RHYTHM™ R3110

User's Guide

AND9171/D
Rev. 2, May−2015

ON Semiconductor®

www.onsemi.com

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:
Literature Distribution Center for ON Semiconductor
P.O. Box 5163, Denver, Colorado 80217 USA
Phone: 303−675−2175 or 800−344−3860 Toll Free USA/Canada
Fax: 303−675−2176 or 800−344−3867 Toll Free USA/Canada
Email: orderlit@onsemi.com

N. American Technical Support: 800−282−9855 Toll Free USA/Canada
Europe, Middle East and Africa Technical Support:
Phone: 421 33 790 2910
Japan Customer Focus Center
Phone: 81−3−5817−1050

ON Semiconductor Website: **www.onsemi.com**

Order Literature: http://www.onsemi.com/orderlit

For additional information, please contact your local Sales Representative

Table of Contents

CHAPTER 1

Introduction

PURPOSE

The RHYTHM R3110 hybrid from ON Semiconductor is a pre-fit DSP system based on a two-channel compression circuit, designed for entry level hearing aids. With no need for software configuration, R3110 offers many features found in high-end hearing aids, including Adaptive Noise Reduction and Adaptive Feedback Cancellation. This manual provides reference design information for the simplest to the most complex examples of deploying R3110 into an entry-level hearing aid. It further details the architecture of R3110 and presents more advanced use cases, including all the different configuration options of R3110. This document also describes how to evaluate R3110 on the hybrid jig as well as a monitoring utility.

INTENDED AUDIENCE

This manual is for anyone who wants to quickly deploy R3110 in a hearing device, or anyone who wants to thoroughly understand all the capabilities and the various use cases of R3110.

CONVENTIONS

This manual displays the following in a `monotype` font:

- Headers
- Connectors
- Switches
- Chip pins
- Configuration settings

MANUAL ORGANIZATION

The RHYTHM R3110 User's Guide contains the following chapters:

- **Chapter 1: Introduction**, describes the purpose of this manual, the intended audience, outlines how the book is organized, and provides a list of suggested reading for more information
- **Chapter 2: Reference Design**, provides the reference schematic and wiring diagrams for the simplest way to deploy R3110 in a basic one-microphone hearing aid.
- **Chapter 3: Rhythm R3110 Architecture**, provides detailed information about the product.
- **Chapter 4: Application Examples**, is a more comprehensive list of application examples starting from the simplest use case described in Chapter 2, "Reference Design", and adding all the features offered by R3110, such as multiple mode, user controls, or fitting capabilities.
- **Chapter 5: Evaluating R3110 on the Hybrid Jig**, explains the evaluation capabilities of the hybrid jig.
- **Chapter 6: Monitoring Utility**, describes the command line utility that allows basic troubleshooting tasks on R3110.

FURTHER READING

For more information, refer to the RHYTHM R3110 datasheet.

CHAPTER 2

Reference Design

INTRODUCTION

This chapter provides the minimum required information to design R3110 in an entry-level hearing aid. It contains all the necessary information to create a "first-time-right" schematic, to select a microphone and a receiver, to learn the recommended wiring, and to see what the expected performance will be once the hearing device is manufactured as per this reference design. For this, you do not have to understand the various aspects of the device's architecture, nor how the device works in any detail.

The design that is proposed in this section is extremely simple: it does not consider multiple modes of operation. It expects just one microphone, a receiver, a battery, a few passive components, and a potentiometer for volume control. For any additional configuration, refer to the subsequent sections of this user's guide.

REFERENCE SCHEMATIC

R3110 is used in this reference design as a one-microphone hearing aid device with no adaptive features, where no configuration is required to have a fully functional hearing instrument. To successfully develop a hearing aid product with no configuration at all, you must comply with the typical microphone and receiver selection guidelines, as described in "Typical Microphone and Receiver". Failure to do so results in a different performance from the intended reference device, and might require further understanding and further configuration of the product.

Figure 1 shows the simplest application of R3110, where the only user control is a linear potentiometer that allows control of the volume range. This external analog volume control works with a three-terminal 100 kΩ – 360 kΩ potentiometer connected between ground (GND) and the regulated voltage (VREG). The volume control has a linear taper. The potentiometer must be connected to the VC pin; it provides a volume control range of 42 dB.

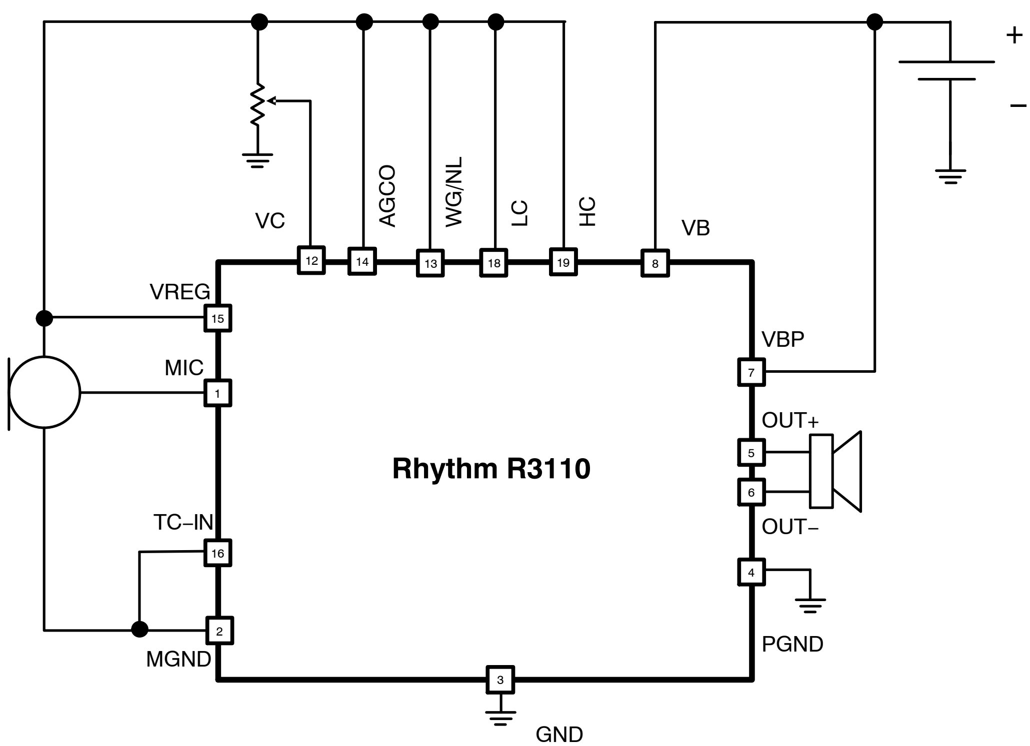

Figure 1. Simplest Reference Schematic using R3110

IMPORTANT DESIGN GUIDELINES

Notice the following important aspects from the reference schematic of Figure 1, and keep them in mind when designing a hearing aid:

- The microphone must be connected to the MIC pin, and powered between VREG and MGND.
- The unused TC-IN analog input must be connected to the MGND pin.
- The MGND pin must *not* be connected to the main ground pin (GND).
- The GND and PGND ground pins must be connected together.
- The four configuration pins (AGCO, WG/NL, LC and HC) must be tied to VREG to ensure that all the parameters they control are configured to their default value. VBP and VB must be connected together, either directly or via a high power filter.

REFERENCE WIRING DIAGRAM

A reference wiring diagram is shown in this section. It corresponds to the schematic proposed earlier. Refer to Figure 2 to understand the recommended wiring of R3110 such that it matches the reference schematic of Figure 1.

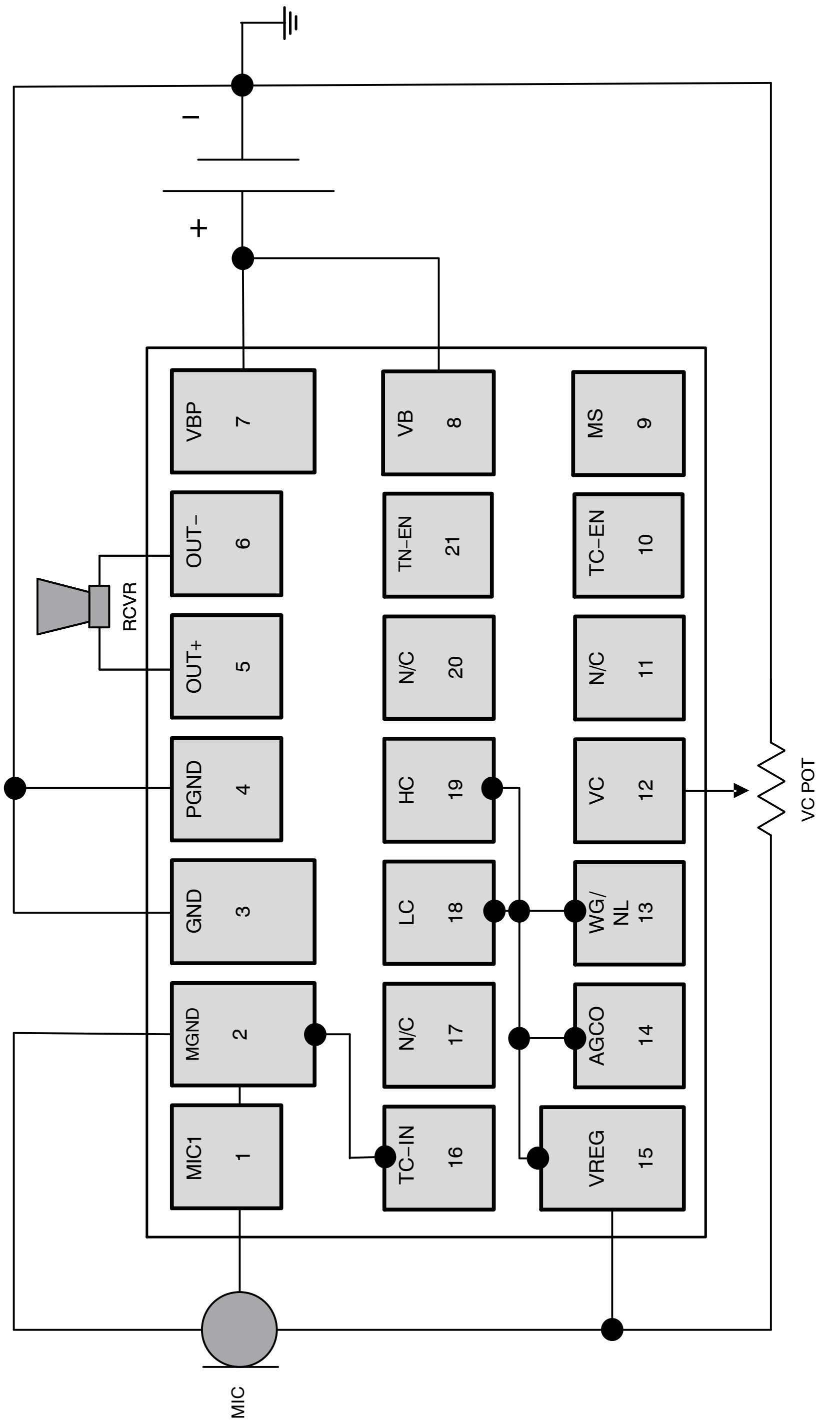

Figure 2. Simplest Wiring Diagram using R3110

TYPICAL MICROPHONE AND RECEIVER

To ensure similar operation of R3110 in the configuration proposed in this section, we expect that the microphone and receiver used in the target product have the following characteristics. The output level (vertical axis) is in dB SPL:

- Microphone sensitivity at 1 kHz: -126 dBV/dB SPL (for example, Sonion™ 9646)
- Receiver sensitivity at 1 kHz: 115.4 dB SPL/dBV (for example, Sonion 2016)

Any deviation from the above numbers results in the device performing differently. Consider the effects carefully before choosing a microphone or receiver with different characteristics.

PERFORMANCE EVALUATION

The performance of R3110 has been measured in our acoustic laboratories using a reference microphone and receiver offering sensitivities as described in “Typical Microphone and Receiver”. With the transducers mentioned in that section, example ANSI S3.22 test results are shown in Figure 3. The hardware configuration matches the diagram shown in Figure 1. The VC potentiometer was adjusted as needed to obtain the appropriate Reference Test Gain. The shell used was a behind−the−ear (BTE) style with a 2−cc coupler. The actual frequency response varies depending on transducers and acoustics (including the coupler, ear hook, shell and tubing materials and sizes).

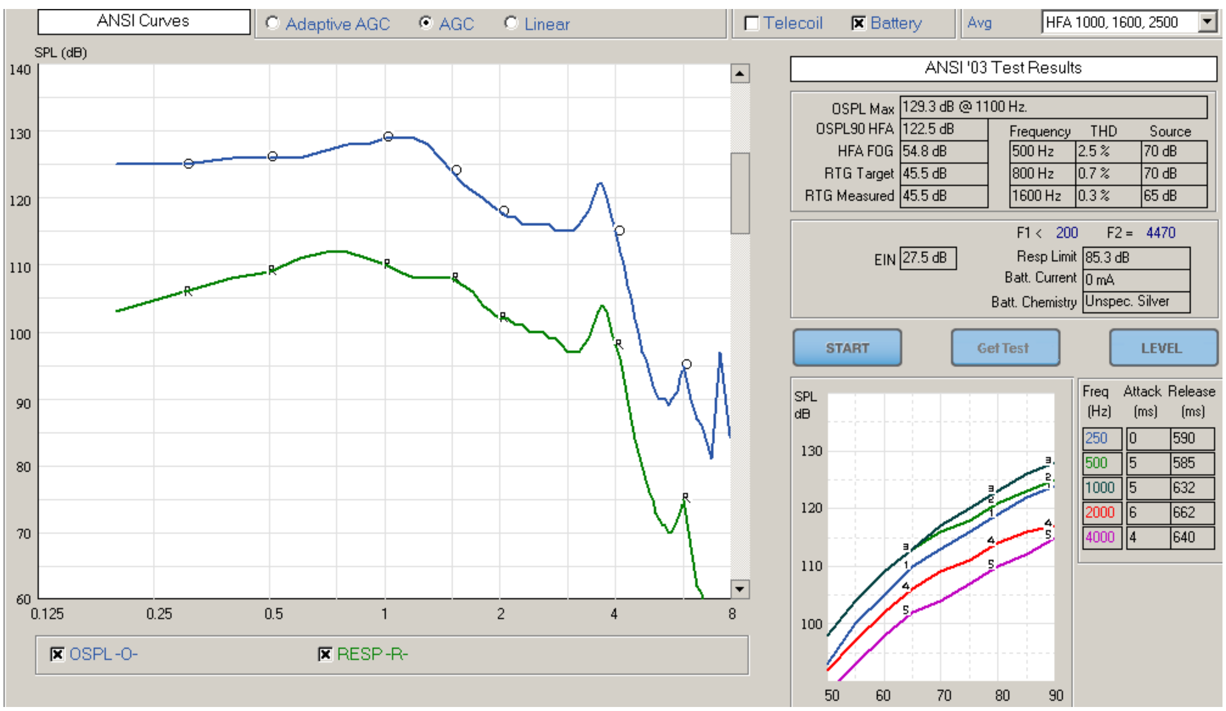

Figure 3. Reference Frequency Response for a Typical Microphone and Receiver

A key part of verifying a new design is making sure that the signal levels are valid for each input and output. The noise floor of the inputs when connected to ground through a 3 kΩ resistor is approximately -97 dB or lower. If you have an input around this level, your inputs are likely shorted. An unconnected input might give a much higher level. The curves above give an example of potential output levels that can be expected if the hardware configuration is similar to that of Figure 1 and with transducer sensitivities as noted in the section “Typical Microphone and Receiver”.

