Si4700/01 Firmware 15 Seek Adjustability and Settings

This document applies to Si4700/01 Firmware 15 parts. It provides an overview of the Silicon Laboratories seek algorithm and addresses firmware 15 adjustable seek settings with explanations and example results.

1. Introduction

An important feature of an FM radio receiver is its ability to reliably identify valid stations during a seek operation. This feature allows end customers to seek from one valid station to the next up and down the FM band. It also allows manufacturers to create host software to automatically populate a list of valid stations in a given area. However, reliably identifying and separating valid stations from noise or poor-quality stations is challenging in any environment, especially portable devices. The Silicon Laboratories Si4700/01 FM Tuner family provides a highly reliable seek algorithm, and also adds adjustability so that manufacturers and/or end users can customize seek settings to accommodate individual tastes or changing RF environments.

2. Si4700/01 Default Seek Qualifiers

The most commonly used measurement of valid stations is the total received power at a given channel compared to a threshold. In the Si4700/01 family, this power measurement is Received Signal Strength Indicator (RSSI), measured as the integrated power after the channel filter for a given channel. The RSSI seek threshold (SEEKTH) is simply the power level above which a valid channel is determined. Setting the seek threshold too high may result in missed valid channels; too low may result in false detections.

To augment the accuracy of this metric, the Si4700/01 incorporates a second indicator of valid channels called Automatic Frequency Control Rail, or AFC rail. AFC rail is used to detect the condition wherein an adjacent channel's power is detected at the tuned frequency, potentially detecting a false positive. If a tuned channel's RSSI is above the seek threshold, but the AFC has tracked from the center of the channel by a given number of kHz, the channel can reliably be determined to be an invalid station.

Using the RSSI threshold in conjunction with AFC rail offers seek performance with a greater than 90% probability of finding only valid stations and a sub-4 second scan time for auto-populating valid stations.

Note: Figures given represent a competitive host micro-controller, 200 kHz channel spacing, and 87.5–108 MHz band setting.

3. Si4700/01 Advanced Seek Offerings

FM environments typically generate a shaped noise profile, making it almost impossible to set a seek threshold which is both above the noise floor and within valid station levels. The noise floor can vary due to many factors including antenna impedance and matching, signal environment, AGC setting, and noise sources. In particular, office and lab environments have elevated noise levels across the FM band due to the presence of electronic and computer equipment. An example RSSI spectrum is shown below in Figure 1. Note that valid stations are indicated by their frequencies.

