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Report on Low Duty Cycle Mitigation for UWB Devices

Reference

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

Modal verbs terminology

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1 Scope

The present document assesses the current LDC mitigation regulations for UWB applications in light of the requirement to have clear test criteria for the harmonised standards. It reviews the current regulations and related measurements to highlight the extra parameters that need to be specified in future harmonised standards. It also proposes a method to measure the duty cycle such that the requirement per hour can be met.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TR 103 181-2 (V1.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD) using Ultra Wide Band (UWB); Transmission characteristics Part 2: UWB mitigation techniques".

[i.2] ETSI EN 302 372 (V2.1.1): "Short Range Devices (SRD);Tank Level Probing Radar (TLPR) equipment operating in the frequency ranges 4,5 GHz to 7 GHz, 8,5 GHz to 10,6 GHz, 24,05 GHz to 27 GHz, 57 GHz to 64 GHz, 75 GHz to 85 GHz; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.3] ETSI EN 302 729 (V2.1.1): "Short Range Devices (SRD);Level Probing Radar (LPR) equipment operating in the frequency ranges 6 GHz to 8,5 GHz, 24,05 GHz to 26,5 GHz, 57 GHz to 64 GHz, 75 GHz to 85 GHz; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.4] CEPT Report 045: "Report from CEPT to the European Commission in response to the Fifth Mandate to CEPT on ultra-wideband technology to clarify the technical parameters in view of a potential update of Commission Decision 2007/131/EC".

[i.5] ETSI EN 302 065-1 (V2.1.1): "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 1: Requirements for Generic UWB applications".

[i.6] ETSI EN 302 065-2 (V2.1.1): "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 2: Requirements for UWB location tracking".

[i.7] ETSI EN 302 065-3 (V2.1.1): "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 3: Requirements for UWB devices for ground based vehicular applications".

[i.8] ETSI EN 302 065-4 (V1.1.1): "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 4: Material Sensing devices using UWB technology below 10,6 GHz".

[i.9] ECC/DEC/(06)04: "ECC Decision of 24 March 2006 on the harmonised conditions for devices using UWB technology in bands below 10.6 GHz, amended 9 December 2011 and amended 8 March 2019".

[i.10] ECC/REC/(11)09: "ECC Recommendation of 21 October 2011 on UWB Location Tracking Systems TYPE 2 (LT2), amended 22 May 2015".

[i.11] ECC/REC/(11)10: "ECC Recommendation of 1 November 2010 on location tracking application for emergency and disaster situations".

[i.12] ECC/DEC/(07)01: "ECC Decision of 30 March 2007 on the harmonised use, exemption from individual licensing and free circulation of Material Sensing Devices using Ultra-Wideband (UWB) technology, amended on 26 June 2009, corrected on 18 November 2016 and amended on 8 March 2019".

[i.13] ETSI TS 103 060 (V1.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Method for a harmonized definition of Duty Cycle Template (DCT) transmission as a passive mitigation technique used by short range devices and related conformance test methods".

[i.14] ETSI EN 303 883 (V1.1.1): "Short Range Devices (SRD) using Ultra Wide Band (UWB); Measurement Techniques".

[i.15] ETSI TS 103 366 (V1.1.1): "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Time Domain based Low Duty Cycle Measurement for UWB".

[i.16] ETSI ERM(18)66b042: "Final minutes of the workshop DG GROW ESOs on 6th December 2018".

[i.17] ETSI EN 303 883-1 (V1.2.1): "Short Range Devices (SRD) and Ultra Wide Band (UWB); Part 1: Measurement techniques for transmitter requirements".

3 Definition of terms, symbols and abbreviations

3.1 Terms

Void.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

F_{mb}	Mitigation bandwith
P_{thresh}	Threshold power
T_{dis}	Disregard time
T_{obs}	Observation period
T_{off}	Off time
T_{on}	On time
T_{span}	Span time of the oscilloscope
T_{trig}	Trigger time of the oscilloscope

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

DAA	Detect And Avoid
LAES	Location tracking Application for Emergency and disaster Situations
LDC	Low Duty Cycle
LT2	Location Tracking type 2
UWB	Ultra-Wide Band

TPC	Transmit Power Control
STF	Special Task Force
FMCW	Frequency Modulated Continuous Wave

4 Duty cycle in UWB regulations

An overview of the use of duty cycle restrictions and permission in UWB regulation is presented in clause 6.1 of ETSI TR 103 181-2 [i.1]. These are summarized in Table 1 and graphically in Figure 1. Trigger-before-transmit for keyless entry systems is new and has also been added.