CHAPTER 3

RHYTHM R3110 Architecture

OVERVIEW

The R3110 hybrid from ON Semiconductor is a pre-fit DSP system based on a two-channel compression circuit designed for entry level hearing aids. R3110 features built-in Adaptive Noise Reduction, Adaptive Feedback Cancellation and Tinnitus Masking.

All sound processing algorithms are pre-programmed for a wide variety of fitting use-cases and hearing aid form factors, but a number of configuration options are still available through hardware settings. Up to four trimmers can be deployed, offering manufacturers the capability to modify most parameters that are important for patient fitting.

R3110 supports the use of a telecoil, enabled either automatically with a magnetic switch, or via an external switch. It provides a variety of user control options: momentary or static switches as well as an analog volume control.

For an overview of the architecture of R3110, see Figure 4.

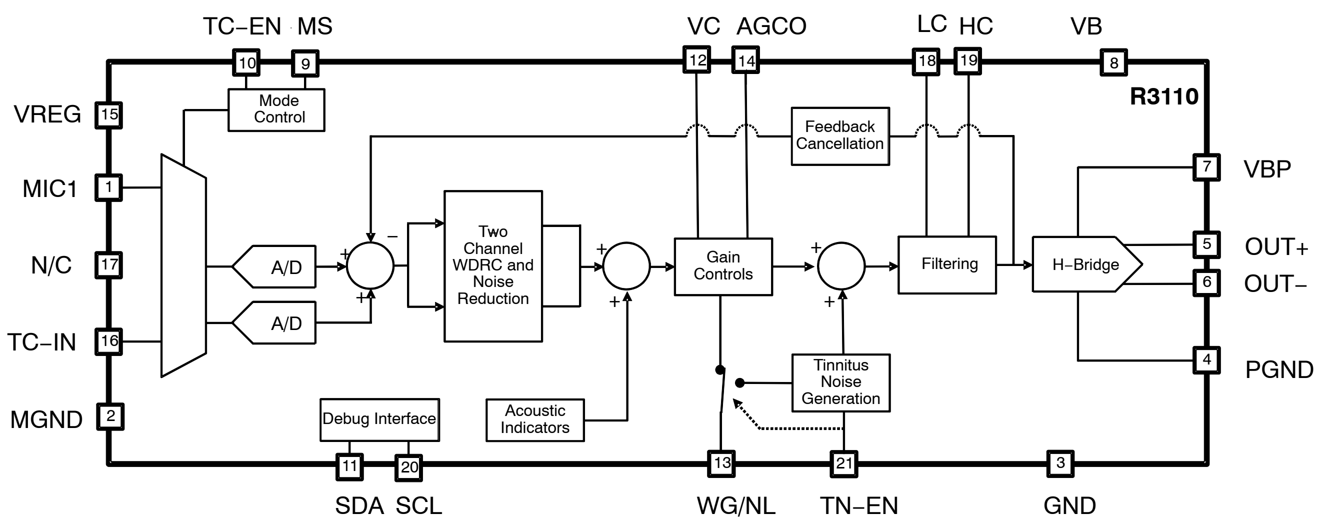

Figure 4. R3110 Block Diagram

INPUT MODES

R3110 provides two analog inputs and three modes: Simple mode, Advanced mode, and Telecoil (TC-IN). The following describes the function of these three modes:

Simple Mode

This is the default mode of operation for R3110. In this mode, the device works as an analog replacement device with mild compression and the Adaptive Noise Reduction and Adaptive Feedback Cancellation algorithms turned off.

Advanced Mode

In this mode, the advanced adaptive features, Noise Reduction and Feedback Cancellation are enabled.

Telecoil Mode (TCM)

R3110 is not processing any microphone signal, but only samples the signal coming from a telecoil device present on the TC-IN pin.

Microphone Inputs

R3110 supports multiple types of three-terminal hearing-aid microphones operating from a regulated voltage of 0.9 V. However, microphone selection affects the behavior of the various sound processing algorithms. Acoustic-referred threshold values for the Wide Dynamic Range Compressor (WDRC) engine and acoustic indicators are also determined by the microphone sensitivity and frequency response. Adaptive feedback suppression and adaptive noise reduction, on the other hand, automatically adjust their behavior according to the properties of the selected microphone.

Microphones use the VREG pin for power and the MGND pin for ground. Unused microphone inputs shall be connected to MGND and it is important to ensure that the MGND pin is not connected to the main ground pin (GND).

Telecoil Support

R3110 supports a telecoil device that can be connected between the TC-IN pin and the MGND pin. The device is designed to support multiple uses of a telecoil, depending on the desired user interface, and allows transitioning into telecoil mode (TCM) upon the closing of a switch connected to the TC-EN pin, as can be seen in Figure 5.

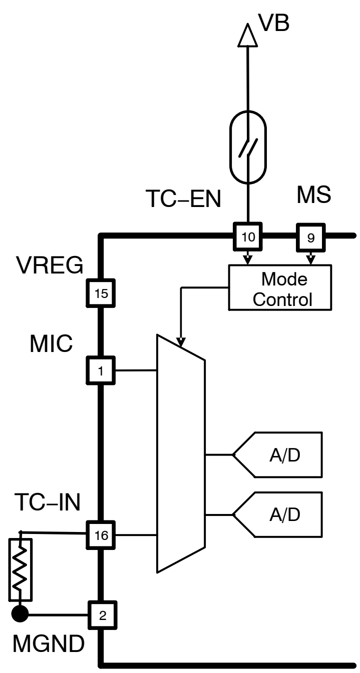

Figure 5. Telecoil Support in R3110

A static 2-pole switch can be used to initiate a transition to TCM mode. Alternatively, with a magnetic switch (such as a GMR or Reed switch) connected to TC-EN, the static magnetic field of a telephone handset closes the switch whenever the handset is brought close to the hearing aid, resulting in R3110 changing to TCM.

The device includes a pull-down resistor to ground on the TC-EN pin; consequently, the selected switch must connect the TC-EN pin to the VB pin to change to TCM. When this functionality is used, the MS pin can be left floating or tied directly to VB when in use with Advanced Mode.

For both cases, static and automatic telecoil control, a de-bouncing algorithm is used to prevent undesired switching in and out of telecoil mode due to mechanical switch bounces. Upon detecting a close-to-open switch transition, the de-bounce algorithm monitors the switch status and switches R3110 out of telecoil mode and back to the initial mode, only when the switch signal has been continuously sampled open over a 1.5-second period.

A third option allows R3110 to enter the TCM only when a momentary push button is used on the mode select pin (MS), and no switch is present on TC-EN. Refer to "Push Button Support" for additional details.

If the hearing aid does not include a telecoil device, connect the TC-IN pin to the MGND pin for optimal performance of R3110. Never connect the MGND pin to the main ground pin (GND).

A/D Converters and Sampling Rate

R3110 includes two second-order sigma-delta analog-to-digital converters that are used to sample the appropriate analog inputs, according to the processing mode in which the device is running. The inputs are preconditioned with anti-alias filtering and amplification before being transmitted to a digital signal processing engine. The system's sampling frequency is fixed at 16,000 Hz, which sets the Nyquist frequency at 8,000 Hz and consequently the processed bandwidth to be 10 Hz – 8,000 Hz.

OUTPUT STAGE

Receiver Output

R3110 is designed to support standard zero-bias receivers. Its output stage includes a digital-to-analog converter that comprises a third-order sigma-delta modulator and an H−bridge. The modulator accepts digital audio data from the Digital Signal Processor (DSP) and converts it into a 64−times oversampled, 1−bit PDM data stream, which is then supplied to the H−bridge. The H−bridge is a specialized CMOS output driver used to convert the 1−bit data stream into a low−impedance, differential output voltage waveform suitable for driving zero−biased hearing aid receivers.

High Power Output Support

For high power devices, a first order RC filter is recommended to ensure a clean power supply to R3110, despite the large current required by the receiver. Refer to Figure 6 for a recommended high-power output filter.

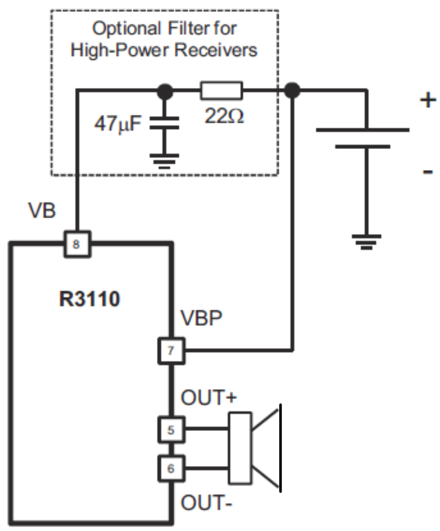

Figure 6. Recommended High−Power Output Filter

DIGITAL SIGNAL PROCESSING ALGORITHMS

Two-Channel WDRC

R3110 offers a two-channel processing system with the I/O characteristics as defined in Figure 7.

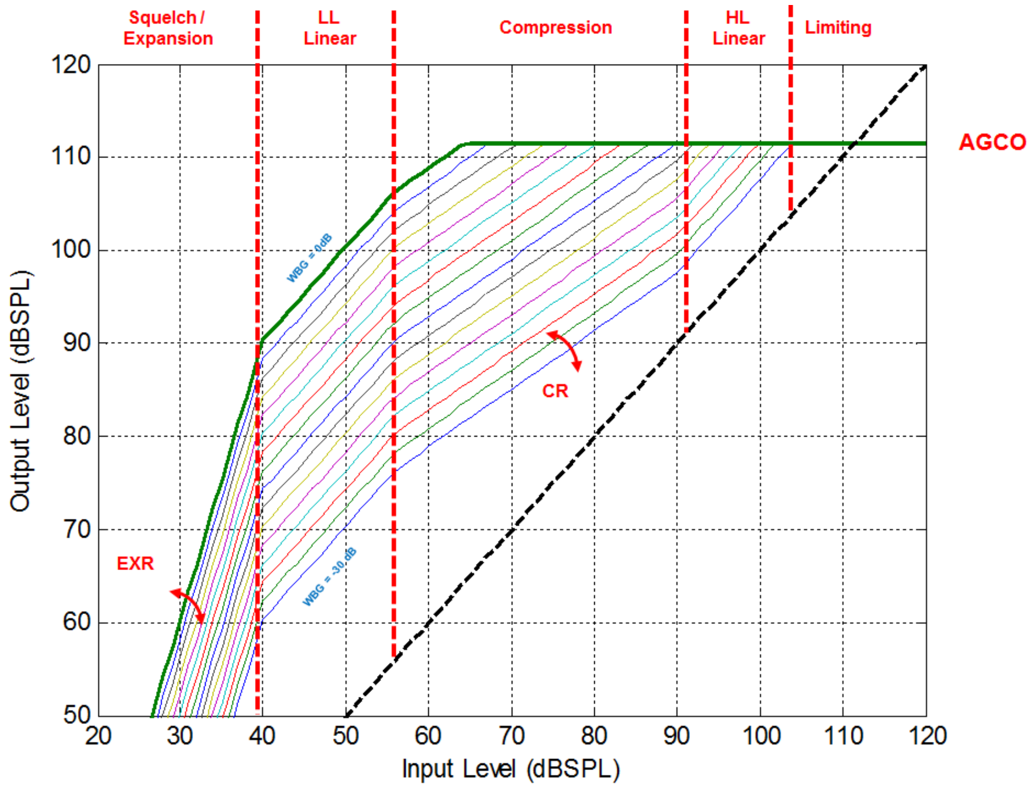

Figure 7. Wide Dynamic Range Compression

The WDRC as defined in R3110 has identical settings for each of the two channels, but the gains in each of these two channels might be different, depending on the dynamics of the incoming signals. The crossover frequency between the two channels is set at 1.625 kHz.

The I/O curve shown in Figure 7 can be divided into five main regions:

- A low input level expansion or squelch region with an expansion ratio of 1:2
- A low input level linear region
- A compression region with a compression ratio of 1.6:1
- High input level linear region (return to linear)
- A limited output region

The configuration of the WDRC parameters has been calculated with a default microphone. and receiver selection such that all the quantities shown on the graph represent acoustic quantities. Any change in microphone or receiver characteristics and or sensitivities will result in a different behavior of the WDRC. In such cases, the WDRC parameters can easily be recalculated, knowing that the microphone sensitivity that was used is -126 dBV/dBSPL, and that the default receiver sensitivity that was used is of 115.4 dBSPL/dBV.

As shown in Figure 7, one of the parameters that can be controlled is the Wideband Gain. A number of curves are shown, with the default value being the maximum wideband gain (0 dB). The minimum value for this parameter is -30 dB, which has a significant impact on the WDRC, as can be seen in the picture.

Another parameter that can be modified on R3110 is the output limiter (AGCO). Figure 8 shows the input/output curve for the default wideband gain configuration (0 dB), but with all the different options of the output limiter and their impact on the output level.

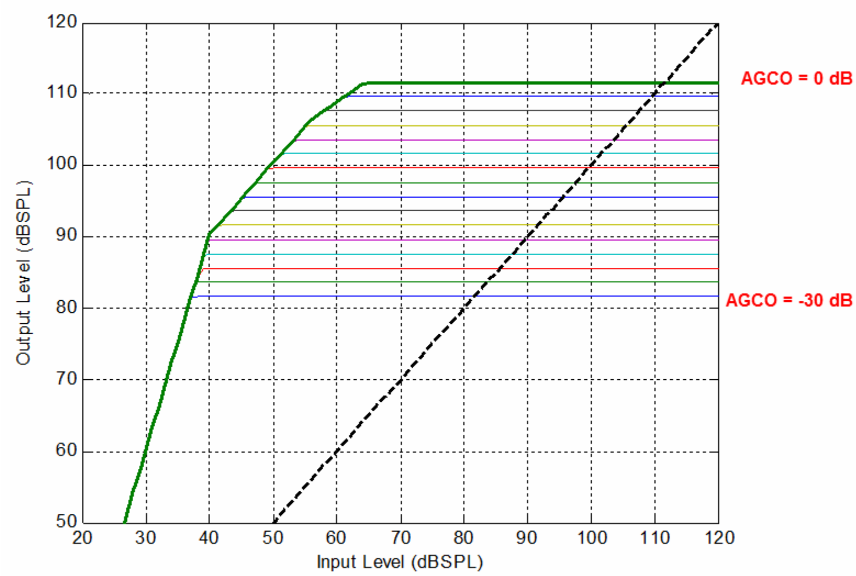

Figure 8. Output Limiting

Adaptive Noise Reduction

The Adaptive Noise Reduction (ANR) algorithm deploys a high resolution 32-band filter bank, enabling the precise reduction of noise. The algorithm monitors the signal-to-noise ratio activity in these bands, and calculates a separate attenuation for each of the 32 bands. The noise reduction gain applied to a given band is determined by a combination of factors:

- Signal−to−Noise Ratio (SNR)
- Masking threshold
- Dynamics of the SNR in each band

The SNR in each band determines the maximum amount of attenuation to be applied to the band: the poorer the SNR, the greater the amount of attenuation. Simultaneously, in each band, the masking threshold variations resulting from the energy in other adjacent bands is taken into account. Finally, the noise reduction gain is also adjusted to take advantage of the natural masking of noisy bands by speech bands over time. Based on this approach, only enough attenuation is applied to bring the energy in each noisy band to just below the masking threshold. This prevents excessive amounts of attenuation from being applied, thereby reducing unwanted artifacts and audio distortion.

The noise reduction algorithm efficiently reduces a wide variety of noise types while retaining natural speech quality and level.

The Advanced Noise Reduction algorithm is available only in Advanced Mode.

Third Generation Adaptive Feedback Cancellation

The third generation Adaptive Feedback Canceller (AFC) reduces acoustic feedback by calculating an estimate of the hearing aid feedback signal and then subtracting it from the hearing aid input signal. The forward path of the hearing aid is not affected. Unlike adaptive notch filter approaches, the AFC in R3110 does not reduce the hearing aid's gain. The AFC is based on a time-domain model of the feedback path. The AFC allows for an increase in stable gain of the hearing instrument while minimizing artefacts on music and tonal input signals. The AFC is fully automatic and is configured in R3110 to support all types of hearing aids, allowing a distance from receiver to microphone as small as 2 cm.

