AN1200.21

Reading channel RSSI during a CAD

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1 Preamble

When implementing antenna diversity techniques, it may be useful to implement a combination of RSSI and CAD detection. This will help picking the best possible signal path on the radio receiver and avoid picking the wrong channel on a false CAD detection (very low probability), all of this at very low energy cost. Indeed, the RSSI information is available during CAD and there is no need to leave the receiver on for some additional time. Even if the end platform does not support antenna diversity, the energy saving made while reading the RSSI during a CAD made this technique essential for all battery powered systems.

2 Channel Activity Detection principles

The Channel Activity Detection mode is designed to detect a LoRa preamble on the radio channel with the best possible power efficiency. Once in CAD mode, the SX127x will perform a very quick scan of the band to detect a LoRa packet preamble.

During a CAD the following operations take place:

- The PLL locks
- The radio receiver captures LoRa preamble symbol of data from the channel. The radio current consumption during that phase is approximately 10 mA.
- The radio receiver and the PLL turn off and the modem digital processing starts.
- The modem searches for a correlation between the Radio captured samples and the ideal preamble waveform. This correlation process takes a little bit less than a symbol period to perform. The radio current consumption during that phase is greatly reduced.
- Once the calculation is finished the modem generates the CadDone interrupt. If the correlation was successful, the CadDetected is generated simultaneously.
- The chip goes back to stand-by mode.
- If a preamble was detected, clear the interrupt, then initiate the reception by putting the radio in RX single mode or RX continuous mode.

The time taken for the channel activity detection is dependent upon the LoRa™ modulation settings used, for instance, the spreading factor and the bandwidth.

For a given configuration, the typical CAD detection time is shown in the graph below, expressed as a multiple of the LoRa™ symbol period. Of this period the radio is in receiver mode for:

$$SymbolTime = \frac{2^{SF}+32}{BW}\ seconds$$

For the remainder of the CAD cycle the radio is in a reduced consumption state. The figure 1 presents the CAD duration in LoRa symbol time.

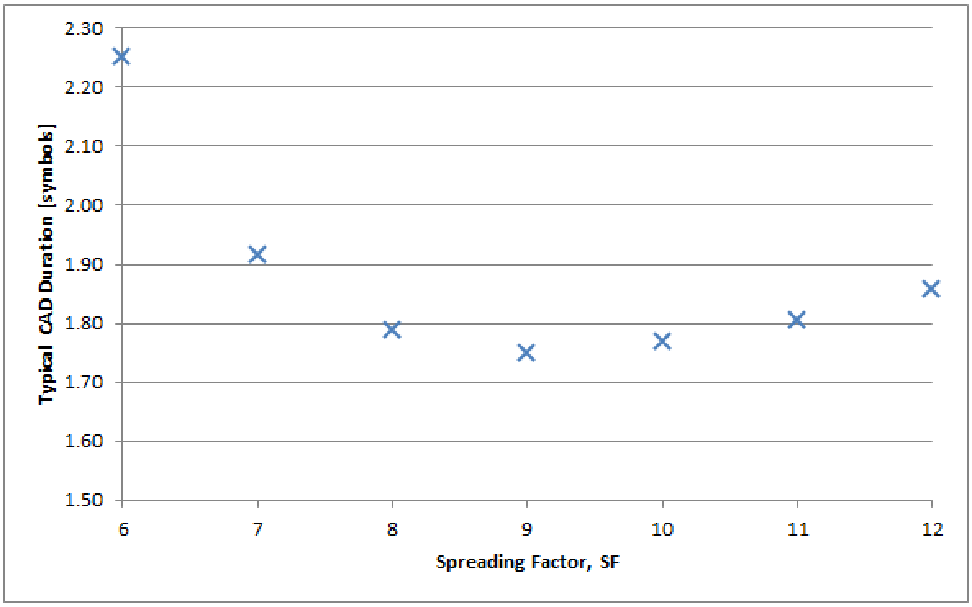

Figure 1: CAD duration depending on Spreading Factor

To illustrate this process and the respective consumption in each mode, the CAD process follows the sequence of events outlined below:

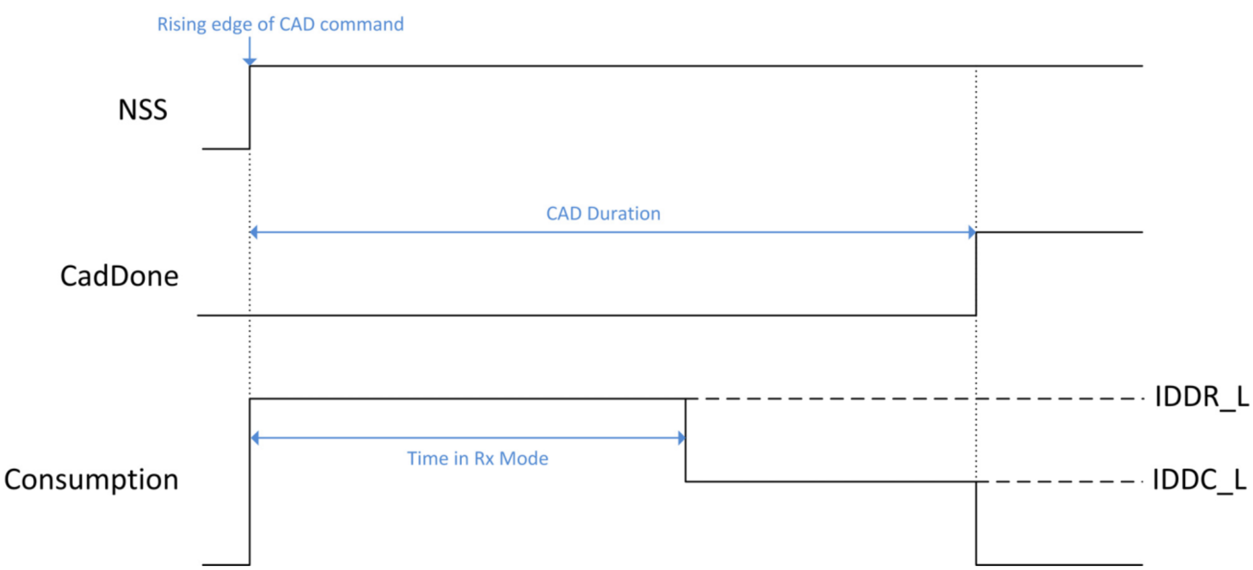

Figure 2: CAD sequence

The receiver is then in full receiver mode for just over half of the activity detection, followed by a reduced consumption processing phase where the consumption varies with the LoRa bandwidth as shown in the table below.

Bandwidth (kHz)	Full Rx, IDDR_L (mA)	Processing, IDDC_L (mA)
125	10.8	5.6
250	11.6	6.5
500	13	8

Figure 3: CAD maximum power consumption

3 Channel Activity Detection in practice

If we look in situ the behavior of the device power consumption during a CAD, we can see the below plot:

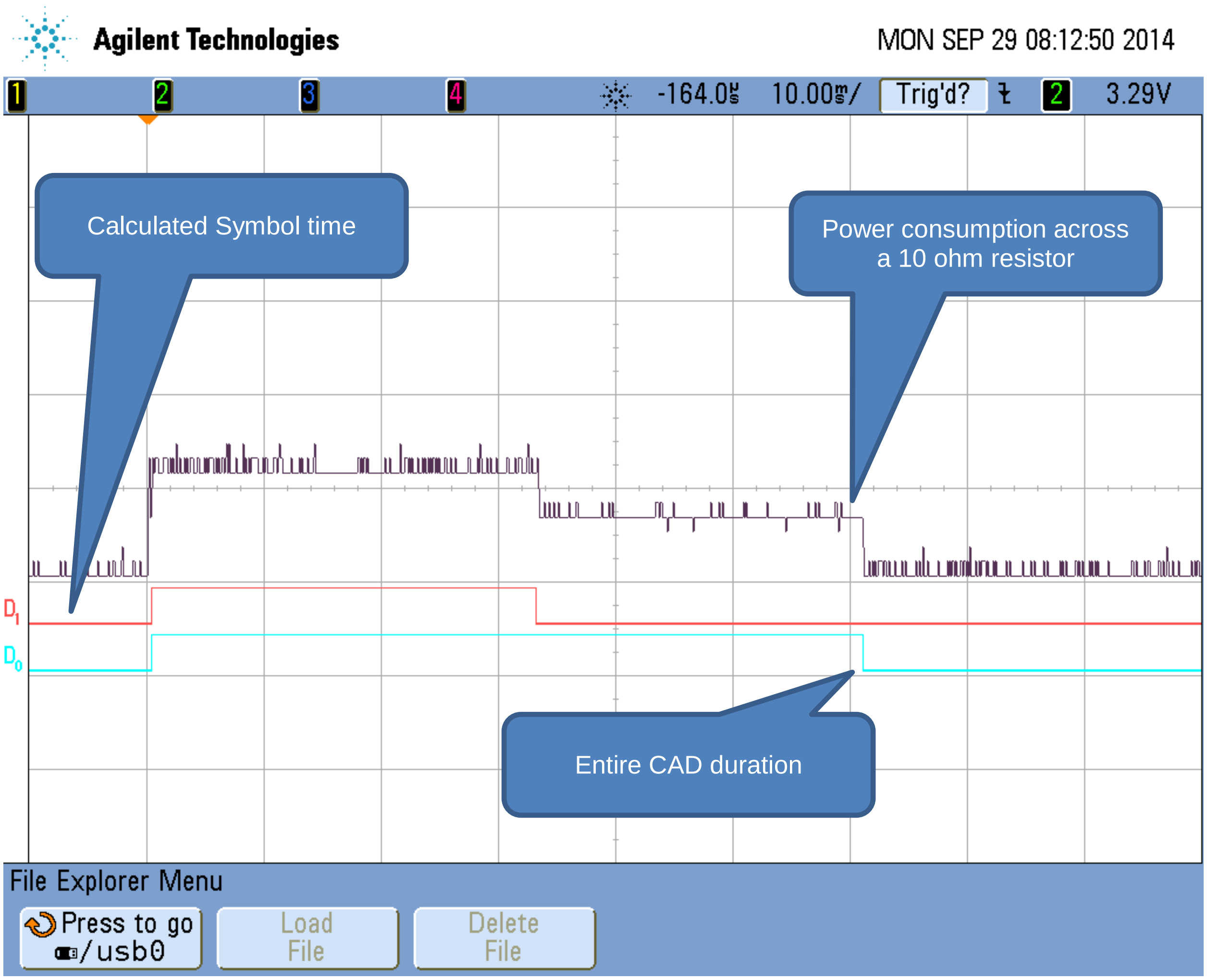

Figure 4: CAD measurement

The above plot has been measured during a CAD while using the setting SF12 and BW=0 (125 KHz) on an SX1272. The graph highlights the consumption of the device during the CAD with a clear distinction between the symbol length and the computation time thereafter.

