ETSI TS 103 060 V1.1.1 (2013-09)

Technical Specification

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

Reference
DTS/ERM-026

Keywords
SRD, testing

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Important notice

Individual copies of the present document can be downloaded from:
http://www.etsi.org

The present document may be made available in more than one electronic version or in print. In any case of existing or perceived difference in contents between such versions, the reference version is the Portable Document Format (PDF). In case of dispute, the reference shall be the printing on ETSI printers of the PDF version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at
http://portal.etsi.org/tb/status/status.asp

If you find errors in the present document, please send your comment to one of the following services:
http://portal.etsi.org/chaircor/ETSI_support.asp

Contents

Intellectual Property Rights

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (http://ipr.etsi.org).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Foreword

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

1 Scope

The present document provides a definition of Duty Cycle Template (DCT) to be used as a frequency and application independent passive mitigation technique, and associated conformance measurement methods.

DCT consists of an active transmission interval followed by an inactive idle interval. The combination of these two provides the basis of the mitigation technique to share spectrum.

Duty Cycle (DC) is a signal property that is the time spent in an active state as a fraction of the total time under consideration. DCT differs from DC by generalizing the definition of a transmission to include operation over a defined observation bandwidth and defined observation time, as they affect the systems under consideration and harmonizing Ultra Wideband and non-Ultra Wideband systems treatment.

As a result, the DCT requirement should define limits on individual transmission parameters in such a way as to avoid harmful interference to victim system receivers even if they are simultaneously operated in close physical proximity and in the same radio spectrum bandwidth at the same time.

2 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.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

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

2.1 Normative references

The following referenced documents are necessary for the application of the present document.

[1] ETSI TR 100 028 (V1.4.1) (all parts): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics".

[2] ANSI C63.5-2006: "American National Standard for Electromagnetic Compatibility - Radiated Emission Measurements in Electromagnetic Interference (EMI) Control - Calibration of Antennas (9 kHz to 40 GHz)".

[3] ETSI TS 102 321 (V1.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Normalized Site Attenuation (NSA) and validation of a fully lined anechoic chamber up to 40 GHz".

[4] ETSI TR 102 273: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties".

2.2 Informative references

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.

Not applicable.

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Duty Cycle Template (DCT): result of Cumulative On-Time (Ton_cum) divided by the Observation period (Tobs)

NOTE: The DCT could be defined for one or more values of Observation period (Tobs). More details are described in clause 4.2.

3.2 Symbols

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

F_{mb} Mitigation bandwidth

NOTE: See clause 4.1.

P_{Thresh} Threshold

NOTE: See clauses 4.1 and 4.2.

T Time
T_{dis} Disregard-Time

T_{obs} Observation period

NOTE: See clause 4.1.4.

T_{off} Off-Time

NOTE: See clause 4.1.7.

T_{on} On-Time

NOTE: See clause 4.1.5.

T_{on_cum} cumulative On-Time

3.3 Abbreviations

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

CF Centre Frequency
DC Duty Cycle
DCT Duty Cycle Template

NOTE: See clause 4.2.

DSO Digital Storage Oscilloscope
ERM Electromagnetic compatibility and Radio spectrum Matters
EUT Equipment under Test

FFT	Fast Fourier Transformation
LDC	Low Duty Cycle
LNA	Low Noise Amplifier
RBW	resolution bandwidth
RTSA	real time spectrum analyzer
SNR	Signal to Noise Ratio
SRD	Short Range Device

NOTE: See clause 4.1.7.2.

TON	On-Time (T_{on})
UWB	Ultra WideBand
VBW	Video Bandwidth

4 Duty Cycle Template

4.1 Parameter Definitions

4.1.1 Transmission

A Transmission is a continuous radio emission, or sequence of emissions separated by intervals shorter than T_{dis} (see clause 4.1.7.2), with a signal level greater than P_{Thresh} (see clause 4.1.2), within the Mitigation Bandwidth F_{mb} (see clause 4.1.3).

4.1.2 P_{Thresh}

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

4.1.3 Mitigation bandwidth (F_{mb})

F_{mb} is the victim receiver bandwidth in which the energy of a DCT device occurs during the operation of that DCT device. If the victim receiver is frequency agile, F_{mb} includes the time-frequency relationship of that agility. F_{mb} shall be defined by regulation authorizing the use of SRDs in subject band.

4.1.4 Observation period (T_{obs})

T_{obs} is defined as a reference interval of time.

4.1.5 On-Time (T_{on})

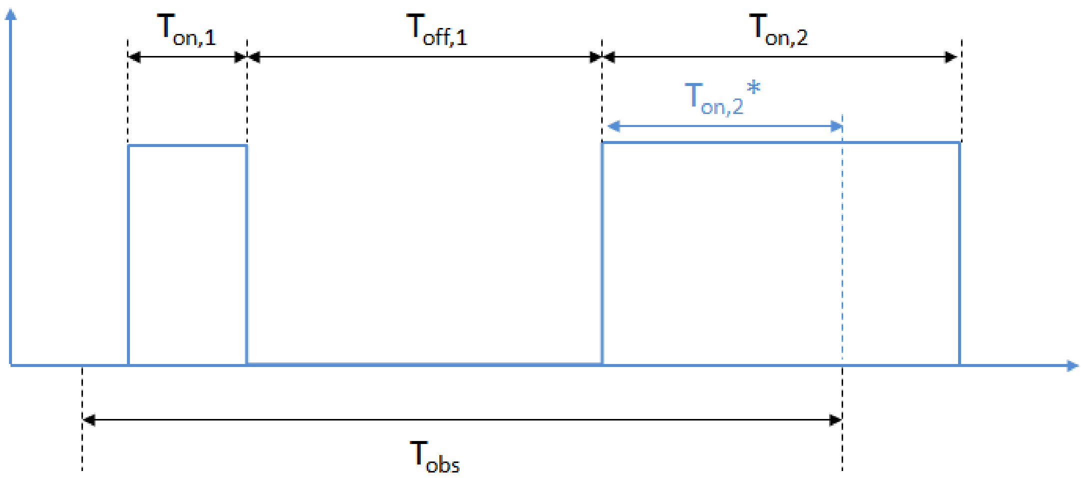
T_{on} is defined as the duration of a Transmission. This is illustrated in Figure 1.

4.1.5.1 Maximum On-Time (T_{on_max})

T_{on_max} is defined as the maximum permissible value of T_{on}.

4.1.6 Cumulative On-Time (T_{on_cum})

T_{on_cum} is defined as the sum of the individual T_{on} times, or part thereof, within $T_{obs,}$ example, see Figure 1.



In this example: $T_{on\_cum} = T_{on,1} + T_{on,2}*$.

Figure 1: Example for Cumulative On-Time

4.1.7 Off-Time (T_{off})

T_{off} is defined as the time duration between two consecutive Transmissions (see Figure 1).

4.1.7.1 Minimum Off – Time (T_{off_min})

T_{off_min} is defined as the minimum permissible value of T_{off}.

4.1.7.2 Disregard-Time (T_{dis})

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 (see Figure 2).