The Adaptive Feedback Canceller is available in Advanced Mode only.

Filtering Functions

Two filters allow you to modify the frequency response of the device. The block diagram in Figure 4 shows the two filters within the filtering box. Two configuration pins (LC and HC) control the frequency shaping of the audio path just before it is returned to the analog world. More details on the usage of these pins can be found in "Configuration Options".

Noise Generator for Tinnitus Treatment

R3110 offers a dedicated pin to control the Tinnitus Treatment noise generation algorithm: TN-EN. This pin has an internal pull-down resistor to ground (GND), which disables the algorithm by default. When activated (pulled to VB), Tinnitus Treatment is generated by deploying amplitude scaled white noise, depending on adjustments made via pin WB/NL. When the TN-EN pin is set high (connected to VB), to enable the tinnitus algorithm, the WB/NL pin controls the generated noise level (NL) as per Table 1. The noise is injected into the audio path, as shown on the block diagram in Figure 4, and the entire audio signal is shaped using the internal filters controlled by the LC and HC pins. The VC pin, and consequently the amount of attenuation that it selects, only affects the audio signal and not the tinnitus noise level. The tinnitus mode can be used in conjunction with either microphones or telecoil modes, with the exception that the wideband gain cannot be controlled by the WG/NL pin anymore; in this configuration it controls the tinnitus noise level instead. In this case, the wideband gain has a fixed value of 0 dB. Figure 9 shows the two usages of the TN-EN pin.

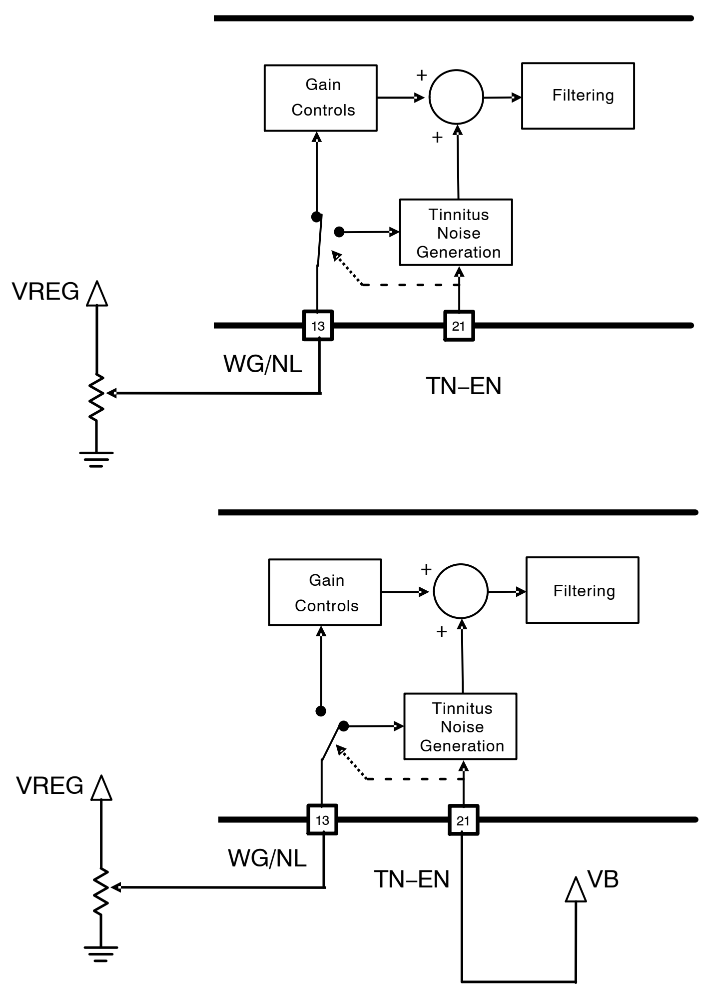

Figure 9. The Two Different Uses of the TN−EN Pin: Top − Tinnitus Disabled, WG; Bottom − Tinnitus Enabled, NL

R3110 can also be used as a tinnitus-only device with no microphones at all, only one receiver. In this configuration, all inputs are connected to MGND (MIC and TC-IN). Refer to “Tinnitus-Only Device”.

Volume Control and Gain Management

The external analog volume control works with a three-terminal 100 kΩ – 360 kΩ potentiometer connected between ground (GND) and the regulated voltage (VREG). The volume control has a linear taper. The potentiometer must be connected to the VC pin; it allows you to control the output attenuation from full scale down to approximately 42 dB under full scale. This volume control does not affect the tinnitus noise signal level.

Acoustic Indicators

R3110 has preconfigured acoustic indicators. Whenever the device transitions between modes, or any of the following events occur, the audio is temporarily faded out and an acoustic indicator is played:

Device startup
Four sequential tones with the following audio frequencies: A4 (440 Hz), F4 (349 Hz), G4 (392 Hz), C4 (262 Hz)

MS pin: mode switches with momentary push button

- Simple mode: one tone at the C5 audio frequency (523 Hz)
- Advanced mode: two sequential tones with increasing audio frequencies G4 (392 Hz) and C5 (523 Hz), 250 ms duration and 50ms silence between the tones
- Telecoil mode: three sequential tones with increasing audio frequencies E4 (330 Hz), G4 (392 Hz) and C5 (523 Hz).

TC-EN pin: telecoil mode enable
Four sequential tones with increasing audio frequencies C4 (262 Hz), E4 (330 Hz), G4 (392 Hz) and C5 (523 Hz)

Low battery
Three sequential tones with decreasing audio frequencies G4 (392 Hz), E4 (330 Hz) and C4 (262 Hz)

All tones exhibit a nominal 32 ms fade-in and fade-out transition time. The duration of all the tones is 250 ms, and the silence duration between tones is 50 ms. The level of the tones is determined dynamically by R3110 based on the WDRC and the volume control.

CONFIGURATION OPTIONS

Hardware Configurability

R3110 is a pre-fit device for which all the sound processing algorithm parameters have been preconfigured. Nonetheless, four parameters have been assigned to four trimmer pins (that are called configuration pins throughout this document), allowing these parameters to be adjusted externally. The configuration pins are:

LC Allows the configuration of the low-cut filter corner frequency

HC Allows the configuration of the high-cut filter corner frequency

WG/NL Allows the adjustment of either the wideband gain or the tinnitus noise level, depending on the state of the TN-EN pin (which enables the tinnitus noise generation algorithm). When configured for its Wideband Gain functionality (WG), this pin controls the overall gain of the device as per the 16 values defined in Table 1. When used in its Noise Level (NL) functionality, it only scales the level of the generated tinnitus noise as per one of the 16 values, which are also defined in Table 1.

AGCO Allows the selection of the maximum output signals to adjust to a particular receiver. The AGC-O module is an output limiting circuit with a fixed compression ratio of ∞: 1. The limiting level is adjustable through the AGCO pin as a level measured in dB from full scale. The maximum output of the device is 0 dBFS (decibels under the full scale). The AGC-O module has its own level detector, with fixed attack and release time constants.

Figure 4 shows the signal path and the relative position of these filtering and amplification blocks in the audio path.

The possible ways to use these pins are:

- No configuration is performed; in this case, the four configuration pins are connected to VREG. R3110 uses its predefined default values for all four parameters. The default values are defined by the configuration #16 in Table 1 below.
- Resistive dividers are used to provide a fixed value to any of the parameters controlled by the four configuration pins. Table 1 shows parameter values related to corresponding configuration numbers (#1 to #16), and Figure 10 lists the corresponding component values to use in the resistive divider (R1 and R2).
- A trimmer can be connected to any of the four configuration pins, allowing the parameter to be controlled by the Audiologist or the end user. The trimmer must be a three-terminal 100 kΩ to 360 kΩ linear taper. The range that the trimmer offers is defined in Figure 10. Maximum gains and frequency ranges are obtained with the default value set #16, which also corresponds to the default position of the trimmer. The position is obtained when the trimmer is turned to its end position, clockwise.

Table 1. PARAMETER VALUES AND RANGES

PIN	LC	HC	WG/NL	WG/NL	AGCO
TN-EN	X	X	0	1	X
Parameter Description	Low-Cut Filter Corner Frequency	High-Cut Filter Corner Frequency	Wideband Gain	Noise Level	AGC-O
Config #	Hz	Hz	dB	dB	dB
16	10	8000	0	-25	0
15	125	7500	-2	-30	-2
14	160	7100	-4	-35	-4
13	200	6700	-6	-40	-6
12	250	6000	-8	-45	-8
11	315	5600	-10	-50	-10
10	400	4750	-12	-55	-12
9	500	4000	-14	-60	-14
8	630	3350	-16	-65	-16
7	800	2800	-18	-70	-18
6	1000	2370	-20	-75	-20
5	1250	2000	-22	-80	-22
4	1600	1700	-24	-85	-24
3	1700	1400	-26	-90	-26
2	1800	1180	-28	-95	-28
1	2000	1000	-30	-100	-30

Config#	Typical Voltage on Pin [mV]	R1 (E24)	R2 (E24)
16	VREG	1K	OPEN
15	870	3.3K	100K
14	831	8.2K	100K
13	782	15K	100K
12	725	24K	100K
11	658	36K	100K
10	579	56K	100K
9	494	82K	100K
8	407	100K	82K
7	321	100K	56K
6	242	100K	36K
5	175	100K	24K
4	118	100K	15K
3	69	100K	8.2K
2	30	100K	3.3K
1	GND	OPEN	1K

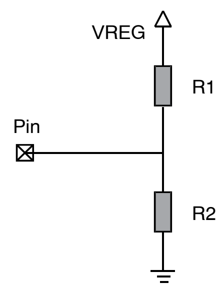

Figure 10. Sixteen Configurations and Their Resistor Values

Push Button Support

R3110 supports the use of momentary switches via the Mode Select (MS) pin. It allows rotation between the three input modes (Simple Mode, Advanced Mode, Telecoil Mode (TCM)) as defined in "Input Modes", in a sequential manner (i.e., Simple Mode, Advanced Mode, TCM, Simple Mode, Advanced Mode, TCM, ...). As shown in Figure 11, a momentary switch must connect the MS pin to the VB pin to enable this functionality. R3110 switches from Simple Mode to Advanced Mode, then TCM, and then rolling over back to Simple Mode, each time the momentary switch is pushed. When this function is not desired in the hearing aid, the MS pin can be left floating.

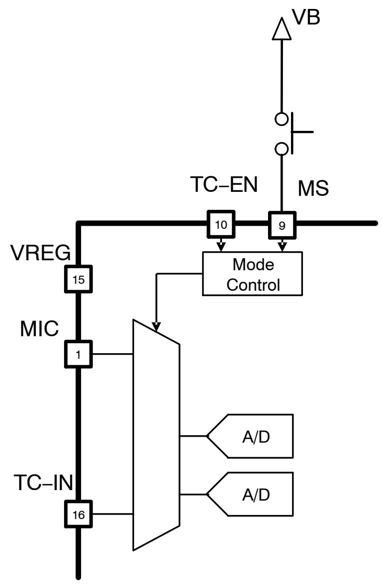

Figure 11. Push Button Support

POWER MANAGEMENT AND LOW BATTERY WARNING

As the voltage of the hearing aid battery decreases under 1.1 V, an audible warning signal is given to the user indicating that the battery life is low. This indicator is repeated every five minutes until the battery voltage is further decreased under 0.88 V, at which point the device shuts down. In addition to this audible warning and before shut down, the hearing aid applies a power management scheme to:

- Ensure proper operation given the weak battery supply
- Maximize the device's usable battery life by reducing the gain

CHAPTER 4

Application Examples

This chapter provides reference schematics for as many application examples as possible, using all the features and functions described in Chapter 3, "Rhythm R3110 Architecture" in many combinations. The chapter is organized into sections that correspond to the number of modes that the hearing aid can provide to the end user:

- "Single-Function Hearing Aid" describes the simplest hearing aid that stays in one mode, which means it has no switches at all. Still, a number of configuration options are available.
- "Dual-Function Hearing Aid" describes application examples for hearing aid products exhibiting two modes, which essentially means that they have one toggle switch to select one or the other of two different modes of operation.
- "Triple-Function Hearing Aid" describes application examples for hearing aids supporting three different modes of operation, mainly through the use of one momentary switch or push button.

"Wiring Reference" shows reference wiring recommendations for the various features of R3110, as well as a complete example of a fully featured hearing aid.

SINGLE-FUNCTION HEARING AID

The simplest hearing aid examples are shown in this section, none of them requiring the use of an external switch. These examples are summarized below:

- Simple hearing aid (may be set to the default boot−up state by wiring the MS pad to VB)
- Simple hearing aid with tinnitus treatment
- Advanced hearing aid
- Advanced hearing aid with tinnitus treatment
- Tinnitus treatment-only device

Each of the following subsections explain these examples, providing reference schematics and design recommendations when applicable.

Simple Hearing Aid

With one microphone, a receiver, a battery and a potentiometer, this hearing aid example described in this section is the simplest use case of R3110. Some optional elements are shown on Figure 12: four trimmers for full parameter control, and an output filter for high-power output devices.

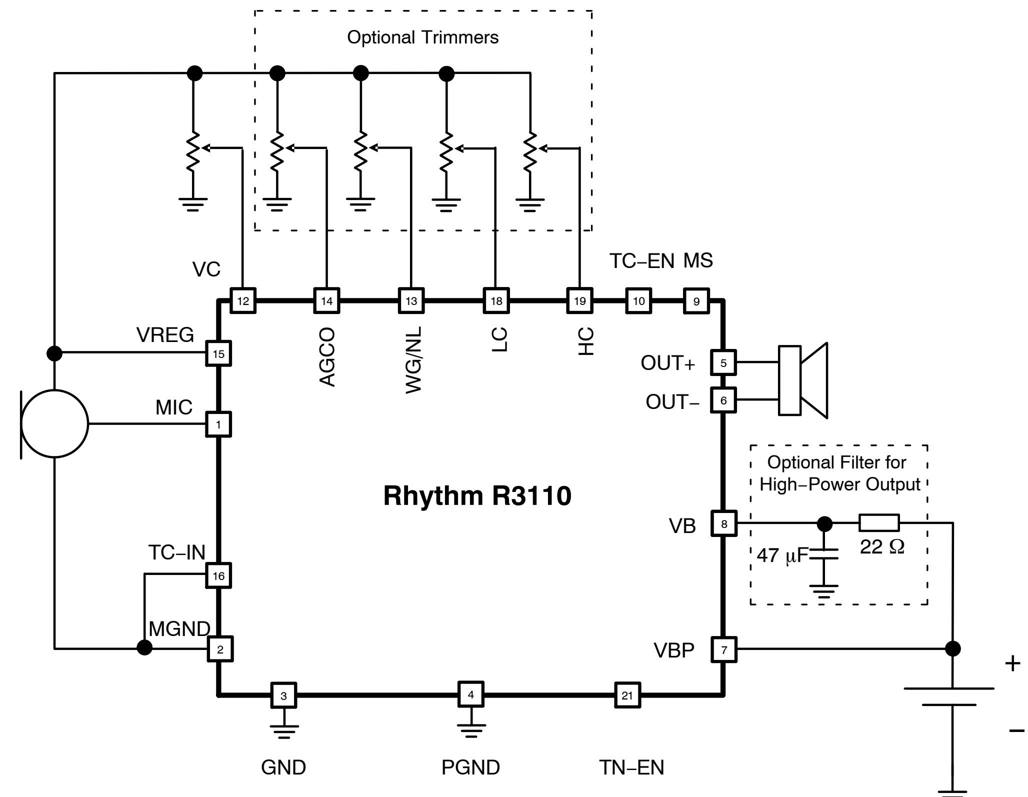

Figure 12. Simple One-Microphone Hearing Aid

Simple Hearing Aid with Tinnitus Treatment

When the TN-EN pin is pulled high, the tinnitus treatment algorithm is enabled in the DSP of R3110. In addition, the WG/NL pin functionality changes to disable wide band gain control, and enable the adjustment of the tinnitus noise level. Details of the tinnitus treatment algorithm can be found in "Noise Generator for Tinnitus Treatment".

