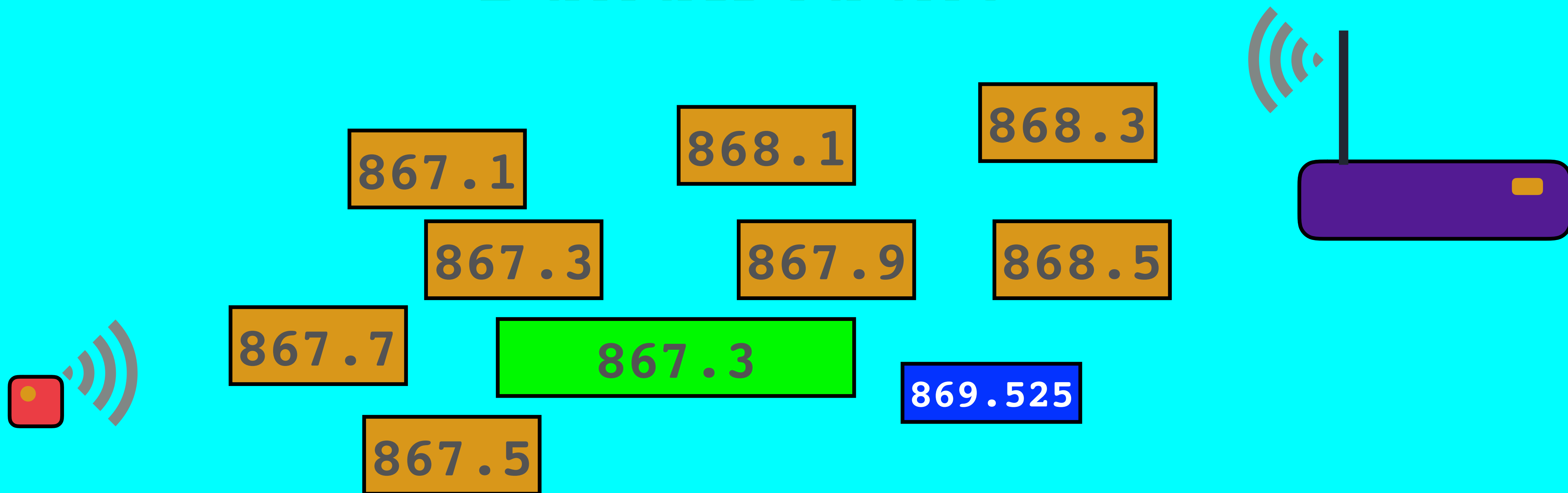


LORA / LORAWAN TUTORIAL I I

Carrier Frequencies & Bandwidths



INTRO

- In this tutorial I will discuss carrier frequencies, bandwidths, ETSI sub bands, dwell time and hop time.

LORAWAN FREQUENCIES

- As mentioned before LoRaWAN uses frequencies in the ISM band.
- On The Things Network (TTN) website you can find the (carrier) frequencies for your country.
- First find the frequency plan which applies to your country:
<https://www.thethingsnetwork.org/docs/lorawan/frequencies-by-country.html>
For example: Netherlands uses frequency plan: EU863-870 (Note: EU433 is not implemented, please ignore it.)
- If you know your frequency plan, find the corresponding LoRaWAN frequencies:
<https://www.thethingsnetwork.org/docs/lorawan/frequency-plans.html>

LORAWAN FREQUENCIES

- Instead of using the The Things Network (TTN) website, checkout the LoRaWAN Regional Parameters document issued by the LoRa Alliance:
<https://lora-alliance.org/lorawan-for-developers>
- This document contains the approved frequency channel plans for various global regions, and follows the established regulatory constraints in those regions.
- In this video I am only focussing on the EU863-870 ISM band, for other ISM bands please consult the LoRaWAN Regional Parameters document.