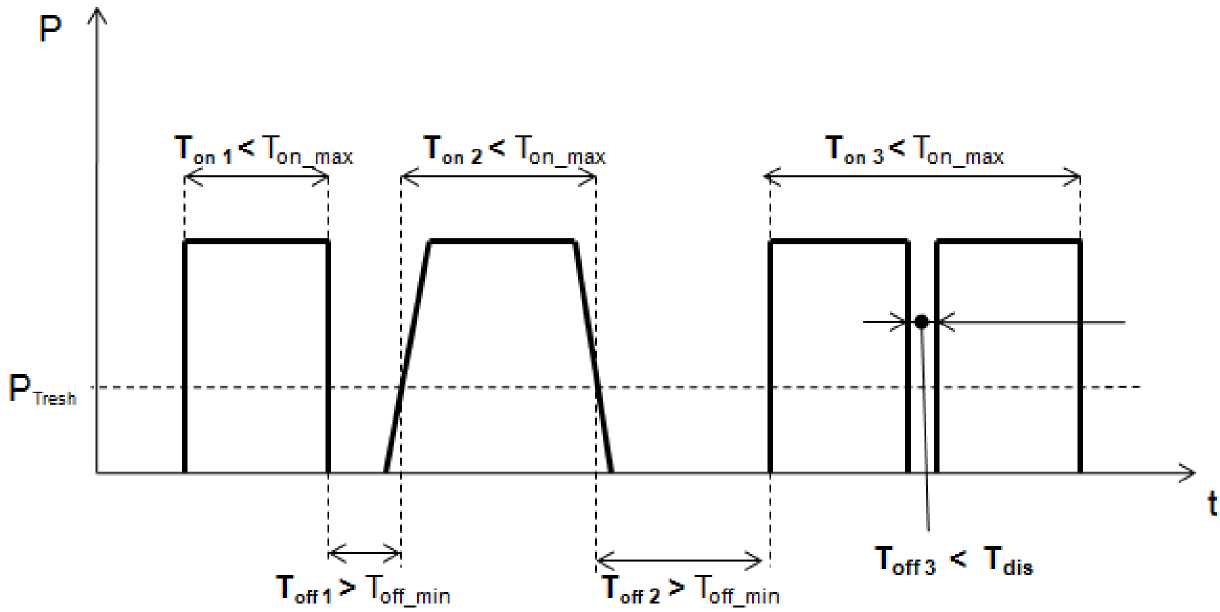


Figure 2: Definition T_{ON} and T_{off} times

4.1.8 Average Off-Time (T_{off_avg})

T_{off_avg} is defined as the average (mean) T_{off} time over T_{obs}.

This parameter is only relevant for UWB systems.

4.2 DCT Definition

DCT is defined as:

$$\frac{T_{on\_cum}}{T_{obs}}$$

$$\frac{T_{on\_cum}}{T_{obs}}$$

Respecting the constraints of T_{on_max} and T_{off_min}.

T_{obs} may take different values for specific cases.

DCT is defined for one or more values of T_{obs}.

It has to be noted that values of T_{obs} shall be defined by regulation.

5 Conformance test methods

5.1 Measurement setup for measuring T_{on}, T_{off}, T_{on_cum} using declared T_{dis}

To measure the duty cycle template (DCT) the measurement instrument shall have a sufficiently high acquisition bandwidth, sampling rate, and data storage capacity suitable for the mitigation bandwidth and the observation time T_{obs}. Possible solutions are to use a real-time spectrum analyser (RTSA) or a fast digital storage oscilloscope (DSO) with signal analysis software for signal acquisition. Duty cycle measurements can be performed in the time and frequency domains (spectrogram) or in the time domain only. In case an external envelope detector is used (as depicted in Figure 4 and Figure 7) the sampling rate of the DSO can be reduced because of the lower bandwidth of the EUT signal envelope.

In all measurements, only transmissions that fall within the frequency mitigation bandwidth and the observation time (F_{mb}) are considered.

5.1.1 Conducted measurements

The preferred method of measurement is conducted (see Figure 3). The antenna output of the EUT is directly connected to the input of the measurement equipment, if possible via a variable attenuator.

The preferred setup consists of a band pass filter (pass band equal to F_{mb}) connected to either a threshold detector (sensitivity P_{thresh}), see Figure 3, or an envelope detector (rise time should be not higher than $1/F_{mb\_min}$, being F_{mb_min} the minimum frequency within the mitigation bandwidth F_{mb}), see Figure 4, and then connected to a DSO.

The alternative setup consists of a RTSA or DSO with signal analysis software for signal acquisition (Figure 5).

