Synchronized Frame Structure

After acquisition mode and synchronization is achieved, both transceivers operate with a synchronized repeated Frame consisting of 10 time slots. Neither transmits during the first (RSSI) so that they can each evaluate the local radio environment. The second is for an exchange of data packets for command, control and to measure and correct slot timing error in order to maintain synchronization. The remaining "DN" slots are reserved for downlink balloon data as required, one packet per slot. Timing is

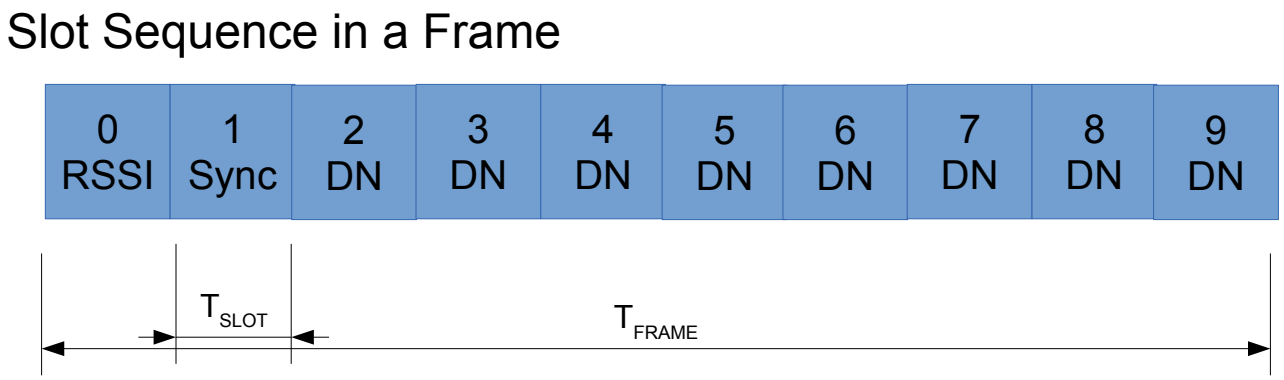

Figure 1: Frame structure. T_{SLOT} is nominally 1 second and T_{FRAME} 10 seconds.

maintained by timer interrupt.

Interrupts are scheduled from slot to slot rather than working off of a fixed timer. This is the easiest way to allow for periodic adjustment of the timing. This will only be done during the SYNC burst by adjusting the scheduling of slot 2 based on the measured timing error (see below). Since this must be done for Slot 1 to Slot 2 timing, it is easier to simply have each slot set the timing for the next slot as well. The only difference is that the time to the next slot is fixed.

RSSI Slot

"RSSI" slot is where both Ground and Balloon are in receive mode and so can measure the external interfering signal levels in all channels. Each will use this to determine which is its preferred receive

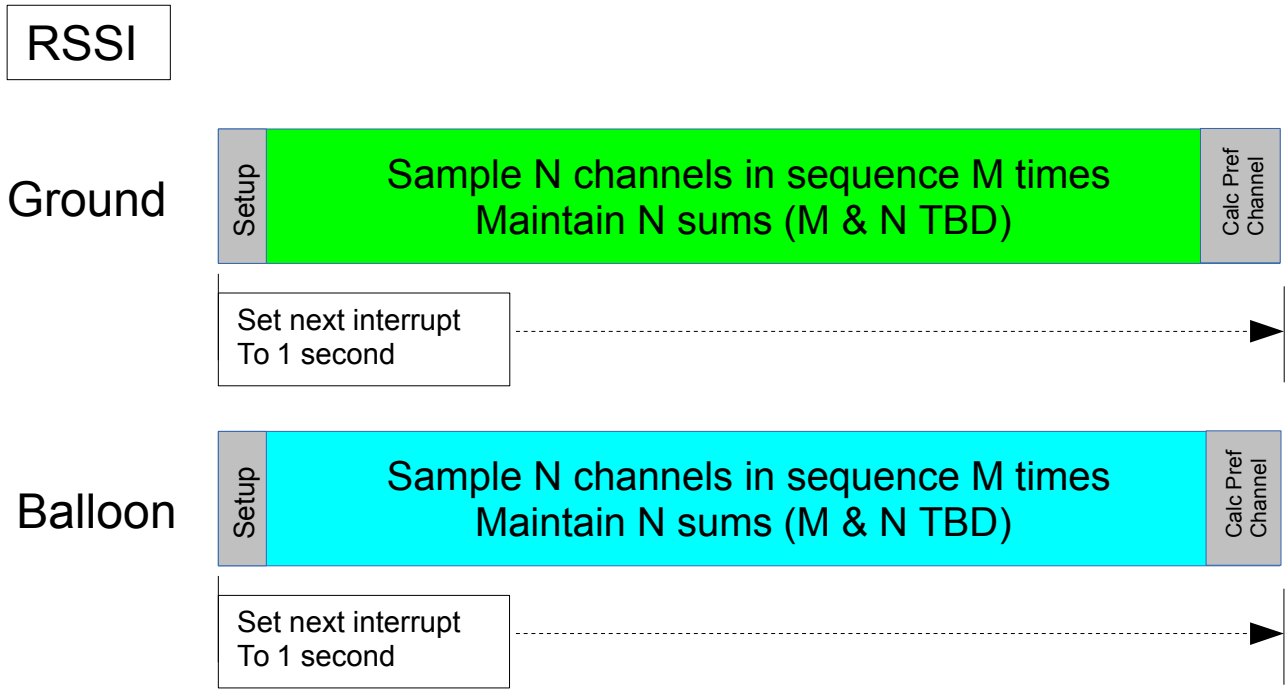

Figure 2: RSSI Slot

channel for the next frame as illustrated in Figure 2. Notice that the interrupt time for the next slot is set at the beginning of the slot as mentioned above.

