Submission to FCC in response to NPRM ET Docket No 03-201, FCC 07-117

By:

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Sirs:

We note that the NPRM seeks comment on a spectrum etiquette for unlicensed transmitters that operate under CFR 47, Sections 15.247 and 15.249 of the rules in the 915 MHz band.

We further note that the question of whether there is the need for a spectrum etiquette arises from increasing congestion in the 915 MHz band and the increasing use of devices making use of the relatively higher conducted output power of 1 Watt, or a radiated power of 4 Watts eirp.

Concern has been expressed, that should a large number of higher power devices using frequency hopping spread spectrum, transmit continuously, then the sum total of these devices could conceivably occupy all available channels, thus blocking communication by lower power devices.

It has been suggested, that a listen-before-talk regime could be effective in improving spectrum sharing. It has also been suggested, that a limitation on duty cycle could be another way to address the problem. Yet a further suggestion proposes the use of a power reduction regime as duty cycle increases.

We believe that these measures alone would not be effective and would furthermore restrict the utility of some higher power systems. We also believe that a spectrum etiquette in itself will not necessarily address the problem of increasing congestion and that there are several inter-related factors which together influence available spectrum occupancy. These factors have the ability to reduce accessibility to clear frequencies and utility of lower power users. A measure of spectrum re-use, is how many users (or systems) can be accommodated in a given amount of radio spectrum in a unit of space.

The main parameters that affect frequency re-use in the 915 MHz unlicensed band are:

- The relative disparity in radiated signal strength between low power users where output power is in the order of a few milliWatts and higher power users who transmit at power levels of up to 4 Watts eirp. If low power and high power users can be separated in frequency, the low power users would have improved protection from blocking and overload.

- Frequency hopping has proven to be effective in reducing the effect on spectrum occupancy of a small number of higher power devices. However, when there is a large number of these devices operating in a radio neighbourhood, the effect is to occupy simultaneously, a large portion of the spectrum. An example of such occupancy would be an installation of 50 or more individual RFID interrogators, using FHSS and output power of 4 Watts eirp, operating at dock doors in a large distribution centre.
- Many devices transmitting in the 915 MHz band, communicate with other devices in a defined direction or zone. Yet, the nature of current transmitting antennas is such, that considerable energy can be radiated in unwanted directions. In particular 15.247 prevents the use of highly directional antennas in the 915 MHz band, by limiting antenna gain to 6dBi. A typical 6dBi antenna has an included 3dB beamwidth of about 60 to 70 degrees of arc, and therefore, can illuminate quite a large geographic area, which in many instances is inefficient. If the interrogator illumination of a reading zone could be more precisely controlled, then less energy would be radiated in unwanted directions allowing better spatial re-use.
- Part 15.247 requires that "the system receivers shall have bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift their frequencies in synchronisation with the transmit signals". If certain types of equipment, such as RFID interrogators, are permitted under certain circumstances, to use two-frequency operation (i.e. separate transmit and receive frequencies), channel loading and hence frequency re-use could be improved considerably. This will be discussed later.
- Radiated emissions are currently measured at a distance of 3 metres from the emitter's antenna. In nearly all cases, frequency sharing and/or re-use is of concern at greater distances, beyond 20 or 30 metres. If an alternative measurement method could be specified, which extrapolated or measured effective radiate power at a distance of say 10 metres, it would allow the use of equipment that employed advanced antenna technologies to provide a higher field intensity at short range i.e. less than 10 meters, while still not exceeding a specified eirp at greater distances. The resulting protection for co-frequency devices at distance would be the same or better.

Considering these factors we would like to propose to the Commission, a number of measures which we believe would:

a) reduce the potential for harmful interference by higher power devices to lower power devices and systems,

b) ensure that system performance can be sustained as band usage increases over the longer term,

c) provide manageable co-existence between unlicensed and licensed systems sharing the same geographic space and radio spectrum, and

d) provide spatial containment and the direction of emissions to where they are really required thus to reduce spillover into unwanted directions.

To illustrate our proposal we will compare the extreme case of two systems; a passive RFID system and a low power two-way telemetering system. The table below shows the key over air parameters of the two systems.