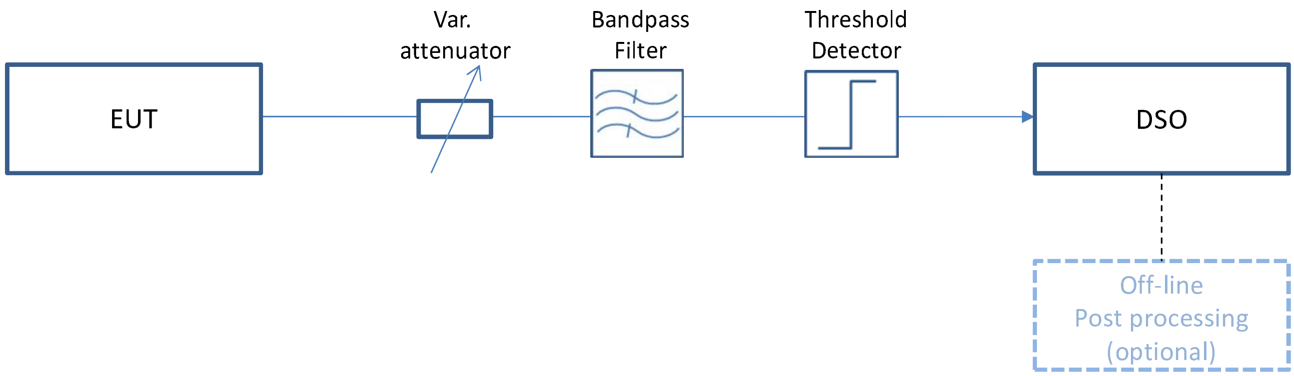


Figure 3: Conducted setup using a Threshold Detector

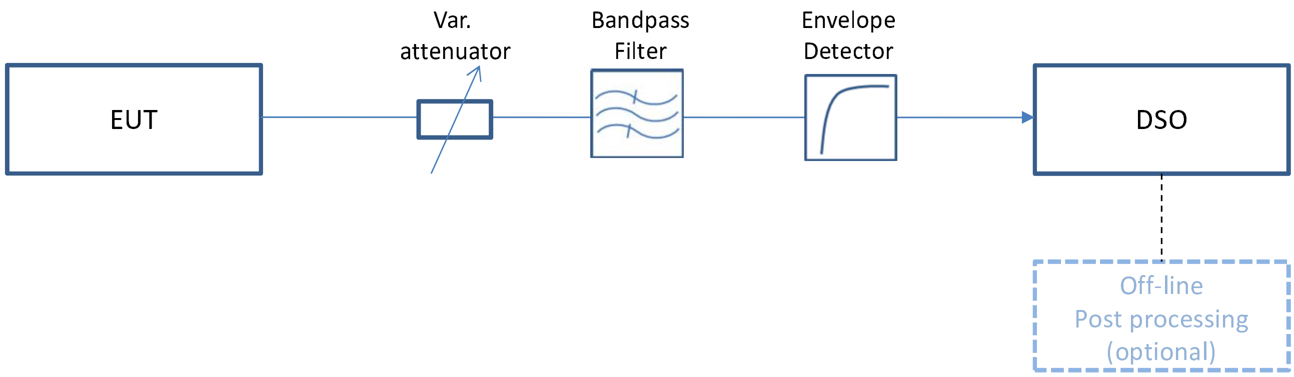


Figure 4: Conducted setup using an Envelope Detector

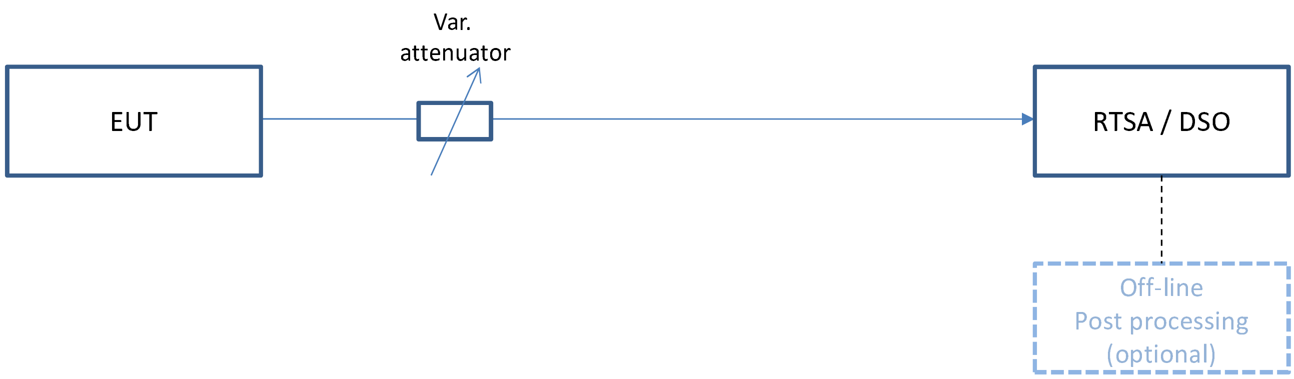


Figure 5: Alternative conducted setup using a RTSA or DSO

5.1.2 Radiated measurements

In case the EUT does not provide an antenna output the measurement shall be done in a radiated manner (see Figure 6, Figure 7 and Figure 8).

The input of the measurement system shall be an antenna suitable for the frequency range covered by F_{mb}. The measurement distance d is not critical in this case; however, it should be ensured by observation that the input stage of the measurement system is not saturated and that a sufficiently high SNR is maintained to allow detection of the signal at the thresholds defined above. If necessary, an LNA may be used to improve the SNR.

The preferred setup consists of a band pass filter (pass band equal to F_{mb}) connected to either a threshold detector (sensitivity P_{thresh}), see Figure 6, or an envelope detector (rise time should be not higher than $1/F_{mb\_min}$, being F_{mb_min} the minimum frequency within the mitigation bandwidth F_{mb}), see Figure 7, and then connected to a DSO.

The alternative setup consists of a RTSA or DSO with signal analysis software for signal acquisition (Figure 8).

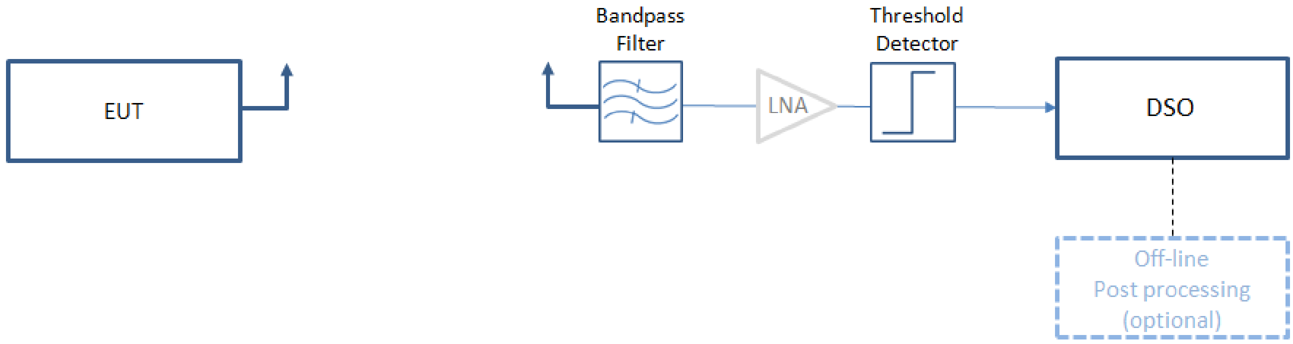


Figure 6: Radiated setup using a Threshold Detector

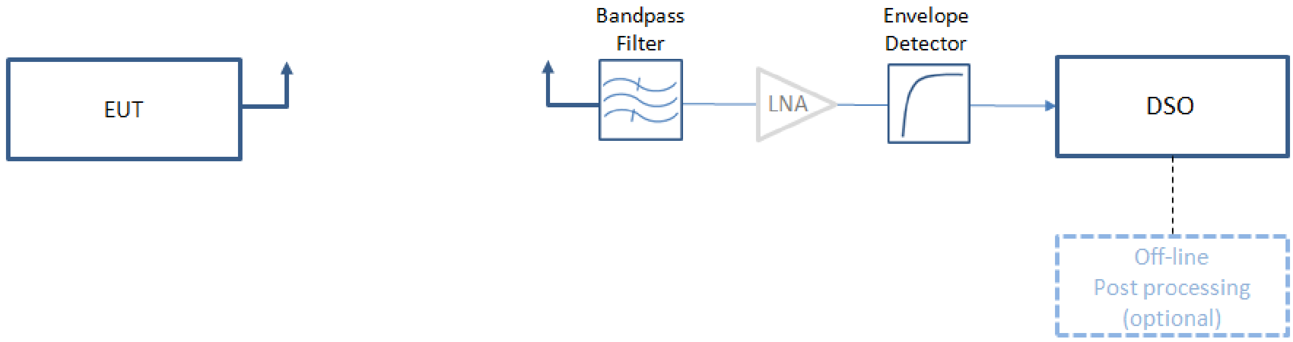


Figure 7: Radiated setup using an Envelope Detector

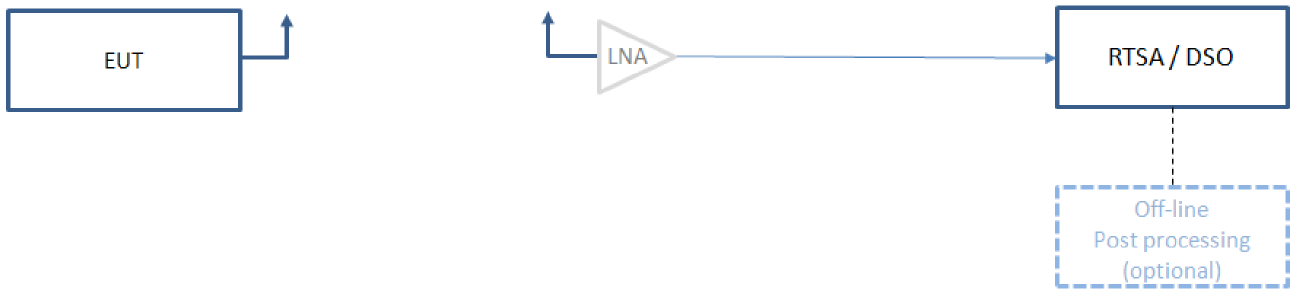


Figure 8: Alternative radiated setup using a RTSA or DSO

5.1.3 Triggered acquisition of signals

For large observation periods T_{obs} continuous recording of the EUT signal may not be feasible due to memory limitations of the measurement equipment.

In this case acquisition of the signal is triggered on a defined power level. This trigger level should be lower than P_{tresh} in order to capture the entire signal of interest. Upon triggering the signal is acquired for a certain period of time ("Acquisition time") which shall be at least as long as the expected duration of the transmission.

The acquired data is then time-stamped and stored in memory. With the next transmission the acquisition is triggered again, and so on, until T_{obs} has been reached.

