

THE DENSE READER PROBLEM IN EUROPE

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OVERVIEW

UHF RFID is the preferred choice for supply chain management applications. The use of radio based applications of which RFID is one, is governed by the national radio regulators, in the UK this is OFCOM. National regulations are based on recommendations from the CEPT (Conference of European Posts and Telecommunications). The Recommendations for Short Range Devices (SRDs) are embodied in CEPT Rec 70-03E. Annex 11 deals specifically with RFID.

ETSI, the European Telecommunications Standards Institute has published a standard EN 302 208 which provides the basis for operation under Cept Rec 70-03E Annex 11. EN 302 208 and Annex 11 provide a band from 865 - 868 MHz divided into 15 channels of 200kHz. The lower 3 channels are limited to a radiated power of 100mW, the upper 2 channels 500mW and the 10 channels in between 2 watts erp (equivalent to 3.2 Watts eirp). This band is not exclusive to RFID but is shared with other non-specific Short Range Devices (SRD). In the USA and Canada RFID is accommodated in the 902 - 928 MHz band where wider bandwidths and frequency hopping spread spectrum are used.

Available channels in the EU

3 channels (sub-bands) of 100mW
10 channels (sub-bands) of 2 Watts
2 channels (sub-bands) of 500mW

THE PROBLEM

RFID, unlike other communications systems, does not provide reciprocity between base station and mobile station. In other words for RFID, the relative transmission range of the base station (reader) is much greater than that of the mobile station (tag). This creates the potential for base stations to interfere with each other over a range of several kilometres, whereas the backscatter signals radiated from tags propagate over distances of a few tens of metres.

EN 302 208 requires the use of Listen Before Talk (LBT) to prevent a base station from transmitting if the channel is already occupied by another transmission. The LBT threshold is set to -96dBm which has the effect of limiting the number of readers able to operate simultaneously in a particular radio neighbourhood to about twenty if all available channels are used.

There have been moves to synchronise reader transmissions in order to allow more readers to transmit at once using a single LBT receiver. However this has the drawback that reading of items cannot be truly event driven because by their nature the arrival of items to be read is random.

In a Distribution Centre (DC) there is a need to operate tens or even hundreds of readers in close proximity to each other. In order to not upset or interfere with the movement of goods, each reader needs to be able to respond to a trigger, either manual or automatic, on demand and asynchronous of other readers. In a multi-vendor environment such as a shopping centre, where the receiving docks belonging to different organisations are in close proximity, synchronisation of readers is impractical.

THE CHALLENGE

The challenge is to provide a means whereby RFID systems are able to operate freely under the following conditions:

- Provide a method for multiple readers to operate in the same radio neighbourhood without undue interaction or mutual interference.
- Allow readers belonging to different organisations to operate independently of each other.
- Allow readers to be truly event driven without the need to wait or be synchronised with other readers.
- Ensure that tag replies can be heard when a reader is operating in an adjacent portal.
- Take account of other non-RFID devices sharing the same channel/s

SOME BASICS

Passive RFID tags are powered by the incident energy from a reader. A signal strength of several volts per metre is required at the tag antenna. Tags inherently have a very broadband response therefore, increasing the attenuation between a reader and 'tags not required to be read' is necessary, no matter what frequency is used.

A heterodyne tone (beat note) is produced when two readers operate simultaneously in close proximity to a tag; the tag rectifier acting as a mixer. This heterodyne signal can interfere with the ability of the tag to reliably decode reader commands.

The wanted signal should typically be at least 20dB stronger than interfering signals. For example two reader transmissions separated by 200kHz will produce a heterodyne of 200kHz at the tag rectifier. It is therefore important that

- The separation between the transmit frequency of two readers should be greater than the cutoff frequency of the tag filter circuit; and
- The separation between the transmit frequency of two readers should be less than the highpass frequency of the tag filter circuit.

Many readers can transmit on the same nominal frequency, provided that

- The reader receivers listen for tag backscatter signals at a frequency far enough removed from the reader transmissions so as to not suffer desense of the receivers.
- The heterodyne/s produced by the reader carriers should be lower in frequency than the highpass cutoff frequency of the tag demodulator and at a level at least 20dB lower than the reader transmitter modulation level.

The backscatter signal from tags is typically less than 250uW.

THE SOLUTION

Separate high power reader transmissions from the much lower power tag backscatter reply. This satisfies the accepted spectrum management principle of keeping devices of similar power levels together and maintaining separation between devices having widely disparate power levels. This means that communication between reader and tags is “2 frequency full duplex”. This can be achieved by operating the tag reply at a baseband data rate high enough to remove the backscatter signal from in-channel to an adjacent channel - example: 320 kb/s will place the sideband at 320kHz removed from the reader transmission. Alternatively it can be achieved by using the dense reader mode (sub-carrier mode) in ISO 18000-6C.

Operate readers on a limited number of channels, separated by at least 3 channel spacing so that the intermediate channels can be used to listen for tag replies. For example using the channel numbers recommended by OFCOM as listed in Schedule 1:

Readers transmit on channels 4, 7, 10 and 13.

Tags backscatter their replies at 300kHz removed on the boundaries between channels 1 and 2, 5 and 6, 8 and 9, 11 and 12 and 14 and 15.

Note: the reason for backscatter on channel boundaries is to avoid the centre of the intermediate channels so as to provide some protection to and from other [non-rfid] SRD devices.

Because readers now listen for tag replies outside their channel, there is no need to have a clear channel before transmitting, as long as the desired transmission is at least 20 dB stronger at a wanted tag than another co-channel reader.

RECOMMENDATIONS

1. Modify the Listen Before Talk requirements in EN 302 208 and CEPT Rec 70-03E Annex 11 to eliminate the need for LBT on Channels 4, 7, 10 and 13.
2. Modify the radiated power output requirement such that 2 Watts ERP is only permitted on Channels 4, 7, 10 and 13 and that power output on channels 5,6,8,9,11 and 12 is limited 100mW.
3. Retain all the other attributes contained within EN 302 208 and Rec 70-03E Annex 11.

THE EFFECT OF THE ABOVE

- Large numbers of readers may be deployed in the same RF neighbourhood.
- Readers will be able to operate asynchronously of each other and be truly event driven.
- Readers will not desense each others' receivers except when they are very close to each other, such as in adjacent dock doors.
- Tag backscatter transmissions will be 'in the clear' on low power LBT channels and therefore there will be no danger of blocking from distant high power users of the channel.
- Low power [SRD] co-users of the band will be protected from High Power reader transmissions on all but the 4 channels allocated for 2 Watt ERP operation.

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Schedule 1
UK Channel numbers - 865 - 868 MHz Band

Channel	Centre Freq	Current Pwr	Proposed Pwr	Proposed LBT
1	865.1	100mW	100mW	✓
2	865.3	100mW	100mW	✓
3	865.5	100mW	100mW	✓
4	865.7	2W	2W	no
5	865.9	2W	100mW	✓
6	866.1	2W	100mW	✓
7	866.3	2W	2W	no
8	866.5	2W	100mW	✓
9	866.7	2W	100mW	✓
10	866.9	2W	2W	no
11	687.1	2W	100mW	✓
12	867.3	2W	100mW	✓
13	867.5	2W	2W	no
14	867.7	500mW	500mW	✓
15	867.9	500mW	500mW	✓