CT23 Container Tag User Manual

Version 5 – June 2007

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Purpose

The purpose of this manual is to describe the operation of the Container Tag CT23 designed to be used in an asset tracking application. The tag features reflect the application requirements for beaconing, excitation and motion sensor integration. For implementation description and detailed functionality please refer to “CT23 Functional Specification”.

1.2 Definitions

Excitation Mode – tag transmits its id together with the exciter id when it is woken up by a valid LF field.
Motion Mode – tag transmits its id when it is moved.
Beacon Mode – tag transmits its ID at pre-determined time intervals.

2 APPLICATION DESCRIPTION

CT23 Container tag is designed for maximum versatility. It can transmit when woken up by an Exciter with a valid ID (Excitation Mode) or it can transmit when moved (Motion Mode). CT23 can also work in a configurable Beacon Mode. The Beacon Mode can be set to work indefinitely, time out after a certain amount of time, turn on and off when entering a field with a specific exciter ID or motion.

3 CT23 OPERATION DESCRIPTION

3.1 CT23 General Functions

CT23 tag can be set to work in one or any combination of the following modes:

Beacon Mode – can be enabled or disabled independently from other modes. The programmable parameters for this mode are:
The time interval (minutes and seconds) between two transmissions;
The number of messages in a beacon transmission ;
Pattern for randomizing messages in a beacon transmission;
Means of turning the Beacon Mode on and off in the field.

Excitation Mode – can be enabled or disabled independently from other modes. The programmable parameters for this mode are:
The number of messages in an excitation transmission;
Pattern for randomizing messages in an excitation transmission;
Excitation Mode can be enabled permanently or only when tag is moving.

Motion Mode – can be enabled or disabled independently from other modes. The programmable parameters for this mode are:
The number of messages in the motion activated transmission;
The motion extension in seconds: duration of stay in Motion Mode after motion stops;
Pattern for randomizing messages in a motion transmission;

3.2 CT23 Detailed Description of the Operation Modes

All modes can be enabled individually and work independently or in any combination. The transmitted UHF message format is the same S23 format for all modes, only the flags fields' content changes according to the mode.

3.2.1 Excitation Mode.

Indicated by the contents of the Control byte.
When enabled (WEM=Y), the tag transmits WEP number of messages each time it enters a valid S95, S21 or S23 fields. For a field to be valid, it has to have a special pattern called exciter ID. If different exciter ID fields overlap and a tag moves from one exciter to another it will transmit WEP number of messages each time it "sees" new exciter ID. In situations where we want to register a tag that leaves and re-enters the field with the same exciter ID, the tag has to be out of the field for more than 1s (black out time).
If a tag enters LF field but the valid excitation pattern can not be recognized (i.e. overlapping fields or interference), the tag does not transmit anything.
When WSE=Y, the Excitation Mode is only active if the tag is in motion. This helps to save battery power.

3.2.2 Motion Mode

Indicated by the contents of the transmitted Control byte.
When enabled (WMM=Y), the tag transmits WMP number of messages when it is shaken or moved.
The tag has to remain motionless for WME seconds before it can recognize the next act of motion and transmit. When WME=0, the motion black out time is 1s. By setting WME to a larger number, we can avoid multiple motion transmissions if the tag's moving pattern includes frequent starts and stops.

3.2.3 Beacon Mode.

Indicated by the contents of the transmitted Control byte. In Beacon Mode the transmissions occur at predetermined intervals that equal to a programmable base time plus a random delay to avoid collisions.

When WBM=Y, the tag transmits WBP number of messages every WIM minutes and WIS seconds.
When WMM=Y, the tag transmits WMB number of messages every WMI seconds so long as it is in motion.
When WEM=Y, the tag transmits WEB number of messages every WEI seconds so long as it is in the valid LF field.
Inter-message intervals within each beacon transmission are randomized.