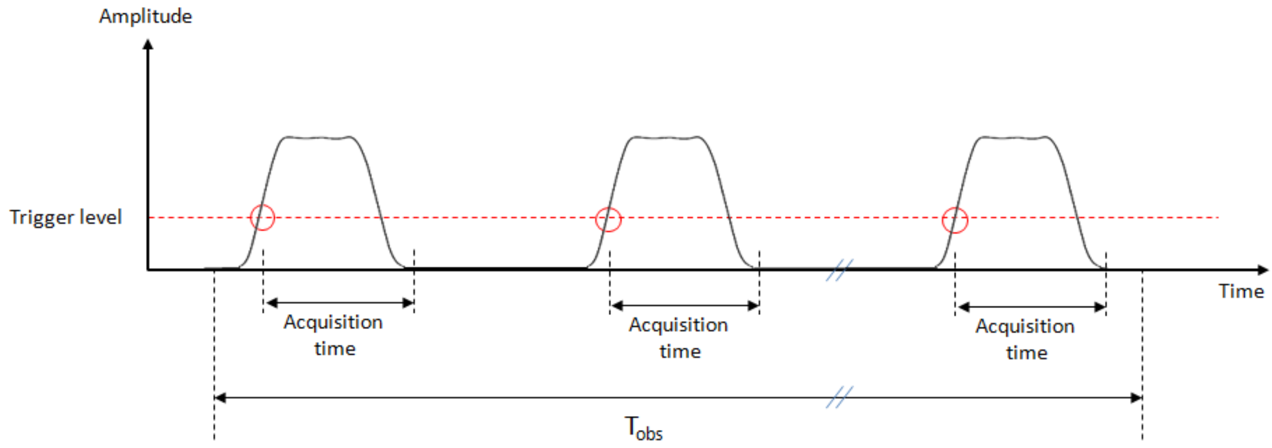


Figure 9

5.2 Measurement Procedure for Systems others than UWB using single or multiple channels

A spectrum analyser is the recommended method for the following measurement. Any other measurement setup shall be adapted accordingly.

Set a spectrum analyser to view the envelope of the signal on zero span, peak detector and single shot or max hold trace when necessary:

1) Set VBW to [1 kHz] (this gives video rise time approximately 0,15 ms and avoids complex features in the envelope).

2) Switch the EUT to normal operation. Trigger several transmissions.

3) Check that entire signal is captured by varying both RBW and CF. A change in CF of 0,5 RBW should make no change to the envelope. Increasing RBW by factor of 3 should make no change.

4) For multiple channel measurement, RBW shall be set at the closest value to the mitigation bandwidth to include all relevant hops.

5) *Note peak of envelope over at least 3 transmissions. From this reference line, calculate* Pt_{hres}.

6) Sample the transmit signal from the device over a period longer than the observation period.

For the purpose of the measurement, use the first positive transition thru P_{thres} following an off period longer or equal to T_{off_min} as a starting point for the T_{obs}.

T_{dis} is declared by the manufacturer. All short duration dips below the T_{dis} are considered as part of T_{on}.

5.2.1 Single channel measurement

1) The Ton time of a transmission is the period that the envelope is above the P_{thres}. The measurement shall be done over at least 10 transmissions and the highest Ton value shall be noted.

2) The highest cumulative Ton time within the reference period T_{obs} shall be calculated and noted.

3) The T_{off} time between transmissions is the period where the envelope is below P_{thres}. The measurement shall be done over at least 10 transmissions and the lowest T_{off} value shall be noted.

4) The cumulative T_{off} over T_{obs} shall be noted.

5) Calculate DCT value with the highest cumulative T_{on} over the T_{obs}.(see clause 4.2).

5.2.2 Multiple channel measurement

1) The T_{on} time of a transmission is the period that the envelope is above the P_{thres}. The measurement shall be done over at least 10 transmissions and the highest T_{on} value shall be noted.

2) The highest cumulative T_{on} time within the reference period T_{obs} shall be calculated and noted.

3) The T_{off} time between transmissions is the period where the envelope is below P_{thres}. The measurement shall be done over at least 10 transmissions and the lowest T_{off} value shall be noted.

4) The cumulative T_{off} over T_{obs} shall be noted.

5) Calculate DCT value with the highest cumulative T_{on} over the T_{obs} (see clause 4.2).

5.3 Measurement Procedure for UWB systems

5.3.1 Time domain measurement

This procedure uses the preferred measurement setup depicted in Figure 3, Figure 4, Figure 6, or Figure 7:

1) For this measurement, a DSO will be used.

2) Switch the EUT to normal operation. For frequency hopping devices, hopping shall be enabled.

3) Adjust the DSO settings so that the signal is displayed for duration at least as large as T_{obs}.

4) Freeze the display. Adjust the DSO's time scale settings so that signal on and off times can be clearly identified. If T_{obs} is too large for the signal to be displayed the signal shall be recorded and stored for offline analysis (see clause 5.1.3).

5) Find the start and stop times of each transmission in the stored measurement samples that are within the observation period. The start and stop times are defined as the points where the power is above P_{Thresh} .

6) Between the saved start and stop times of each individual transmission, calculate the T_{on} time. Save these T_{on} values.

7) Between the saved stop and start times of two subsequent transmissions, calculate the T_{off} time. Save these T_{off} values.

8) DCT is the sum of all T_{on} times (=T_{on_cum}) divided by the duration of the observation period.

9) Calculate the compound DC for the mitigation band. The compound DC is the sum of the DCs for the individual frequencies calculated before.

5.3.2 Time and Frequency Domain measurement (Spectrogram)

This procedure uses the alternative measurement setup depicted in Figure 5 or Figure 8:

1) Switch the EUT to normal operation. For frequency hopping devices, hopping shall be enabled.

2) If a DSO is used it shall be switched to frequency domain analysis mode (FFT).

3) On the RTSA or DSO select a frequency and span suitable to capture the mitigation band. Use the following settings:

   - RBW = 50 MHz
   - VBW ≥ RBW
   - Detector function: Peak
   - Trace: Max. hold

4) Select the "Spectrogram" display.

5) Set signal scale so that:

- Max. value = signal peak
- Min. Value = signal peak -10 dB (see clause 4.1.2).

6) Run the measurement and let the display stabilize.

7) Freeze the trace so that the duration of the displayed signal at least as large as T_{obs}. If T_{obs} is too large for the signal to be displayed the signal shall be recorded and stored for offline analysis (see clause 5.1.3).

8) Determine the start and end times of each transmission within the observation period, for instance by using delta markers. Record the values.

9) Between the saved start and stop times of each individual transmission, calculate the T_{XON} time. Save these T_{XON} values.

10) Between the saved stop and start times of two subsequent transmissions, calculate the T_{XOFF} time. Save these T_{XOFF} values.

11) The DCT is the sum of all T_{XON} times ($=T_{ON\_cum}$) divided by the duration of the observation period (see clause 4.2).

5.4 Measurement uncertainties

For the test methods, according to the present document, the measurement uncertainty figures shall be calculated in accordance with the guidance provided in TR 100 028 [1] and shall correspond to an expansion factor (coverage factor) k = 1,96 or k = 2 (which provide confidence levels of respectively 95 % and 95,45 % in the case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian)).

Table 1 is based on such expansion factors.

Table 1: Maximum measurement uncertainty (extracted from TR 102 273 [4])

Parameter	Uncertainty
Radio Frequency	$\pm 1 \times 10^{-5}$
all emissions, radiated	±6 dB (see note)
conducted	±3 dB
temperature	±1 °C
Humidity	±5 %
DC and low frequency voltages	±3 %
NOTE: For radiated emissions measurements below 2,7 GHz and above 10,6 GHz it may not be possible to reduce measurement uncertainty to the levels specified in Table 10 (due to the very low signal level limits and the consequent requirement for high levels of amplification across wide bandwidths). In these cases alone it is acceptable to employ the alternative interpretation procedure specified in clause 5.6.2.	