Figure 13 shows a reference schematic for this application example. For a wiring diagram, refer to "Wiring Diagram for Fully Featured Hearing Aid".

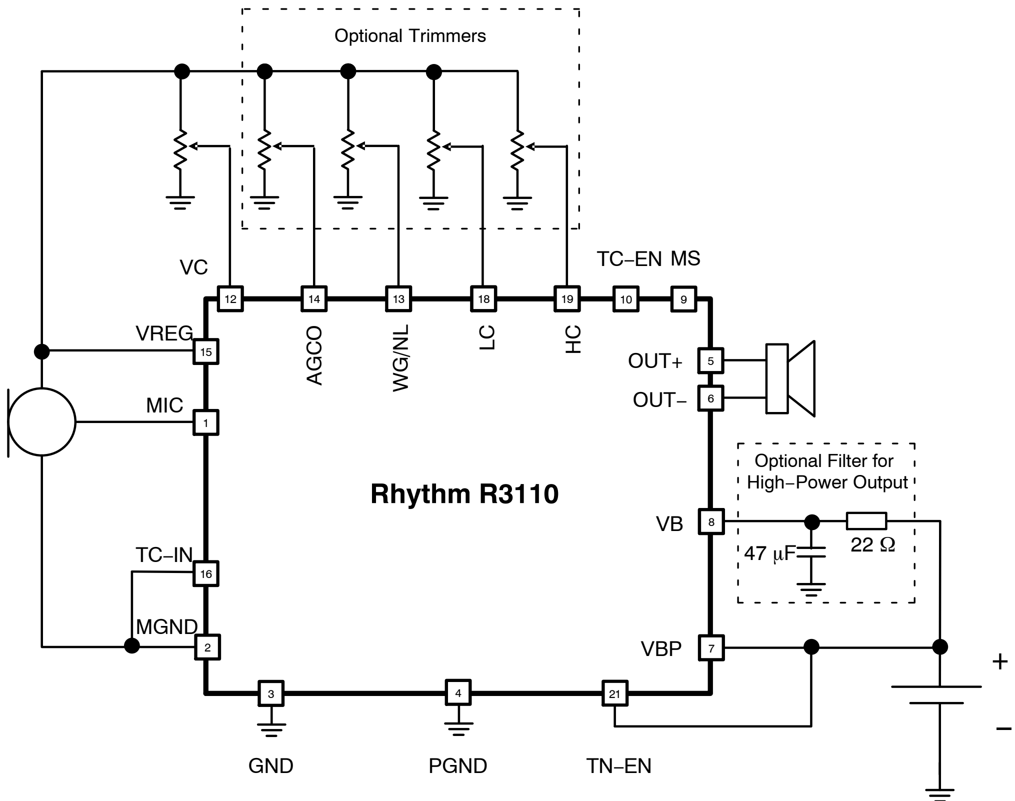

Figure 13. Simple One-Microphone Hearing Aid with Tinnitus Treatment

Advanced Hearing Aid

R3110 allows for the use of advanced hearing aid algorithms. Advanced Mode can be configured by tying the MS pin to the VB pin.

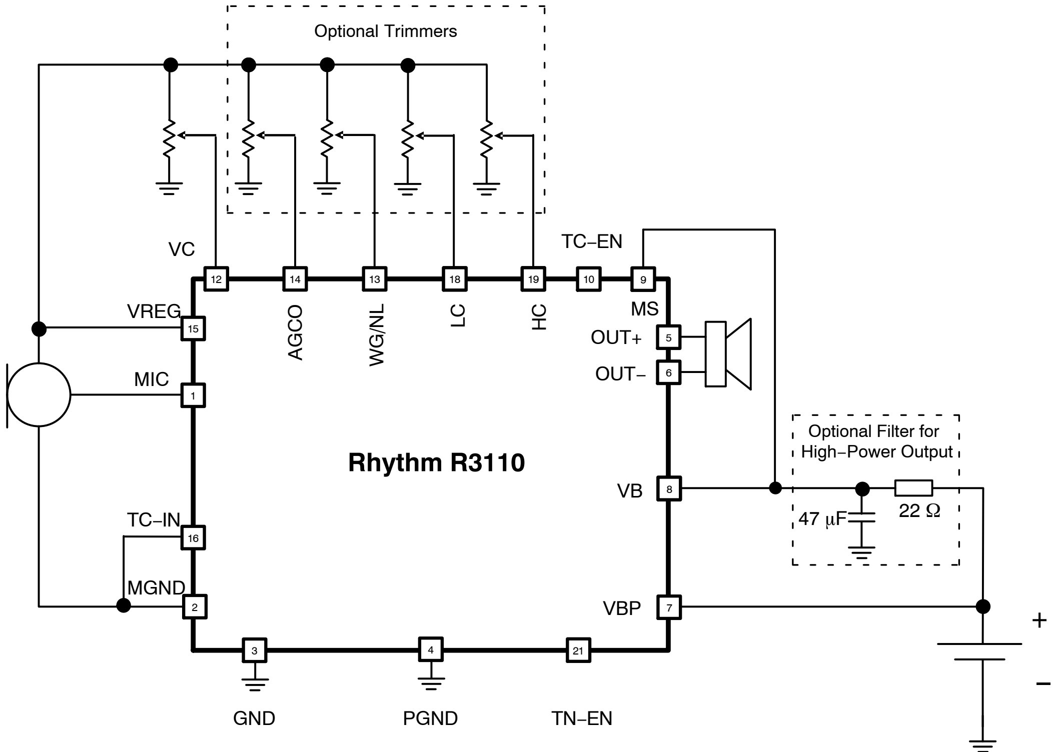

Figure 14. Advanced Hearing Aid

Tinnitus-Only Device

R3110 can be used with no microphone at all, and become a tinnitus noise generation device. In this case, all analog inputs must be connected to the MGND pin as shown on Figure 15. The WG/NL pin offers a capability to adjust the level of the generated noise. It can be used with a potentiometer such that the user can control the tinnitus noise level. The HC and LC pins can be used to adjust the frequency shape of the generated noise. VC is not used because no microphone signal is being transmitted, and consequently, this pin would have no effect.

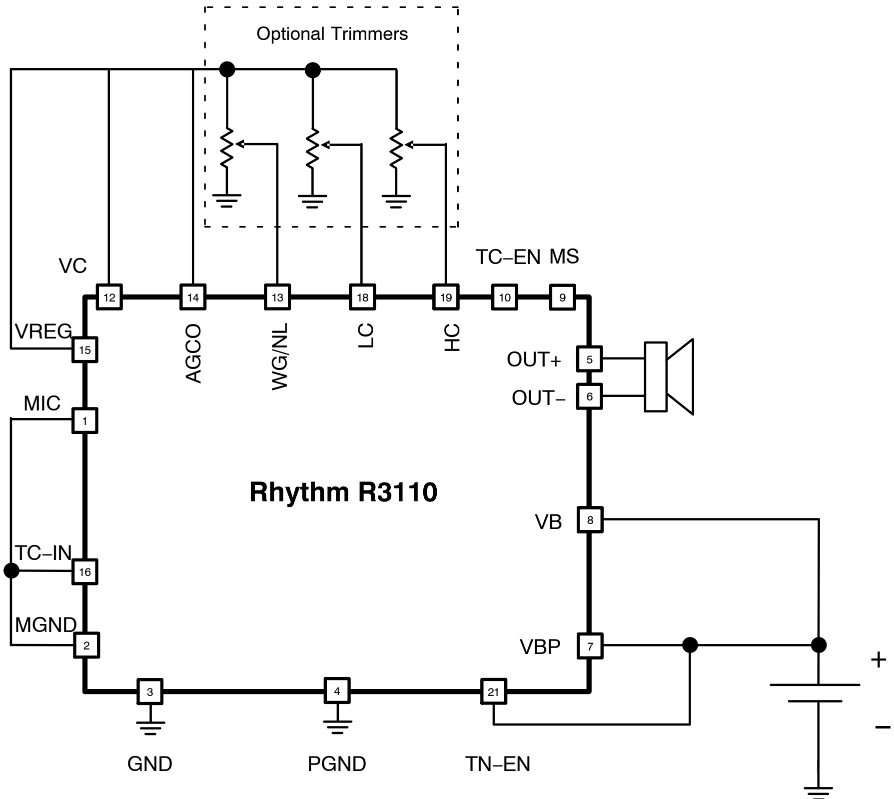

Figure 15. Tinnitus-Only Device

DUAL-FUNCTION HEARING AID

This section contains examples that require the use of a switch to enable additional functionality of R3110. These examples are summarized below:

- Simple hearing aid with telecoil
- Simple hearing aid with telecoil and tinnitus treatment
- Tinnitus treatment-only device telecoil

Each of the following subsections explains these examples, providing reference schematic and design recommendations when applicable.

Simple Hearing Aid with Telecoil

With a switch connected to the TC-EN pin, R3110 offers two different processing modes. The switch can be a manual toggle switch or a magnetic switch, such as a GMR or a Reed switch. In this configuration, R3110 either processes the signal sampled by the single microphone or the signal captured by the telecoil. Figure 16 shows the static toggle switch example, whereas Figure 17 shows the use of a magnetic switch.

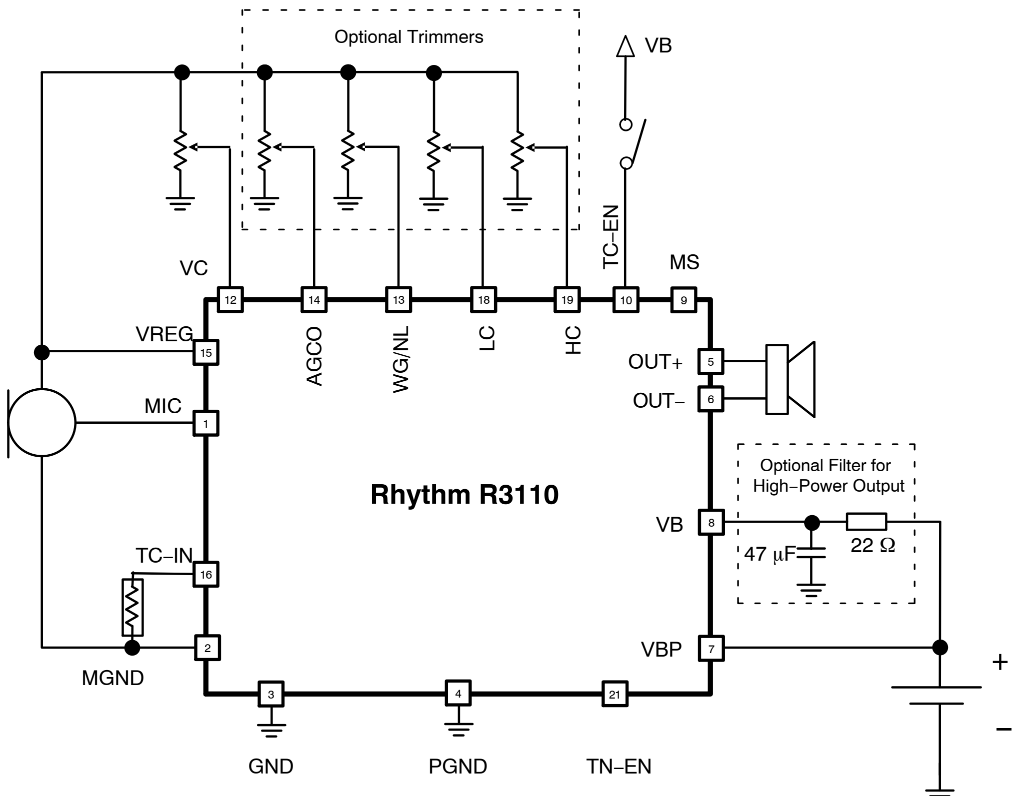

Figure 16. Simple Hearing Aid with Telecoil, Controlled by a Static Switch

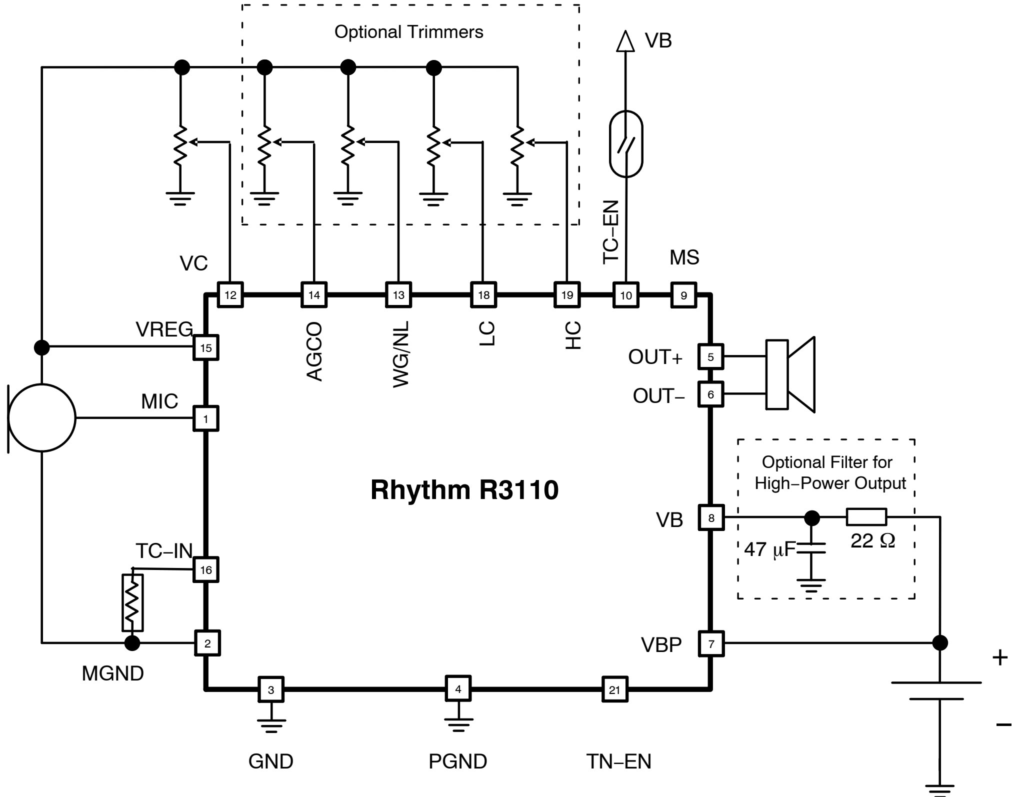

Figure 17. Simple Hearing Aid with Telecoil, Controlled by a Magnetic Switch

Simple Hearing Aid with Telecoil and Tinnitus Treatment

The tinnitus treatment algorithm can be enabled on the simple hearing aid example described under "Simple Hearing Aid with Tinnitus Treatment", with the same impact on the WG/NL pin. Refer to Figure 13 for an illustration of this example.

