ETSI TS 103 366 V1.1.1 (2016-05)

TECHNICAL SPECIFICATION

Short Range Devices (SRD)
using Ultra Wide Band technology (UWB);
Time Domain based Low Duty Cycle Measurement for UWB

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

The present document can be downloaded from:
http://www.etsi.org/standards-search

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or
print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any
existing or perceived difference in contents between such versions and/or in print, the only prevailing document is the
print of the Portable Document Format (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
https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx

If you find errors in the present document, please send your comment to one of the following services:
https://portal.etsi.org/People/CommiteeSupportStaff.aspx

Copyright Notification

ETSI

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 (https://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).

The MATLAB® computations used for the present document are contained in archive ts_103366v010101p0.zip which accompanies the present document.

NOTE: MATLAB® is an example of a suitable product available commercially. This information is given for the convenience of users of the present document and does not constitute an endorsement by ETSI of this product.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

1 Scope

The present document specifies a time domain procedure for Duty Cycle (DC) measurement. The procedure is applicable to all Ultra Wide Band (UWB) signal types, and it is an alternative to the frequency domain procedure for DC measurement described in ETSI TS 102 883 [1]. In general, the DC measurement in the time domain will provide more accurate results compared to the DC measurement in the frequency domain.

2 References

2.1 Normative 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 reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://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.

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

[1] ETSI TS 102 883 (V1.1.1) (08-2012): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD) using Ultra Wide Band (UWB); Measurement Techniques".

[2] IEEE Std 802.15.4™-2015: "IEEE Standard for Low-Rate Wireless Personal Area Networks (WPANs)". IEEE Computer Society Sponsored by the LAN/MAN Standards Committee.

[3] ECC/DEC/(06)04: "The harmonised conditions for devices using Ultra-Wideband (UWB) technology in bands below 10.6 GHz".

[4] ETSI TS 103 060 (V1.1.1) (09-2013): "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".

[5] CEPT ECC Report 094: "Technical requirements for UWB LDC devices to ensure the protection of FWA system", Nicosia, December 2006.

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 reference 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.

Not applicable.

3 Definitions, symbols and abbreviations

3.1 Definitions

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

burst: A emitted signal whose time duration (T_{on}) is not related to its bandwidth, as defined in ECC Report 094 [5].

Duty Cycle: The percentage of the transmitter sum of all burst duration "on" relative to a given period, as defined in ECC Report 094 [5].

pulse: A radiated short transient UWB signal whose time duration is nominally the reciprocal of its UWB - 10 dB bandwidth, as defined in ECC Report 094 [5].

transmission: Sequence of emissions separated by intervals shorter than T_{dis}", as defined in ETSI TS 103 060 [4].

3.2 Symbols

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

B	pulse bandwidth
Bursts	number of bursts during the acquisition time
DC on time (%)	Duty Cycle measurement as a percentage of the acquisition time computed considering all the loaded files
DC on T_{obs} (%)	Duty Cycle measurement as a percentage of the whole observation period
f_c	sampling frequency
$T_{Activeperiod}$	the whole active period of the transmission
T_{dis}	time interval below which interruptions within a transmission are considered part of T_{on} (disregard time), as defined in ETSI TS 103 060 [4]
Time (s)	acquisition time
T_{off}	Defined as "the time interval between two consecutive bursts when the UWB emission is kept idle" in ECC/DEC/(06)04 [3]. Defined as "the time duration between two consecutive transmissions" in ETSI TS 103 060 [4].
T_{offPi}	T_{off} time, measured by the Spectrum Analyzer, while sending Packet$_i$ (see clause 4)
T_{off} (s)	sum of the individual T_{off} times during the acquisition time
T_{obs}	reference interval of time (observation period), as defined in ETSI TS 103 060 [4]
T_{on}	Defined as "the duration of a burst irrespective of the number of pulses contained" in ECC/DEC/(06)04 [3]. Defined as "the duration of a transmission" in ETSI TS 103 060 [4].
$T_{on(bursts)}$	duration of all the bursts
T_{on} (s)	sum of the individual T_{on} times during the acquisition time
T_{onPi}	T_{on} time, measured by the Spectrum Analyzer, while sending Packet$_i$ (see clause 4)
$t_{Packeti}$	sum between the T_{on} time and the T_{off} time while sending Packet$_i$ (see clause 4)
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:

BW   Band Width
CMOS   Complementary metal oxide semi-conductor
DC   Duty Cycle
DUT   Device Under Test
IC   Integrated Circuit
LDC   Low Duty Cycle
MMI   Man Machine Interface
PHR   Physical HeadeR
PPDU   Physical Protocol Data Unit
PRF   Pulse Repetition Frequency
PSDU   Physical Service Data Unit
SHR   Synchronization HeadeR
UWB   Ultra Wide Band

4   Motivation for the Duty Cycle measurement in the time domain

The frequency domain procedure for DC measurement, described in ETSI TS 102 883 [1], relies on the use of a Spectrum Analyzer. The procedure allows calculating the DC through the measurements of the T_{on} and T_{off} parameters according to a predefined disregard time T_{dis} (see Figure C.1 in the present document).

Nevertheless the accuracy of the Spectrum Analyzer is generally not sufficient in order to measure "small values" (typically in the order of magnitude of microseconds) of the T_{on} and T_{off} parameters. This may also be the case whenever "small values" of T_{dis} are considered.

As a consequence, in some cases, the frequency domain procedure for DC measurement could result in overestimating the actual DC.

In order to provide a more accurate measurement of the T_{on} and T_{off} parameters, a time domain procedure for DC measurement is described in the present document. The procedure considers the use of an Oscilloscope, in order to capture the transmitted signal, and a Post Processing Tool (see Annex B), in order to calculate the refined DC measurement.

To better understand the principle of the DC measurement in the time domain, it is possible to consider a generic T_{obs} observation period during which some packets, with different durations, can be sent (see Figure 1):
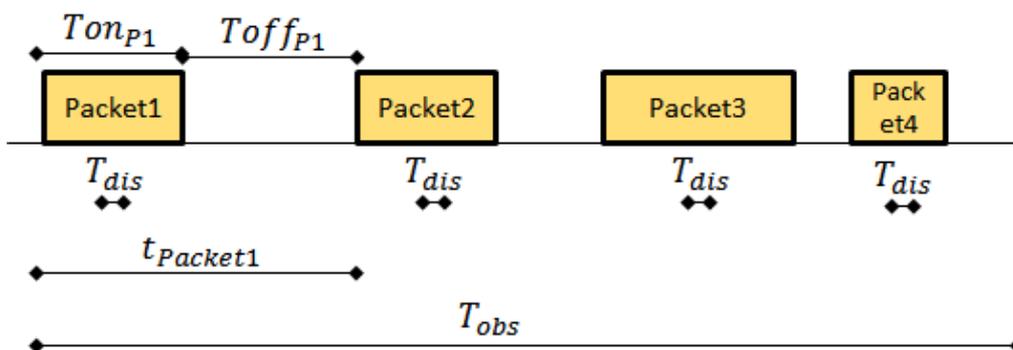

Figure 1: T_{on} and T_{off} measurement by using a Spectrum Analyzer

As illustrated in Figure 1, the Spectrum Analyzer is capable to measure the T_{on} and T_{off} parameters related to the sending of Packet$_i$. In particular, in Figure 1:

- T_{obs}: is the observation period;

- T_{onPi}: is the T_{on} time, measured by the Spectrum Analyzer, while sending Packet$_i$;

- T_{offPi}: is the T_{off} time, measured by the Spectrum Analyzer, while sending Packet$_i$;

- $t_{Packeti}$: is the sum between the T_{on} time and the T_{off} time while sending Packet$_i$;

- T_{dis}: is the disregard time.

On the other hand, the Spectrum Analyzer is generally not capable to measure T_{on} and T_{off} periods occurring between two consecutive bursts related to the sending of Packet$_i$ (see Figure 2).