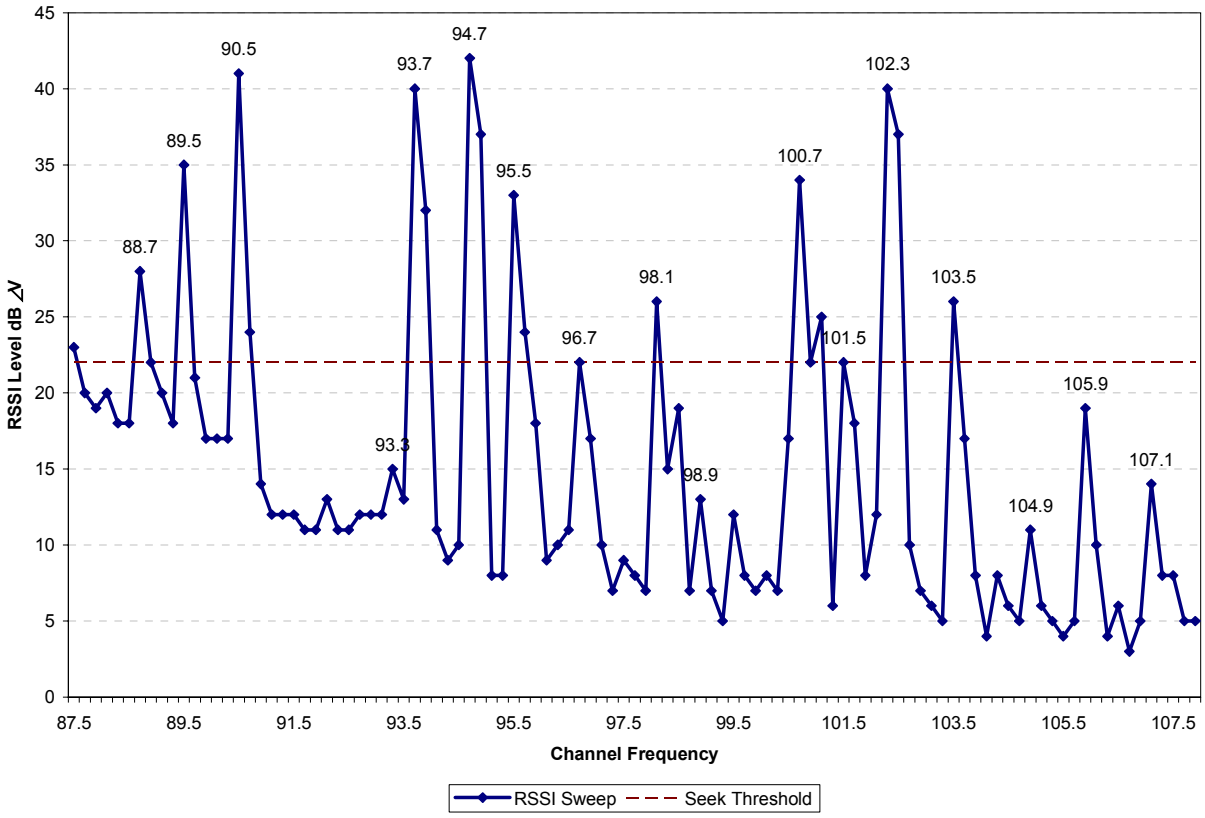

Figure 1. Sample RSSI Spectrum

In Figure 1, the valid stations at 93.3, 98.9, 104.9, 105.9, and 107.1 are difficult to detect since their RSSI levels are below the noise level of the spectrum at some unpopulated channels. Setting the RSSI seek threshold to a value of 12 would likely detect these valid stations, but could have false positives at many invalid channels. Setting the seek threshold to 22 as shown avoids false detections but could miss these valid stations.

The Si4700/01 Firmware 15 devices incorporate additional valid station qualifiers to more reliably detect lower RSSI stations and screen out invalid stations. These qualifiers are optional and adjustable so that customers and end users may adjust seek as desired.

The additional qualifiers run sequentially to the first two tests discussed above. The first qualifier, audio SNR, compares a tuned channel's audio SNR to an audio SNR threshold. The audio SNR threshold is adjustable in SEEKSNR[3:0]. Example SEEKSNR[3:0] threshold values and likely results are shown in Table 1.

Table 1. Sample SEEKSNR[3:0] Settings

SEEKSNR[3:0] Write Value	Desired Audio SNR Threshold	Seek Result Relative to Default Seek Metrics
0x0	Disabled	NA
0x4	Good audio SNR threshold	Increased reliability, only good stations qualified below SEEKTH
0xF	Very good audio SNR threshold	Increased reliability, only very good stations qualified below SEEKTH

The second qualifier in Si4700/01 Firmware 15 devices measures the number of FM impulses detected at a tuned channel. FM Impulse noise occurs in all FM detectors when the SNR of a received station becomes very low and the received noise causes the FM detector to make instantaneous phase jumps, resulting in audible "clicks." For a noisy signal, more FM impulses are typically received, and conversely for a higher quality signal, fewer or no FM impulses are received. The Si4700/01 Firmware 15 detects these FM impulses and applies a smoothing filter to minimize their impact on sound quality. This is an improvement over previous versions of the Si4700/01 family. With Si4700/01 Firmware 15, FM impulses can also be used as a metric to determine the quality of the audio present on a given channel. This qualifier is optional and adjustable.

With Si4700/01 Firmware 15, the SEEKCNT[3:0] register sets a threshold for the number of FM impulses allowed on a tuned channel within a defined period.

Note: The period and algorithm for measuring FM impulses is proprietary to Silicon Laboratories, Inc. and will not be explained further.

Table 2 provides some example settings and approximate results.

Table 2. Sample SEEKCNT[3:0] Settings

SEEKCNT[3:0] Write Value	Desired Impulse Threshold	Seek Result Relative to Default Seek Metrics + Audio SNR Threshold
0x0	Disabled	NA
0x8	Allows more FM impulses	Increased reliability, more stringent valid station requirements
0xF	Allows fewer FM impulses	Highest reliability, most stringent valid station requirements

Note: By increasing the stringency of SEEKSNR and SEEKCNT settings, stations that have low SNR or high levels of FM impulse noise may be rejected. Typically, these stations do not have good audio quality and customers do not wish to listen to them; however, if customers are specifically searching for these stations, be aware that a stringent seek algorithm may disqualify them as valid stations.

4. Si4700/01 Seek Algorithm Sequencing

The Si4700/01 Firmware 15 seek algorithm sequencing is shown in the flowchart in Figure 2.