Parameter	**Low Power Telemetry**	**RFID System**
Output power eirp - fixed	5 mW	4 Watts
Output power eirp - mob	5 mW	- 60dBm backscatter
Antenna gain - fixed	-3 to 6 dBi	6dBi
Antenna gain - mobile	-3 to 0 dBi	0dBi (omni-directional)
Channel width	50kHz to 200kHz	200kHz or 500 kHz
Communication mode	Single frequency simplex	Half-duplex – fixed station always transmits carrier while listening for tag backscatter; they are strictly speaking full duplex systems
Tolerable system latency i.e. time from event trigger to system response	In most cases several hundred milliseconds to seconds	Less than 10 milliseconds

In the case of the telemetry system, the forward link (base to mobile) and return link (mobile to base) both transmit with an output power of less than typically 10 mW and certainly less than 25 mW. The communications channel is reciprocal, in that both stations have similar output powers and similar receiver sensitivities. Because the system operates in a single frequency simplex mode both ends of the link can operate comfortably in the same channel. In most instances, the telemetry system is not required to transmit its data instantly and a delay of a few hundred milliseconds or even seconds will not result in any system degradation. A typical telemetry system may operate over distances of up to several hundred metres and often the base and mobile units will not be in direct line of sight of each other, nor will the precise direction be known.

In the case of a passive RFID system, the forward link (interrogator to tag) transmits a high power signal in order to provide energy for the tag. The tag reply ‘backscatter modulates’ the incident carrier wave from the interrogator, the resulting backscatter signal being simultaneously received and demodulated by the interrogator. This backscatter signal typically has a re-radiated signal strength in the order of 40 to 120 dB below the radiated signal of the interrogator, depending on how far away the tag is from the interrogator. This means that a large spatial separation is required between interrogators simultaneously operating on the same or adjacent channels in order to prevent one interrogator from blocking a tag reply at the nearby interrogator’s receiver. Because an RFID interrogator is required to energise and read the identity from a plurality of tags passing through a small read zone, any delay in interrogation will mean that tags will enter and leave the read zone before they can be identified. The read zone is usually very well defined and where multiple interrogators are present in the same space, with not much spatial separation, it is desirable to limit the beamwidth or coverage of the RFID antenna.

Let us consider the factors.

Transmit output power

Telemetry devices transmit at a relatively low output power, therefore they can operate simultaneously at relatively close distances. RFID interrogators transmit at relatively high power in order to provide energy for the tags. Therefore, their transmissions travel much further and so have much greater potential to interfere with the telemetry systems. This in turn means the RFID and telemetry systems require greater spatial separation between themselves.

Occupied bandwidth / spectrum mask

The currently allowed spectrum mask is very loosely defined, which means that users on adjacent frequencies could be subjected to considerable interference due to modulation sidebands and noise.

Antenna radiation patterns

Telemetry systems generally require their transmissions to have a broad or even omni-directional radiation pattern because the exact location of the fixed and mobile units may not be easy or even necessary to determine.

An RFID system on the other hand, generally requires a controlled antenna radiation pattern in order to define a read zone and to minimise interference with other RFID interrogators in the same radio neighbourhood. Often it is necessary to provide special shielding or screening of read zones to minimise emissions into adjacent read zones, typically at multiple dock doors in a distribution centre.