In the table and figure, red colour is used to indicate a mandatory duty cycle restriction. Green is used to show optional duty cycle limits which if respected allow the device to transmit at higher power levels.

In total, there are essentially three different duty cycle related requirements:

- Maximum T_{on}
- Minimum mean T_{off} per second
- Maximum duty cycle (either per second or per hour)
  - Equivalent to minimum sum T_{off} per second or per hour
  - Equivalent to maximum sum T_{on} per second or per hour

Tank level probing radars (ETSI EN 302 372 [i.2]) also use a duty cycle defined over one-hour periods. For level probing radars, duty cycle is an optional mitigation technique (ETSI EN 302 729 [i.3]).

Based on CEPT Report 045 [i.4], the ETSI EN 302 065 series of Harmonised Standards ([i.5] to [i.8]) includes a trade-off between duty cycle and transmit power in Annex C where the T_{on} can be increased as long as the transmit power is reduced proportionally and the average T_{off} remains above 38 ms.

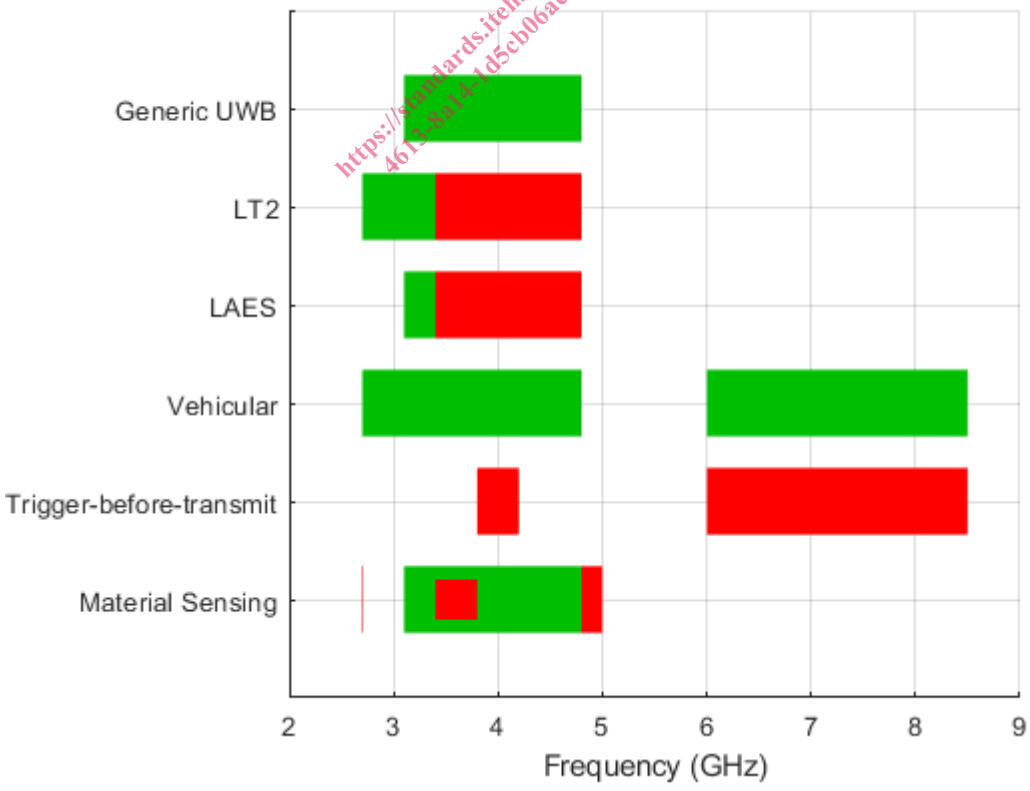

Figure 1: Duty cycle applicability in UWB regulations

Table 1: Duty cycle applicability in UWB regulations

Application	Frequency range	Duty cycle specifications
Generic UWB *ECC/DEC/(06)04 [i.9]*	3,1 to 4,8 GHz	T_{on} max = 5 ms T_{off} mean ≥ 38 ms (averaged over 1 sec) Σ T_{off} > 950 ms per second Σ T_{on} < 18 s per hour
Location tracking type 2 (LT2) *ECC/REC/(11)09 [i.10]*	2,7 to 3,4 GHz	DAA & A maximum duty cycle of 5% per transmitter per second and a maximum T_{on} = 25 ms also apply
	3,4 to 4,8 GHz	A maximum duty cycle of 5 % per transmitter per second and a maximum T_{on} = 25 ms apply
Location tracking for emergency services (LAES) *ECC/REC/(11)10 [i.11]*	3,1 to 3,4 GHz	DAA & a maximum duty cycle of 5 % per transmitter per second also applies.
	3,4 to 4,8 GHz	A maximum duty cycle of 5 % per transmitter per second For indoor and mobile transmitters, additional maximum duty cycle of 1,5 % per transmitter per minute.
Vehicular UWB *ECC/DEC/(06)04 [i.9]*	2,7 to 4,8 GHz 6,0 to 8,5 GHz	T_{on} max = 5 ms T_{off} mean ≥ 38 ms (averaged over 1 s) Σ T_{off} > 950 ms per second Σ T_{on} < 18 s per hour (see note) Exterior limit also applies