4 CT23 DEFAULT PARAMETER SETTINGS

Default values that will fit most applications are:

WSD	=	1	inter-message random delay in Excitation or Motion modes
WUD	=	"xxxxx"	5 characters of user data
WBM	=	Y	enables Beacon Mode
WIM	=	120	sets minutes of the inter-beacon duration
WIS	=	0	sets seconds of the inter-beacon duration
WBP	=	3	sets number of messages in a beacon transmission
WCE	=	N	sets automatic On/OFF control by exciter ID
WBD	=	0	sets beacon time out in hours with 0 for no TO
WR1	=	1	inter-message random delay in Beacon mode
WEM	=	Y	enables Excitation Mode
WEP	=	20	sets number of messages in an excitation transmission
WEI	=	30	sets beacon transmission interval in seconds for when the tag is sitting in the field
WEB	=	0	sets number of messages in beacon transmission when sitting in the field
WMM	=	Y	enables Motion Mode
WMP	=	5	sets number of messages in the motion activated transmission
WMI	=	30	sets beacon transmission interval in seconds for when the tag is continuously shaken
WMB	=	3	sets number of messages in beacon transmission when continuously shaken
WME	=	10	sets motion extension in seconds: duration of stay in Motion Mode after motion stops
WSE	=	Y	motion sensor controlled Excitation Mode: when entering LF field transmit excitation messages only when in motion (Y) or always (N)

5 REGULATORY COMPLIANCE

5.1 FCC

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Caution: Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

5.1.1 Maximum Transmission Time

To comply with 15.231(a) of FCC regulations, the maximum transmission time of CT23 in Excitation or Motion modes must not exceed 5 seconds.
To minimize collisions in an application, CT23 tags are programmed with different values for the WSD parameter, which ensures that inter-message durations are randomized differently for individual tags. To ensure sufficient transmission redundancy in an application a certain optimum number of transmitted messages is selected and programmed into a CT23 tag: WEP for excitation transmissions and WMP for motion transmissions. Combination of all three parameters affects the overall transmission duration. The following table was generated by taking into account all possible randomization patterns for a single Motion or Excitation transmission and selecting the worst (longest) case scenario. Each cell shows the maximum possible transmission time for a given message number and randomization pattern. In green are the fields that fall below 5 seconds. From this table we can see that for our typical application (WEP=20, WMP=5 and WSD=10..30) we comply with the FCC regulation for maximum transmission time.

Maximum time in seconds required to transmit a packet (burst) of WEP or WMP number of messages for a specific value of WSD.