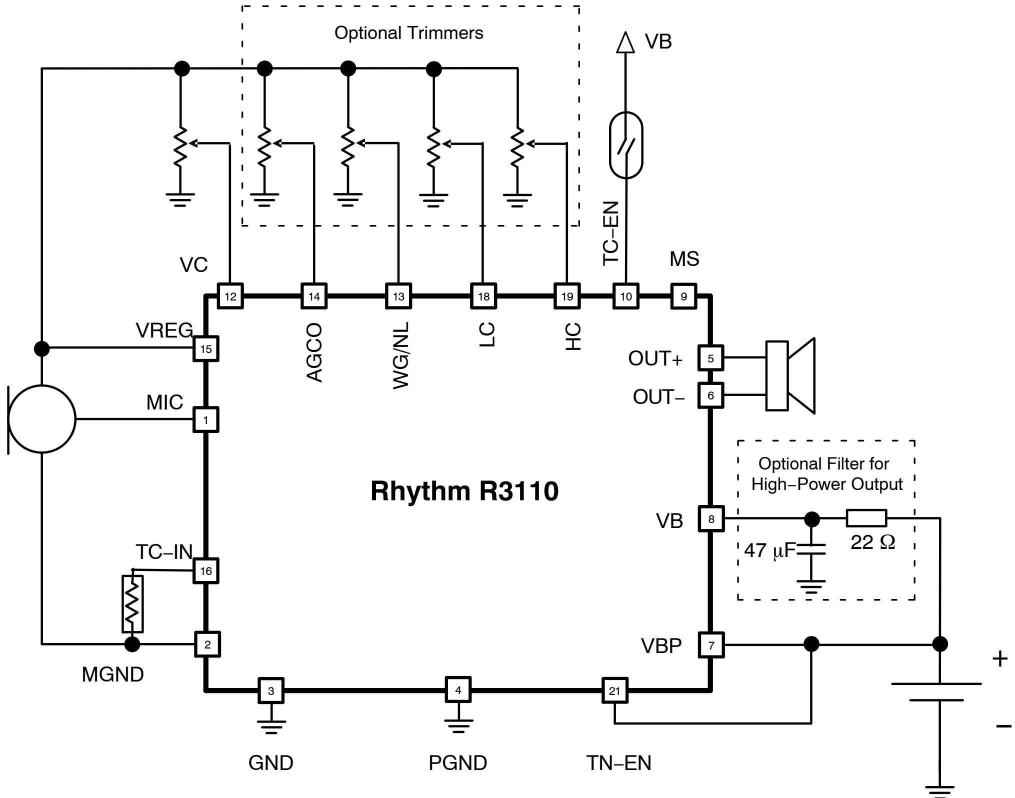

Figure 18. Simple Hearing Aid with Autocoil and Tinnitus Treatment

Tinnitus Treatment Device with Telecoil

Some tinnitus treatment devices require a telecoil mode, even though there is no microphone on the hearing device. Figure 19 provides the schematic for such an example. Similar to the previous tinnitus-only application example discussed in "Tinnitus-Only Device", the use of the volume control and the output limiting functions have been removed because they have no impact in this case.

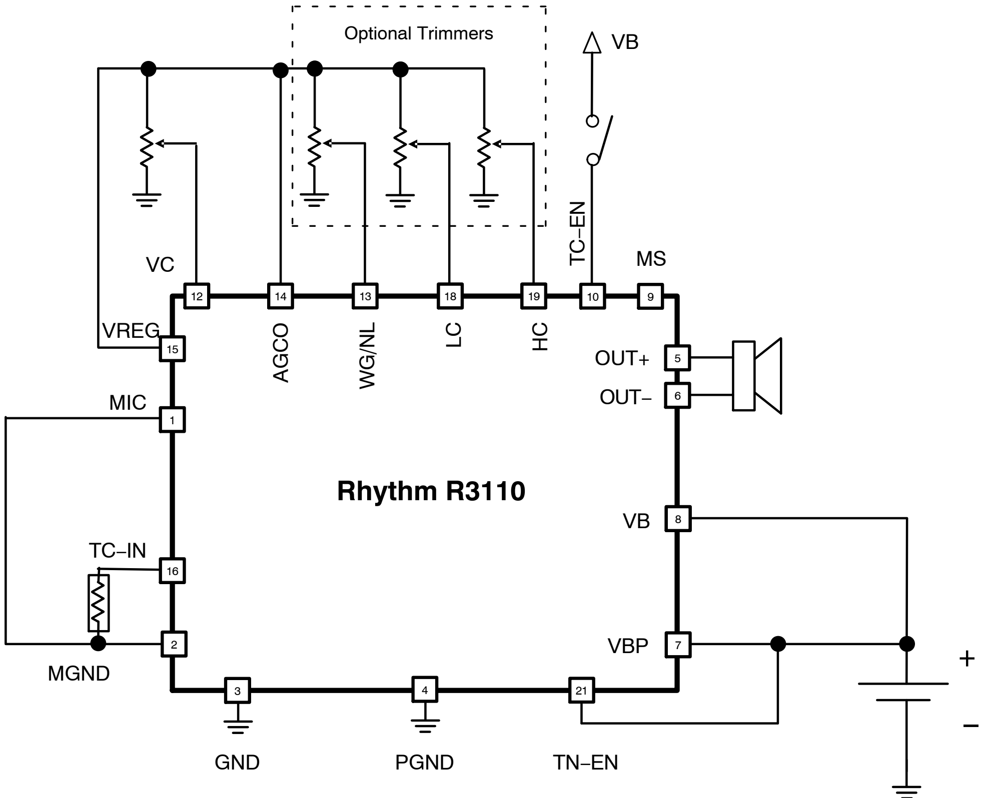

Figure 19. Tinnitus Treatment Device with Telecoil

TRIPLE-FUNCTION HEARING AID

This section contains application examples that require the use of a single push button to enable additional functionality of R3110. These examples are summarized below:

- Cycle through Simple, Advanced and Telecoil modes
- Cycle through Simple, Advanced and Telecoil with tinnitus treatment
- Simple hearing aid with noise reduction control and telecoil
- Simple hearing aid with noise reduction control, telecoil and tinnitus treatment

Each of the following subsections explains these examples, providing reference schematics and design recommendations when applicable.

Cycle Through Simple, Advanced and Telecoil Modes

A typical application of R3110 allows users to access most of its functionality through the use of a momentary switch, also known as a push button. The user can cycle through the following modes at the push of a button:

1. Simple hearing aid mode
2. Advanced mode for noisier situations
3. Telecoil mode for use with a handset compatible with a magnetic switch

Figure 20 illustrates this application.

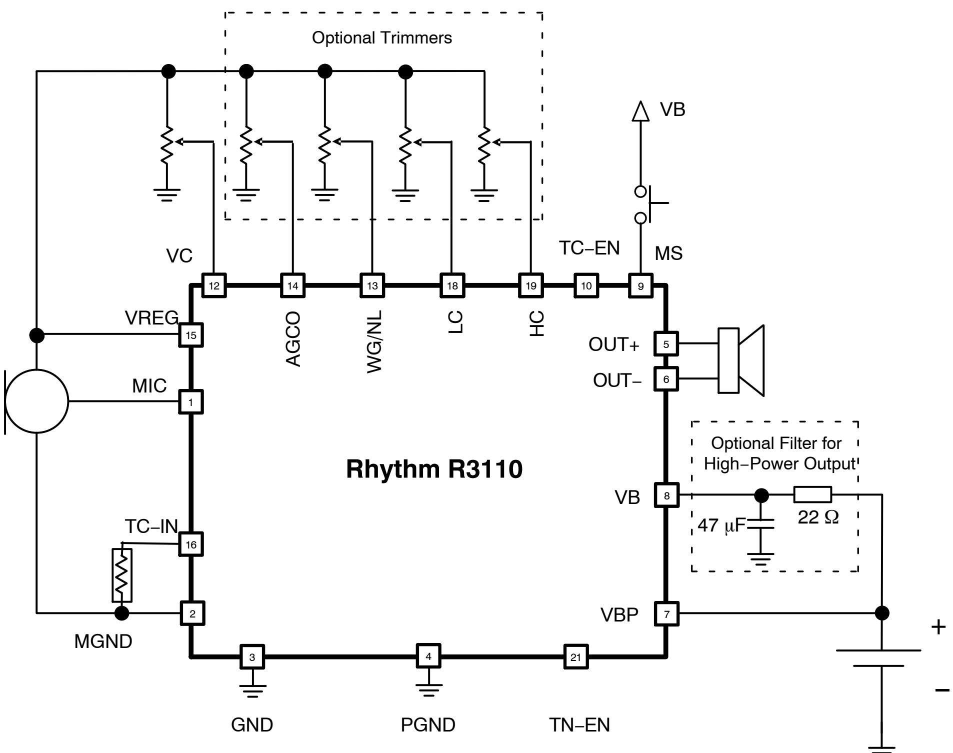

Figure 20. Advanced Hearing Aid with Push Button

Cycle Through Simple, Advanced and Telecoil with Tinnitus Treatment

The hearing aid with push button described in "Cycle Through Simple, Advanced and Telecoil Modes" can be modified to provide tinnitus treatment. When the TN-EN pin is pulled high, the tinnitus treatment algorithm is enabled in the DSP of R3110. In addition, the WG/NL pin functionality changes to disable wide band gain control, and enable the adjustment of the tinnitus noise level. Details of the tinnitus treatment algorithm can be found in the "Noise Generator for Tinnitus Treatment".

Figure 21 shows a reference schematic for this application example. For a wiring diagram, refer to "Wiring Diagram for Fully Featured Hearing Aid".

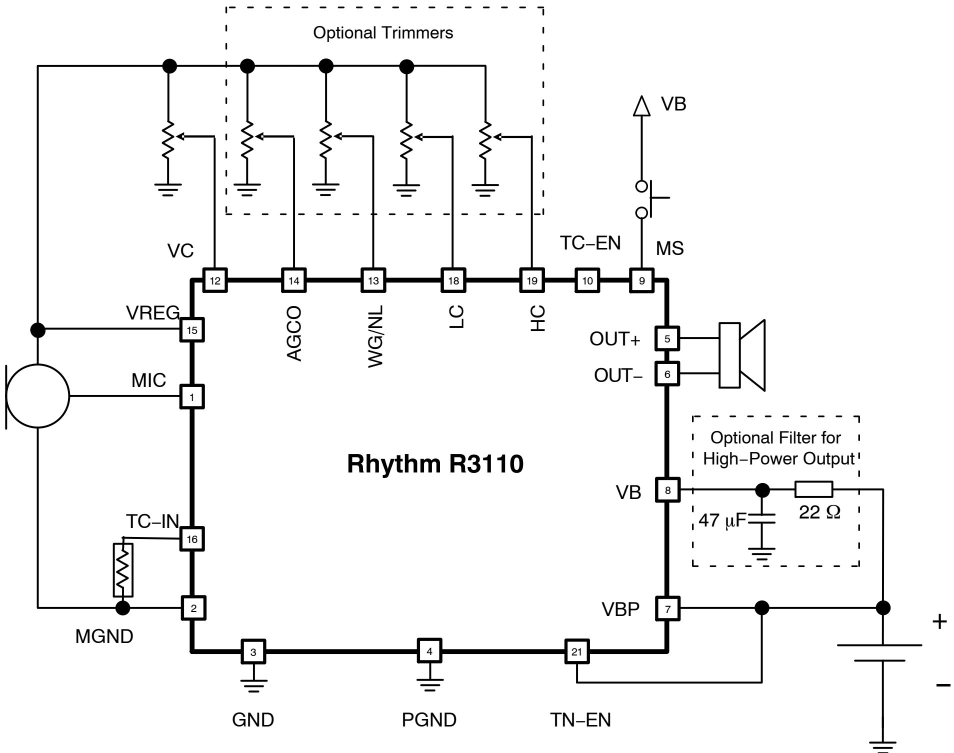

Figure 21. Advanced Hearing Aid with Push Button and Tinnitus Treatment

WIRING REFERENCE

A reference wiring diagram has been described in "Reference Wiring Diagram". Refer to this section for reference wiring information to build the simplest entry-level hearing aid with R3110. This section provides additional information on wiring R3110 for selected features. It culminates with a full-feature wiring diagram.

Dealing with Grounds

You must carefully wire the different ground pins of R3110. The ground pins are:

GND The main system ground, connected to the negative terminal of the battery.
PGND The H-Bridge ground; must be connected to the main system ground.
MGND The microphone ground; must not be connected to the other two ground pins. Only use it to connect the negative terminal of the input transducers (i.e., the microphones and the telecoil).

Figure 22 shows a graphical representation of how to wire these three ground pins.

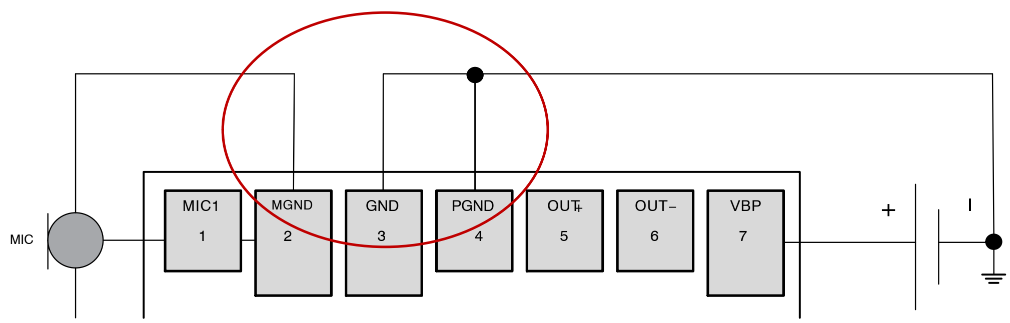

Figure 22. Ground Connections

Power Supply Connection

Figure 23 shows the recommended wiring for the two power supply pins, VB and VBP, with the optional external filtering that is required for high power hearing aids, as described in "High Power Output Support".

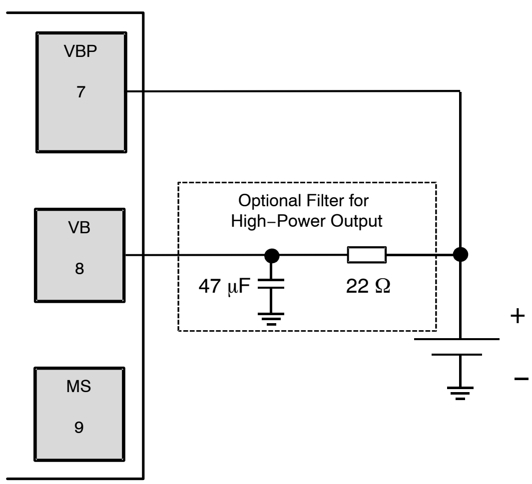

Figure 23. Power Supply Connection

Shorting Unused Analog Inputs

Depending on the number of transducers required by the hearing aid, take care to properly ground the unused inputs. Figure 24 shows the recommended wiring for the tinnitus-only use case where no analog inputs are required, similar to the application example described in “Tinnitus-Only Device”.

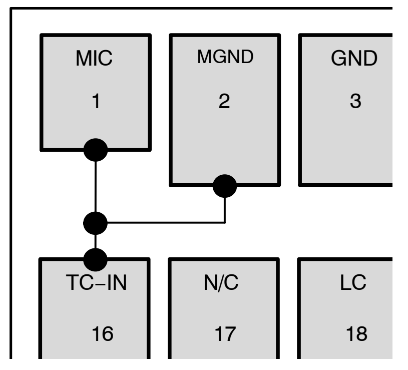

Figure 24. Grounding Unused Analog Inputs

Wiring Unused Control Pins

R3110 offers hardware configuration of some important parameters through four configuration pins—LC, HC, AGCO and WG/NL—as detailed in “Hardware Configurability”. For a hearing aid design that does not use the configuration options, these pins must be connected to the VREG pin to ensure that the signal processing algorithms are properly using the default parameter values. Figure 25 shows the recommended wiring for the ultimate use case where none of these configuration pins are required.