In fact, by considering the transmission of a single packet, it may be the case that the transmission is composed of several bursts, separated by T_{off} periods greater than T_{dis}, that cannot be measured by the Spectrum Analyzer. Indeed, for small values of T_{dis}, the measurement can only be done in the time domain with an Oscilloscope, which is capable to detect the individual bursts occurring during the observation time T_{obs}.
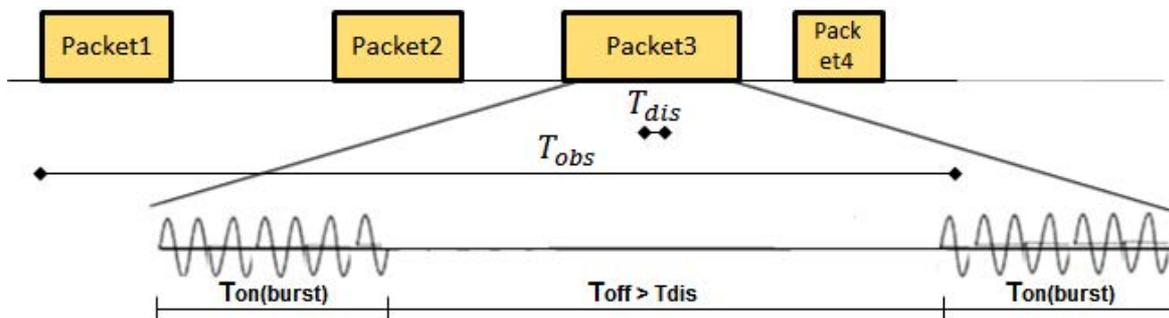

Figure 2: T_{on} and T_{off} measurement by using an Oscilloscope

In the Figure 2 above, for example, during the transmission of Packet$_3$, the Oscilloscope will be able to detect the T_{off} period between the two $T_{on(burst)}$. Since this T_{off} period is greater than T_{dis}, it can be considered as an additional T_{off} period occurring during the observation time T_{obs}. With the use of the Spectrum Analyzer, this T_{off} period would have been considered part of T_{on}.

The principle of the time domain procedure for DC measurement is thus to provide a method for the calculation of the DC based on the fine-grained analysis of the data acquired by the Oscilloscope during the observation time T_{obs}.

5 Measurement procedure for UWB systems

5.1 DUT preparation

No specific DUT preparations are necessary for performing the DC measurement in the time domain.

5.2 General test setup

5.2.0 General

The following tools shall be used to execute the time domain procedure for DC measurement:

- One 50 Ohm cable;

- One Oscilloscope with the following minimum requirements:

    a) Sampling frequency > 2B (where B is the pulse bandwidth): this requirement is enough to detect the envelope of the signal and ensure the correct operation of the measurement procedure.

    b) Input bandwidth > f_{max} (where f_{max} is the highest frequency, i.e. the upper boundary to the operating bandwidth).

- One Personal Computer with installed a Post Processing Tool.

5.2.1   Conducted emission

Figure 3 illustrates the general test setup to execute the time domain procedure for DC measurement in the case of conducted emission.
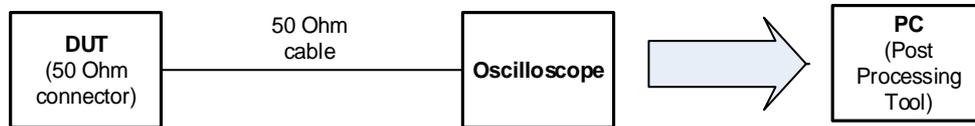

**Figure 3: General test setup to execute the time domain procedure for
DC measurement in the case of conducted emission**

5.2.2   Radiated emission

Figure 4 illustrates the general test setup to execute the time domain procedure for DC measurement in the case of radiated emission.
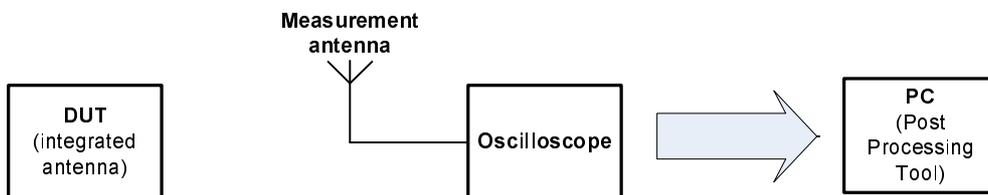

**Figure 4: General test setup to execute the time domain procedure for DC
measurement in the case of radiated emission**

5.3   Time domain procedure for DC measurement

In order to calculate the T_{off} periods, it shall be taken into account the value of the T_{dis} parameter. In fact, given the definition of **Duty Cycle** reminded in paragraph 3.1 (i.e. "the percentage of the transmitter sum of all burst duration "on" relative to a given period"), it is possible to consider as T_{off} periods only the inter-burst intervals greater than T_{dis}.

The Time Domain Procedure for DC Measurement is illustrated in Figure 5. The procedure consists of the following steps:

    1)   Configure the Oscilloscope as follows:

        a)   Set the signal sampling frequency f_c of the Oscilloscope ($f_c > 2B$, where B is the pulse bandwidth).

        b)   Adjust the time division in accordance with the memory storage of the Oscilloscope.

        c)   Adjust the vertical amplitude of the Oscilloscope (set the vertical scale of the oscilloscope to display the entire dynamic range of the waveform).

        d)   Set the trigger time of the Oscilloscope at the time zero $\langle Ttrig = 0 \rangle$.

    2)   Consider the T_{obs} time and check if the Oscilloscope is capable to acquire and store the whole observation period:

        a)   If it is the case, save the signal acquired during the whole T_{obs} time, and go to step 3.

        b)   Otherwise:

            i)   Save the signal that the Oscilloscope can acquire and store.

            ii)   Record the time $\langle Tspan \rangle$ of the acquired signal.

iii)   Set the new trigger time as: $Ttrig = Ttrig + Tspan$.

iv)   Check if the new trigger time is less or equal than the T_{obs} time:

1)   If it is the case, repeat the steps from i to iv.

2)   Otherwise, go to step 3 (post processing of all acquired and stored signal during T_{obs}).

3)   Load in the Post Processing Tool (see Annex <B> to the present document) all the points acquired by the Oscilloscope and relative to T_{obs}.

4)   Inside T_{obs}, identify only the bursts. In accordance with the definition of burst in ECC Report 094 [5] (i.e. "an emitted signal whose time duration (T_{on}) is not related to its bandwidth"), and the definition of disregard time T_{dis} in ETSI TS 103 060 [4] (i.e. "the time interval below which interruptions within a transmission are considered part of T_{on}"), consider each burst as T_{on} time.

5)   Calculate the sum of all $T_{on(bursts)}$ (sum all T_{on} identified in step 4) inside T_{obs}: $\sum T_{on(bursts)}^{Tobs}$.