FCC Limit 15.231 (a) : 5.0 s

WEP, WMP \ WSD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6
4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9
5	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2
6	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.4	1.4	1.5
7	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.8
8	0.9	0.9	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.8	1.8	1.8	1.8	1.9	1.9	1.9	2.0	2.0	2.0
9	1.0	1.0	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.4	1.4	1.4	1.5	1.5	1.5	1.6	1.6	1.6	1.7	1.7	1.7	1.8	1.8	1.8	1.9	1.9	1.9	2.0	2.0	2.0	2.1	2.1	2.1	2.2	2.2	2.2	2.3
10	1.1	1.1	1.1	1.2	1.2	1.3	1.3	1.3	1.4	1.4	1.4	1.5	1.5	1.6	1.6	1.6	1.7	1.7	1.7	1.8	1.8	1.8	1.9	1.9	2.0	2.0	2.0	2.1	2.1	2.1	2.2	2.2	2.2	2.3	2.3	2.4	2.4	2.4	2.5	2.5
11	1.2	1.2	1.3	1.3	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.6	1.7	1.7	1.8	1.8	1.8	1.9	1.9	2.0	2.0	2.0	2.1	2.1	2.2	2.2	2.2	2.3	2.3	2.4	2.4	2.4	2.5	2.5	2.6	2.6	2.7	2.7	2.7	2.8
12	1.3	1.3	1.4	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8	1.9	1.9	1.9	2.0	2.0	2.1	2.1	2.2	2.2	2.3	2.3	2.3	2.4	2.4	2.5	2.5	2.6	2.6	2.7	2.7	2.7	2.8	2.8	2.9	2.9	3.0	3.0
13	1.4	1.4	1.5	1.5	1.6	1.6	1.6	1.7	1.7	1.8	1.8	1.9	1.9	2.0	2.0	2.1	2.1	2.2	2.2	2.3	2.3	2.4	2.4	2.5	2.5	2.6	2.6	2.7	2.7	2.8	2.8	2.9	2.9	3.0	3.0	3.1	3.1	3.2	3.2	3.3
14	1.4	1.5	1.5	1.6	1.7	1.7	1.8	1.8	1.9	1.9	2.0	2.0	2.1	2.1	2.2	2.2	2.3	2.3	2.4	2.4	2.5	2.6	2.6	2.7	2.7	2.8	2.8	2.9	2.9	3.0	3.0	3.1	3.1	3.2	3.2	3.3	3.3	3.4	3.5	3.5
15	1.5	1.6	1.6	1.7	1.7	1.8	1.8	1.9	2.0	2.0	2.1	2.1	2.2	2.2	2.3	2.4	2.4	2.5	2.5	2.6	2.6	2.7	2.7	2.8	2.9	2.9	3.0	3.0	3.1	3.1	3.2	3.3	3.3	3.4	3.4	3.5	3.5	3.6	3.7	3.7
16	1.6	1.6	1.7	1.8	1.8	1.9	2.0	2.0	2.1	2.1	2.2	2.3	2.3	2.4	2.4	2.5	2.6	2.6	2.7	2.7	2.8	2.9	2.9	3.0	3.1	3.1	3.2	3.2	3.3	3.4	3.4	3.5	3.5	3.6	3.7	3.7	3.8	3.8	3.9	4.0
17	1.7	1.7	1.8	1.8	1.9	2.0	2.0	2.1	2.2	2.2	2.3	2.4	2.4	2.5	2.6	2.6	2.7	2.8	2.8	2.9	3.0	3.0	3.1	3.2	3.2	3.3	3.3	3.4	3.5	3.5	3.6	3.7	3.7	3.8	3.9	3.9	4.0	4.1	4.1	4.2
18	1.8	1.8	1.9	2.0	2.1	2.1	2.2	2.3	2.3	2.4	2.5	2.5	2.6	2.7	2.7	2.8	2.9	3.0	3.0	3.1	3.2	3.2	3.3	3.4	3.4	3.5	3.6	3.6	3.7	3.8	3.9	3.9	4.0	4.1	4.1	4.2	4.3	4.3	4.4	4.5
19	1.9	2.0	2.0	2.1	2.2	2.3	2.3	2.4	2.5	2.6	2.6	2.7	2.8	2.8	2.9	3.0	3.1	3.1	3.2	3.3	3.4	3.4	3.5	3.6	3.7	3.7	3.8	3.9	3.9	4.0	4.1	4.2	4.2	4.3	4.4	4.5	4.5	4.6	4.7	4.8
20	2.0	2.1	2.2	2.2	2.3	2.4	2.5	2.5	2.6	2.7	2.8	2.8	2.9	3.0	3.1	3.2	3.2	3.3	3.4	3.5	3.5	3.6	3.7	3.8	3.9	3.9	4.0	4.1	4.2	4.2	4.3	4.4	4.5	4.6	4.6	4.7	4.8	4.9	4.9	5.0