EU863-870 ISM BAND CHANNEL FREQUENCIES

- LoRaWan frequencies used in Europe, for example in the Netherlands (TTN freq. plan: EU863-870)

Channel	Uplink freq (MHz)	SPREADING FACTOR & BANDWIDTH RANGE
0	868.1	SF7BW125 to SF12BW125
1	868.3	SF7BW125 to SF12BW125 and SF7BW250
2	868.5	SF7BW125 to SF12BW125
3	867.1	SF7BW125 to SF12BW125
4	867.3	SF7BW125 to SF12BW125
5	867.5	SF7BW125 to SF12BW125
6	867.7	SF7BW125 to SF12BW125
7	867.9	SF7BW125 to SF12BW125
8	868.8	FSK

EU863-870 ISM BAND CHANNEL FREQUENCIES

- LoRaWan frequencies used in Europe, for example in the Netherlands (TTN freq. plan: EU863-870).

Download freq (MHz)	SPREADING FACTOR & BANDWIDTH RANGE
	Uplink channels 0-8 (RX1)
869.525	SF9BW125 (RX2 downlink only)

- For uplinks there are 8 channels to use.
- For downlinks the same 8 channels are used for receive slot 1 (RX1) and one channel for receive slot 2 (RX2).

Note: The receive slots are explained in Tutorial 4 “LoRaWAN Device Classes”.

EU863-870 ISM BAND CHANNEL FREQUENCIES

- If your country uses the EU863-870 ISM band, than according to the LoRaWAN Regional Parameters document every EU868MHz end device must implement the following default channels:
 - 868.10 MHz, bandwidth = 125 kHz
 - 868.30 MHz, bandwidth = 125 kHz
 - 868.50 MHz, bandwidth = 125 kHzand additional 5 frequencies.
- The other 5 frequencies can be freely attributed by the network operator. For example, The Things Network implemented the following frequencies: 867.1, 867.3, 867.5, 867.7 and 867.9.

CHANNEL

- Earlier the word channel is used. A channel is just an agreed-upon set of specific frequencies with additional information included in the agreement.
- For example when using the TTN freq. plan: EU863-870 the uplink channel 3 refers to:
 - carrier frequency: 867.1 MHz
 - SF7BW125 to SF12BW125
- The LoRaWAN Regional Parameters used by The Things Network can also be found at: <https://github.com/TheThingsNetwork/gateway-conf>