6)   Calculate the DC measurement in T_{obs} as a percentage with the following formula:
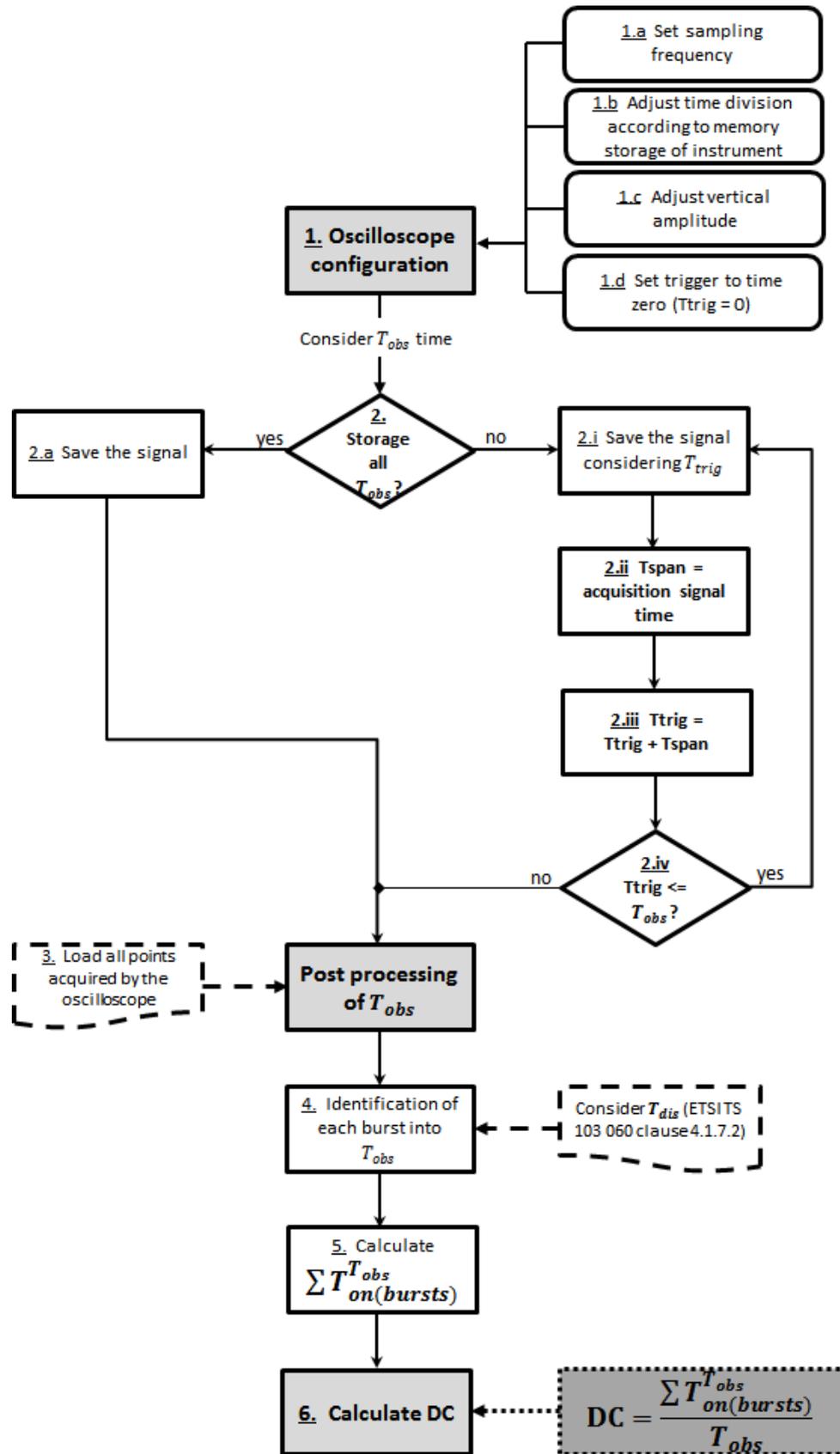
$$DC = \frac{\sum T_{on(bursts)}^{Tobs}}{T_{obs}}$$

Figure 5: Flow chart of time domain procedure for DC measurement by using an Oscilloscope

Annex A (informative):
Example

A.1   Introduction

The present annex describes an example of applying to a Device Under Test (DUT) both the frequency domain procedure for DC measurement (see clause A.2) and the time domain procedure for DC measurement (see clause A.3).

The example considers a DUT utilizing a pulse UWB technology for short range applications. The DUT used in the example embeds the Decawave® DW1000 chip, see note (http://www.decawave.com), a fully integrated, low power, single chip CMOS radio transceiver IC compliant with the IEEE 802.15.4-2015 [2] UWB standard.

NOTE: Decawave® DW1000 is the trade name of a product supplied by Decawave®. This information is given for the convenience of users of the present document and does not constitute an endorsement by ETSI of the product named. Equivalent products may be used if they can be shown to lead to the same results.

The transmitter configuration used in the example has the following main properties:

- 110 Kbps of data rate;

- 1 024 symbols of preamble;

- 64 MHz of PRF (preamble code 9);

- 3 993,6 MHz of centre frequency with 499,2 MHz of bandwidth.

In the example of transmission, two bytes of payload (lasting around 1,8 ms) are sent periodically every 34,2 ms.

Since the packets sent have all the same length and format, in order to compute the DC, it is enough to consider a T_{obs} time including the transmission of a single packet (see clause A.2). The DC will always be the same also by considering the transmission of more than one packet.

In the example of transmission, the disregard time T_{dis} has a predefined value of 2 µs.
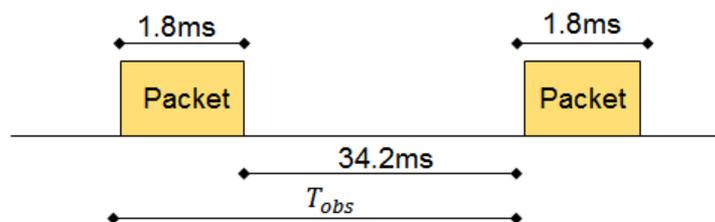

Figure A.1: Example of transmission

A.2   DC measurement in the frequency domain

By using the Spectrum Analyzer (see clause A.3), it is possible to display the "train" of packets sent during the example of transmission:
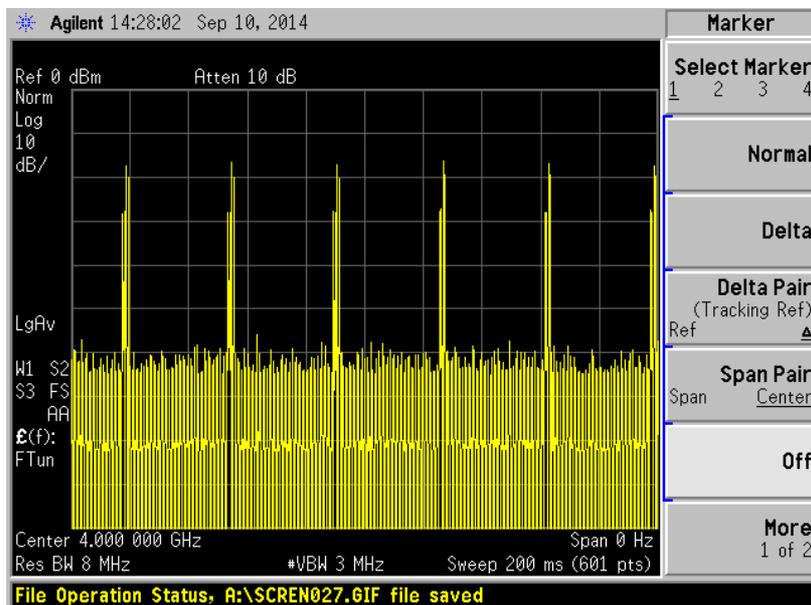

Figure A.2: Train of packets sent during the example of transmission (using the DW1000 chip)

By zooming-in a transmission (see clause A.3), it is possible to see the whole "active period" of the transmission, but it is not possible to measure the T_{on} and T_{off} parameters inside it. Indeed, the Spectrum Analyzer is capable to measure the T_{on} and T_{off} parameters only in case the T_{dis} parameter is also measurable with the same tool.
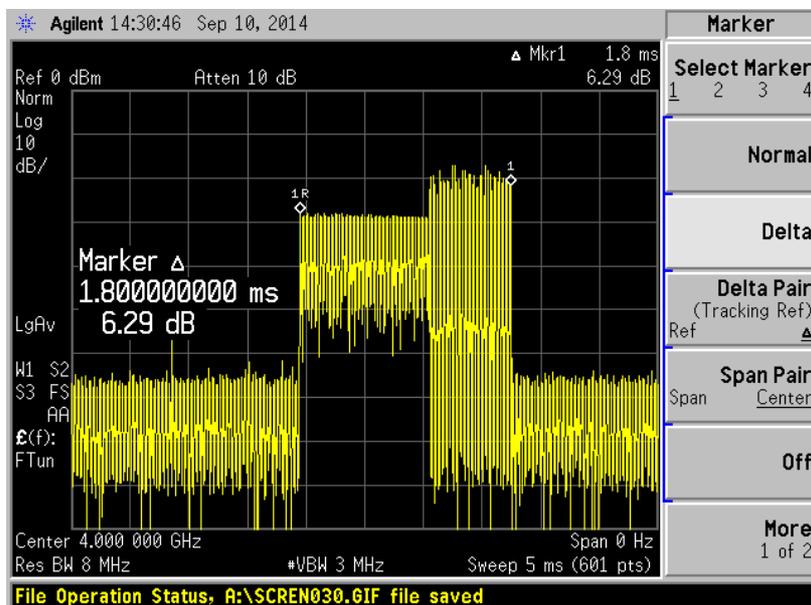