21	2.1	2.1	2.2	2.3	2.4	2.5	2.6	2.6	2.7	2.8	2.9	3.0	3.0	3.1	3.2	3.3	3.4	3.5	3.5	3.6	3.7	3.8	3.9	3.9	4.0	4.1	4.2	4.3	4.3	4.4	4.5	4.6	4.7	4.8	4.8	4.9	5.0	5.1	5.2	5.2
22	2.2	2.3	2.4	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.4	5.5
23	2.3	2.4	2.5	2.6	2.7	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.3	5.4	5.5	5.6	5.7	5.8
24	2.4	2.5	2.6	2.7	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.8	5.9	6.0
25	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3
26	2.5	2.6	2.7	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5
27	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7
28	2.6	2.7	2.8	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9
29	2.7	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.9	7.0	7.1	7.2
30	2.8	2.9	3.1	3.2	3.3	3.4	3.5	3.6	3.8	3.9	4.0	4.1	4.2	4.4	4.5	4.6	4.7	4.8	4.9	5.1	5.2	5.3	5.4	5.5	5.7	5.8	5.9	6.0	6.1	6.3	6.4	6.5	6.6	6.7	6.8	7.0	7.1	7.2	7.3	7.4
31	2.9	3.0	3.1	3.2	3.4	3.5	3.6	3.7	3.9	4.0	4.1	4.2	4.3	4.5	4.6	4.7	4.8	5.0	5.1	5.2	5.3	5.4	5.6	5.7	5.8	5.9	6.1	6.2	6.3	6.4	6.5	6.7	6.8	6.9	7.0	7.2	7.3	7.4	7.5	7.7
32	2.9	3.0	3.2	3.3	3.4	3.5	3.7	3.8	3.9	4.1	4.2	4.3	4.4	4.6	4.7	4.8	4.9	5.1	5.2	5.3	5.4	5.6	5.7	5.8	5.9	6.1	6.2	6.3	6.5	6.6	6.7	6.8	7.0	7.1	7.2	7.3	7.5	7.6	7.7	7.8
33	3.0	3.2	3.3	3.4	3.5	3.7	3.8	3.9	4.1	4.2	4.3	4.5	4.6	4.7	4.9	5.0	5.1	5.2	5.4	5.5	5.6	5.8	5.9	6.0	6.2	6.3	6.4	6.5	6.7	6.8	6.9	7.1	7.2	7.3	7.5	7.6	7.7	7.9	8.0	8.1
34	3.1	3.2	3.4	3.5	3.6	3.8	3.9	4.0	4.2	4.3	4.5	4.6	4.7	4.9	5.0	5.1	5.3	5.4	5.5	5.7	5.8	5.9	6.1	6.2	6.3	6.5	6.6	6.7	6.9	7.0	7.1	7.3	7.4	7.5	7.7	7.8	8.0	8.1	8.2	8.4
35	3.2	3.3	3.5	3.6	3.7	3.9	4.0	4.1	4.3	4.4	4.6	4.7	4.8	5.0	5.1	5.3	5.4	5.5	5.7	5.8	6.0	6.1	6.2	6.4	6.5	6.6	6.8	6.9	7.1	7.2	7.3	7.5	7.6	7.8	7.9	8.0	8.2	8.3	8.4	8.6
36	3.3	3.4	3.5	3.7	3.8	4.0	4.1	4.3	4.4	4.5	4.7	4.8	5.0	5.1	5.3	5.4	5.5	5.7	5.8	6.0	6.1	6.3	6.4	6.5	6.7	6.8	7.0	7.1	7.3	7.4	7.5	7.7	7.8	8.0	8.1	8.3	8.4	8.5	8.7	8.8
37	3.3	3.5	3.6	3.8	3.9	4.1	4.2	4.4	4.5	4.6	4.8	4.9	5.1	5.2	5.4	5.5	5.7	5.8	6.0	6.1	6.3	6.4	6.6	6.7	6.9	7.0	7.1	7.3	7.4	7.6	7.7	7.9	8.0	8.2	8.3	8.5	8.6	8.8	8.9	9.1
38	3.4	3.6	3.7	3.9	4.0	4.2	4.3	4.5	4.6	4.8	4.9	5.1	5.2	5.4	5.5	5.7	5.8	6.0	6.1	6.3	6.4	6.6	6.7	6.9	7.0	7.2	7.3	7.5	7.6	7.8	7.9	8.1	8.2	8.4	8.5	8.7	8.8	9.0	9.1	9.3
39	3.5	3.6	3.8	3.9	4.1	4.2	4.4	4.5	4.7	4.9	5.0	5.2	5.3	5.5	5.6	5.8	5.9	6.1	6.2	6.4	6.6	6.7	6.9	7.0	7.2	7.3	7.5	7.6	7.8	8.0	8.1	8.3	8.4	8.6	8.7	8.9	9.0	9.2	9.3	9.5
40	3.5	3.6	3.8	4.0	4.1	4.3	4.4	4.6	4.8	4.9	5.1	5.2	5.4	5.6	5.7	5.9	6.0	6.2	6.3	6.5	6.7	6.8	7.0	7.1	7.3	7.5	7.6	7.8	7.9	8.1	8.3	8.4	8.6	8.7	8.9	9.1	9.2	9.4	9.5	9.7