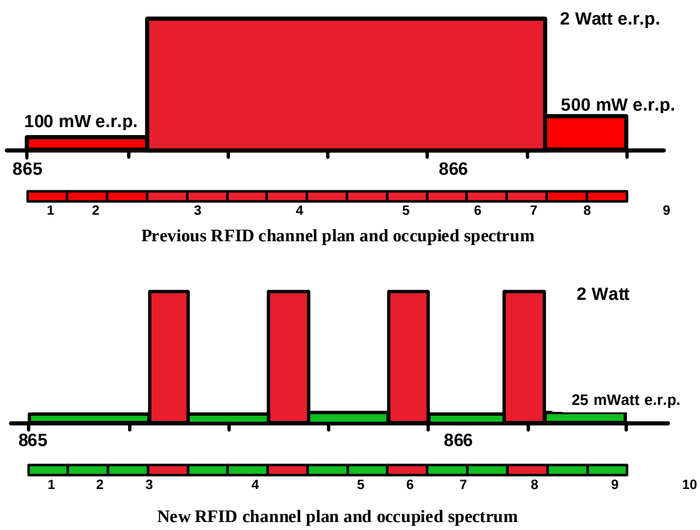
Transmit Latency

Most telemetering systems are used for remote monitoring of data or events. In many cases the gathering of the data is not time sensitive, so a delay of tenths of seconds or even seconds does not have an impact on the collection of the data. In the case of many RFID applications, an interrogator is required to collect data from as many as several hundred tags passing through a read zone where tags may be present for less than a second. A read event will be triggered as items to be read enter the read zone. Any delay in transmission by the interrogator would result in missing tags, and so miss the items to which they are attached. This means that any delay is unacceptable. In Europe, listen-before-talk was originally proposed as a spectrum etiquette to facilitate good neighborliness, but was found to be unworkable. As a result the radio regulations have been changed to eliminate this requirement.

We propose the following measures, which we believe will lead to better band sharing, particularly if implemented as a package.

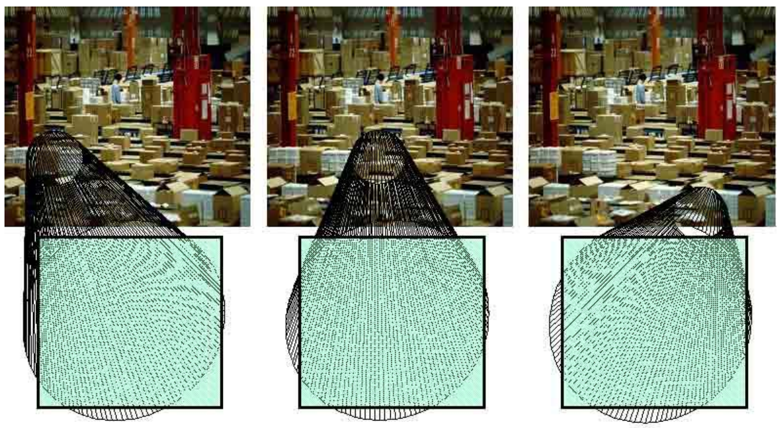
1. Identify and allocate a portion of the 915 MHz band which can be channelized and used for fixed frequency (i.e. no frequency hopping) emissions having a conducted power output of 1 Watt. Allocate alternating high power and low power blocks within this band segment. See the diagram. This will permit spectral separation of low power and high power equipment. Low power users will have access to the full 915 MHz band but high power users would be limited to the designated channels thereby providing protection for low power users. High power users would still be permitted to use FHSS where fixed frequency operation is not possible.

2. Within the channelized band referred to in 1 above, permit split frequency operation, so that base and mobile units may transmit (or in the case of RFID tags to backscatter) on separate frequencies. Tests conducted by ETSI[1] for changes to the European bands showed that it was possible for multiple high power systems to transmit simultaneously on the same frequency, when using two frequency operation, thus allowing more users to be accommodated per MHz in a given space. The diagram below shows the previous and new RFID channel plans in Europe. Interrogators transmit on the 2 Watt channels and receive the tag backscatter signals on the low power 25mW channels. The 25 mW channels may also be used by generic short range (low power) devices.



European RFID spectrum allocation

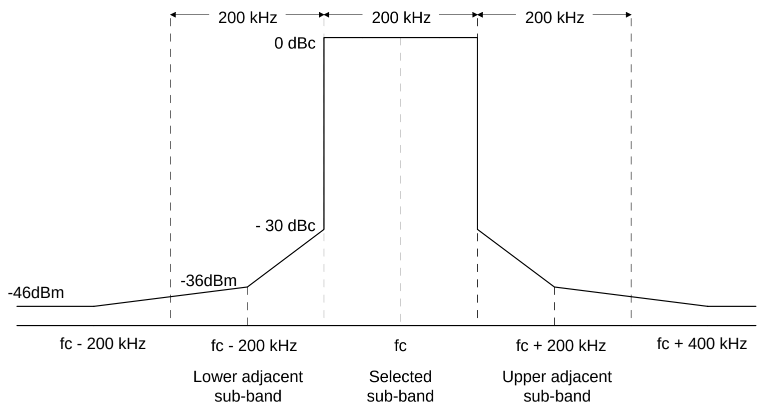
3. Permit the use of higher gain [more than 6dBi] or advanced technology antennas in the 915 MHz band in order to allow more precise direction of transmissions into the required zone. Where higher gain antennas are to be used outdoors, apply the same rules as presently contained in part 15.247 (c)(1)(i) or (c)(2) as applicable. See the following illustration of a steerable antenna directed in turn towards three groups of tags in different areas covered by an antenna.