Figure A.3: T_{on} measurement with the Spectrum Analyzer

In the example of transmission, the DC calculation by using the Spectrum Analyzer considers the whole packet as T_{on}, see Figure A.4.
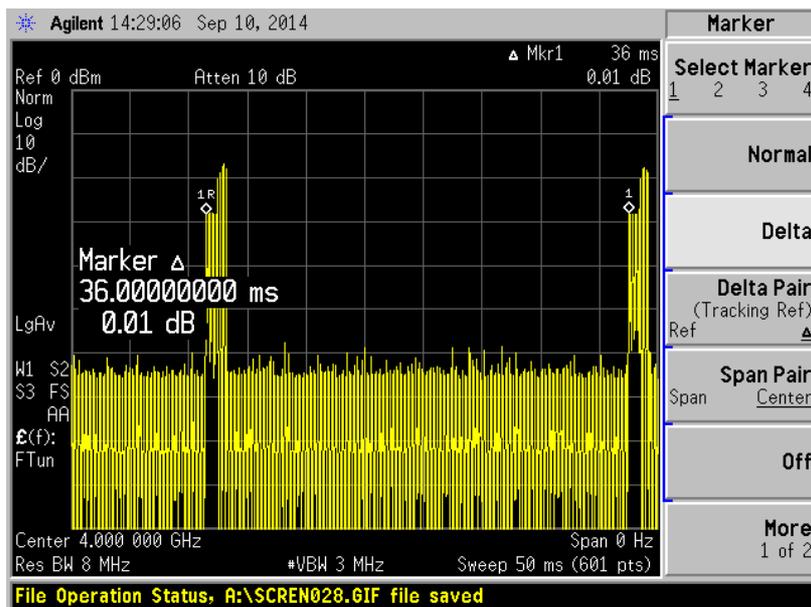
Figure A.4: T_{obs} time measurement with the Spectrum Analyzer

The DC calculated in the frequency domain will be the following:

$$DC(\%) = \frac{t_{Activeperiod}}{T_{obs}} = \frac{1.8ms}{36ms} = 5\%$$

A.3   DC measurement in the time domain

For the DC measurement in the time domain, the reader can refer to the procedure illustrated in Figure 5.

The example of transmission considers sending packets compliant with the IEEE 802.15.4-2015 [2] UWB standard (see Figure A.5).
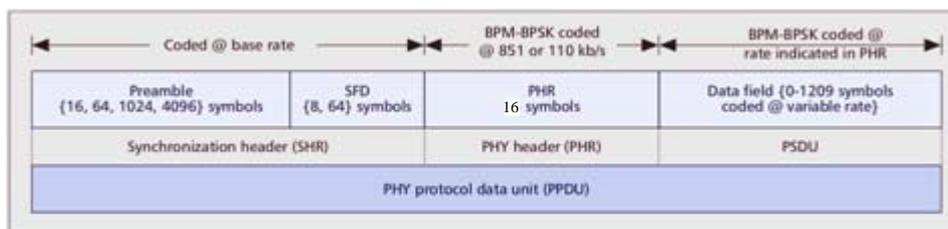

Figure A.5: Packet format defined in the IEEE 802.15.4-2015 [2] UWB standard

The PPDU (Physical Protocol Data Unit, i.e. a transmitted packet) is composed of three fields: SHR (Synchronization HeadeR), PHR (Physical HeadeR), and PSDU (Physical Service Data Unit).

The SHR can be of different lengths (for details, please refer to the IEEE 802.15.4-2015 [2] UWB standard), and it is only composed of pulses.

Instead, the transmission of the PHR and of the PSDU fields uses a different modulation scheme with respect to the one used for the transmission of the SHR field: PHR and PSDU are sent by using *bursts*, which length is given by the product of the duration of a single pulse by the length of a burst code. The length of a burst code can be at most 127 according to the IEEE 802.15.4-2015 [2] UWB standard.

Therefore, the SHR field is composed only by pulses, and each pulse duration is given by *1 / BW* where *BW is* the signal bandwidth, whilst the PHR and the PSDU fields are composed only by bursts, and each burst duration is given by *1 / BW × 127*.

Figure A.6 below shows the "active period" of a packet transmission captured by the Oscilloscope.

Figure A.6: "Active period" of a packet transmission captured by the Oscilloscope

Note that the SHR field of a transmitted packet corresponds to a much more "dense" signal with respect to the one observable during the transmission of the remaining part of the packet itself (i.e. the PHR and the PSDU fields).

By zooming-in the first part of the signal, it is possible to see the presence of only individual pulses lasting around two nanoseconds each (see Figure A.7).
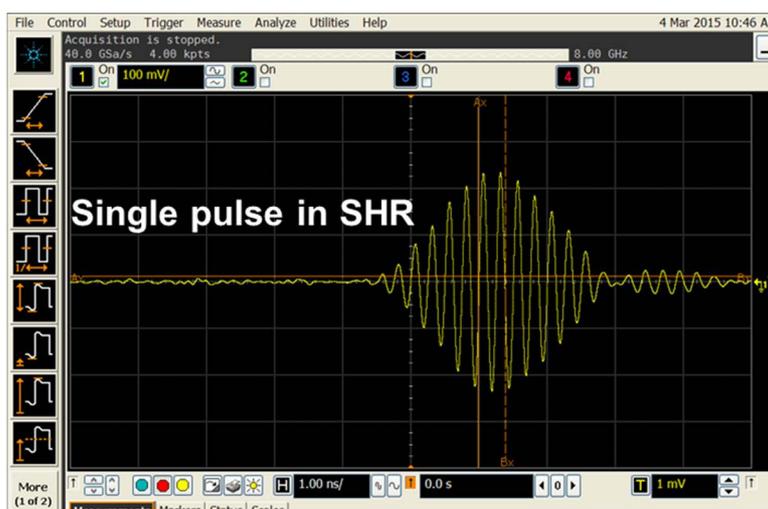

Figure A.7: Single pulse in the transmission of the SHR field of a packet

The intervals between the pulses of the SHR field of a transmitted packet are not periodic but, in any case, their duration is in the order of magnitude of nanoseconds (see Figure A.8).
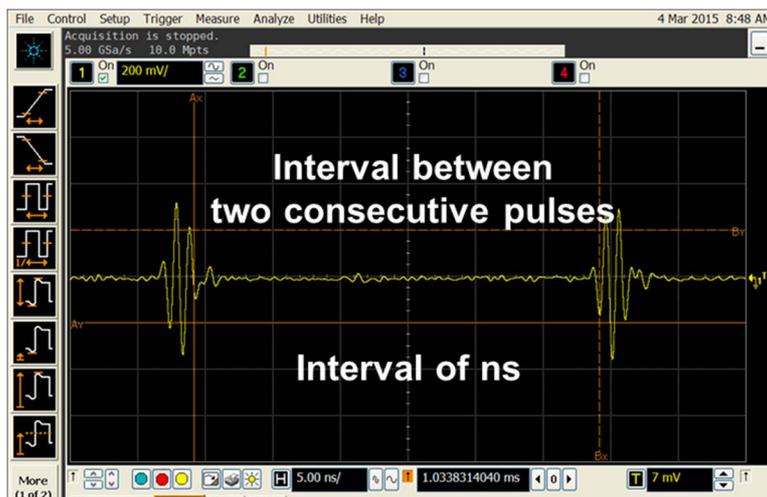
**Figure A.8: Interval between two consecutive pulses
in the transmission of the SHR field of a packet**