Trigger-before-transmit *ECC/DEC/(06)04 [i.9]*	3,8 to 4,2 GHz	LDC ≤ 0,5 % (in 1 h)
	6,0 to 8,5 GHz	LDC ≤ 0,5% (in 1 h) or TPC
Material sensing *ECC/DEC/(07)01 [i.12]*	2,69 to 2,70 GHz 3,4 to 3,8 GHz 4,8 to 5,0 GHz	Limitation of the Duty Cycle to 10 % per second in each of these dedicated bandwidths
	3,1 to 4,8 GHz	The LDC mitigation technique and its limits is defined in the relevant version of the Harmonised European Standard ETSI EN 302 065-1 [i.5]. When LDC is implemented, no fixed outdoor permitted.
NOTE: Within the band 3,4 GHz to 4,8 GHz, this requirement does not apply for operation with vehicle speed above 40 km/h. For vehicle speeds between 20 km/h and 40 km/h a gradual implementation of the long-term duty cycle limit from 18 s to 180 s per hour is required.		

5 T_{on} and T_{off} definition

ECC/DEC/(06)04 [i.9] defines T_{on} and T_{off} as:

- T_{on}
  - T_{on} is defined as the duration of a burst irrespective of the number of pulses contained.
- T_{off}
  - T_{off} is defined as the time interval between two consecutive bursts when the UWB emission is kept idle.

These definitions of T_{on} and T_{off} depend heavily on the interpretation of the concept of a burst.

Previously, ETSI TC ERM organized a Special Task Force (STF 411), with members from TG28 and TGUWB, to find a harmonised definition and measurement methods for low duty cycle transmissions. STF 411 published its recommendations as ETSI TS 103 060 [i.13] in September 2013.

To decide whether signals are on or off, ETSI TS 103 060 [i.13] first defines a threshold power level, P_{thresh}, above which signals are considered on. Clause 4.1.2 of ETSI TS 103 060 [i.13] specifies that:

> *Unless otherwise defined P_{thresh} is -26 dBc for systems other than UWB and -10 dBc for UWB systems.*

This power is measured in a limited mitigation bandwidth, F_{mb}.

Furthermore, ETSI TS 103 060 [i.13] also defines a disregard time, T_{dis}, in clause 4.1.7.2:

> *"T_{dis} is defined as the time interval below which interruptions within a transmission are considered part of T_{on}. T_{dis} is a measurement procedure parameter, it is not subjected to restrictions but it must be declared by the device manufacturer".*

Both concepts are illustrated in Figure 2, which was copied from ETSI TS 103 060 [i.13].