5.5 Test sites and general arrangements for measurements involving the use of radiated fields

This annex introduces the test site which may be used for radiated tests. The test site is generally referred to as a free field test site. Both absolute and relative measurements can be performed in these sites. Where absolute measurements are to be carried out, the chamber should be verified. A detailed verification procedure is described in TS 102 321 [3] and ANSI C63.5 (2006) [2].

Annex A (normative): DCT Examples

This annex provides illustrative examples on the definitions contained in the present document.

A.1 Single-channel transmission inside F_{mb} – signals other than UWB

In the first example in Figure A.1, a single-channel device performs a number of Transmissions over the observation period. F_{mb} in this example spans several EUT channels. The calculation of T_{on} [option 2] includes any "off" intervals smaller than T_{dis}. T_{on} is used to obtain T_{on_cum} and the DCT value over a given observation period T_{obs}.

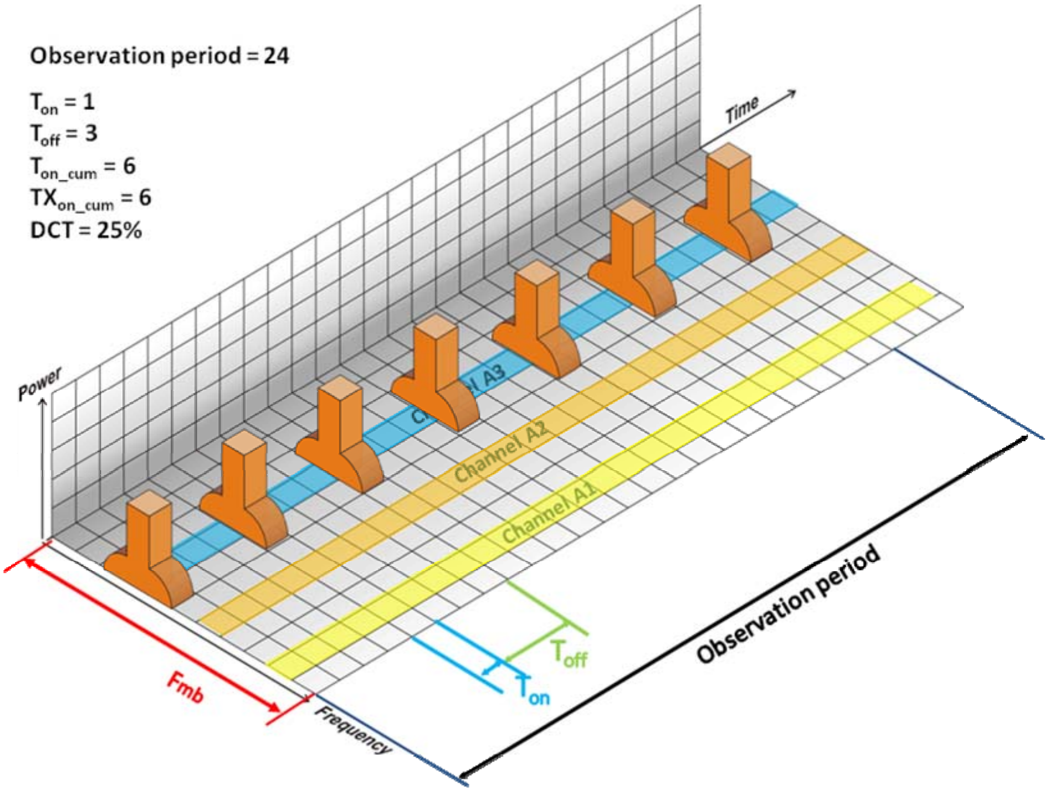


Figure A.1: Single-channel transmissions

A.1.1 One single channel with two Observation periods T_{obs}

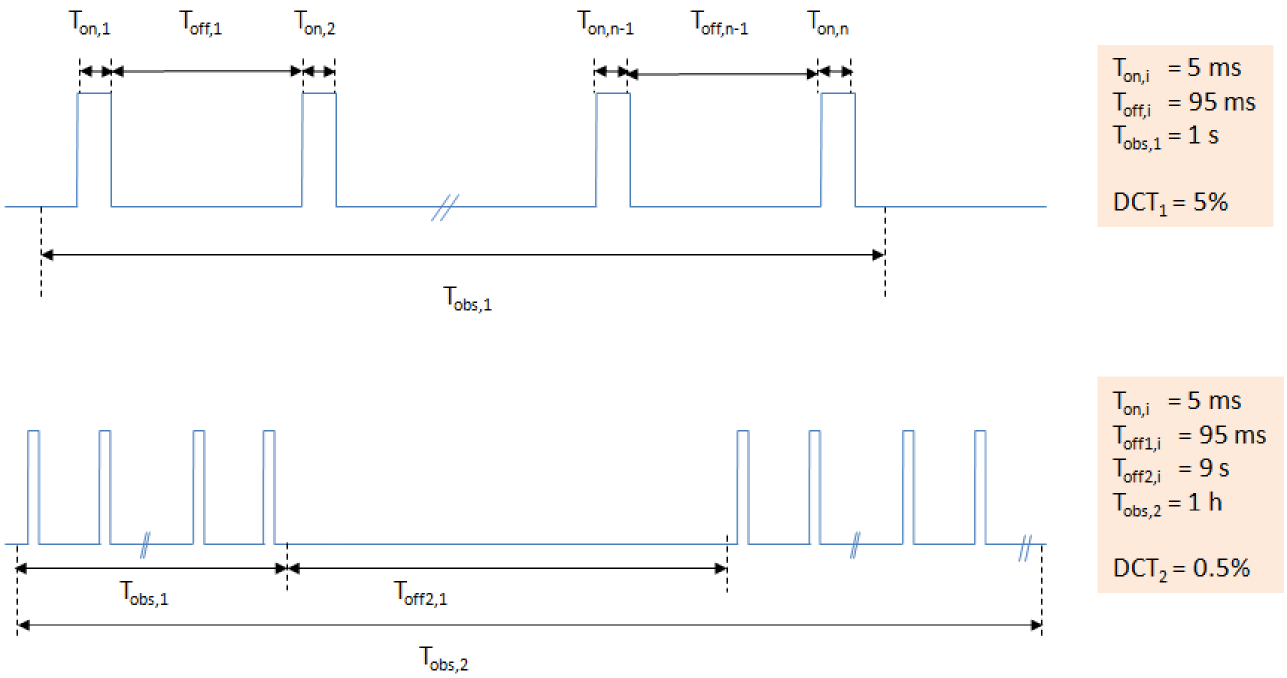
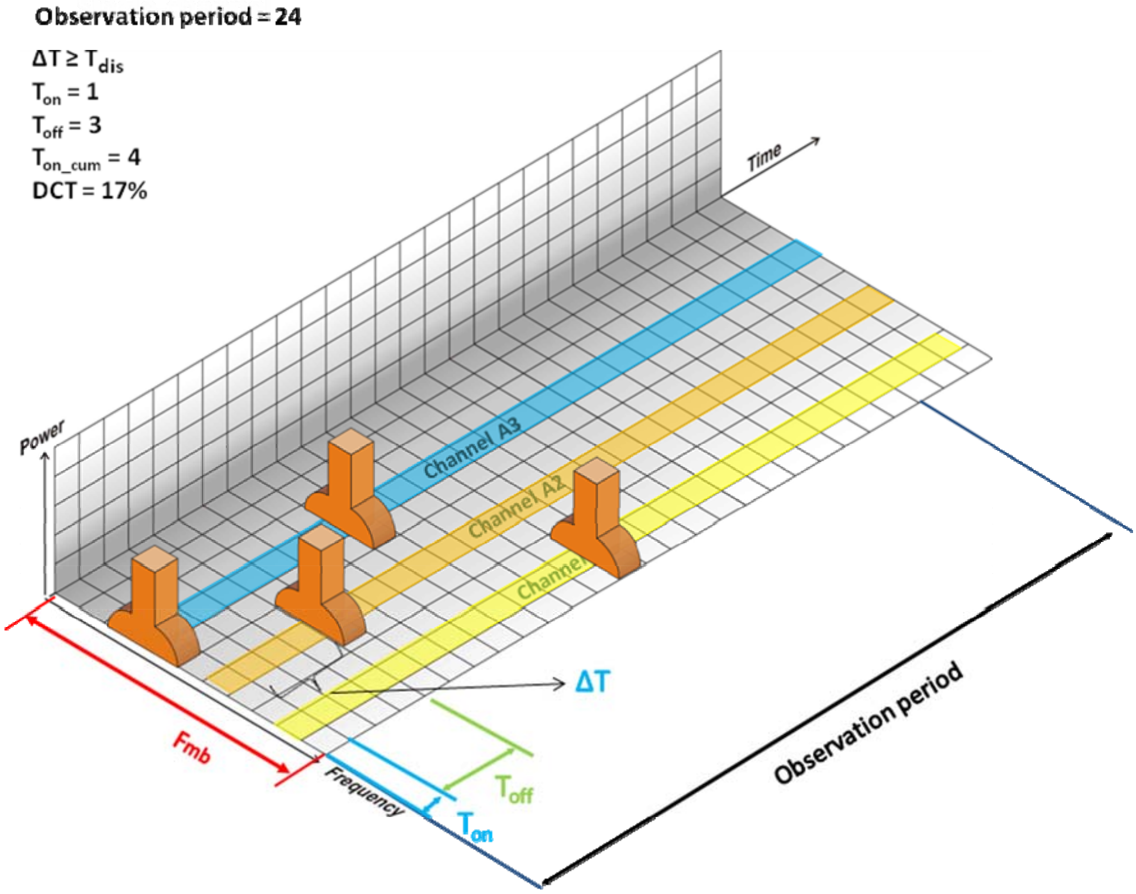


