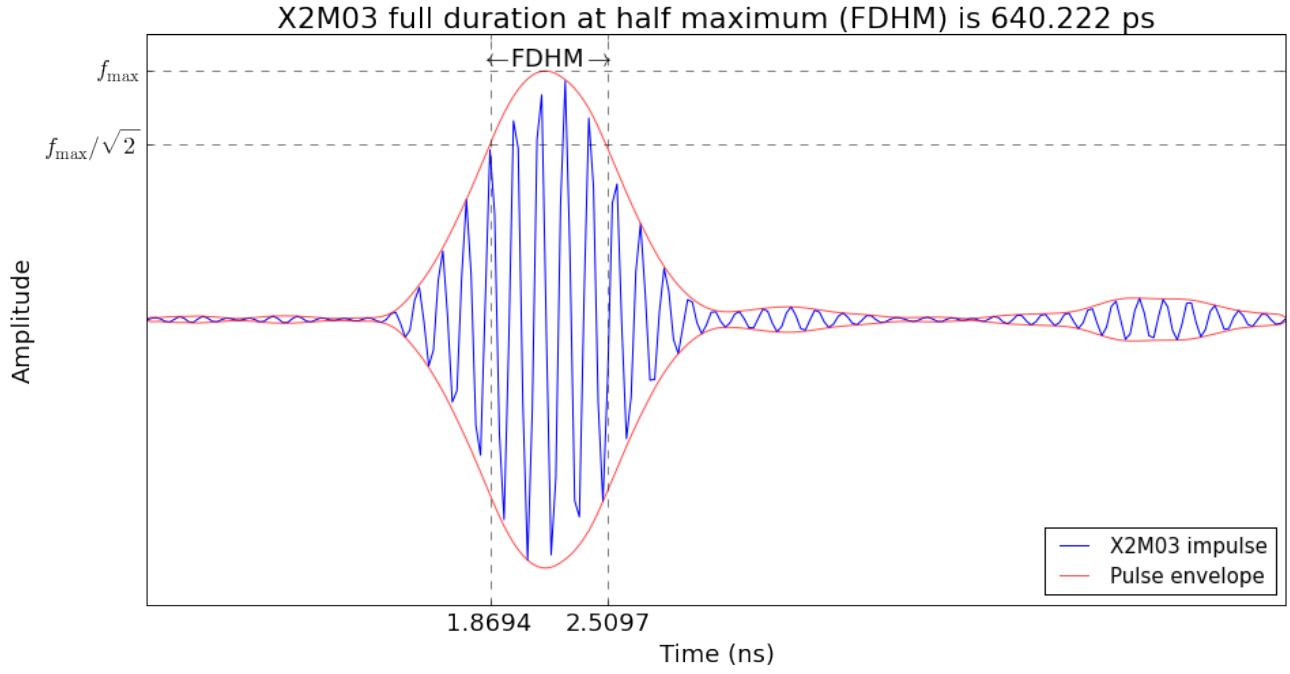

Fig. 2. The X2M03 impulse.

The Full Duration at Half Maximum (FDHM) pulse width is τ_{X2M03} = 640.2 ps and will later on be used to calculate peak power during pulse transmission.

The PRF restrictions of maximum 30 MHz applies to all further XeThru X2M03 sensor references.

2.2.1 Transmission Power List

The transmission power of different technologies are used to compare XeThru technology with other, more recognized, electromagnetic sources. The listed non UWB power levels are taken from [2].

Table 1. Transmission power list.

Technology	Transmitted power EIRP (Watt)
5 GHz WIFI	1.0 W
UMTS/3G mobile phone (Power class 2 mobiles)	0.5 W
2.4GHz WiFi	0.1 W
Typical laptop WLAN	32 mW
Bluetooth Class 2 10m range	2.5 mW
Theoretical UWB FCC mask device	556.0 μ W
Theoretical UWB ETSI mask device	185.3 μ W
XeThru sensor, X2M03	84.0 μ W

2.3 Safety Regulations

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) released guidelines on electromagnetic safety in 1998 [1] and reconfirmed the document in 2012. The European Council Recommendation 1999/519/EC acknowledges the guidelines, which specifies the Specific Absorption Rate (SAR) limits in Europe.

2.3.1 Basic Restrictions

ICNIRP defines SAR limits for electromagnetic fields, to prevent whole-body heat stress and excessive localized tissue heating. SAR is defined as the power absorbed per mass of tissue, with the units of watts per kilogram (W/kg). ICNIRP states that the reference levels were developed with the safety of extra sensitive population groups, such as elderly, infants and younger children, in mind. The following basic restrictions apply in the frequency range from 100 kHz to 10 GHz.