Steerable Interrogator Antenna Beam

4. Modify the radiated power test methods to allow field strength to be alternatively measured at a distance of 10 metres or greater (to be specified). This would allow the use of beam focusing or advanced technology antennas that provide a strong field at shorter distances and have a rapid fall-off in signal strength at longer distances such that the emitted signal strength is at or below the current required level in the far field.

5. Require a tighter transmitter spectral mask, similar to that required for Part 90 transmitters or in the case of RFID according to ISO/IEC 18000-6C[2]. It has been shown in tests conducted by ETSI[1], that RFID transmitters operating according to International Standard ISO/IEC 18000-6C[2] Annex I, “dense reader mode” are capable of extremely high density channel sharing. (Annex I is attached hereto for reference).



Proposed Spectrum Mask for RFID Interrogators in Europe

It is our submission, that by implementing the proposals above, the concerns expressed by petitioners over increasing congestion in the 915 MHz band will be more than adequately addressed and resolved.

We have consciously not provided any detailed technical proposals at this time, but would be pleased to discuss our observations and proposals in details with the Commission.

Notes:

1. ETSI, European Telecommunications Standards Institute, TG/34, RFID task group and TG/28, Low Power Devices task group
2. ISO/IEC 18000-6C, International Standard, Information technology – Radio Frequency Identification for item managements – Part 6: Parameters for air interface communications at 860 MHz to 960 MHz.

ISO/IEC 18000-6 - ANNEX I

(normative)

Dense- and multiple-interrogator channelised signalling

This Annex describes channelised signalling in the optional dense- and multiple-interrogator modes. It provides several alternative methods that interrogators may use, where permitted by local regulatory authorities, to manage frequency-band usage.

A.1 Dense-interrogator modes

In environments containing two and more interrogators, the range and rate at which interrogators singulate tags can be improved by preventing interrogator transmissions from colliding with tag responses, either temporally or spectrally. This Annex describes time-division multiplexing (TDM) and frequency-division multiplexing (FDM) methods that can minimize interrogator-on-tag collisions. If permitted by local regulations, interrogators that are claimed to operate in dense-interrogator environments shall support one of the TDM or FDM methods described below, determined using the algorithm in Figure I.1. Regardless of the choice, Interrogator signalling (both modulated and CW) shall be centred in a channel with the frequency accuracy specified in 9.3.1.2.1, and interrogator transmissions shall satisfy the dense-interrogator transmit mask in figure 40. If an interrogator uses SSB-ASK modulation, the transmit spectrum shall be centred in the channel during R=>T signalling, and the CW shall be centred in the channel during tag backscatter.

TDM: Interrogator transmissions and tag responses shall be separated temporally, with synchronized interrogators first commanding tags, then all interrogators transmitting CW and listening for tag responses.

FDM: Interrogator transmissions and tag responses shall be separated spectrally, using one of the three frequency plans described below.

Channel-boundary backscatter: Interrogator transmissions shall be centred in channels, and tag backscatter shall be situated at channel boundaries.

Adjacent-channel backscatter: Interrogator transmissions shall be centred in odd-numbered channels, and tag backscatter shall be situated in even-numbered channels.

In-channel backscatter: Interrogator transmissions shall be centred in channels, and tag backscatter shall be situated near but within the channel boundaries.

A.1.1 Examples of dense-interrogator mode operation

Figure I.2, shows examples of the single TDM and three FDM dense-Interrogator modes defined in A.1. For optimum performance, this specification recommends that interrogators choose BLF and M to allow a guardband between interrogator signalling and tag responses.

Example 1: TDM

ERC REC 70-03E Annex 1 allows the band from 869.4–869.65 MHz to be used as a single 250kHz channel. By the algorithm in Figure I.1, the dense-interrogator mode will be TDM. Example 1 of Figure I.2 shows one possible operating mode, in which interrogator transmissions use DSB-ASK modulation with Tari=25µs, and tag backscatter is 20 kbit/s data on an 80 kHz subcarrier (BLF=80kHz, M=4).