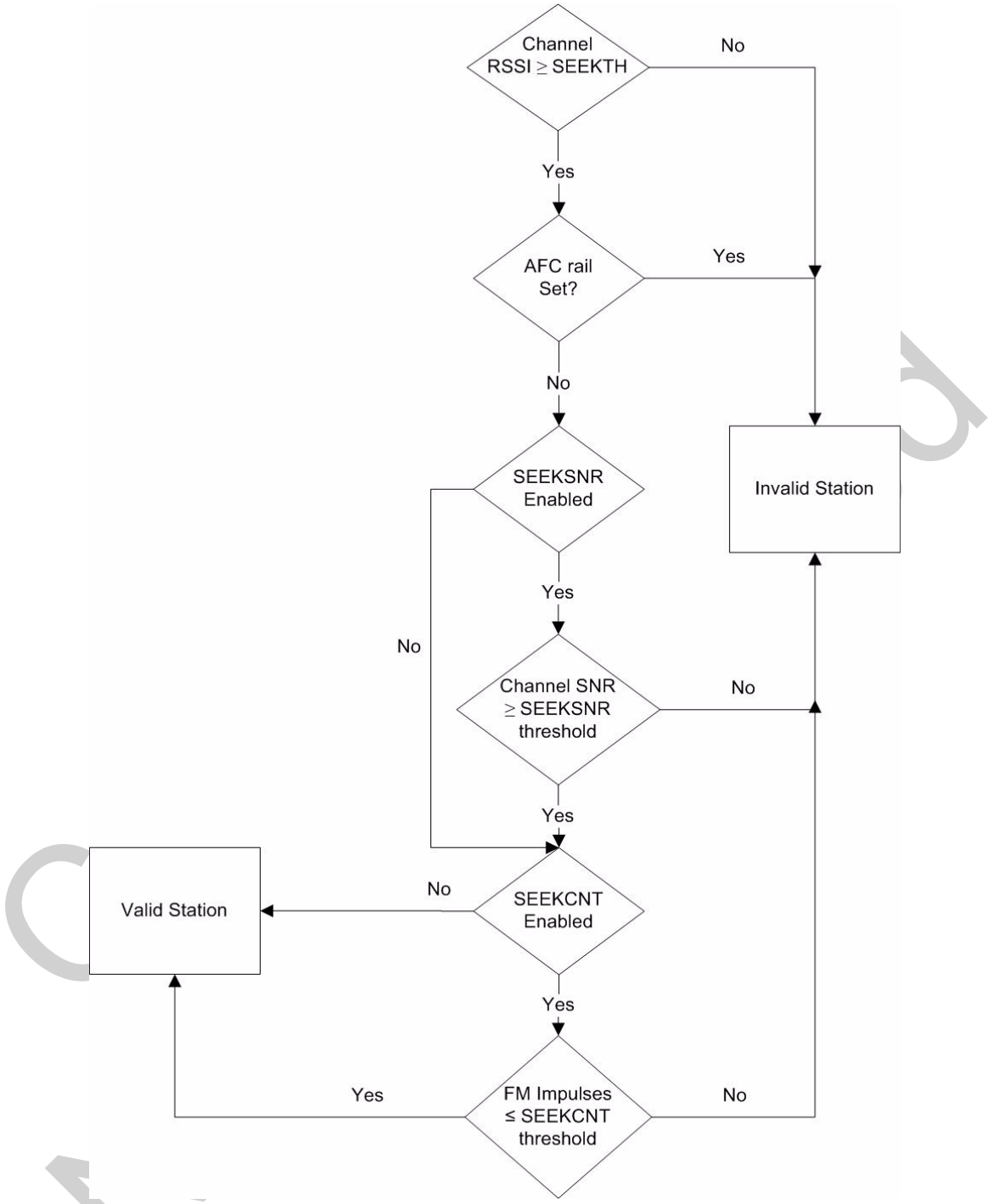

Figure 2. Seek Sequence Flowchart

Note: Both Audio SNR and FM impulse count are independent and can be run as additional qualifiers with or without the other.

5. Si4700/01 Seek Results Comparisons

Figure 3 compares Silicon Laboratories field trials with existing and new seek parameters. The graph illustrates that by setting the RSSI seek threshold at 25, invalid channels are not detected; however several valid stations are missed. Conversely, with the RSSI threshold at 12, several invalid stations are identified. With the new optional qualifiers enabled with the RSSI threshold at 12, the invalid stations are rejected and valid stations are reliably identified.