Table 2. SAR basic restrictions.

	Whole-body average SAR (W/kg)	Localized SAR (Head and trunk) (W/kg)	Localized SAR (Limbs) (W/kg)
SAR limit, general public	0.08	2	4

2.3.2 Reference Levels

ICNIRP has defined reference levels for comparison with measured values of physical quantities. Compliance with all reference levels given in these guidelines will ensure compliance with the basic restrictions given in Table 2. The relevant reference levels are:

Table 3. ICNIRP reference levels for public exposure.

Frequency range	E-field strength (V/m)	H-field strength (A/m)	B-field (QT)	Equivelant plane wave power density S_{eq} (w/m^2)
2-300 GHz	61	0.16	0.20	10

A note for pulsed systems, such as XeThru devices, suggests that *"S_{eq} (power density) as averaged over the pulse width should not exceed 1,000 times the reference levels or that field strengths should not exceed 32 times the field strength reference levels"*. The reference levels are given for the condition of maximum coupling of the electrical field to the exposed individual and therefore provides maximum protection.

The electrical and magnetic fields, **E** and **H** fields, can be calculated from the power density. Power density at a given distance R, can be calculated by using the following formula:

$$S = \frac{EIRP}{4\pi * R^2} \quad (3)$$

where EIRP is the transmitted power. ICNIRP defines the far field as the region where the distance from a radiating antenna exceeds the wavelength of the radiated electric, magnetic and electromagnetic fields. For objects in far field, the electrical field strength is then given by

$$E = \sqrt{S \cdot Z_0} \quad (4)$$

where Z_0 is the characteristic impedance of vacuum, $Z_0 = 120\pi\Omega$.

The magnetic field strength is given by

$$H = \frac{E}{Z_0} \quad (5)$$

The magnetic flux density and the magnetic field strength are proportionally dependent when propagating in air. Thus, in describing a magnetic field for protection purposes, only one of the quantities **H** or **B** needs to be specified.

3 Compliance Evaluation

A device emitting energy in the 2-300 GHz range complies to the SAR limits if the field strengths are less than listed in Table 3. The electrical field is calculated from Eq. (4) and listed in Table 4. All of the listed technologies are well below ICNIRP's reference levels and the XeThru sensor X2M03 is 486 times below.

Table 4. ICNIRP compliance.

Technology	Transmitted power EIRP (Watt)	E-field strength @ 0.4 meter (V/m)	Times less than ICNIRP reference level
5 GHz WIFI	1.0 W	13.69	4.5
UMTS/3G mobile phone (Power class 2 mobiles)	0.5 W	9.68	6.3
2.4GHz WiFi	0.1 W	4.33	14.1
Typical laptop WLAN	32 mW	2.45	24.9
Bluetooth Class 2 10m range	2.5 mW	0.68	89.1
Theoretical UWB FCC mask device	556.0 μ W	0.32	189.0
Theoretical UWB ETSI mask device	185.3 μ W	0.19	327.2
XeThru sensor, X2M03	84.0 μ W	0.126	486.0

The XeThru technology is a pulsed system and there is one additional recommendation to follow; the field strength as averaged over the pulse width should not exceed 32 times the field strength reference levels. The given transmitted power from a UWB device is averaged over time, with higher peak power during pulse transmission. The peak power, P_{peak} can be estimated by

$$P_{\text{peak}} = \frac{P_{\text{average}}}{\tau \cdot \text{PRF}} \quad (6)$$

where τ is the transmitted pulse length and PRF is the system's Pulse Repetition Frequency. The X2M03 sensor transmits 84.0 μ W at a PRF = 30 MHz and a pulse length of τ_{X2M03} = 640.2 ps. This gives a peak power of P_{peak} = 4.4 mW and an E-field strength of 0.91 V/m. This is 2155 times less than the reference level of 61 V/m x 3 2.

The XeThru sensor is well below all regulations and transmits less energy than other technologies. The following figure shows the electrical field strength as a function of distance. The dashed line shows the field strength of the X2M03 device at 0.4 meters and the intersecting points show which distance that corresponds to the same field strength for the other technologies.