Figure A.2: Single-channel transmissions with two Observation periods

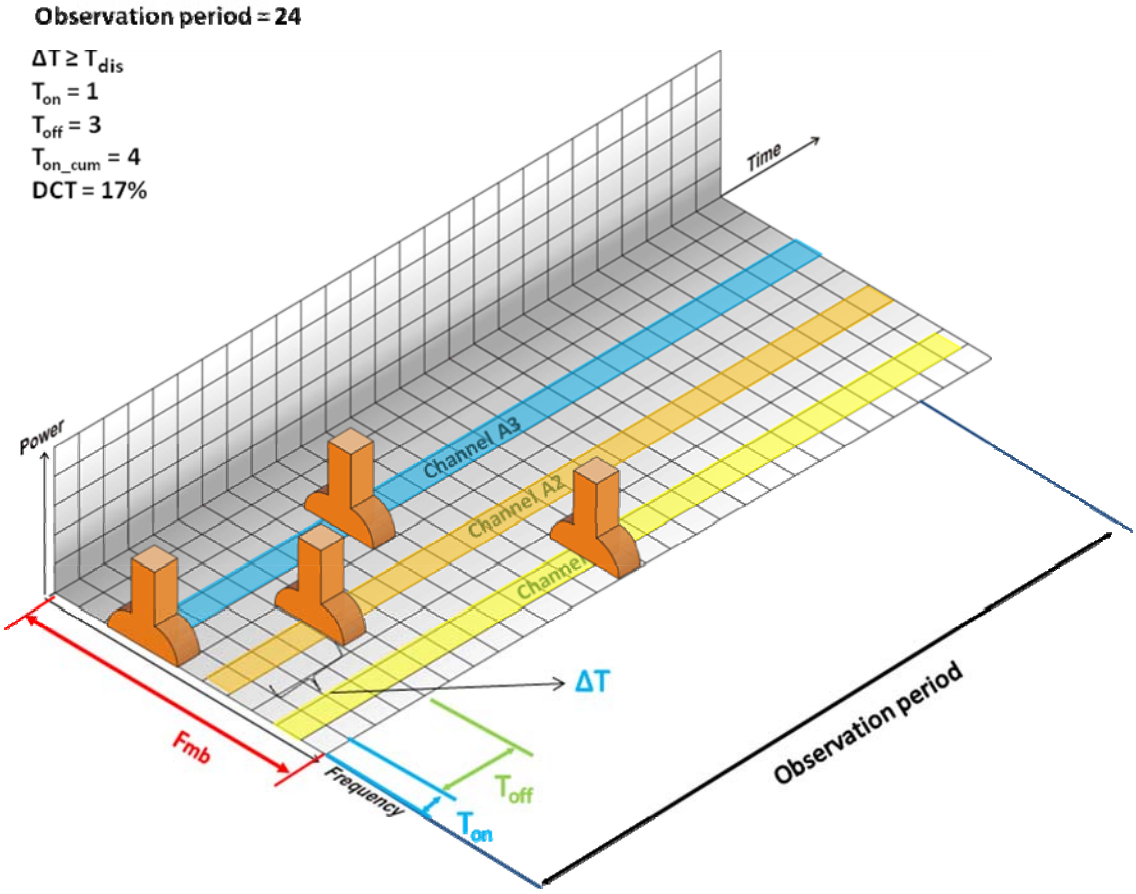
A.2 Multi-channel transmission inside F_{mb} – for signals other than UWB

The following example shows a multi-channel signal where several EUT channels fall within F_{mb}. Figure A.3 and Figure A.4 illustrating the calculation of T_{on} and T_{off} in the cases where the separation between signals is larger or smaller than T_{dis}. The corresponding values for T_{on_cum} and DCT are shown. Note that when the separation is larger than T_{dis} it shall also be larger than T_{off_min}.



NOTE: The case where the signal separation ΔT is larger than T_{dis}.

Figure A.3: Multi-channel transmissions



NOTE: The case where the signal separation ΔT is smaller than T_{dis0}.

Figure A.4: Multi-channel transmission

A.3 Multi-channel transmission inside and outside F_{mb} - for signals other than UWB

In the example in Figure A.5, Transmissions occur over different EUT channels. T_{on} and T_{off} are obtained considering Transmissions on any channel within F_{mb}. T_{on_cum} should be used to determine the DCT.

The separation between the individual transmissions is < T_{dis}, but the separation of the "transmission groups" is > T_{dis}.

