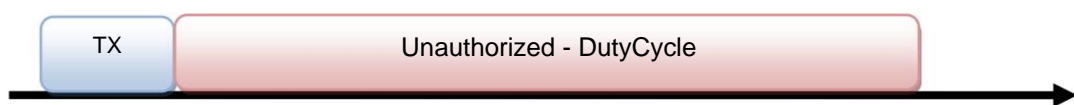


The use of Class C actuators, especially pilot wires, in LoRaWAN must be accompanied by an optimized Radio network architecture and LoRaWAN server configuration.

Indeed, to change the state of the pilot wires, it is necessary to send a command to them. However, since LoRaWAN operates on a free radio band, each communicating element (sensor and gateway) is constrained by a portion of time during which the device can transmit. This is called the "duty cycle".

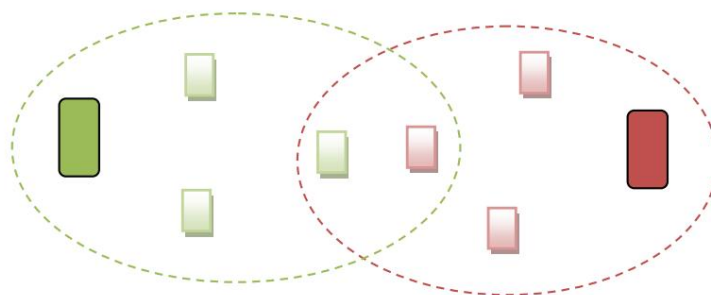
This constraint is very significant for gateways in this use case. Gateways use the 869.525 Hz channel, which allows a 10% duty cycle. Thus, over a 3600-second period, the gateway is authorized to transmit for 360 seconds. However, some LoRaWAN servers manage the duty cycle not on a rolling hourly basis, but pause after each transmission.



The downlink response time depends on the data rate used. In LoRaWAN, data rates range from SF12 (DR0), the slowest but with the greatest range, to SF7 (DR5), the fastest but with the shortest range. By default, downlink communication with a Class C actuator uses SF12, which translates to 1483 ms for an 8-byte frame (<https://avbentem.github.io/airtime-calculator/ttn/eu868/8>).

In this case, following a downlink transmission, it is necessary to pause for 14.9 seconds before access to the radio network is freed up.

One of the first solutions would be to add gateways that would allow for parallel sending of commands. The network architecture must be designed to include one gateway per zone, without the gateways completely overlapping.

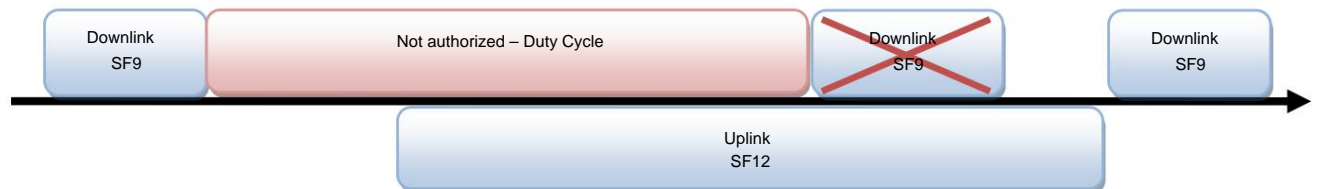


In this case, we immediately double the number of commands that can be sent to the actuators for the same delay.

Furthermore, some gateways can transmit at a power of +27dBm, while a sensor transmits at a maximum of +14dBm. To achieve the longest possible range symmetry between the uplink and downlink, the sensor must be in SF12 at +14dBm, but the gateway can only be at +27dBm in SF9: $\text{Range (+14dBm/SF12)} = \text{Range (+27dBm/SF9)}$.

Thus, by increasing the downlink bandwidth (RX2 window), the transmission time will decrease. For a command, the transmission delay would drop to 186 ms, which would reduce the pause time due to the duty cycle to 1.86 seconds.

However, in all cases, it is best to wait for the return frame from the actuator before sending the next frame on a specific gateway to avoid causing a collision.



Furthermore, during a power outage there may be network saturation when the actuators turn back on and try to connect to the LoRaWAN network.

The pilot wires make an initial association request at random intervals of 10 minutes, then repeat the operation, doubling the time each time: 20 minutes, 40 minutes, and so on, up to once every 6 hours. These association requests are made using SF12 on 3 channels defined by the standard.

Depending on the number of sensors and gateways, there can be significant traffic congestion. To avoid this, it is best to have several gateways, well-positioned per zone, configuring them with as many channels as possible (up to 8) and enabling ADR (Analysis of Data Rates), so that once devices are integrated into the network, they release the 3 default frequencies and use the fastest data rate appropriate for the range.

To summarize, the radio network must be properly configured to ensure the best possible overall system quality:

- Redundancy of gateways to be positioned by zone.
- Configure RX2 in SF9 if gateway transmits at +27dBm.
- Configure 8 channels per gateway.
- Configure the use of ADR on the gateway.
- Wait for the sensor response and the minimum duty cycle delay before sending a New order.