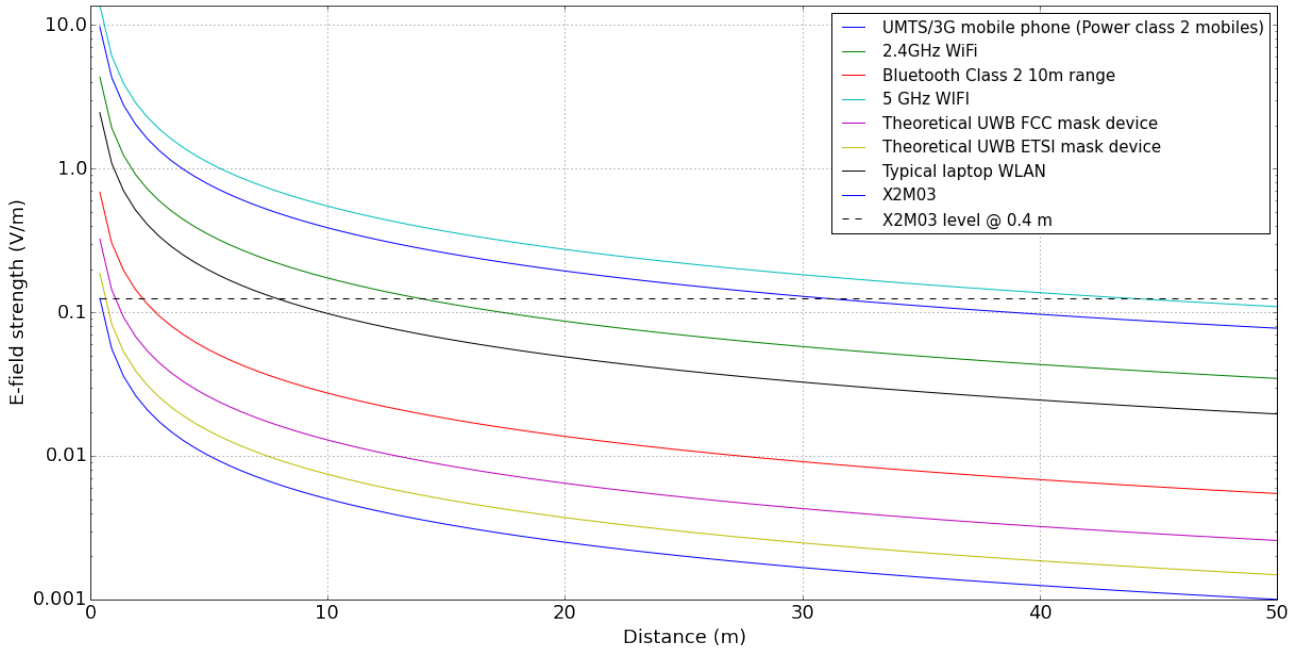

Fig. 3. Electrical field strength at different distances.

The corresponding differences are given in Table 5.

Table 5. Corresponding distance.

Technology	Distance that corresponds to a XeThru X2M03 device at 0.4 meters (m)
5 GHz WIFI	43.6
UMTS/3G mobile phone (Power class 2 mobiles)	30.9
2.4GHz WiFi	13.8
Typical laptop WLAN	7.8
Bluetooth Class 2 10m range	2.2
Theoretical UWB FCC mask device	1.0
Theoretical UWB ETSI mask device	0.6
XeThru sensor, X2M03	0.4

4 Conclusion

The XeThru technology and sensors are completely harmless according to ICNIRP's research on electromagnetic radiation. The ICNIRP guidelines are based on consensus of all the existing scientific results and provide protection against all established health effects of non-ionizing radiation exposure. The XeThru devices transmit less power than other devices are allowed to unintentionally send; the energy is regarded as noise. Placing the XeThru X2M03 sensor on your nightstand has the same effect as having a 5 GHz router at a distance of 44 meters or your phone at 31 meters.

5 References

[1]	ICNIRP, "Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). International Commission on Non-Ionizing Radiation Protection," *Health Phys,* vol. 74, no. 4, 1998.
[2]	"Wikipedia," [Online]. Available: https://en.wikipedia.org/wiki/DBm. [Accessed 15 01 2016].
[3]	ETSI EN 302 065-1 V1.3.1 (2014-04): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive; Part 1: Requirements for Generic UWB applications", page 12.
[4]	FCC (GPO) Title 47, Section 15 of the Code of Federal Regulations SubPart F: Ultra-wideband

6 Document History

Rev.	Release date	Change description
1.0	2016-Feb-04	Initial release

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