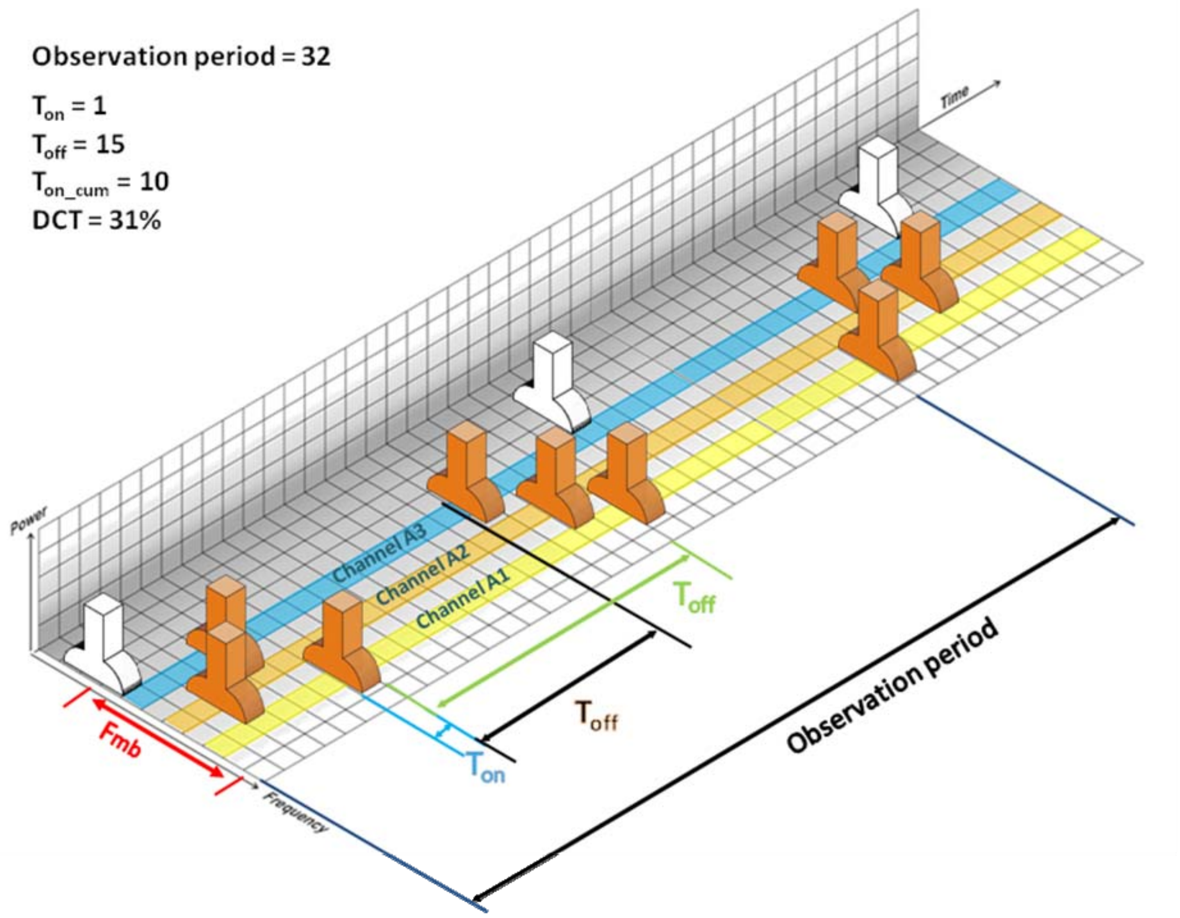


Figure A.5: Multi-channel transmissions

A.4 Single-channel transmission over F_{mb} - UWB signals

In the example in Figure A.6, an Ultra Wideband signal occupying a constant frequency range (larger than F_{mb}) is shown. In the example, T_{on} includes gaps are smaller than T_{dis}.

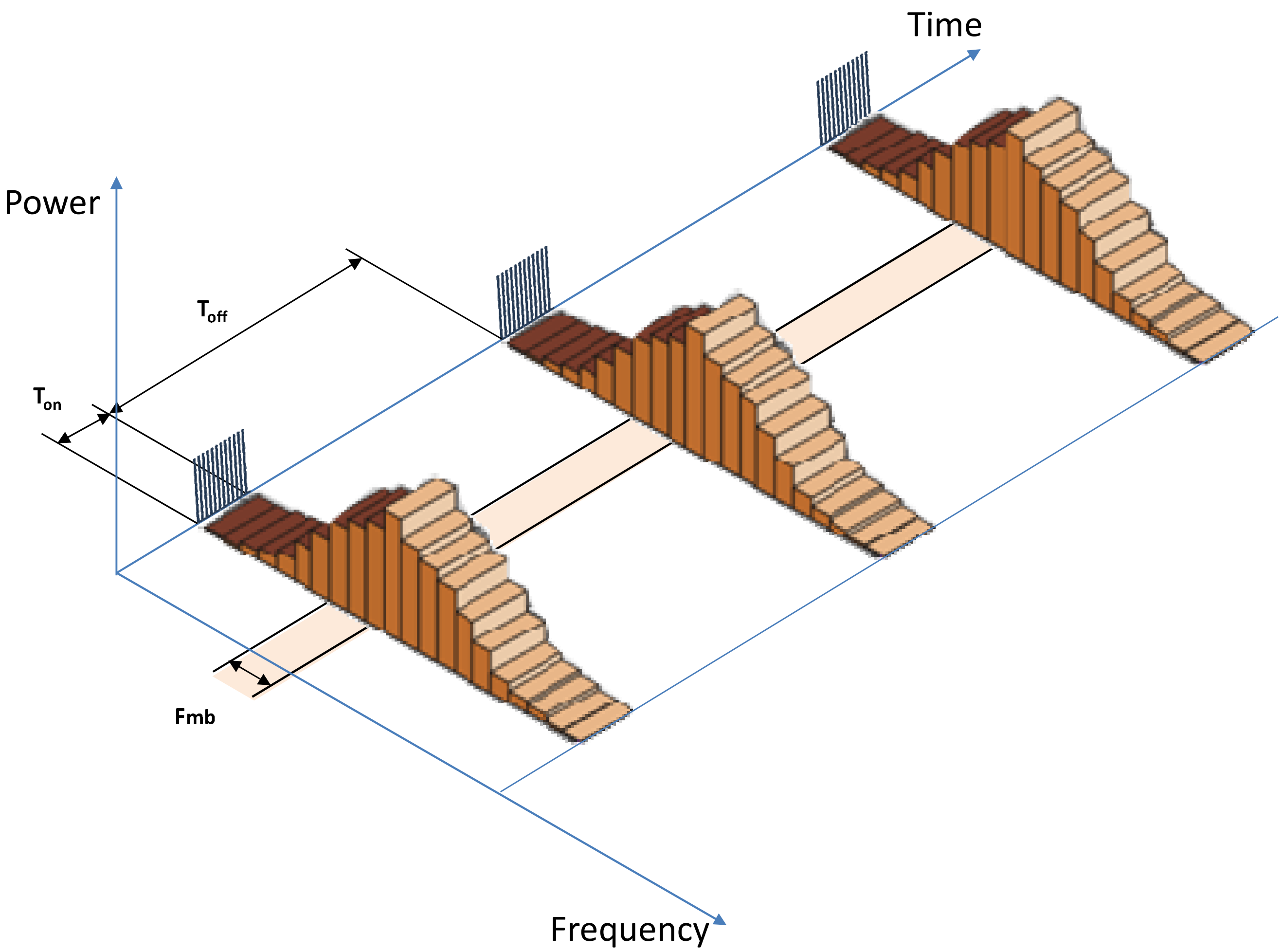


Figure A.6: Single-channel UWB signal

A.5 Multi-channel transmission over F_{mb} - UWB signals

The following example refers to frequency hopping UWB signals. In the example in Figure A.7, F_{mb} spans only a single channel of the UWB signal. Therefore, $T_{on} = T_{on}$, and $T_{off} = T_{off}$.