EU863-870 ISM BAND CHANNEL FREQUENCIES

LoRaWan frequencies used in Europe
TTN freq. plan: EU863-870

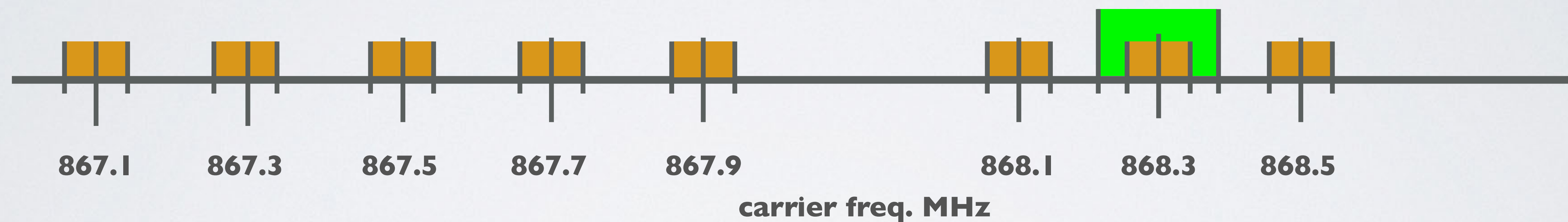
Bandwidth

 125 kHz @ SF 1-7, for downlink slot 1

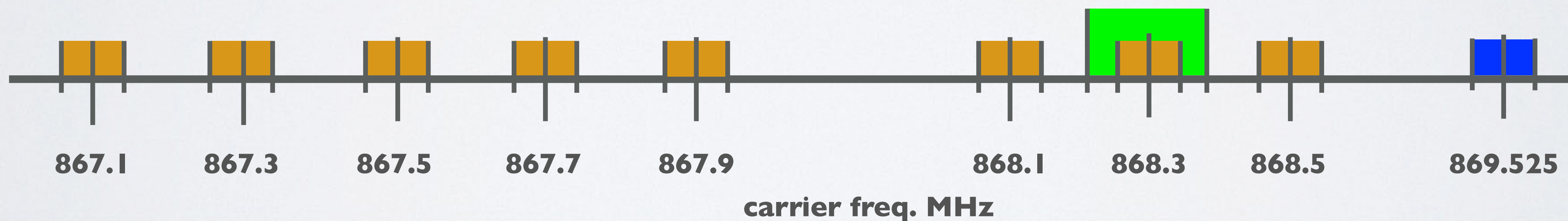
 250 kHz @ SF7, for downlink slot 1

 125 kHz @ SF9 for downlink slot 2

Uplink frequencies



Downlink frequencies

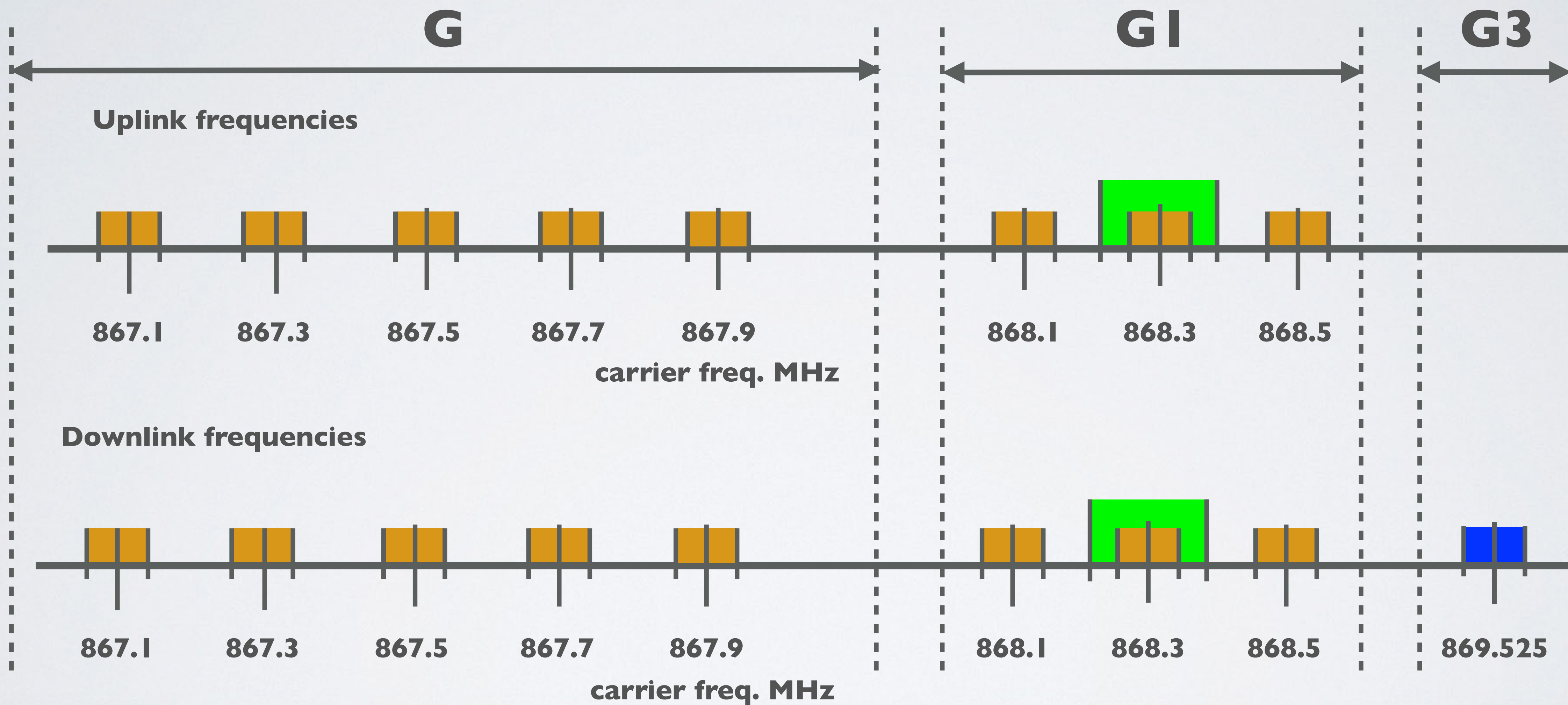


ETSI SUB BANDS 863-870

- ETSI divides the 863-870 MHz band (referenced “G”) into 5 sub-bands: G, G1, G2, G3 and G4. [5]
- Each sub band has different constraints in term of ERP, duty cycle and channel bandwidth.