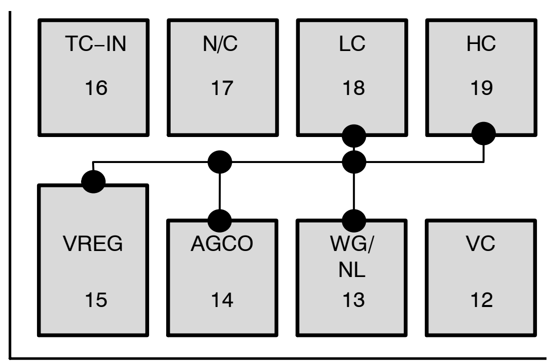

Figure 25. Connecting Unused Configuration Pins

Wiring Switches

The following switches can be used with R3110:

- Figure 26 shows how to wire a manual toggle switch to control a telecoil.
- Figure 27 shows how to connect a magnetic switch to control telecoil.
- Figure 28 shows how to connect a momentary push button to switch between the three operating modes.

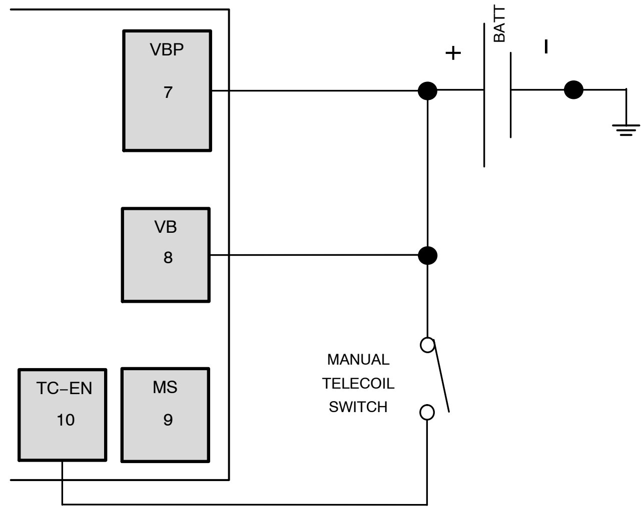

Figure 26. Wiring a Manual Toggle Switch for Telecoil Control

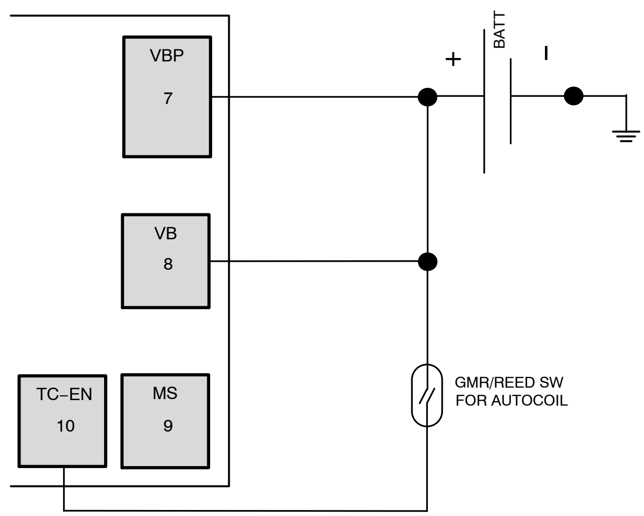

Figure 27. Wiring a Magnetic Switch (GMR or Reed) for Telecoil Control

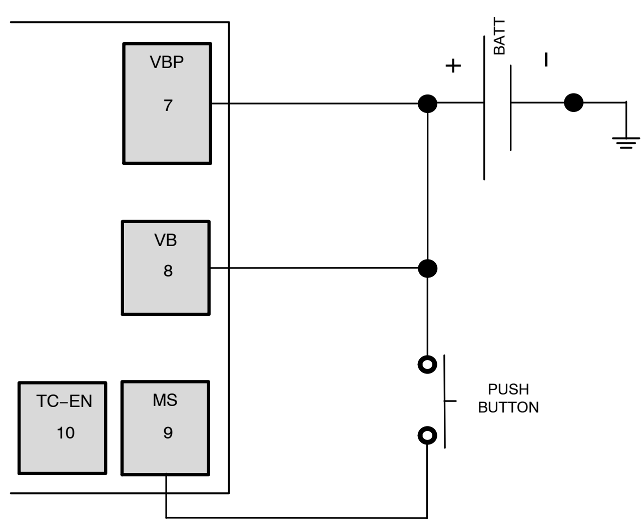

Figure 28. Wiring a Momentary Push Button for Mode Selection

Wiring to Enable Tinnitus Masking

The use of the Tinnitus Masking feature in R3110 is described in "Noise Generator for Tinnitus Treatment". Figure 29 shows the recommended wiring to enable this functionality through the TN-EN pin, as well as the recommended potentiometer connection to offer noise level control to the end user.

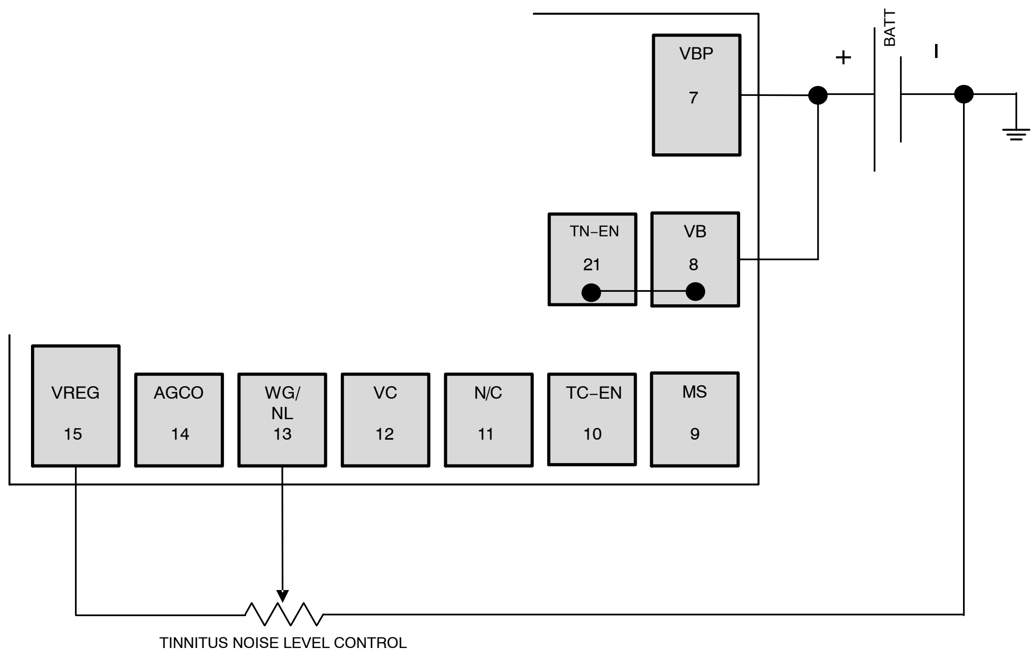

Figure 29. Wiring to Enable Tinnitus Masking

Wiring Diagram for Fully Featured Hearing Aid

This section provides a complete wiring example of a hearing aid that features two microphones and a telecoil, uses a momentary switch to cycle through the three operating modes of R3110, offers the audiologist four trimmers for patient fitting and parameter configuration, and provides a volume control potentiometer for the end user to control the output volume. This example is shown on Figure 30.

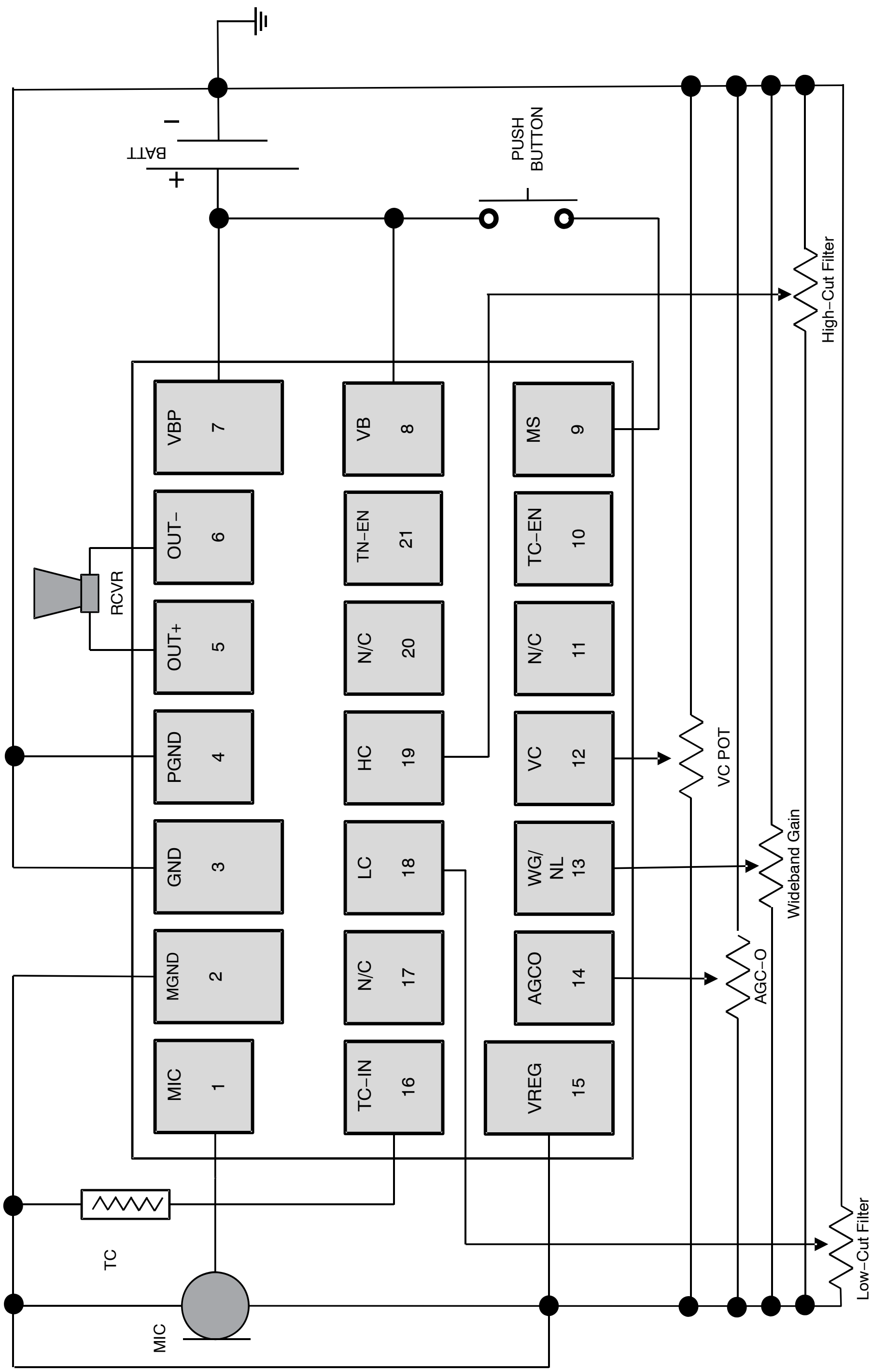

Figure 30. Wiring Diagram for a Fully Featured Hearing Aid

CHAPTER 5

Evaluating R3110 on the Hybrid Jig

OVERVIEW

The hybrid jig from ON Semiconductor is designed to enable you to evaluate new products, and conveniently perform incoming quality control and failure analysis on preconfigured products, without having to wire the units. This chapter is intended to be a quick start guide for using the hybrid jig with R3110.

The hybrid jig is designed with two components: a universal hybrid board and an adapter module. The universal hybrid board provides a consistent layout for all hybrids, regardless of pin−out, to simplify evaluation when using multiple products. The adapter module acts as an interface with the specific hybrid and routes the various pins to the appropriate location on the universal hybrid board. An illustration of the hybrid jig is shown on Figure 31.

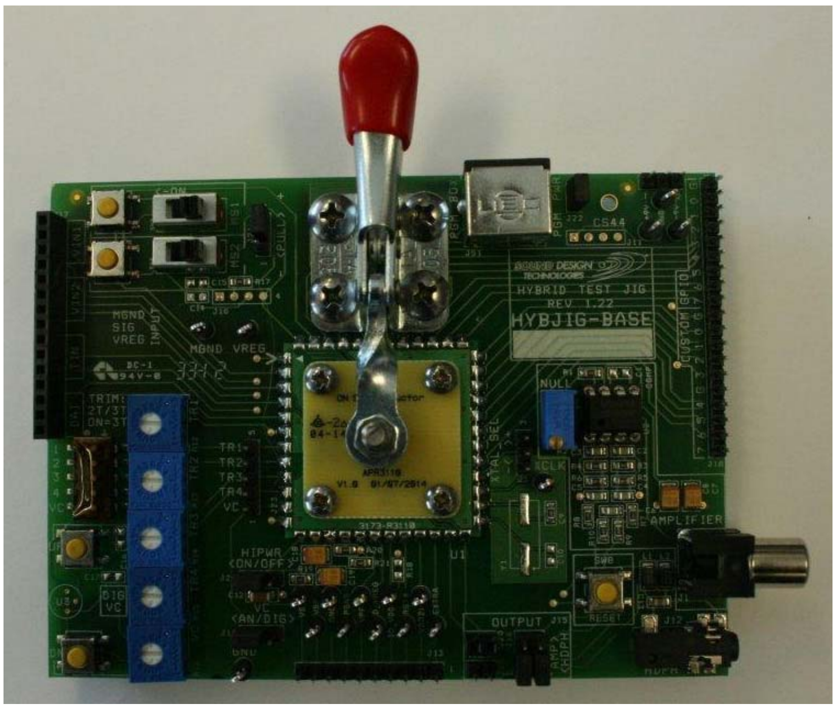

Figure 31. Hybrid Jig

INSERTING AND EXTRACTING THE HYBRID

The socket used on the R3110 hybrid jig is designed for easy, tool−free use. To ensure the proper function of the socket, the clamp must be aligned with the adaptor plate before inserting the hybrid. See the following subsections for details.

Aligning the Clamp

1. Ensure that the rubber plunger sits flush with the top of the yellow adaptor plate near the end of the range of motion of the clamp. The R3110 socket is shown in Figure 32 with the R3110 aperture plate.
2. Using minimal force, lock the clamp into place.
3. Ensure that the rubber plunger lines up with the cutout in the yellow adaptor plate.
4. Tighten all nuts fully if adjustment is required.

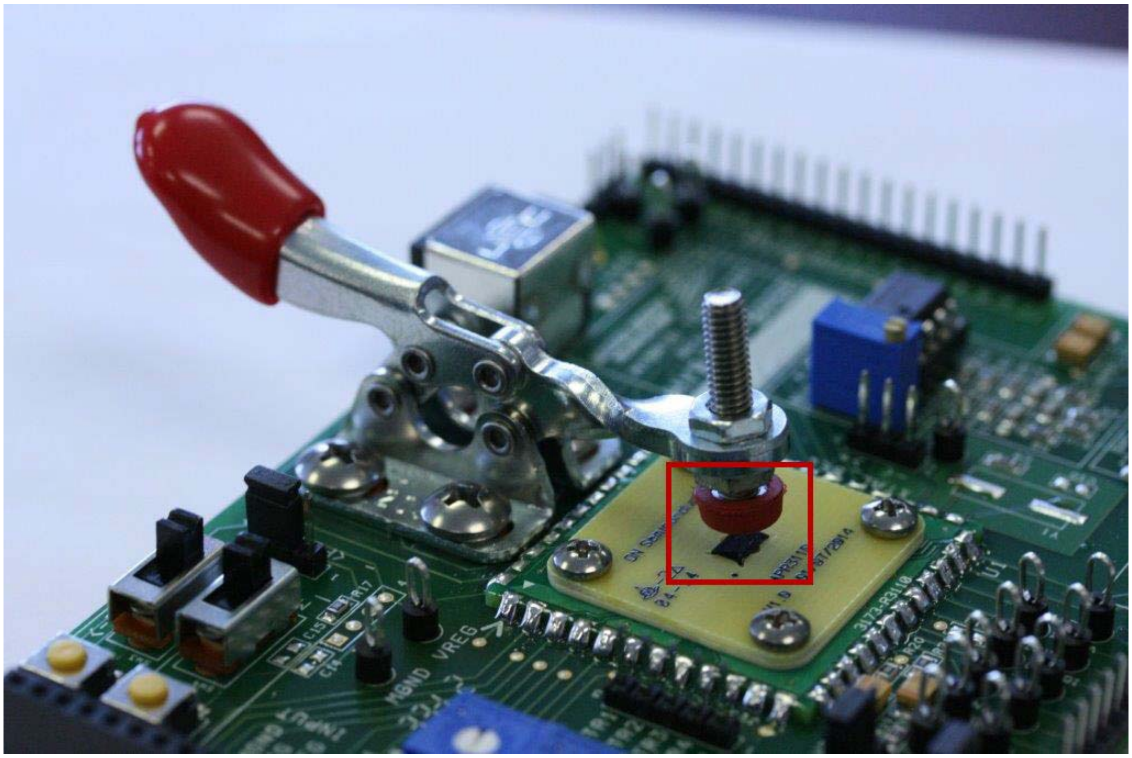

Figure 32. Aligning the Clamp with the Adaptor Plate

Inserting the Hybrid

First ensure that the clamp is aligned as described in "Aligning the Clamp" before following this procedure.