Example 2: FDM Channel-boundary backscatter

FCC 15.247, dated October 2000, authorizes frequency-hopping operation in the ISM band from 902–928 MHz with 500kHz maximum channel width, and does not prohibit channel-boundary backscatter. By the algorithm in Figure I.1, interrogators will use 500kHz channels with channel-boundary backscatter. Table I.1 shows the channelisation and channel numbering; example 2 of Figure I.2 shows interrogator transmissions using PR-ASK modulation with Tari=25µs, and 62.5 kbit/s tag data backscatter on a 250kHz subcarrier (BLF=250kHz; M=4). Interrogators centre their R=>T signalling in the channels shown in Table I.1, with transmissions unsynchronized in time, hopping among channels.

Example 3: FDM Adjacent-channel backscatter

ERC REC 70-03E Annex 11 specifies fifteen 200kHz channels in the 865 – 868 MHz frequency range, and does not prohibit adjacent-channel backscatter. By the algorithm in Figure I.1, interrogators will use 200kHz channels with adjacent-channel backscatter. Figure I.3 shows the channel numbering; example 3 of Figure I.2 shows interrogator transmissions using SSB-ASK modulation with Tari=25µs, and 50 kbit/s tag data backscatter on a 200kHz subcarrier (BLF=200kHz, M=4).

Example 4: FDM In-channel backscatter

A hypothetical regulatory environment allocates four 500kHz channels and disallows adjacent-channel and channel-boundary backscatter. By the algorithm in Figure I.1, interrogators will use 500kHz channels with in-channel backscatter. Example 4 of Figure I.2 shows interrogator transmissions using PR-ASK modulation with Tari=25µs, and 25 kbit/s tag data backscatter on a 200kHz subcarrier (BLF=200kHz, M=8).

A.2 Channelisation in multiple- and dense-interrogator environments

When Interrogators in multiple- and dense-Interrogator environments instruct tags to use subcarrier backscatter, the Interrogators shall adopt the channelisation determined by the algorithm in I.1. When interrogators in multiple- and dense-interrogator environments instruct tags to use FM0 backscatter, the interrogators shall adopt a channelisation that is in accordance with local regulations. Regardless of the backscatter data encoding, interrogator transmissions shall satisfy the multiple- or dense- interrogator transmit mask in clause 9.3.1.2.11.