On the other hand, the PHR and the PSDU fields of a transmitted packet are composed only of bursts. Each burst duration is the product of the pulse duration by the burst code. In the example, the pulse duration is around 2 ns and the burst code is 127 (maximum value admitted by the IEEE 802.15.4-2015 [2] UWB standard). Thus, the burst duration is around 254 ns (see Figure A.9).
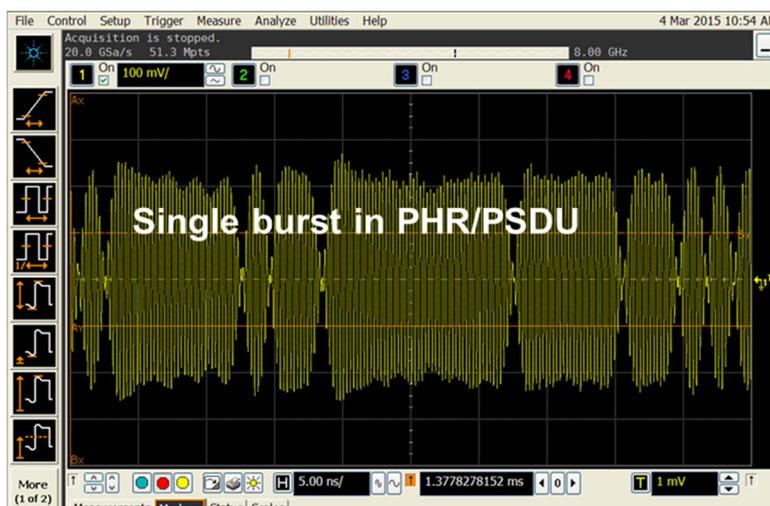

**Figure A.9: Single burst duration in the transmission of the
PHR field (and of the PSDU field) of a packet**

The interval between two consecutive bursts is not periodic, and it is a duration that can be considered as part of the T_{off} time (see Figure A.10).

Indeed, by definition in ECC/DEC/(06)04 [3], it is considered T_{off} time *the time interval between two consecutive bursts when the UWB emission is kept idle*, and a burst is *an emitted signal whose time duration is not related to its bandwidth.*

Therefore, in the example, since the T_{off} periods between two consecutive bursts are in the order of magnitude of several microseconds, and considering that it is verified the constraint $T_{off} > T_{dis}$ ($T_{dis} =$ disregard time $= 2$ µs), the actual T_{on} period to be considered, while transmitting the PHR and the PSDU fields of a packet, is composed only by the duration of all the bursts (i.e. it is the sum of $T_{on(bursts)}$).
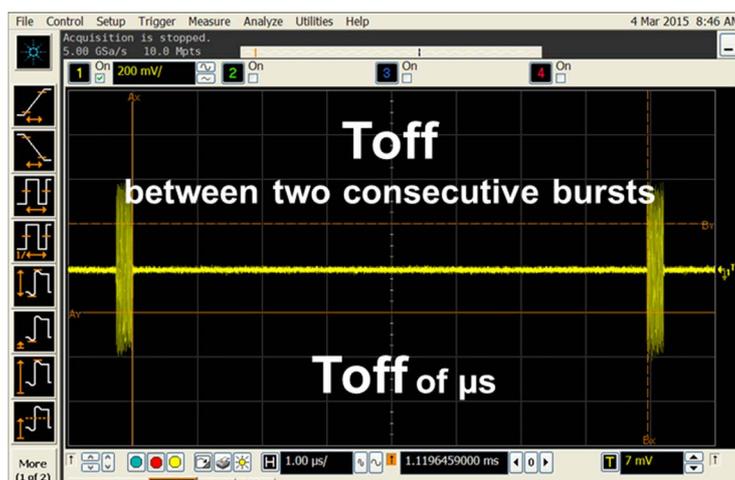
**FigureA.10: T_{off} period between two consecutive bursts in the transmission of the
PHR field (and of the PSDU field) of a packet**

To summarize the example described in the present annex, the time required to transmit the SHR field of a packet should be considered as T_{on} (i.e. as one single burst): in fact, during this time, there is no transmitted signal whose duration is not related to the bandwidth (definition of a burst) but only pulses whose duration is nominally the reciprocal of the bandwidth (definition of a pulse). Instead, the time required to transmit the PHR and the PSDU fields is composed of both T_{on} periods (whenever there are bursts) and T_{off} periods (intervals between two consecutive bursts greater than T_{dis}). This is illustrated graphically in Figure A.11 below.
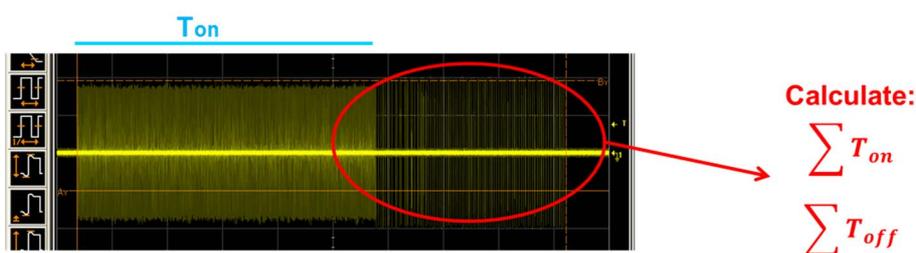

Figure A.11: Fine-grained analysis of the transmission of a packet

The following values have been considered:

- T_{obs} = 1,8 ms + 34,2 ms = 36 ms;

- Sum of T_{on} = 1,19 ms.

In conclusion, the DC measurement in the time domain will be calculated as follows:

$$DC(\%) = \frac{\sum T_{on(bursts)}^{Tobs}}{T_{obs}} = 3,3\%$$

Note that the DC measurement in the time domain (3,3 %) is more accurate than the one in the frequency domain (5 %) since, in the time domain, it is possible to appreciate the T_{on} and the T_{off} periods occurring between bursts.

Annex B (normative):
Use of the MATLAB® Post Processing Tool to compute the DC

The present annex describes the procedure that computes the DC measurement by using a Post Processing Tool implemented in MATLAB®. It is worthwhile noting that it is possible to execute the same procedure by using any other tool having analogous mathematical capabilities.

The steps executed by the MATLAB Post Processing Tool, detailed below, are in accordance with the procedure for the DC measurement in the time domain shown in Figure 5.

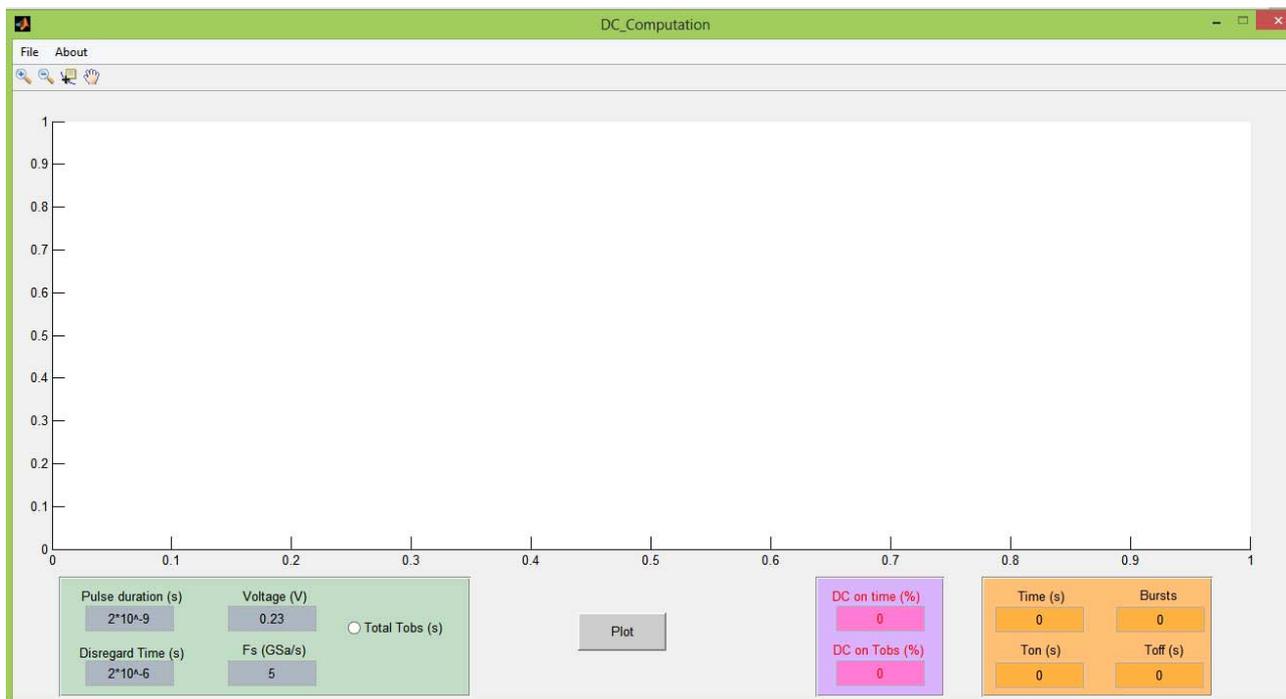Figure B.1 illustrates the MMI of the MATLAB Post Processing Tool.