1. Fully open the clamp.
2. Align the pin 1 marker on the hybrid with the marker on the adaptor plate.
3. Insert the hybrid into the socket (ensure that the hybrid is fully inserted and level).
4. Fully close the clamp, ensuring that it locks into place.

CAUTION: Do not apply more than 1 kg to the end of the lever to close the clamp, or you risk damaging the hybrid, the socket, and the board. If the clamp is difficult to close, see steps 1 and 2 of "Aligning the Clamp".

Extracting the Hybrid

To extract the hybrid, gently pull on the hybrid with your fingers, use an electronic vacuum pen, or insert tweezers in the extraction holes of the alignment plate. Be careful not to puncture the membrane with the tweezers.

HYBRID ADAPTOR MODULE

The hybrid adaptor module acts as an interface with the R3110 hybrid and routes the various pins to the appropriate location on the universal hybrid board. The schematic of the hybrid adaptor module is shown in Figure 33.

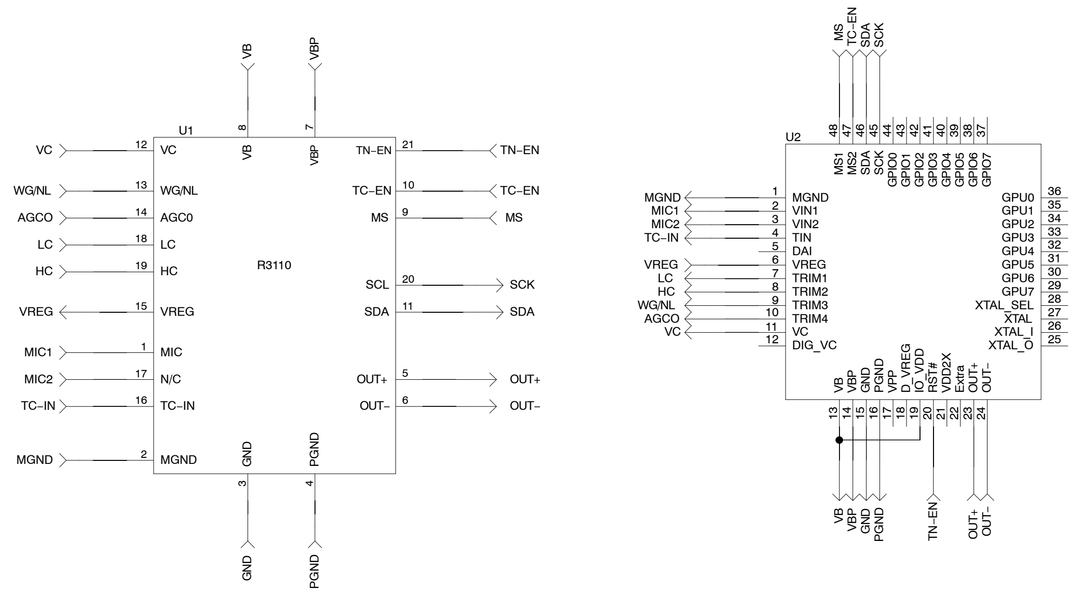

Figure 33. R3110 Hybrid Jig Adaptor Module Schematic

INPUTS

The universal hybrid jig supports up to four inputs, labelled VIN1, VIN2, TIN and DAI, on the upper left corner of the board. The input orientation (MGND, signal, VREG) is listed on a legend in the silkscreen in the same general area. To identify the inputs, refer to the adapter module schematic. For example, the R3110 adapter module on the right side of Figure 33 shows that VIN1 on the universal board connects to the MIC of R3110. Furthermore, VIN2 connects to MIC2, TIN connects to TC−IN, and DAI and Mic2 is unused. Use the appropriate connections to connect your three−terminal microphones on VIN1 (MIC on R3110), or VIN2 (MIC2 on R3110) and your telecoil on TIN (TC−IN on R3110).

OUTPUTS

Possible output settings on the universal hybrid jig are:

- Listen to the processed output of R3110 by directly connecting a zero−bias receiver to the output stage of R3110.
- Connect a 3.5mm headphone jack to listen to the filtered output signal.
- Use an RCA connector to access the on−board amplified output.

To use a receiver, remove the jumpers from headers J15 and J16, which removes the LC low−pass filter effects. Insert the receiver into either the male or female 2−pin header on J19 or J20.

Using standard 3.5 mm headphones requires shorting pins 2 and 3 of headers J15 and J16. Insert the 3.5 mm jack connector of your headphones in header J12.

To use the on−board amplification circuitry, change the jumpers on J15 and J16 to short pins 1 and 2 and apply ±9 V on the test loops in the upper right corner of the board, or on the J2 header. You can then access the amplified output on the RCA connector J1.

A summary of the configuration options is provided in Table 2.

Table 2. JUMPER CONFIGURATIONS FOR OUTPUT CIRCUIT ON J15 AND J16

Configuration	Jumper Pins	Jumper Positioning
Amplifier	1−2	Top of board or AMP
Headphones	2−3	Bottom of board or HDPH
Receiver	Open	N/A

POWER SUPPLY OPTIONS

Power is supplied from the programming box on the 6−pin mini−DIN connector, directly on J22, or through the optional CS44 socket. When getting power from the 6−pin mini−DIN connector, J22 must be shorted. When powering directly from J22, remove the jumper and connect 1.3 V to pin 1. When using the optional CS44 connector, you must wire a 4−pin header or CS44 connector to J11. The pin orientation is listed on the underside of the universal hybrid board.

The universal hybrid board is equipped with the high power application circuit described in "High Power Output Support". This RC filter can be enabled and disabled using the J24 header, according to Table 3.

Table 3. JUMPER CONFIGURATIONS FOR HIGH POWER APPLICATIONS ON J24

Configuration	Jumper Pins	Jumper Positioning
High Power Circuit Disabled	1−2	Right−hand side / HIPWR OFF
High Power Circuit Enabled	2−3	Left−hand side / HIPWR ON

ANALOG VOLUME CONTROL AND TRIMMERS

The volume control and four trimmers can be set up in 2−terminal or 3−terminal configurations through a dip switch (SW9) on the left side of the universal hybrid board. As listed on the silkscreen, turning a switch off or on enables 2−terminal or 3−terminal mode, respectively, for its corresponding trimmer or volume control. For R3110, the five switches must be set to 3−terminal mode. Each trimmer and volume control has a corresponding wiper and test point.

Analog Volume Control

The volume control can be configured on the universal hybrid board to be used in analog or digital mode, but R3110 only supports analog volume control. Consequently, the J14 header must be configured by shorting pins 2 and 3 at all times (see Table 4).

Table 4. JUMPER CONFIGURATIONS FOR VOLUME CONTROL CIRCUIT ON HEADER J14

Configuration	Jumper Pins	Jumper Positioning
Digital Volume Control	1−2	Right−hand side / VC DIG
Analog Volume Control	2−3	Left−hand side / VC AN

Trimmers

Four wipers are available on the universal hybrid board. They connect to the four configurations pins of R3110 as per Table 5.

Table 5. TRIMMER ASSIGNMENT AND DESCRIPTION

Wiper Name	R3110 Pin Name	Wiper Pin Description
TR1	LC	Low−Cut Filter Corner Frequency
TR2	HC	High−Cut Filter Corner Frequency
TR3	WG/NL	Wideband Gain / Noise Level
TR4	AGCO	Output Limiter (AGC−O)

By default, all trimmers are turned to their upper right position (i.e., turned clockwise to the end of the trimmer range).

The parameter values and range that can be obtained with the four trimmers are described in detail in Table 1 in "Hardware Configurability".

SWITCHES

The universal hybrid jig supports both momentary and static switches called MS1 and MS2. R3110 is designed for a predefined usage of these two pins. MS on R3110 is labelled MS1 on the hybrid jig, and designed to operate only with a momentary switch; TC−EN is labelled MS2 and designed to operate only with a static switch. See "Telecoil Mode" below and "Push Button for Mode Control" below for implementation details. Header J21 defines whether the switches are configured as pull−up or pull−down. To operate with R3110, the switches must be pulled up when activated. Consequently, a header must be shorting pins 2 and 3 on J2 (Top of the board / PULL +).

NOTE: When using the momentary switches, leave the static switches in the off position.

Telecoil Mode

Telecoil Mode is typically controlled on R3110 with a toggle switch on the TC−EN pin. On the universal hybrid board, the TC−EN pin is mapped to the MS2 set of switches.

For correct operation of the TC−EN functionality designed in R3110, do not use the momentary switch for MS2, only the toggle switch. To activate Telecoil Mode, put the switch on the left side position (ON). This ties the TC−EN pin to VB and enables Telecoil Mode on R3110. Further details on telecoil support can be found in "Telecoil Support".

Push Button for Mode Control

R3110 supports the use of a momentary switch connected to its MS pin to cycle through three operating modes as defined in "Input Modes". On the universal hybrid board, this pin is mapped to the MS1 set of switches.

For correct operation of the MS functionality, do not use the toggle switch for MS1, only the momentary switch. To initiate a mode switch in R3110, push on the button. It momentarily ties the MS pin to VB and causes R3110 to cycle through the modes one at a time.

RESET

The Reset button on the universal hybrid board (SW8) has no impact when used with R3110, as there is no equivalent functionality in R3110. The RST# pin, usually serving the reset function, has been repurposed to support the tinnitus treatment feature of R3110 as described in "Tinnitus Treatment" below.

TINNITUS TREATMENT

The universal hybrid board contains no native support for the tinnitus treatment feature available in R3110. Nonetheless, two unused pins of header J13 are repurposed to provide easy access to the Tinnitus Noise Enable pin of R3110, and to allow an easy connection of this pin to VB, allowing you to evaluate the tinnitus treatment algorithm. The two repurposed signals on the board are labelled RST# and IO_VDD.

The Tinnitus Noise Enable pin of R3110 (TN−EN) is connected to the header pin RST# of J13. The VB pin of R3110 is connected to the header pin IO_VDD of J13. These two pins are side−by−side on header J13 (pins 3 and 4). Connect a jumper on these two pins to enable the tinnitus treatment algorithm on R3110.

TEST POINTS

The universal hybrid board contains various test points. Most notably, J13 interfaces with the power lines as noted on the silkscreen traces. For example, the left−most pin is a test point for VB. The board also features:

- Drilled holes to insert optional test loops
- Test points for trimmers and the volume control on header J23 (left side of the board)
- Test loops for MGND, VREG, and XCLK
- A tinnitus treatment algorithm control pin described in "Tinnitus Treatment" above

CUSTOM/GPIO HEADER

Header J18 (upper right corner) is of no particular use. It is not connected to any of the R3110 pins.

EXTERNAL CRYSTAL CIRCUITRY

The XTAL_SEL section of the universal hybrid board provides an option for external oscillation circuitry, but R3110 does not support this feature.

SCHEMATICS

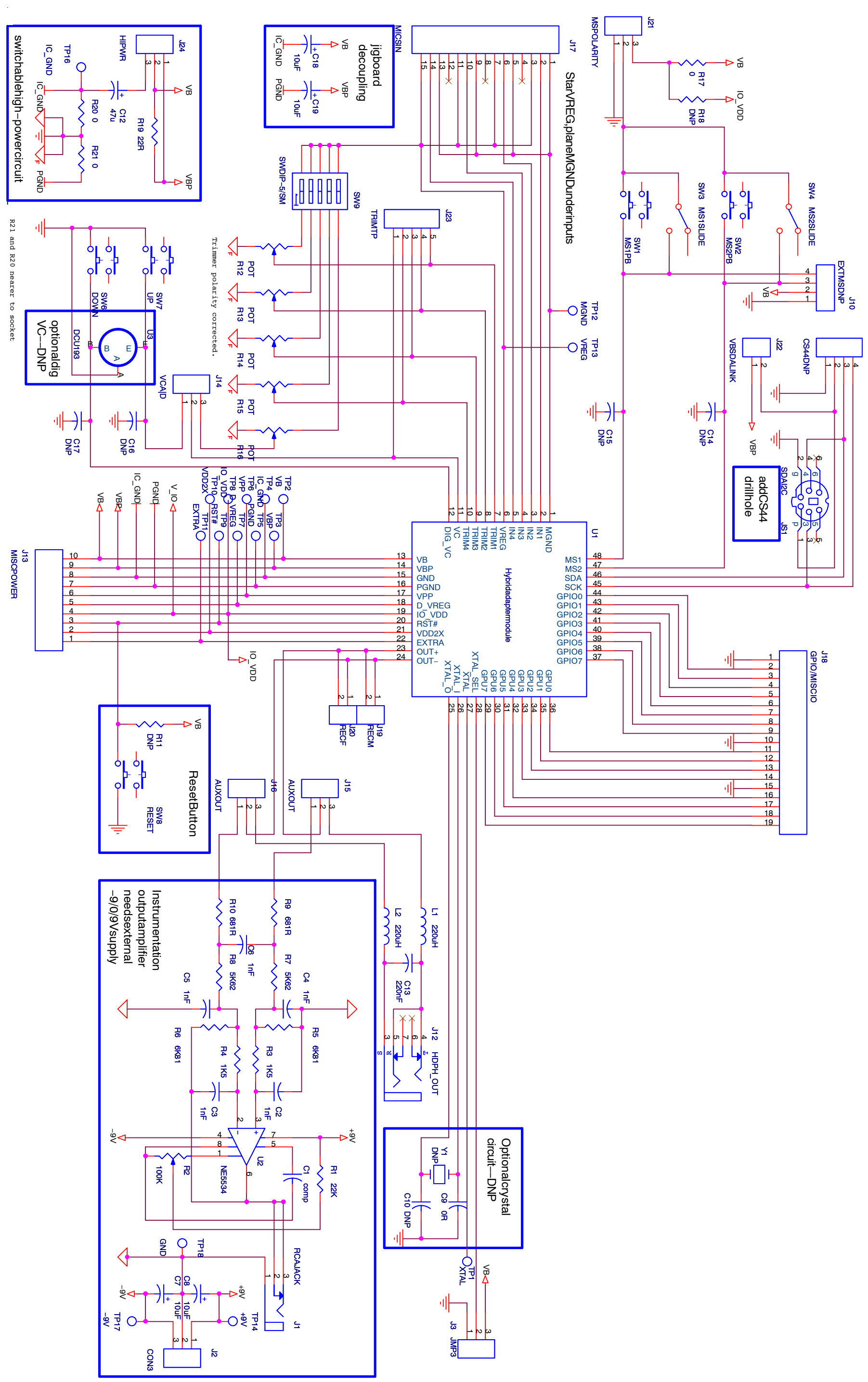

Figure 34. Universal Hybrid Jig Schematic

CHAPTER 6

Monitoring Utility

OVERVIEW

R3110 offers a monitoring utility that allows basic troubleshooting capabilities. The utility supports I^2C mode: a two−wire interface that uses the SDA pin for bidirectional data, and the SCL pin as the interface clock input. I^2C communication support is available on the HI-PRO (serial or USB versions) and the ON Semiconductor DSP Programmer 3.0.