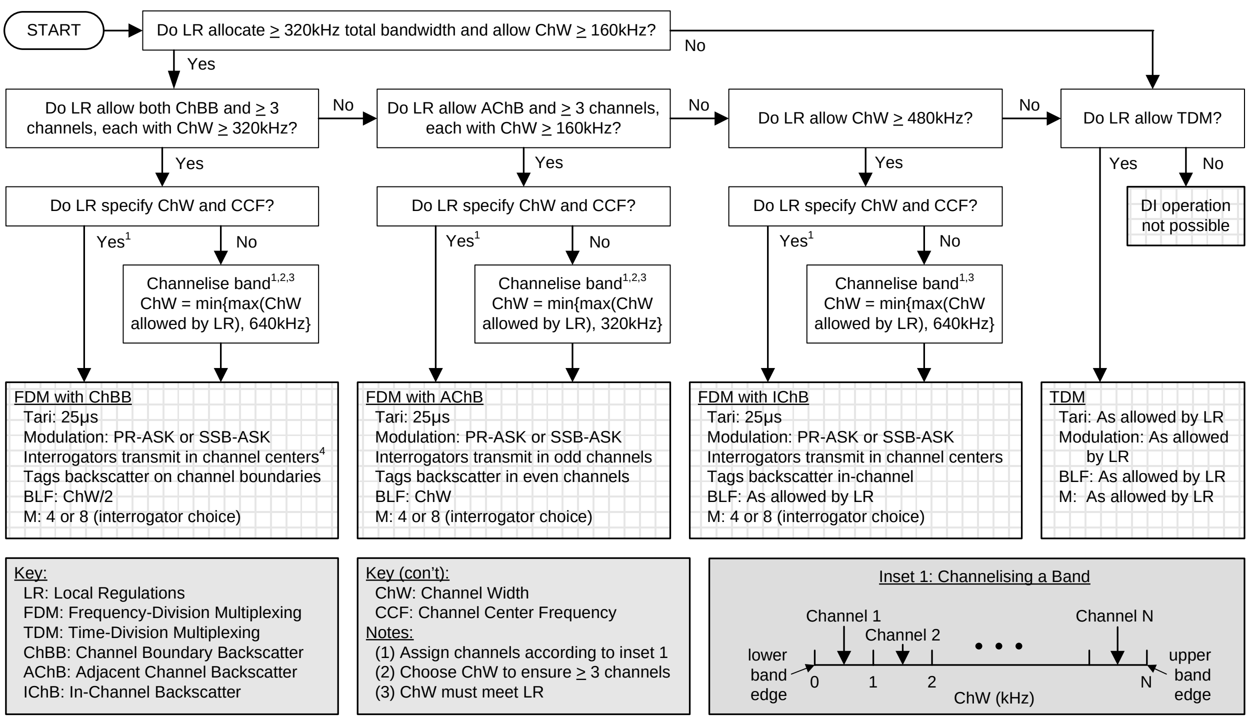


Figure I.1 — Algorithm for determining channelisation and dense-interrogator-mode parameters