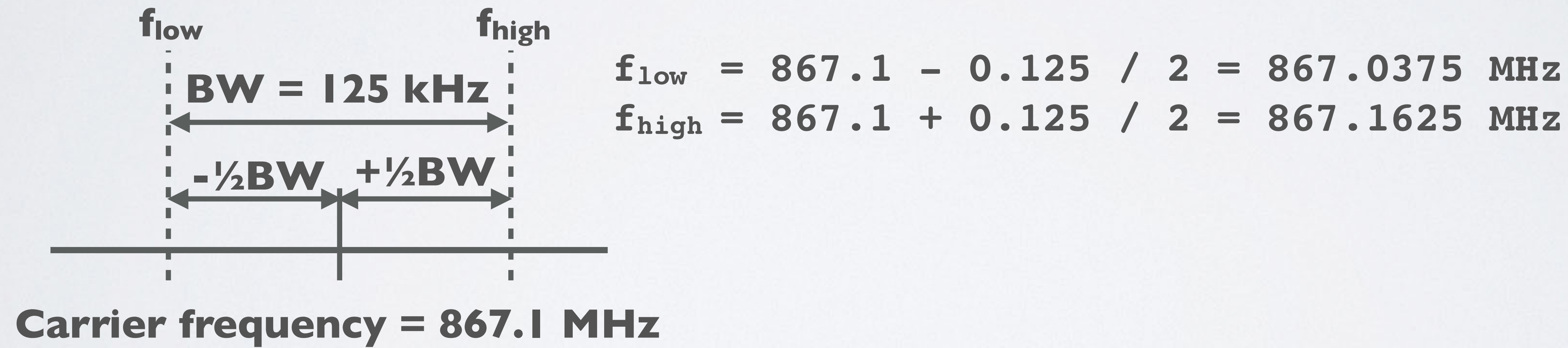
Name	Band (MHz)	Limitations
G	863.0 – 868.0	ERP<25 mW – duty cycle < 1%
G1	868.0 – 868.6	ERP<25 mW – duty cycle < 1%
G2	868.7 – 869.2	ERP<25 mW – duty cycle < 0.1%
G3	869.4 – 869.65	ERP<500 mW – duty cycle < 10%
G4	869.7 – 870.0	ERP<25 mW – duty cycle < 1%

