NORDIC ID

AN005 Tuning and AutoTune Procedures

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CONTENT

FIGURES

1 Why is leakage cancellation needed in first place?

UHF RFID radio works in a different way than other radio systems which are either time or frequency divided. This means that transmitted and received signals are in different frequency or they are not on at the same time (time division). This way the isolation between the transmitter and the receiver is not so critical.

In UHF RFID, the transmission and reception need to be simultaneously on. The tag replay comes only with very minor frequency separation (link frequency which is in order of 40 – 640 kHz), so it cannot be filtered out from the TX at operation frequencies. Therefore, a solution to separate the TX and RX is to use a directional component. Circulator or nowadays almost every time a RF coupler. This approach has certain limitations, which are demonstrated in Figure 1.

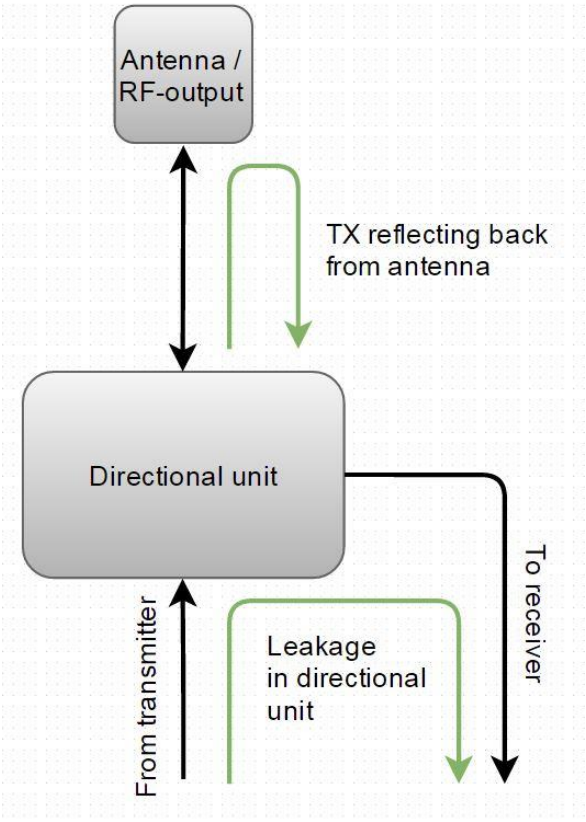

Figure 1. Paths for TX to go into receiver.

As described, there are two ways how the TX can leak into the receiver section and interfere the reception. The first is the leakage in directional unit, which is because real life components are not ideal. The isolation in RF couplers is approximately 25-30dB. The second source is the antenna - if the matching of the antenna is not sufficient, the portion of the power fed to the antenna will reflect back and go directly into the receiver. A common requirement for antenna matching is to have S11 (reflection attenuation) better than 15dB. Reflection attenuation indicates the amount of power that will not go into the antenna but reflects back. Therefore, if S11 is 10 dB (10 times) and we feed 1W into antenna, the 100 mW will reflect back.

The challenge is that the leakage generates the decreased performance of the receiver. There will be more reception errors and decreased sensitivity.

2 Implementation of tuning and autotune functions

The basic idea behind the leakage cancellation technology is to eliminate this TX leakage signal. This can be done in many ways. Current implementation is to feed the cancellation signal into the RX line. When this cancellation signal is with the same amplitude but in an opposite phase, it will cancel the unwanted interference signal from the RX line. In order to achieve this, we have a specific circuitry adjusting this cancellation signal. This circuitry can be controlled by a manual tuning command or by using a fully automated AutoTune functionality. Tuning values are frequency debendand, which means that the full UHF RFID frequency range has been devided into frequency groups. When certain frequency is applied, the circuitry will use the correlating area tuning value. Figure 2 indicates this approach.

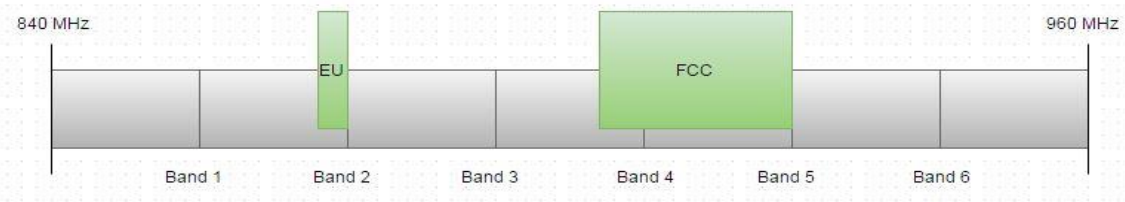

Figure 2. Tuning band division.

2.1 Manual tuning command

Manual tuning should be done after the installation of the reader and the antenna system (this is when all other settings are applied to the reader as well). This is recommended, especially with fixed readers. Manual tune is not recommended to be utilized in normal use because it takes time. Tune command includes the parameters; 1) band, 2) depth and 3) antenna. 1) Band refers to the Figure 2. For example when using a reader in EU region, tuning needs to be done for band 2 and for all the enabled antennas. If the FCC region is used, then bands 4 and 5 need to be selected. No harm can be done by tuning all the bands. It only takes time. 2) Depth parameter effects to the time which the procedure takes. There are fast and wide settings available. Fast setting takes about 1 second (all bands and one antenna) and wide takes about 16 seconds with similar conditions. Wide setting is recommended to be used.

Nordic ID devices with fixed antennas are tuned in production.