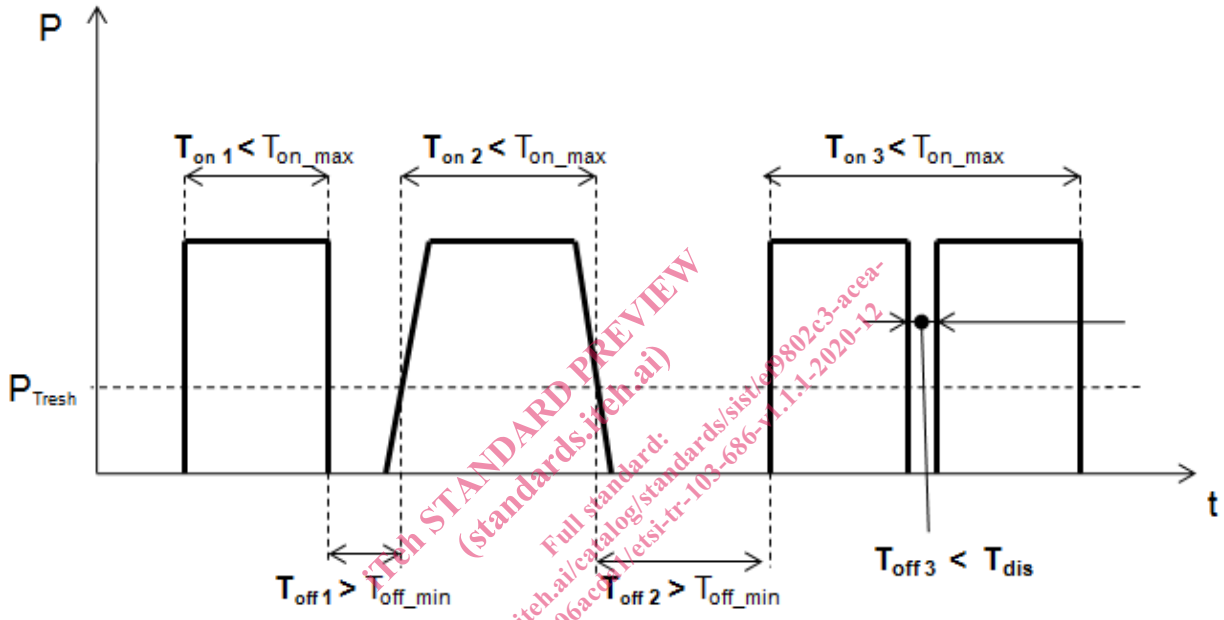

Figure 2: Illustration P_{thresh}, T_{on}, T_{off} and T_{dis}

This additional factor T_{dis} ignores 'internal' gaps in the UWB signal and allows UWB signals to meet the restrictions on the mean T_{off} time. Previously, the harmonised standards let the manufacturer declare the T_{dis} used. Since the European Commission no longer allows manufacturer declarations in harmonised standards, a suitable value for T_{dis} will have to be chosen for each application-specific harmonised standard.

ETSI TS 103 060 [i.13] does not use the burst concept. However, following its definitions, a burst is a series of pulses separated from the next pulse by time intervals less than the disregard time T_{dis}.

6 Current procedures

6.1 Measurements in ETSI EN 303 883

At the time of writing, all relevant Harmonised Standards ([i.5], [i.6], [i.7] and [i.8]) refer to ETSI EN 303 883 [i.14], clause 7.4.8 for the measurement of the duty cycle. That clause contains two alternative methods, method 1 based on measurements with a spectrum analyser in clause 7.4.8.1 and method 2 with a high-speed sampling oscilloscope in clause 7.4.8.2.

Method 1, from clause 7.4.8.1, configures the spectrum analyser in zero span mode, centred on the frequency at which the highest mean spectral density was observed. The resolution bandwidth should be set to the 'highest available bandwidth' up to a maximum of 50 MHz. There is no clear definition of P_{thresh}. The method then measures the T_{on} and T_{off} in a pulse frame with maximum T_{on} and minimum T_{off} taking into account T_{dis} from ETSI TS 103 060 [i.13].