Figure B.1: MMI of the MATLAB Post Processing Tool

The following parameters shall be set by the user:

- The Pulse *duration*;

- The Disregard time;

- The Sampling frequency;

- The *Mean voltage of the signal*.

The values of these parameters shall be set by reading on the Oscilloscope the following data:

- Pulse duration in the SHR field of the transmitted packets;

- Sampling frequency with which the Oscilloscope performs the acquisition;

- Mean voltage of the signal. This value is useful to detect the signal to noise ratio. In the MATLAB code, it is taken the 30 % of this value to separate signal from noise.

The Disregard time value shall also be specified. Remembering that the Disregard time is defined as "the time interval below which interrupts within a transmission are considered part on T_{on}", this parameter shall be declared by the device manufacturer.

NOTE: In the MMI, the 'Total T_{obs} (s)' check-box is to be checked if the file(s) loaded in the tool do not cover the whole observation period.

Below the reader will find two examples explaining when the 'Total T_{obs} (s)' check-box shall be checked by the user.

EXAMPLE A:

The 'Total T_{obs}(s)' check-box shall not be checked: this case occurs when the tool can process all the files acquired from the oscilloscope at once.

Once these files are loaded by the user in the tool (through the 'File' menu), the following parameters shall be set by the user in the MMI (see Figure B.1):

- The *Pulse duration* (2 ns in the example);

- The *Disregard time* (2 µs in the example);

- The *Sampling frequency* (5 GSa/s in the example); and

- The *Mean voltage of the signal* (0,23 V in the example).

By clicking the 'Plot' button, the DC calculation is executed.

The MATLAB code performs the following steps:

1)   Load the selected file(s);

2)   Find the sampling time, and transform each pulse and burst in "high level". Any other point is mapped as 'low level';

3)   Find all $T_{on(burst)}$ in the acquisition time considering the value of the Disregard time parameter, see Figures B.2 and B.3.
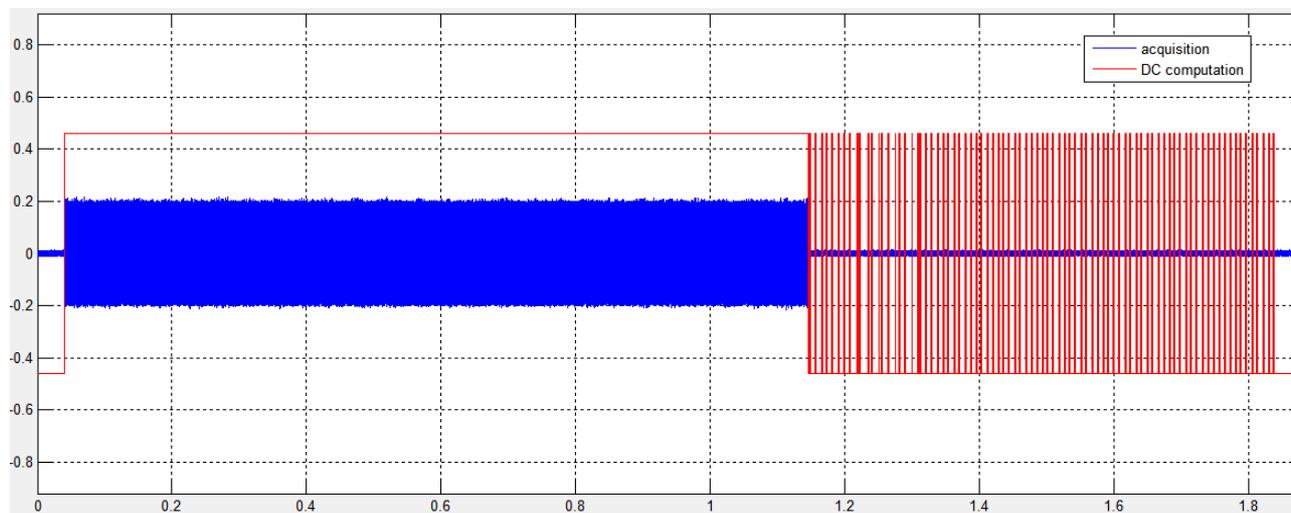

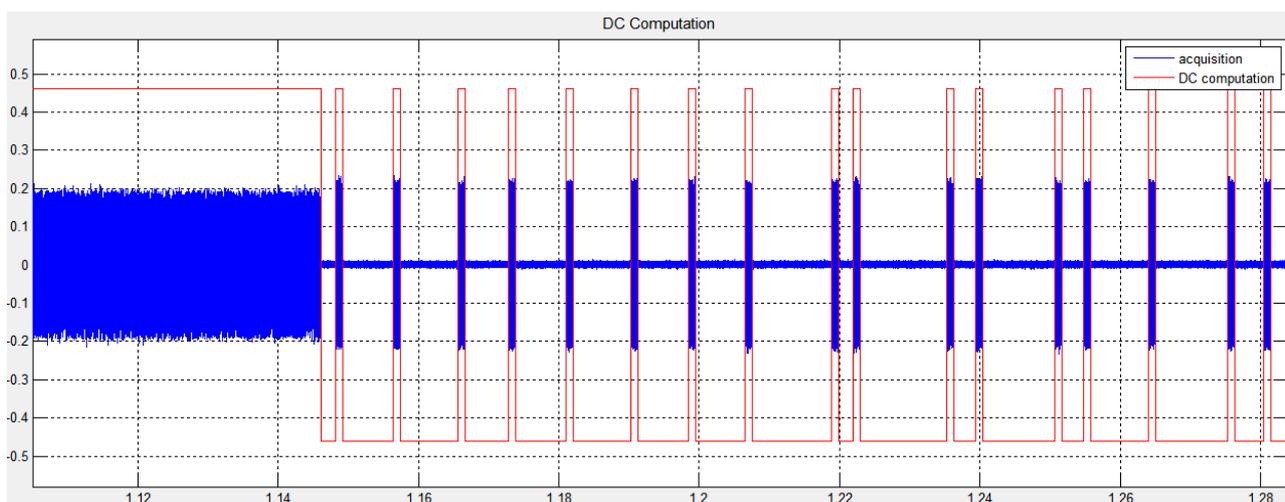**Figure B.2: $T_{on(burst)}$ considering the value of the Disregard time parameter**

Figure B.3: Zoom-in on T_{on} and T_{off} times in the PHR and PSDU fields of the transmitted packet

1) Compute the sum of all $T_{on(burst)}$ within T_{obs}:

$$\sum T_{on(bursts)}^{Tobs} ;$$

2) Compute DC as follows:

$$DC(\%) = \frac{\sum T_{on(bursts)}^{Tobs}}{T_{obs}}$$

The results of the elaboration by the tool are displayed in the bottom right-hand side of the MMI (see Figure B.4):

- '*DC on time (%)*': Duty Cycle measurement as a percentage of the acquisition time computed considering all the loaded files;

- '*DC on T_{obs} (%)*': Duty Cycle measurement as a percentage of the whole observation period;

- '*Time (s)*': acquisition time;

- '*Bursts*': number of bursts during the acquisition time;

- '*T_{on} (s)*': sum of the individual T_{on} times during the acquisition time;

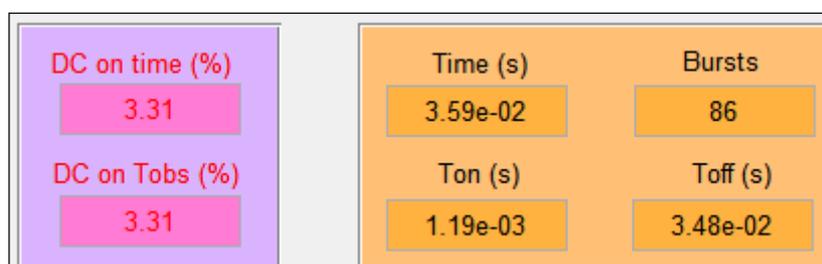- '*T_{off} (s)*': sum of the individual T_{off} times during the acquisition time.