5.1.2 Maximum Duty Cycle

To comply with 15.231(a) of FCC regulations from average transmitted power point of view, the maximum transmission Duty Cycle for CT23 in Excitation or Motion modes must not exceed 20% in any 100ms time window.

The maximum value of duty cycle in CT23 is achieved when 100ms window falls on the Excitation or Motion transmission bursts. The following table was generated by taking into account all possible randomization patterns for a Motion or Excitation transmission and selecting the worst case scenario where the maximum number of individual messages comprising a transmission occur within 100ms. Each cell shows the maximum possible duty cycle for a given message number and randomization pattern. In green are the fields that fall below 20%. From this table we can see that for our typical application (WEP=20, WMP=5 and WSD=10..30) we comply with the FCC regulation for maximum duty cycle.

Max Duty Cycle: 20 % **Annex 3**

WEP,WMP \ SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
2	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
3	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
4	16	16	16	16	16	16	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
5	20	20	20	20	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
6	24	24	24	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
7	29	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
8	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
9	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
10	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
11	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
12	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
13	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
14	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
15	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
16	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
17	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
18	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
19	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
20	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
21	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
22	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
23	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
24	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
25	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
26	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
27	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
28	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
29	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
30	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
31	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
32	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
33	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
34	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
35	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
36	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
37	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
38	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
39	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
40	33	29	29	24	20	20	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8

Maximum possible Duty Cycle in any 100ms time window during a transmission of one packet of MsgNo messages
(set by BP, MP, EP, EB, MB tag parameters).
This graph also depends on values of CC and EN parameters set in TagParms form.

Maximum Duty Cycle, %

5.1.3 Predetermined Transmissions Timing

To comply with 15.231(e) of FCC regulations, the following rules must be met:

a) total transmission (burst) length must be less than 1 second;
b) Inter-beacon duration must be 30 or more times longer than transmission duration;
c) Inter-beacon duration must be more than 10 seconds.

CT23 pattern of predetermined transmissions depends on the combination of three different programming parameters: number of messages in a beacon, inter-beacon duration and inter-message (within a beacon transmission) randomization. Different applications may require different combination for optimum performance.

To ensure compliance with the regulations, special software was designed to calculate actual values for the restricted criteria (green fields in the table below) based on the CT23 parameters. Below is a sample of the application with typical setting for CT23 and we can see that the resulting transmission pattern complies with the regulations. The last condition of less than 20% during 100ms window comes from the averaging factor used for transmitted power testing.

Beacon Mode		**FCC 15.231 (e) conditions**		
WBP	3	0.27	<= 1s	Total transmission (burst) length must be less than 1 second.
WEB	0	10.00	>= 10s	Inter-beacon duration must be more than 10 seconds.
WMB	3	36.58	>= 30 times	Inter-beacon duration must be 30 or more times longer than transmission duration.
WR1	1			
WIS	0			
WIM	120	**FCC 15.231 (a-e) conditions - transmitted power averaging factor**		
WEI	60	0.12	<=20%	Maximum duty cycle must be less than 20% within any 100ms time window.
WMI	10			

5.2 CT23 Declaration for ETSI EN 300 220-1 [8.10.3]

When operating in Excitation mode CT23 will transmit messages less than 20 times a day, whenever it will pass through a valid 125 kHz excitation field with a special modulation pattern. The range of receiving this field is about 5m around a Lyngsoe Systems exciter. Each typical transmission has up to 40 messages of 5ms each so total transmission time is 200ms. Assuming the 20 transmissions are spread around a typical postal work day of 16 hours get a typical duty factor of 20*0.2/3600/16=0.0069%.

When operating in Beaconing mode CT23 can be programmed to transmit three messages 5ms long each every 10s. This would give a total tx time of 15ms every 10,000 ms so a duty factor of 0.15%.

When operating in Motion mode, in a typical scenario, the transmitter may transmit 10 times / hour five messages each time. This would give a total tx time of 10*5*5 ms every 3,600,000 ms so a typical duty factor of 0.0069%. However, for example during transportation using trucks, if the transmitter will be continuously shaken and if this feature is enabled, it will start transmitting periodic messages - three messages 5ms long each every 10 seconds. This means 0.15% duty factor for the worst case motion scenario.

If we add all these duty factors in the very unlikely case that they will all occur within one hour, we get 0.0096+0.15+0.15=0.31% duty factor over one hour interval so **the transmitter fits in Class 2 – less than 1% channel occupancy.**