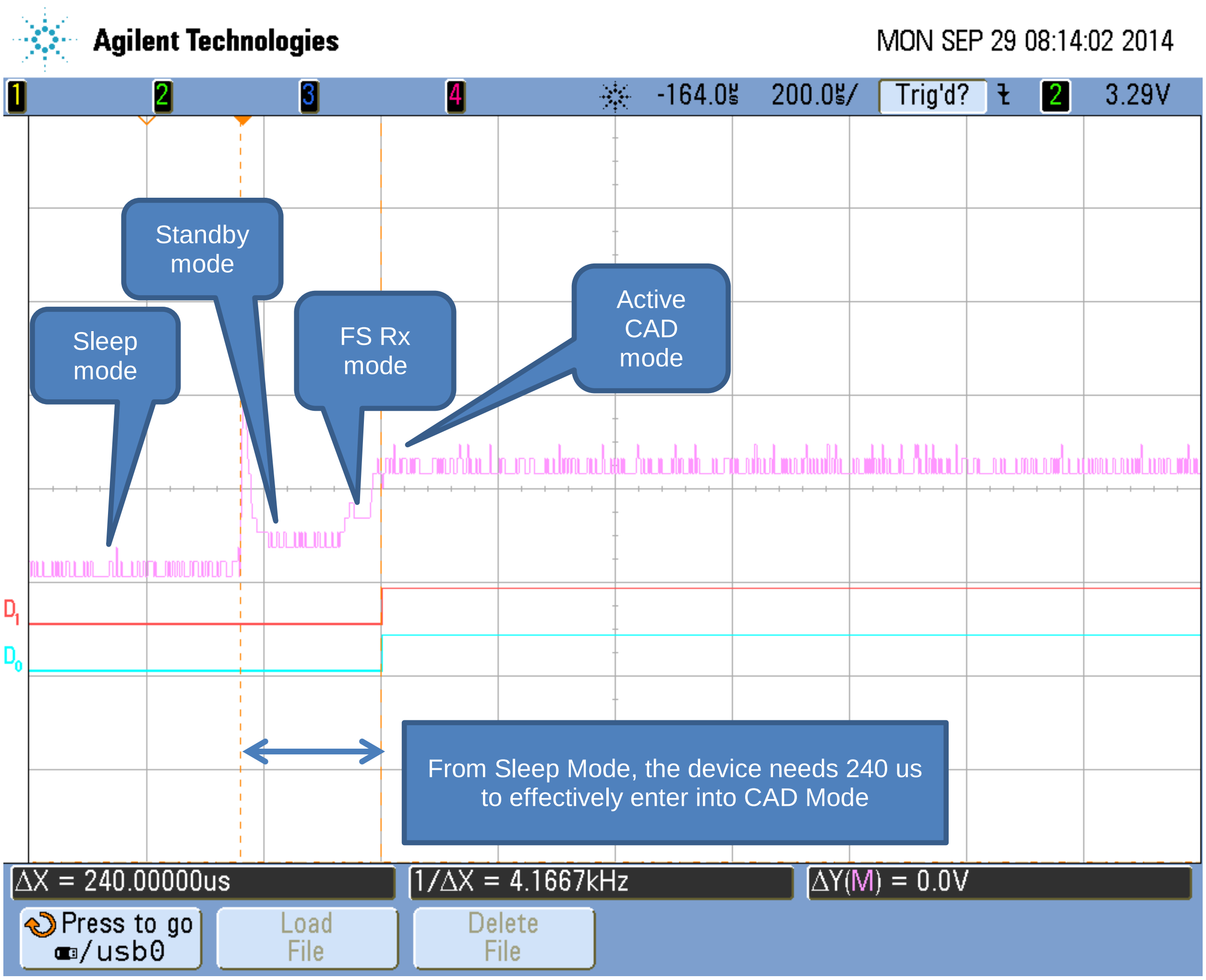

Figure 5: CAD Start-up

The figure 5 above highlights the internal process of the chipsets when going from Sleep Mode to CAD mode. It is important to notice that the device will implicitly go through several stages of operating mode before to effectively starting the reception of the symbol. The time taken is measured at 240 us and is identical for all SF and all bandwidth.