EU863-870 FREQUENCIES AND SUB BANDS

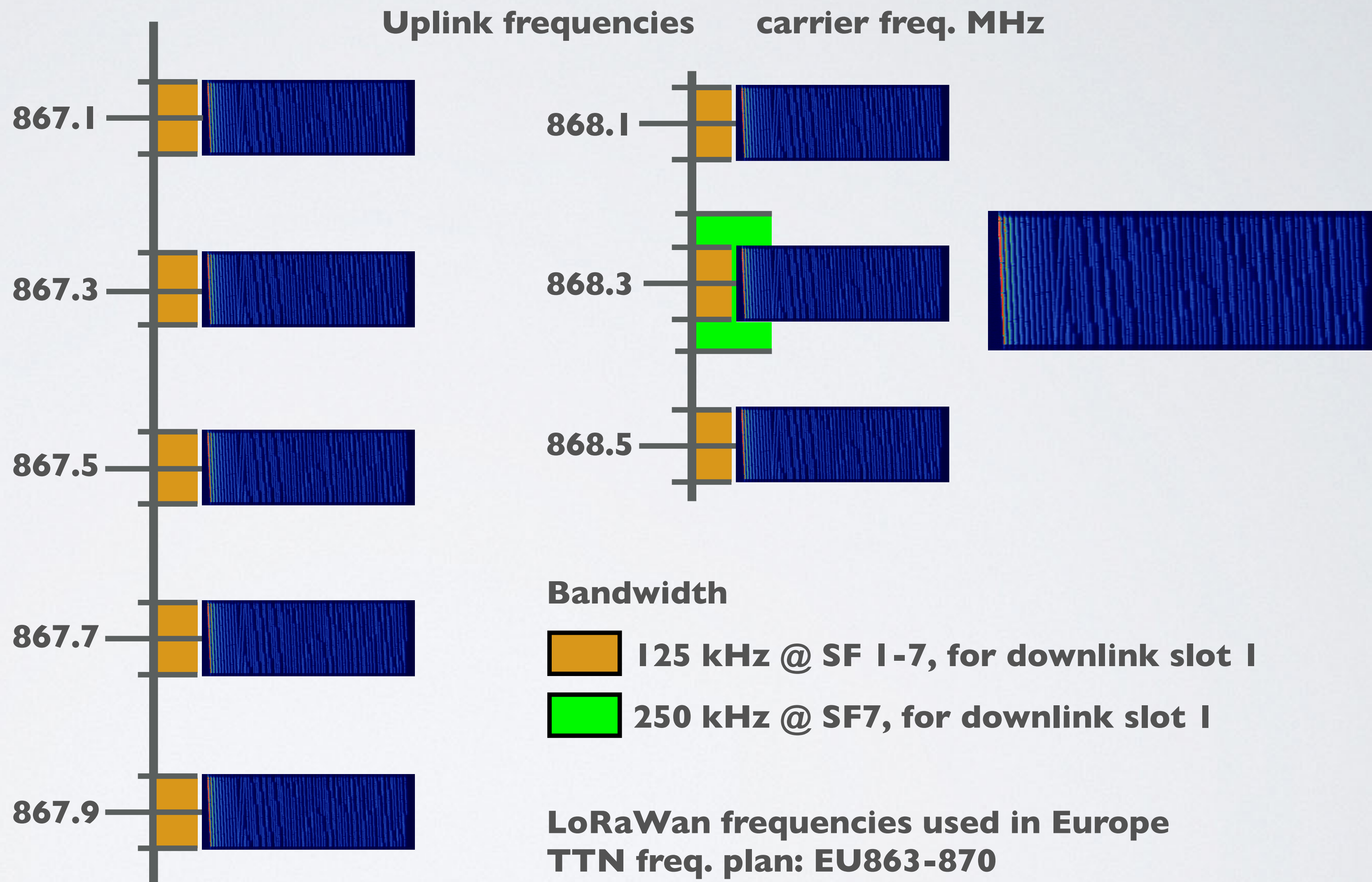
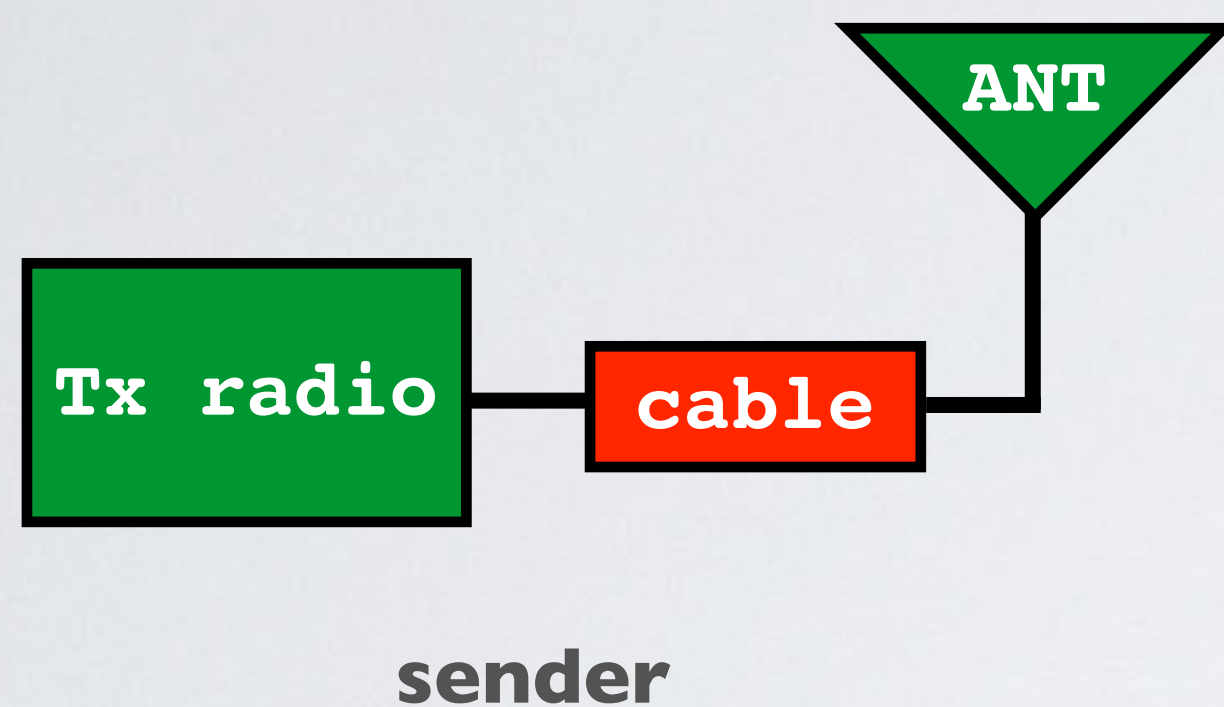