The RSSI should ideally sequence through each channel, one reading each and then this process repeated as many times as possible during the slot, keeping a sum of each channel's readings. This would make the readings less sensitive to short bursts of noise. However, changing channels in the transceiver chip presumably starts the RSSI settling process (this is not clear in the CC101 specification), which is much longer than the time between RSSI updates once settled on a channel. For a likely transmission rate (1.2 kb/s) and at low RF levels, the CC1101 takes 1585 µs to settle but the RSSI updates every 140 µs after that ([2], Table 2).

So, the measurements for each of N channels should be taken by changing channel, waiting 1600 µs to settle, then M readings in sequence, 140 µs apart. The total time taken is nominally (1.6 + 0.14M)N ms. For all 256 channels, this allows up to 16 measurements per channel for a 1 second slot.

At the end of the measurements, an algorithm determines which channel to use during the next frame. The algorithm should initially be simply choosing the channel with the lowest average RSSI. More sophisticated algorithms can be developed later.. The desired channel will be included in the SYNC packet during the next slot.

SYNC Slot

The SYNC slot is an exchange of data packets between ground and balloon as illustrated in Figure 3. First, the Ground sends a packet that contains balloon subsystem and payload commands, the time from slot interrupt to the end of the transmission (T_{GND}), and the assigned balloon transmit channel for the next frame based on the RSSI analysis. If the balloon received the packet, it transmits an acknowledgment packet that includes telemetry from balloon subsystems and payloads as well as the assigned ground transmit channel for the next frame.

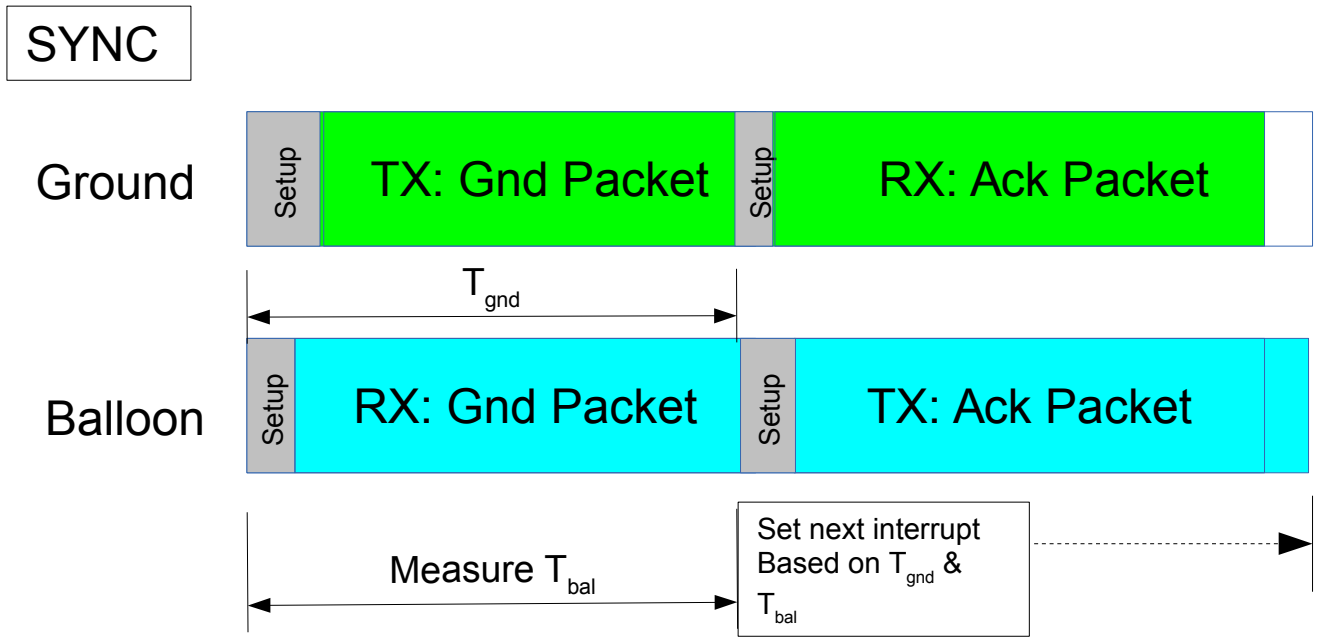

Figure 3: SYNC slot

Data	Bytes	Description
tGround	2	Time from slot start to end transmission in milliseconds.
chanRXGnd	1	Channel number for balloon TX next frame.
command[0]	1	Four bits address, four bits command.
command[1]	1	“
...	...	...
command[K-1]	1	“

Table 1: Ground SYNC data payload

Data	Bytes	Description
	2	Time from slot start to end transmission in milliseconds.
chanRXBalloon	1	Channel number for ground TX next frame.
gpsBalloon	20	GPS position, ground velocity, timestamp (4 bytes each)
sensor data	?	“
...	...	...
sensor data	?	“

Table 2: Balloon SYNC data payload

Acquisition Mode

A simple approach to acquisition will initially be used where the ground repeats SYNC slots on a pre-arranged channel continuously until an acknowledgment is received after which the synchronized frame sequence is picked up at slot 2.

Bibliography

[1] CC1101 Single-Chip Low Cost Low Power RF-Transceiver, Data sheet (cc1101.pdf)

[2] DN505 RSSI Interpretation and Timing (swra114.pdf)