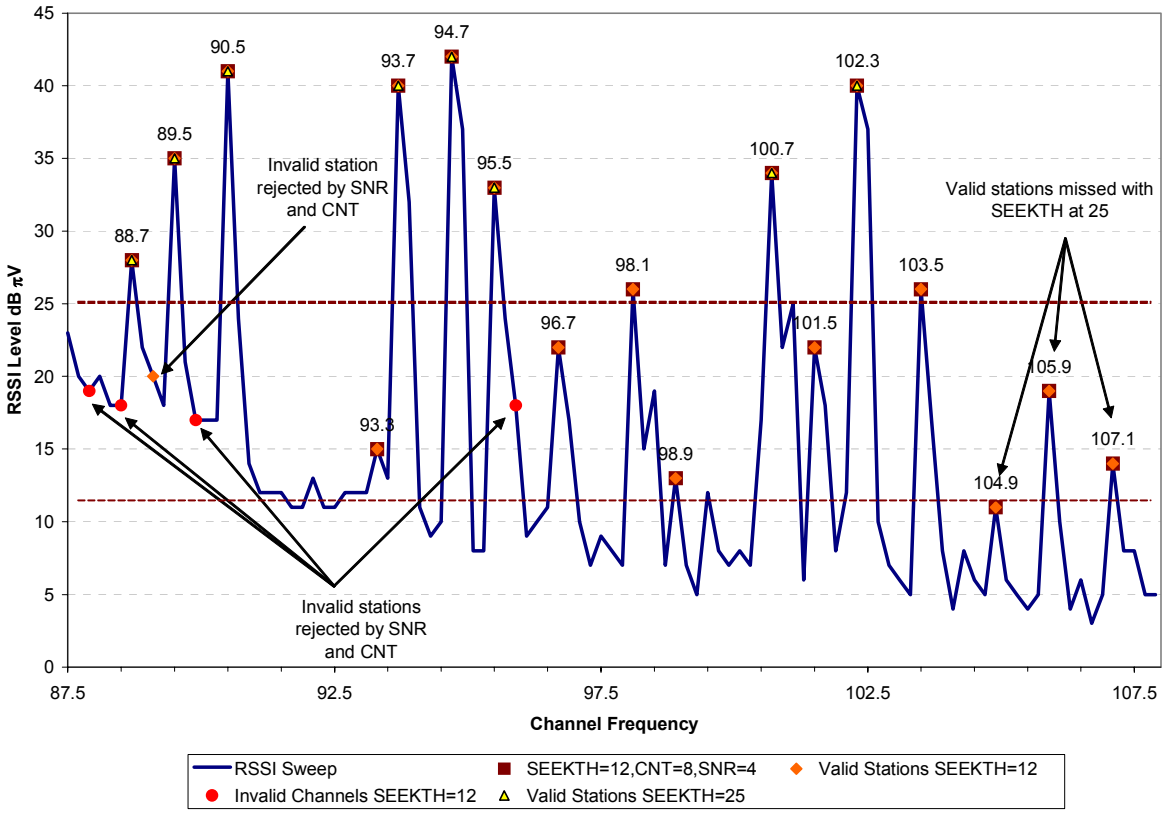

Figure 3. Seek Results Comparison

6. Si4700/01 Seek Settings Recommendations

Table 3 summarizes the seek settings discussed above. These settings are adjustable to address the customers' system design, target markets, and subjective preferences and have been found to yield good performance in most applications.

Table 3. Summary of Seek Settings

Configuration	Comments	SEEKTH[7:0]	SEEKSNR[3:0]	SEEKCNT[3:0]
Default	Compatible with Firmware 14	0x19	0x0 (disabled)	0x0 (disabled)
Recommended	Relative to Firmware 14	0x19 (typical)	0x4 – Good audio SNR	0x8 – Fewer FM impulses
More Stations	Reduced SEEKTH identifies valid stations in low RSSI environments	0xC (typical)	0x4 – Good audio SNR	0x8 – Fewer FM impulses
Good Quality Stations Only	Identifies only high quality stations	0xC	0xF – Excellent audio SNR	0xF – Fewest FM impulses
Most Stations	Seek algorithm relies solely on AFC rail, SNR and FM impulse; Most valid stations identified; Potential for slightly longer seek time	0x0	0x4 – Good audio SNR	0xF – Fewest FM impulses

NOTES:

CONTACT INFORMATION

Silicon Laboratories Inc.

4635 Boston Lane
Austin, TX 78735
Tel: 1+(512) 416-8500
Fax: 1+(512) 416-9669
Toll Free: 1+(877) 444-3032

Email: FMinfo@silabs.com
Internet: www.silabs.com