COMMUNICATION INTERFACE

In the block diagram of R3110, as shown on Figure 4 in "Overview", two pins show as N/C (No Connect). These pins (11 and 20) provide access to the communication interface of R3110.

No software configuration is allowed through this interface, but the monitoring utility described in this section uses these two pins to retrieve the required information from R3110:

- Pin 11: SDA: Communication Data Pin
- Pin 20: SCL: Communication Clock

On the hybrid test jig, these pins are connected to the 6-pin mini-DIN connector, and consequently provide a communication interface between the computer and R3110, provided that one of the interface hardware boxes described in "Overview" (above) is being used. This setup is illustrated in Figure 35.

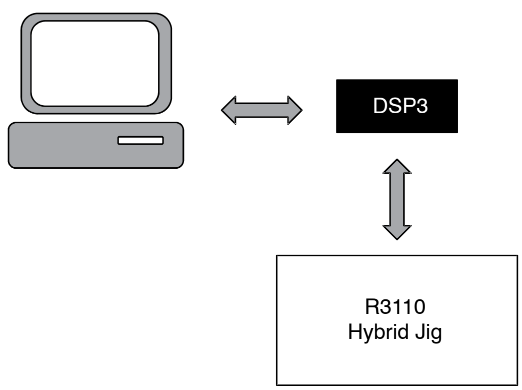

Figure 35. Hybrid Jig Setup

To use the monitoring utility in your product design environment, connect pins 11 and 20 on test points, such that the utility can also run on the end products, and provide basic evaluation or trouble shooting information.

To make the use of the basic command line tool easier, a set of batch files is provided which may be excecuted from within the Windows environment. These files are located on the R3110 product page at www.onsemi.com. Once you have downloaded the file, please follow these steps:

1. Download and unzip the files to the R3110MU\bin\ directory
2. Right click on the batch file name with the required parameters and save a shortcut to your desktop
3. Clicking on the desktop shortcut will launch the R3110 Monitor utility with the correct parameters.

INSTALLATION INSTRUCTIONS

The monitoring utility is available from the MyON website. Contact your local ON Semiconductor customer support representative to get access.

The minimum system requirements for installing the monitoring utility are:

- One of the following versions of Microsoft® Windows®:
  - Windows XP Service Pack 3
  - Windows Vista Service Pack 2
  - Windows 7 Service Pack 1
  - Windows 8 or later
- .NET Framework 4 (if not already installed with your operating system)
- HI-PRO programmer drivers and/or DSP3 programmers drivers, depending on the programmer you are using

The file that you download consists of a self-extracting executable file that installs the utility on the computer. Once the files are saved, you can run the monitoring utility from any Microsoft Windows command prompt.

OPERATING INSTRUCTIONS

To run the monitoring utility:

1. Open a Windows command prompt.
2. Change the directory to your installation folder.

The standard usage of the monitoring utility is shown on Figure 36.

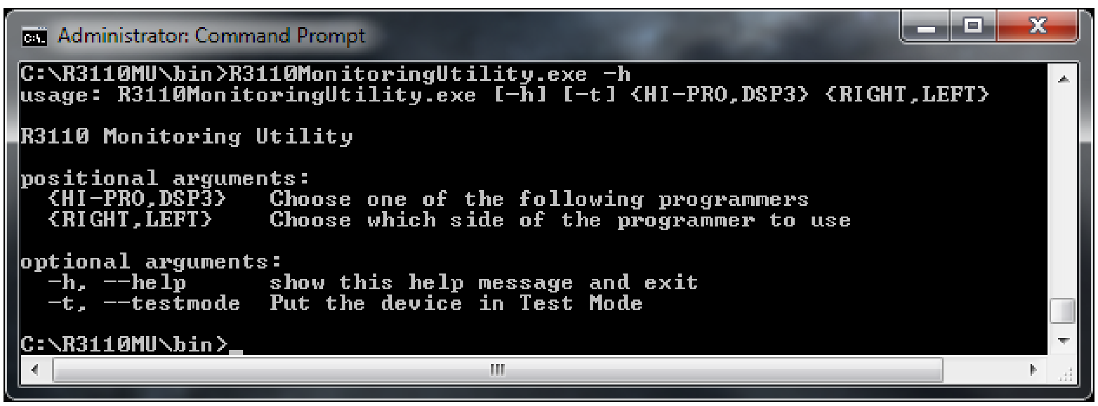

Figure 36. Usage Instructions for the R3110 Monitoring Utility

3. Select the appropriate interface programmer and which side of the programmer to use
4. Run the command as shown at the top of Figure 36. Assuming that a valid communication interface with R3110 was set up, the utility returns useful information about the device. An example can be seen in Figure 37.

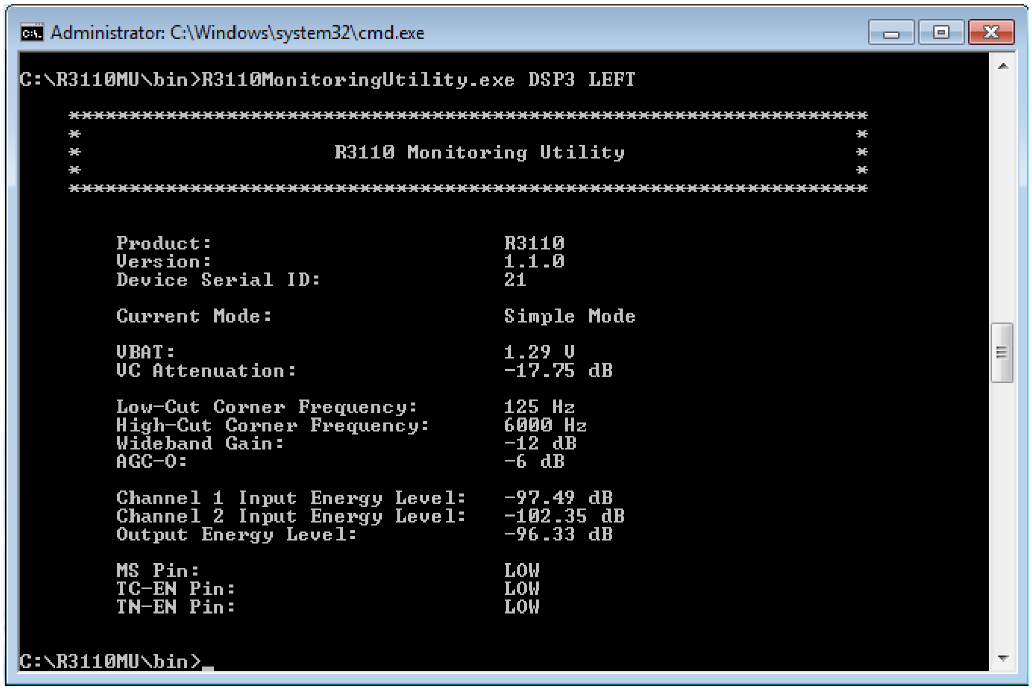

Figure 37. Monitoring Utility Output

The monitoring utility automatically selects which parameters it reports depending on the state of the TN-EN pin. When TN-EN is LOW, the monitoring utility displays the wideband gain, as shown in Figure 37. Alternatively, when TN-EN is HIGH, the monitoring utility displays the tinnitus noise level. Note that when the wideband gain is not displayed, R3110 uses the value of 0 dB as its default.

Table 6 details the parameters returned by the utility, provides a description of what the parameters mean, shows the range of values that each parameter can take, and provides troubleshooting information based on the returned values.

Table 6. MONITORING UTILITY: PARAMETER DETAILS

Parameter	Expected Values	Description	Possible Actions
Product	R3110	This parameter confirms that the device under test is a R3110 hybrid.	If the value is different from R3110, this monitoring utility will not work.
Version	1.1.0	This parameter provides information on the version of the firmware contained in the OTP of the device.	N/A
Device Serial ID	A 6-digit number	This number identifies the device under test. It contains information about the production time and date, as well as the production lot and tests.	N/A
Current Mode	Simple Mode Advanced Mode Telecoil Mode	Display the operating mode that the device is currently running. The default mode is the Simple Mode. The other two modes can only be reached by using switches or connections to either the MS pin or the TC-EN pin.	Further push on the MS switch, or toggle the TC-EN switch, to reach the desired mode.
VBAT	1.34	Battery voltage measurement.	If the measurement is under 1.1 V, replace the battery or adjust the power source.
VC Attenuation	0 dB to 42 dB	Indicates the current attenuation applied to the output signal, based on the voltage on the VC pin.	If the value does not match your expectations, verify the connection of your analog potentiometer, or ensure that the voltage on the VC pin is what you expect.

Table 6. MONITORING UTILITY: PARAMETER DETAILS

Parameter	Expected Values	Description	Possible Actions
Low-cut corner frequency	10 to 2000 Hz	Indicates the value read on the LC configuration pin and used in the filtering structure.	If the value does not match your expectations, verify the connection of your trimmer, or ensure that the voltage on the LC pin is what you expect.
High-cut corner frequency	1000 to 8000 Hz	Indicates the value read on the HC configuration pin and used in the filtering structure.	If the value does not match your expectations, verify the connection of your trimmer, or ensure that the voltage on the HC pin is what you expect.
Wideband Gain	0 dB to -30 dB	Indicates the value read on the WB/NL configuration pin when the TN-EN pin below is at the LOW position. When the TN-EN is in HIGH position, this parameter is not shown by the utility because it uses its default value of 0dB.	If the value does not match your expectations, verify the connection of your trimmer, or ensure that the voltage on the WG/NL pin is what you expect.
Tinnitus Noise Level	-25 dB to -100 dB	Indicates the value read on the WB/NL configuration pin when the TN-EN pin below is at the HIGH position. When the TN-EN is in LOW position, this parameter is not shown by the utility because the tinnitus noise generator is disabled on the device.	If the value does not match your expectations, verify the connection of your trimmer, or ensure that the voltage on the WG/NL pin is what you expect.
AGC-O	0 dB to -30 dB	Indicates the value read on the AGCO configuration pin and used in the output limiter algorithm.	If the value does not match your expectations, verify the connection of your trimmer, or ensure that the voltage on the AGCO pin is what you expect.
Channel 1 Input Energy Level	Refer to "Performance Evaluation"	Provides reference information on the energy level of the first WDRC channel. Allows you to check the level of the lower frequency portion of the input signal.	If the measured value is very low, the transducer (or transducers) in use in the current mode might have a bad connection. For more information, refer to "Performance Evaluation".
Channel2 Input Energy Level	Refer to "Performance Evaluation"	Provides reference information on the energy level of the second WDRC channel. Allows you to check the level of the higher frequency portion of the input signal.	If the measured value is very low, the transducer (or transducers) in use in the current mode might have a bad connection. For more information, refer to "Performance Evaluation".
Output Energy Level	Refer to "Performance Evaluation"	Provides reference information on the energy level of the output stage. Allows you to check on the receiver connection.	If no signal can be heard, and the output energy level is high, the receiver might have a bad connection. For more information, refer to "Performance Evaluation" .
MS Pin	HIGH or LOW	State of the MS pin. This pin is LOW when the push button on the MS pin is released, and HIGH, when leaving the push button pressed for a long time.	Check on the push button connection if the observed behavior does not match the description.
TC-EN Pin	HIGH or LOW	State of the TC-EN pin. This pin is LOW when the current mode is TMM or OMM, and HIGH when the current mode is TCM. When no switch is connected on the TC-EN pin, this pin reads LOW. When the switch is activated (pulled high), this pin reads HIGH.	Check on the toggle switch connection if the observed behavior does not match the description.
TN-EN Pin	HIGH or LOW	State of the TN-EN pin. Allows you to control the correct configuration of the tinnitus treatment algorithm, which is active when the TN-EN pin is HIGH, and inactive when the pin reads LOW.	Check your hardware connection if the state of the pin does not match your expectations.

Using the R3110 Monitoring Utility, you can put R3110 into Test Mode, which disables adaptive algorithms and can be useful when running tests that require this configuration.

There is also a secondary mechanism to enter Test Mode which does not require the use of a computer or the connection of the I2C pads. When a voltage of greater than 1.5 V is applied to the VB pad during boot, R3110 will enter Test Mode, even with MS tied to VB (which would normally enable Advanced Mode). It is recommended to use a voltage between 1.52 V and 1.57 V if possible. Do not exceed the maximum supply voltage as described in Table 1.

You can exit Test Mode by restarting R3110 (at nominal voltage) regardless of how it entered Test Mode. When comparing results with and without adaptive algorithms running, you should expect to see some differences, depending on the test signal used.

NOTES: Test Mode is not necessary in R3110's Simple Mode.
The best value to use for the voltage−based trigger to test mode is 1.55 V.

PRODUCTION TEST SUPPORT

The monitoring utility also provides a special command allowing customers to run a production test on the R3110 hybrids. This function disables a number of non-linear algorithms that would alter standard production test procedures, and so allows repeatable tests to be performed on the device in a production environment.

To put the device in production test mode, the monitoring utility must be installed on the computer, and the command executed with the `--testmode` or `-t` arguments, as seen in Figure 36 on page 44. When the monitoring utility is executed with this argument, it does not return diagnostic information; instead, it returns a message that the device is in test mode, as illustrated in Figure 38.

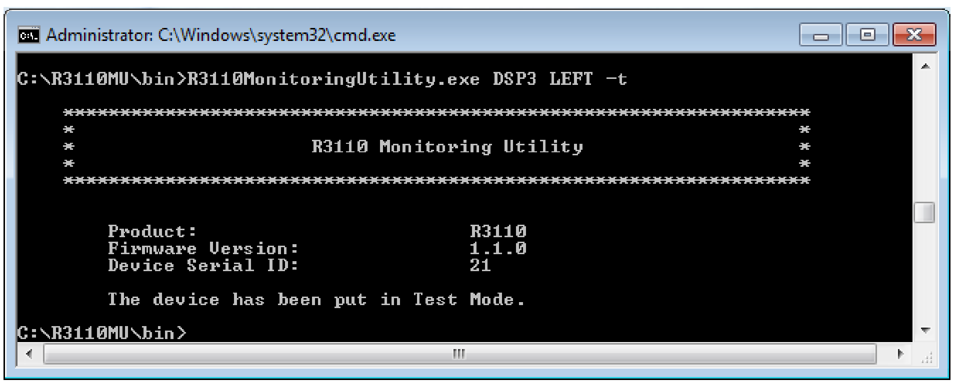

Figure 38. Output from Test Mode

To restore the device to normal operation, perform a power cycle on the R3110 hybrid. Re-running the utility without power cycling, even without the test mode flag, does not take the device out of test mode.

NOTE: When running without the test mode flag, the utility reports all information without indicating whether the device is still in test mode.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:
Literature Distribution Center for ON Semiconductor
P.O. Box 5163, Denver, Colorado 80217 USA
Phone: 303−675−2175 or 800−344−3860 Toll Free USA/Canada
Fax: 303−675−2176 or 800−344−3867 Toll Free USA/Canada
Email: orderlit@onsemi.com

N. American Technical Support: 800−282−9855 Toll Free USA/Canada
Europe, Middle East and Africa Technical Support:
Phone: 421 33 790 2910
Japan Customer Focus Center
Phone: 81−3−5817−1050

ON Semiconductor Website: **www.onsemi.com**

Order Literature: http://www.onsemi.com/orderlit

For additional information, please contact your local Sales Representative