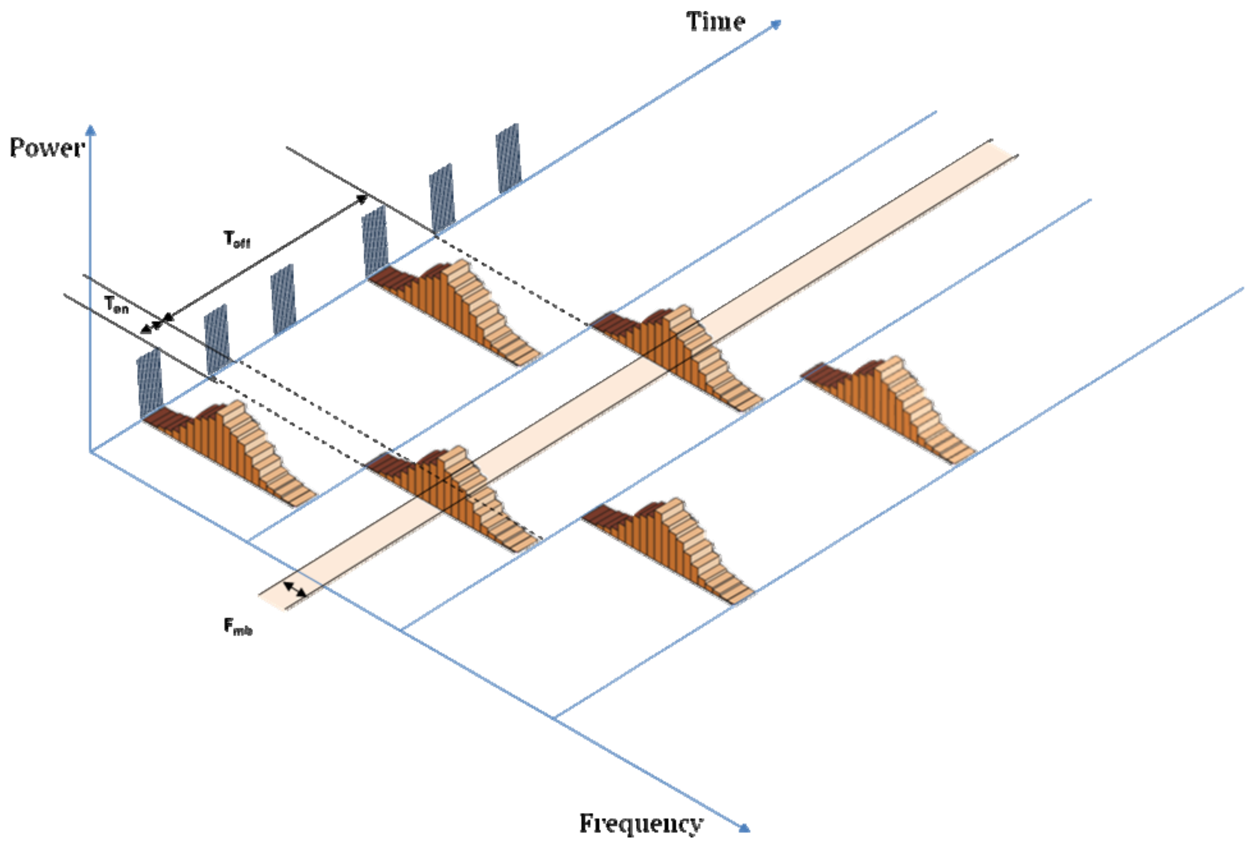
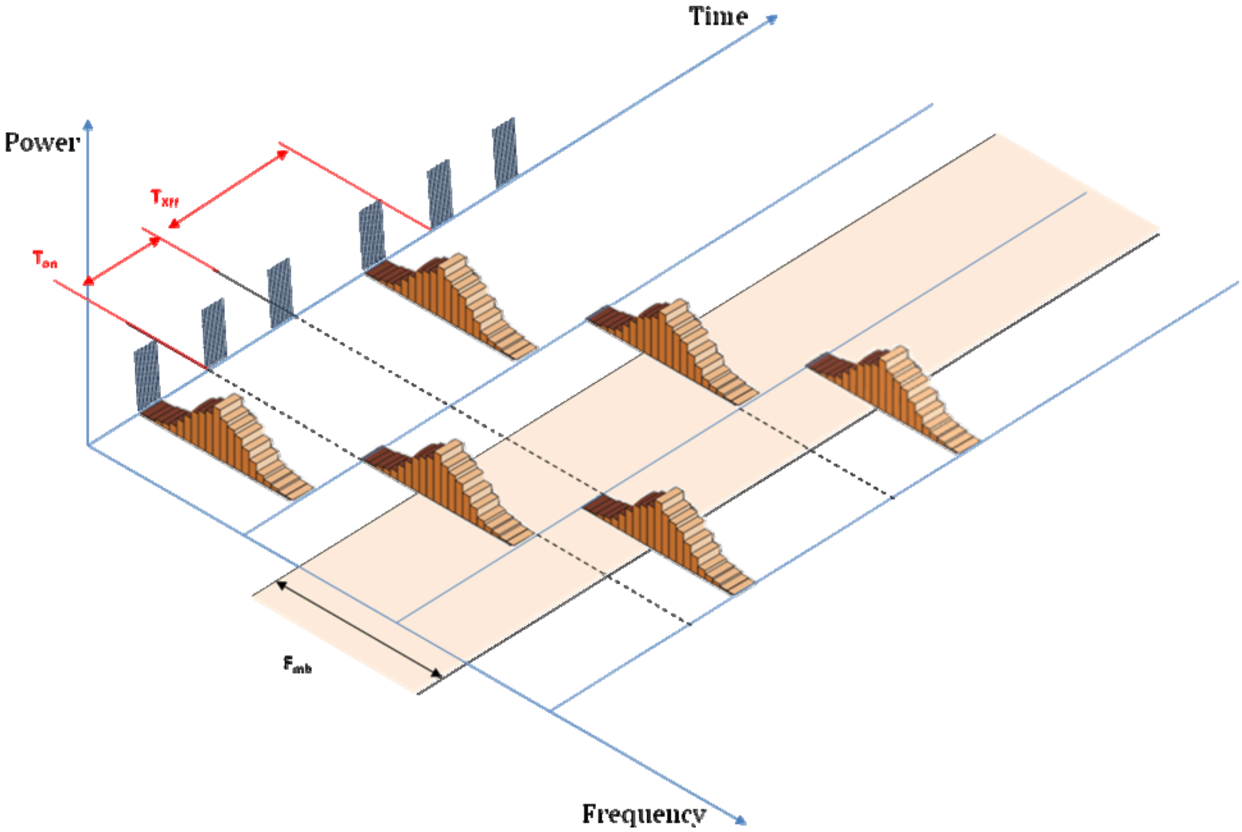


Figure A.7: Multi-channel UWB signal

A.6 Multi-channel transmission - UWB signals

In the final example (Figure A.8) F_{mb} spans several UWB signal channels. T_{on} and T_{off} are calculated accordingly, taking into account the channels contained within F_{mb}. For the calculation of T_{on}, it is assumed that the gaps between second and third Transmissions are smaller than T_{dis}.



NOTE: In this example F_{mb} spans several UWB channels.

Figure A.8: Multi-channel UWB signal

Annex B (informative): Bibliography

ECC Report 94: "Technical requirements for UWB ldc devices to ensure the protection of FWA systems"; Nicosia, December 2006.

ECC Report 170: "Specific UWB applications in the bands 3.4 - 4.8 GHz and 6 - 8.5 GHz location tracking applications for emergency services (LAES), location tracking applications type 2 (LT2) and location tracking and sensor applications for automotive and transportation environments (LTA)"; Tallinn, October, 2011.

Recommendation ITU-R SM.328-11: "Spectra and bandwidth of emissions".

ECC REC (06)01: "Bandwidth measurements using FFT techniques"; Recommendation approved by the "Working Group Frequency Management" (WGFM).

History

Document history		
V1.1.1	September 2013	Publication