**Figure B.4: Results displayed by the MATLAB Post Processing Tool
when 'Total T_{obs} (s)' is not checked**

NOTE: In this case, 'DC on time (%)' and 'DC on T_{obs} (%)' are the same, because the acquisition time and the whole observation period are equal.

EXAMPLE B:

The 'Total T$_{obs}$ (s)' check-box shall be checked: this case occurs when the tool cannot process all the files acquired from the oscilloscope at once, i.e. the tool does not have enough computational resources to process all of them in a single iteration.

In this case, the user shall follow the following steps:

1)   Load a smaller number of files;

2)   Check the 'Total T$_{obs}$ (s)' check-box;

3)   In the text box shown below the 'Total T$_{obs}$ (s)' check-box, insert the whole observation period on which the Duty Cycle calculation shall be performed;

4)   Click on the 'Plot' button to execute the DC measurement calculation regarding the loaded files.

The steps 1 to 4 above shall be repeated by the user in successive iterations, until all the files acquired from the oscilloscope have been loaded and processed by the tool. At the end of each iteration, the user shall restart the tool.

Note that, at the end of each iteration:

- The calculated 'DC on Time (%)' will correspond to the percentage of the duty cycle with respect to the acquisition time of all the loaded files;

- The calculated 'DC on T$_{obs}$ (%)' will correspond to the percentage of the duty cycle with respect to the whole observation period.

Eventually, the user can compute the total duty cycle with respect to the whole observation period by adding all the 'DC on T$_{obs}$ (%)' computed by the tool at each iteration.

For example, consider the following assumptions:

- The whole observation period is 50 ms;

- The data acquired by the oscilloscope during the whole observation period are saved in five different files, named 'UWB_part1', 'UWB_part2', … , 'UWB_part5, each file corresponding to 10 ms of acquisition;

- The tool can not process all the files in a single iteration;

- Two iterations are required:

    - The first one to load and process the files called 'UWB_part1', 'UWB_part2' and 'UWB_part3',

    - The second one to load and process the files called 'UWB_part4', and 'UWB_part5'.

In the first iteration, the user loads the files called 'UWB_part1', 'UWB_part2' and 'UWB_part3' in the tool (see Figure B.5).
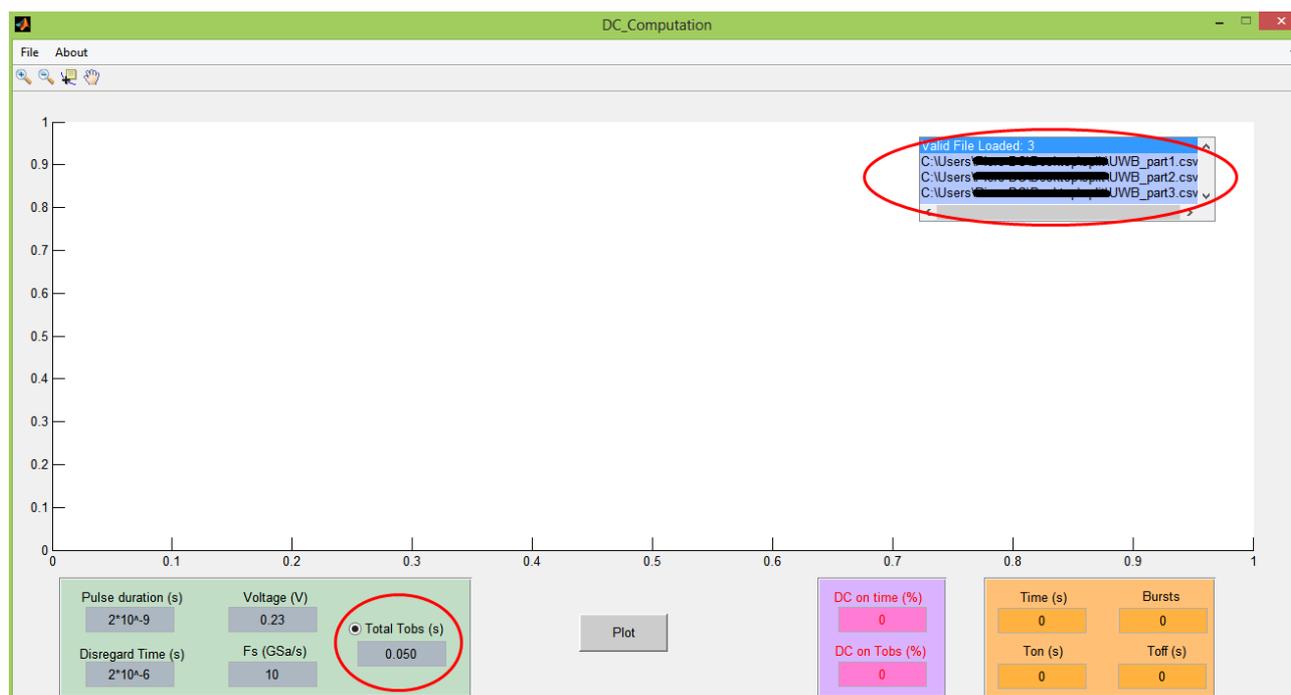
Figure B.5: Files loaded in the first iteration

Note that the user shall check the 'Total T_{obs} (s)' check-box, and shall enter in the field below the 'Total T_{obs} (s)' check-box the value 0,050 (i.e. 50 ms).

By clicking the 'Plot' button, the following results are displayed at the end of the first iteration, see Figure B.6:

Figure B.6: Results displayed at the and of the first iteration

In the second iteration, the user loads the files called 'UWB_part4' and 'UWB_part5' in the tool (see Figure B.7).
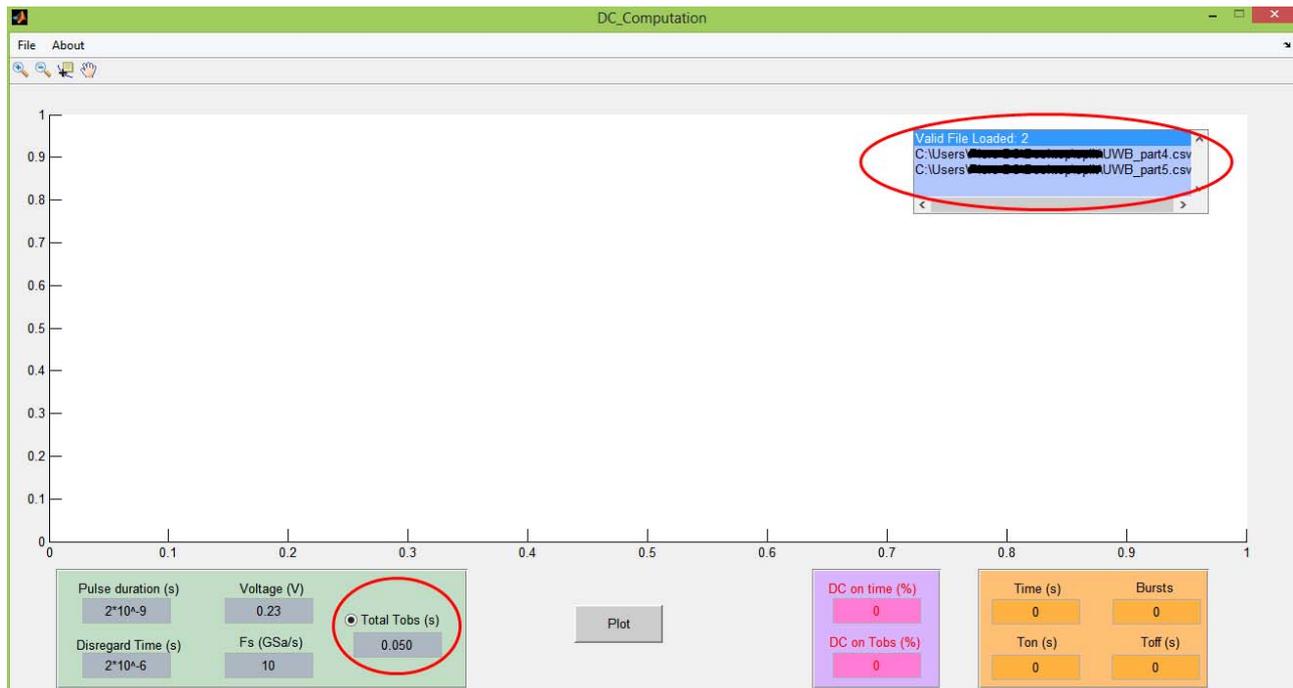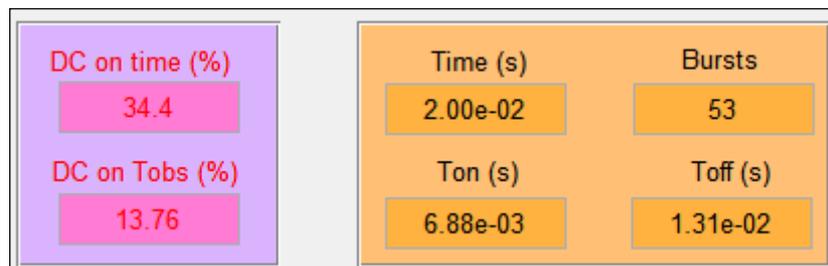
Figure B.7: Files loaded in the second iteration

Also in this case, note that the user shall check the 'Total T_{obs} (s)' check-box, and shall enter in the field below the 'Total T_{obs} (s)' check-box the value 0,050 (i.e. 50 ms).

By clicking the 'Plot' button, the following results are displayed at the end of the second iteration, see Figure B.8:

FigureB.8: Results displayed at the and of the second iteration

The total Duty Cycle measurement as a percentage of the whole observation period will be the sum of the 'DC on T_{obs} (%)' values computed by the tool at each iteration, that is:

$$\text{'DC on } T_{obs} \text{ (%)'} = 24{,}82 + 13{,}76 = 38{,}58$$

Annex C (informative): Recall: Procedure for DC measurement in the frequency domain

For completeness of the present document, the procedure for DC measurement in the frequency domain by using a Spectrum Analyzer is recalled in Figure C.1 below.
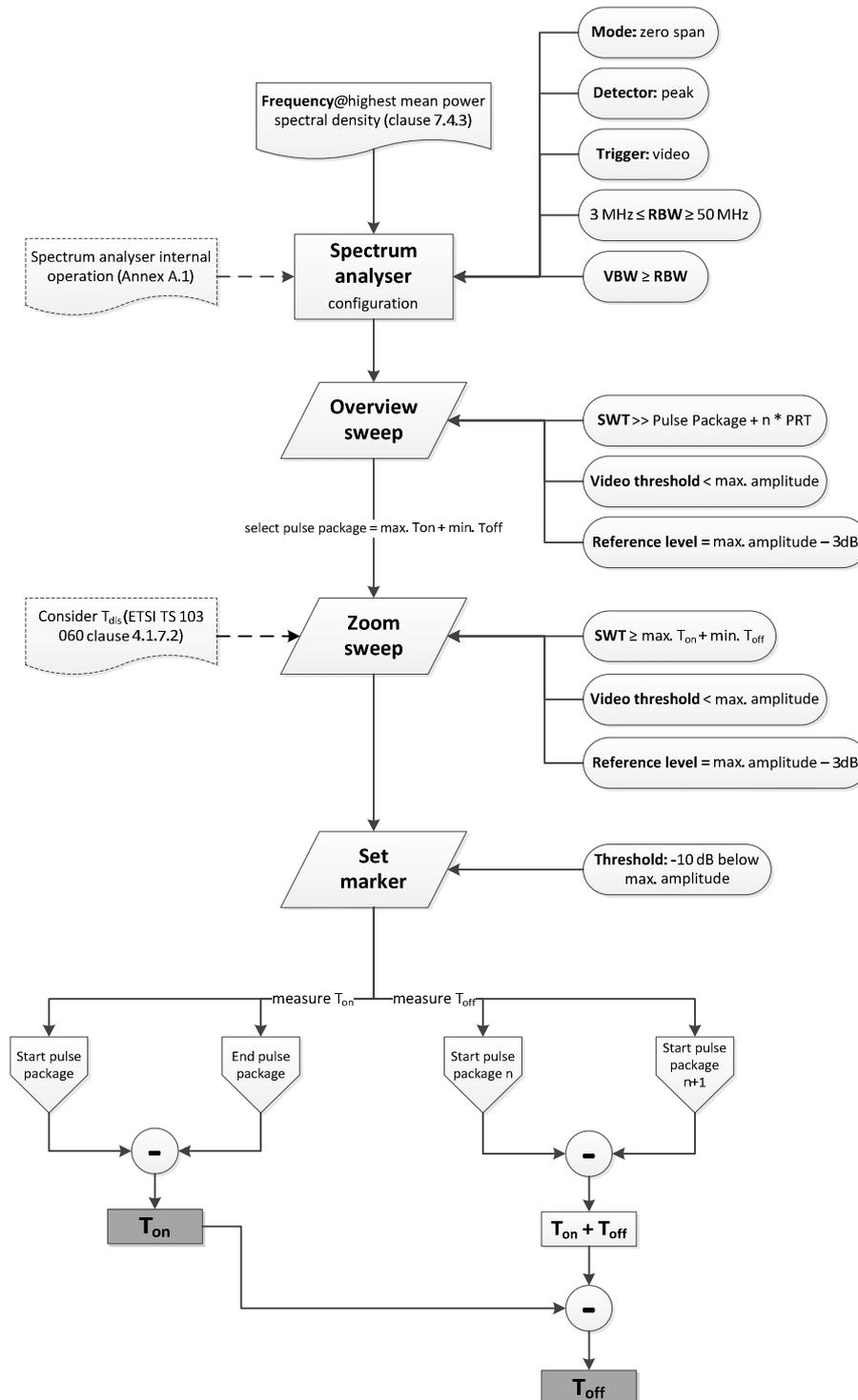

Figure C.1: Flow chart of the frequency domain procedure for DC measurement by using a Spectrum Analyzer

Annex D (informative):
Bibliography

Recommendation ITU-R SM.1538: "Technical and operating parameters and spectrum requirements for short-range radio-communication devices".

DecaWave DW1000 User Manual.

> NOTE: Available from www.decawave.com.

www.etsi.org.

CEPT ECC/DEC/(06)12 amended of 31 October 2008 on the harmonised conditions for devices using Ultra-Wideband (UWB) technology with Low Duty Cycle (LDC) in the frequency band 3.4-4.8 GHz.

CEPT ECC/DEC/(06)12 of 1 December 2006 on the harmonised conditions for devices using Ultra-Wideband (UWB) technology with Low Duty Cycle (LDC) in the frequency band 3.4-4.8 GHz.

History

Document history		
V1.1.1	May 2016	Publication