2.2 AutoTune functionality

Environment near the antenna will change the antenna impedance seen by the reader. For example, with POS-reader, like Nordic ID Sampo, the antenna impedance will vary depending on if the items are nearby the antenna or not. This applies to all Nordic ID readers as well. To answer this challenge the AutoTune functionality has been implemented. By using this function the reader will always operate with its maximum available performance level. Figure 3 indicates the AutoTune procedure.

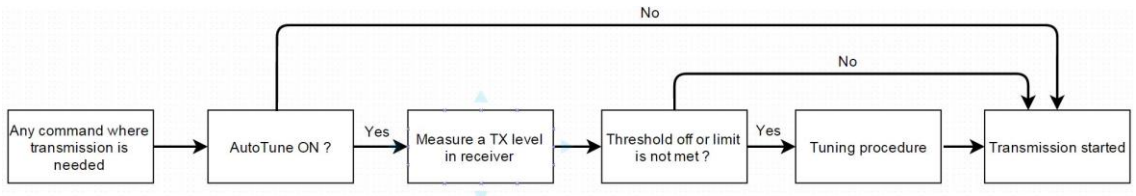

Figure 3. Flow chart of the AutoTune procedure.

AutoTune will adjust the leakage cancellation circuitry continuously when the reader operates. This way the reader can adjust into different antenna impedance loads. This procedure is done every time when a command including transmission is sent to the reader. If AutoTune is enabled, the tuning is always done. This is not required if the environment has not changed. To optimize the speed, the threshold parameter for AutoTune function is also introduced. This means that the reader measures the current TX level in the receiver and if the threshold limit is met, the tuning procedure is skipped in order to save time. Recommended threshold values are following:

- High sensitivity -20
- Nominal sensitivity -10
- Low sensitivity -5

By default, AutoTune is enabled with threshold in all of fixed readers (Nordic ID AR series, Nordic ID Sampo series and Nordic ID Stix).

2.2.1 Benefits

The biggest benefit is that the reader always operates with its maximum performance. In real life this means less reception errors and increased sensitivity. Without AutoTune there is a possibility that if antenna impedance changes dramatically, the receiver is blocked due to the big amount of TX signal reflecting back from the antenna. Figure 4 shows how the AutoTune works.

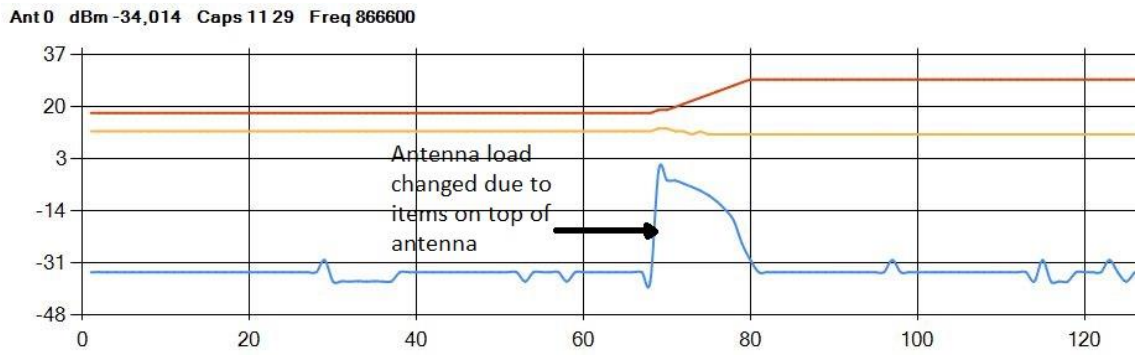

Figure 4. AutoTune in action.

In figure 4 the blue line is the TX power level in the receiver. You can see there how the TX interference level will increace significantly when the antenna load is changed due to environment change. Within few seconds (depends on the settings and tag population) the tuning circuitry has adapted the reader into a new antenna load and TX interference level is back at the minimum possible level.

2.2.2 Influnce to read speed

AutoTune will always decrease the read speed. The amount depends greatly on the settings and the size of the tag population. Figure 5 indicates the fixed duration times that the AutoTune procedure takes. Power level measurement at the beginning takes about 2 ms and if the tuning procedure will be conducted it takes additional 16 ms. The actual tuning procedure is skipped if the threshold requirement is met. As can be seen from the duration times, it is recommended that threshold is used in order to increase the reading speed.

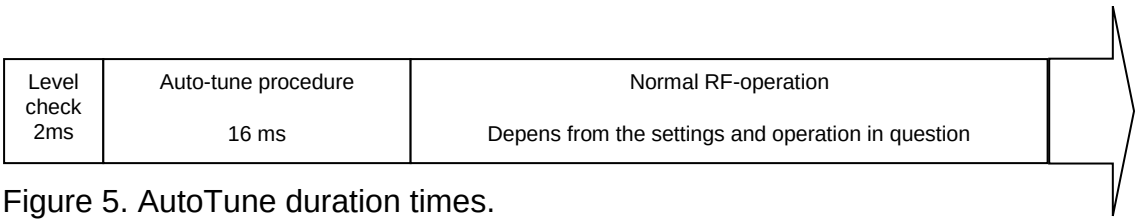

Figure 5. AutoTune duration times.

The duration of the command depends on the operation which is conducted. 96bit read/write takes about 30-40ms. If an inventory is performed it depends on Q and Round values (because these adjust the number of the response slots). Normally one inventory round can take 100 – 300 ms. The larger the tag population is, the smaller is the impact to the read speed and vice versa. In normal use the decrease is between 5 – 15%.