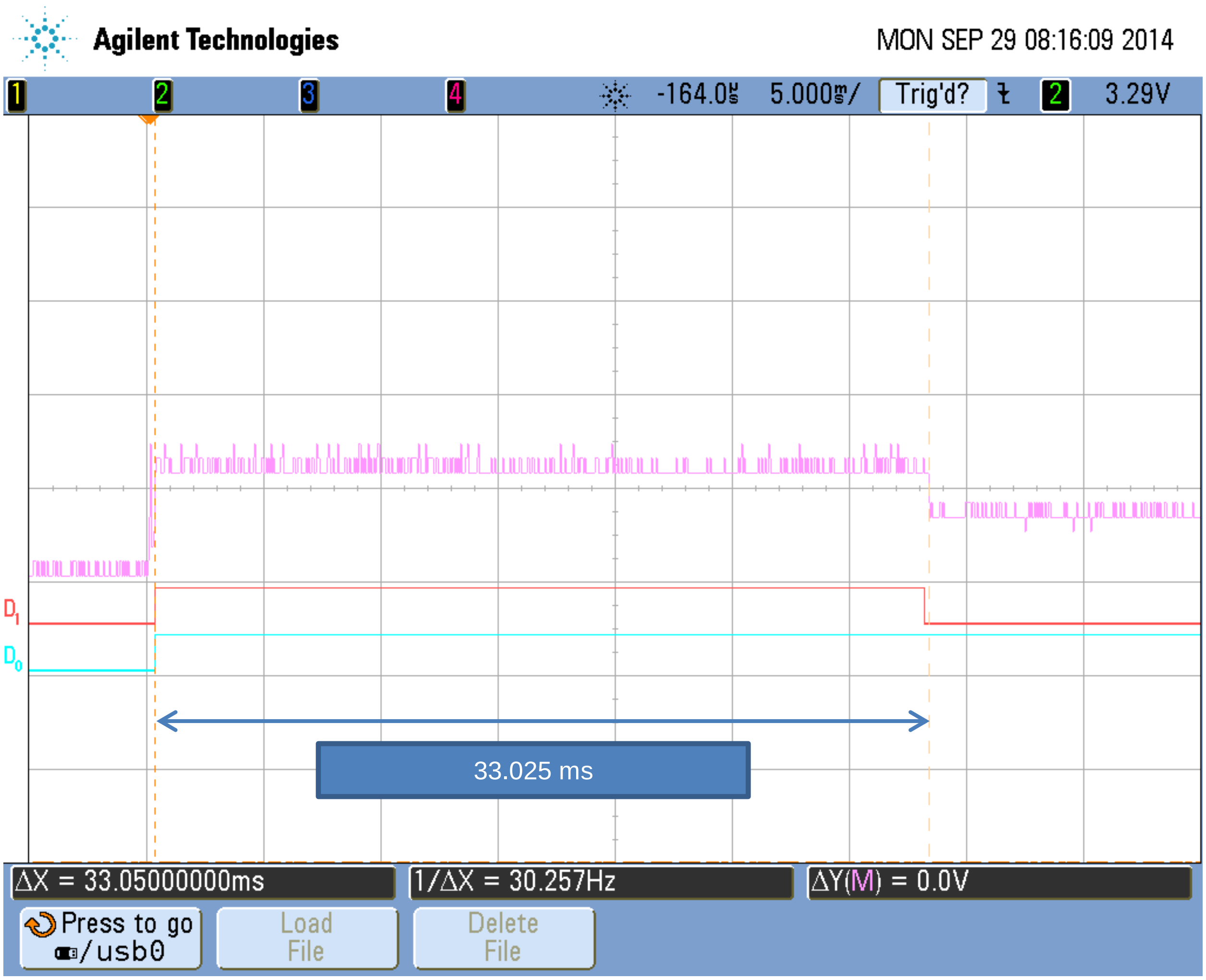

Figure 6: CAD Symbol Time measurement

The figure 6 above highlights the symbol time measure through the power consumption of the device and the calculated symbol time. The formula used to compute the symbol time being:

$$SymbolTime = \frac{2^{SF} + 32}{BW}$$

For SF12 and a bandwidth of 125 kHz, the formula gives us a calculated Symbol Time of 33.024 ms which is identical to the measured symbol time.

Figure 7: CAD Duration

For the full duration of the CAD, the measured value corresponds to 1.85 times the symbol duration as theoretically shown on Figure 1.

4 Reading Rssi during a CAD

During a CAD, The device is effectively in Reception mode for the duration of one LoRa symbol. It is therefore possible to read the RSSI of the signal present within the LoRa bandwidth.

While in reception, the RSSI is sample every 8uS and is asymptotically analyzed. This means that the RSSI value is being calculated along the length of the symbol duration and is directly related to the number of point previously analyzed.

Figure 8: RSSI measure while in CAD

The figure 8 above highlight the moment where the RSSI read from the device is accurate.

5 Source code

To ease the reading of the RSSI, it is possible to compute the most accurate point of the measure. This is done using a simple timer and by computing the length of the LoRa symbol.

The code below highlights the process mechanism:

```
symbolTime =  ( pow( (float)2, (float)LORA_SPREADING_FACTOR ) ) + 32 ) / 125000;      // SF7 and BW = 125 KHz
symbolTime = symbolTime * 1000000;                                                    // symbol Time is in us

   while( 1 )
   {
      t.reset( );                        // Reset the Timer
      Radio.StartCad( );                 // Set the device into CAD mode
      t.start( );                        // Start the Timer

      while( t.read_us ( ) < 240 );      // 240us are needed for the device to go into CAD Mode from Sleep Mode

      while( t.read_us ( ) < symbolTime + 240);          // We wait for Symbol Time and 240 us to be at the very end of
                                                         // the symbol duration

      rssi[i++] = Radio.GetRssi( MODEM_LORA );           // We can now read the RSSI
      t.stop( );                                         // Stop the Timer
      while( State != CAD_DONE );                        // Wait for the end of the CAD process
   }
```

Using this method, it is possible to validate the presence of a valid LoRa preamble and to read the RSSI in a single and easy step.

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