BANDWIDTH

- LoRaWAN only uses the following bandwidth ranges: 125 kHz, 250 kHz and 500 kHz. Which of these 3 ranges are actual used depends on the region or frequency plan. For example in Europe only the bandwidths 125kHz and 250 kHz are used.
- The relationship between bandwidth and carrier frequency can be seen in the figure below.

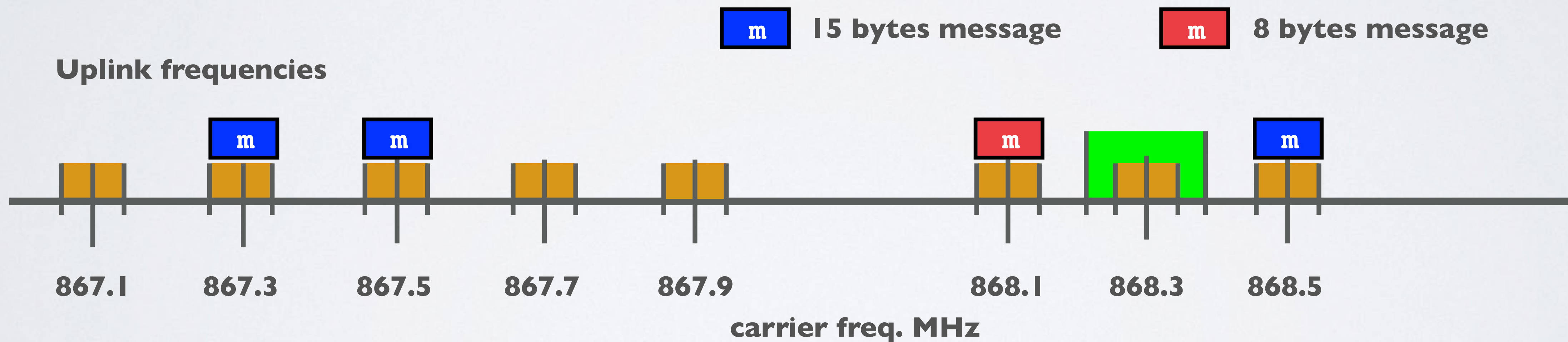


CARRIER FREQUENCIES & BANDWIDTHS



CHANGING FREQUENCIES FOR EVERY TRANSMISSION

- An end device changes channel in a pseudo-random fashion for every transmission. Changing frequencies makes the system more robust to interferences.
- For example in Europe for uplink transmissions 8 different frequencies are used.



DWELL TIME & HOP TIME

- Dwell time (or transmit time) is the amount of time needed to transmit on a frequency.
- Hop time is the amount of time needed to change from one frequency to another in which the radio is not transmitting