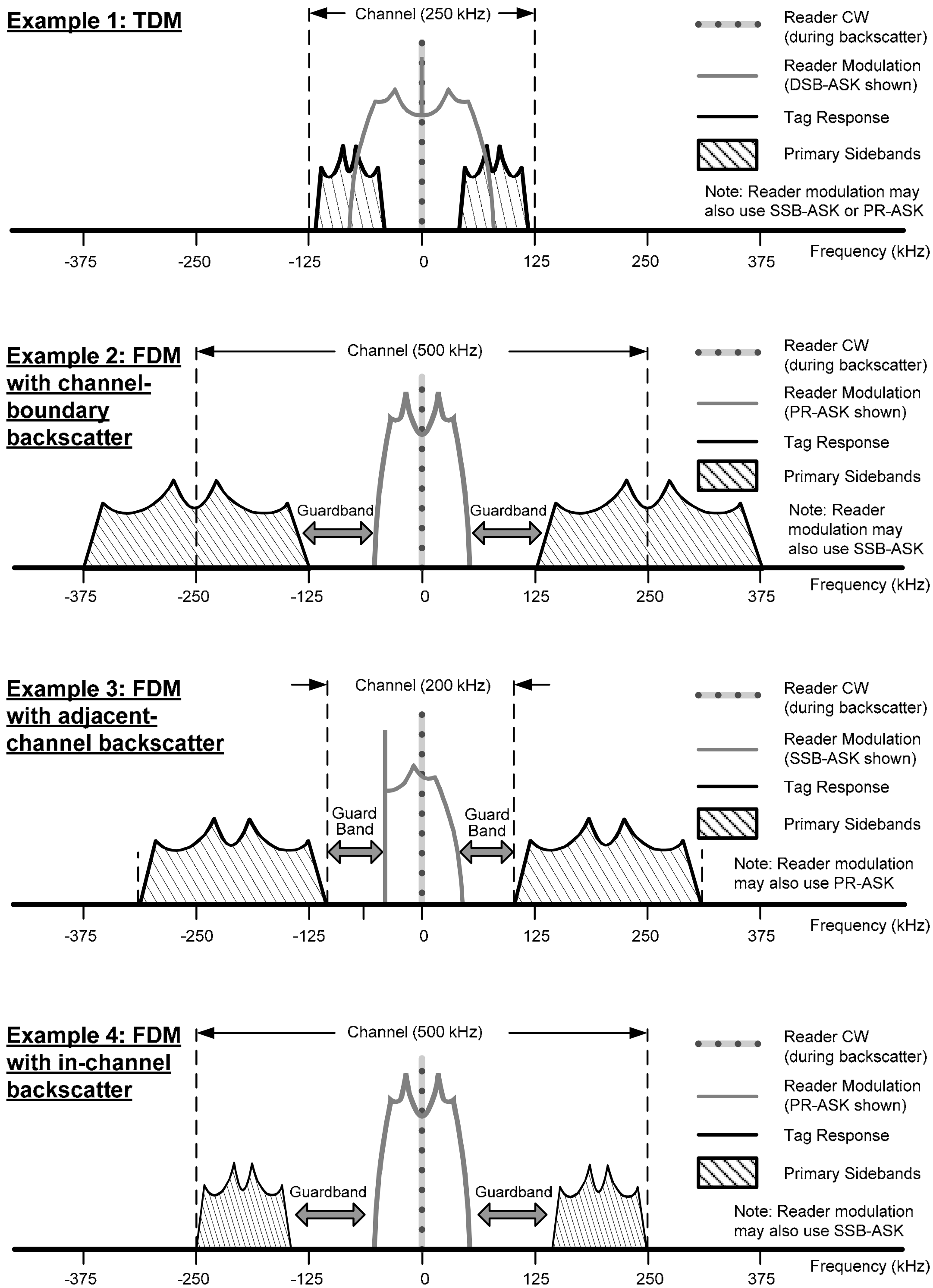


Figure I.2 — Examples of dense-interrogator mode operation

A.2.1 Example channelisation

In the FCC 15.247 environment from example 2 above, Interrogators will use the channelisation in Table I.1.

Table I.1 — Channelisation for Example 2

Commanded tag backscatter format	Channel width	Channel centre frequencies f_c	Guardbands
Subcarrier	500 kHz	Channel 1: 902.75 MHz Channel 2: 903.25 MHz • • Channel 50: 927.25 MHz	Lower bandedge: 902 MHz – 902.5 MHz Upper bandedge: 927.5 MHz – 928 MHz

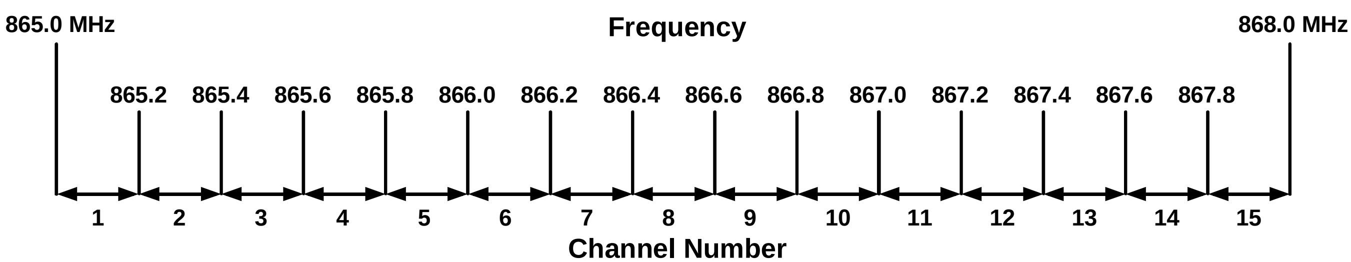
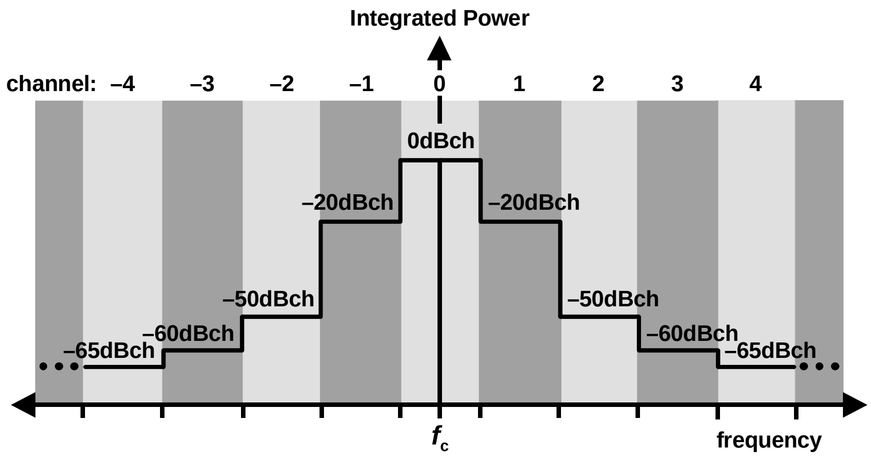


Figure I.3 — Channel numbering for Example 3



Transmit Mask for Multiple Interrogators