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1 General

This document describes ZSSC3170's signal outputs and settings for the pulse width modulation (PWM) and Local Interconnect Network (LIN) interfaces.

There are three pins used for signal outputs:

- LIN - LIN interface
- HOUT – PWM/HSS (high-side switch)
- LOUT – PWM/LSS (low-side switch)

For normal operation in actual applications, there must be only one signal output that is configured and active. Idle outputs must not be connected.

Figure 1.1 ZSSC3170 Block Diagram

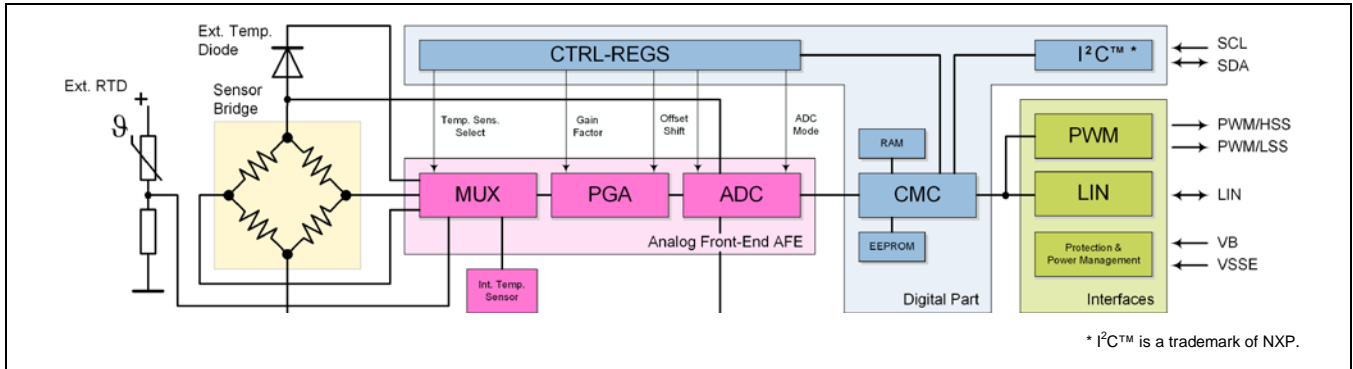
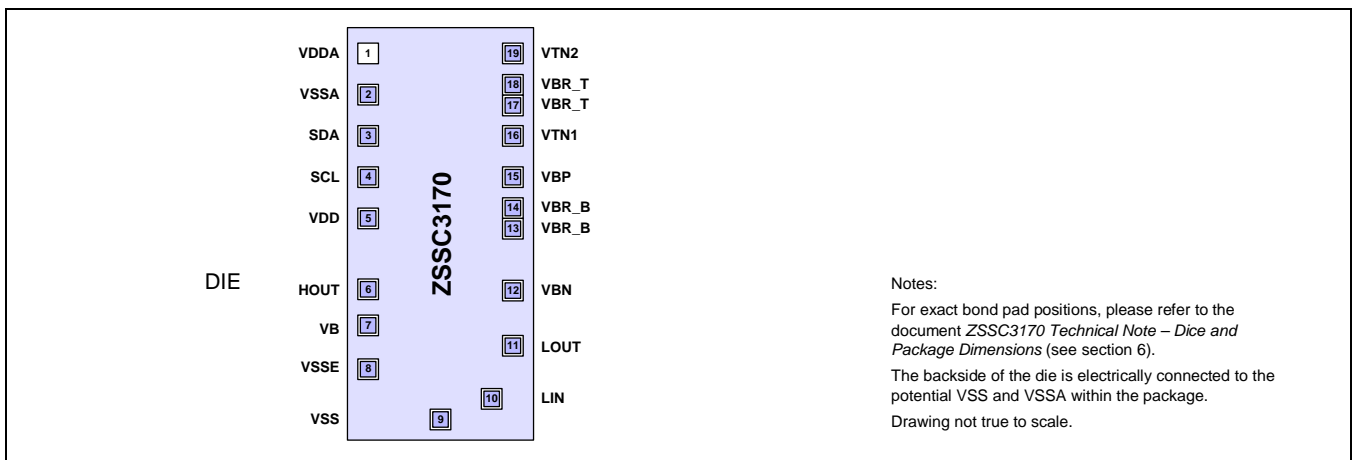


Figure 1.1 provides a block diagram of the ZSSC3170. An important advantage of this mixed-signal device is that noise sensitivity is greatly reduced because the calibration equipment and the ZSSC3170 are connected digitally.

Figure 1.2 Pin Configurations for Die Package



1.1. LIN Output

The output of the integrated LIN transceiver at the LIN pin is compliant with LIN revisions 2.1, 2.0 and 1.3. For details, refer to *ZSSC3170 LIN Interface Description*. For LIN Physical Layer Conformance Tests, the control pins of the integrated LIN transceiver can be accessed separately in the LIN Conformance Test Mode.

1.2. PWM Outputs HOUT and LOUT

In PWM mode, the output signal is provided at the HOUT or LOUT pin. The outputs are protected from short circuit overload by current limiters and time monitoring. Driving the signal lines with slew-rate-limited edges reduces electromagnetic emission. At the HOUT pin, a voltage higher than the maximum supply voltage can be tolerated. The notably low leakage current of the LOUT pin is designed to cover the requirements of some unique electronic control units (ECU).

2 Operational Modes

The ZSSC3170 supports three operational modes. For each mode, signal outputs behave differently:

- Normal Operational Mode (NOM)
- Command Mode (CM)
- Diagnostic Mode (DM)

2.1. Normal Operation Mode (NOM)

Either the LIN or PWM interface can be active in NOM. Using both interfaces simultaneously during NOM is not available.

- LIN Mode: LIN communication is always accessible. This is used for reading the sensor signal using a publisher frame or for end-of-line configuration and calibration using transport layer services in response to communication requests of the LIN master.
- PWM Mode: In NOM, the ZSSC3170 provides a PWM signal via the HOUT or LOUT pin. Upon power-up, if no *START_CM* command (see section 3) is received during the 30ms start window, the ZSSC3170 enters NOM and begins transmitting measurement results via the PWM signal, and it is no longer possible to send commands to the ZSSC3170 via the PWM pins without cycling power off and on. If instead a *START_CM* is received during the start window, the ZSSC3170 enters Command Mode (CM) and waits for further commands. To enter NOM from CM, send the *STRT_CYC_EEP* or *STRT_CYC_RAM* command (see section 3).

2.2. Command Mode (CM)

In CM, a full set of commands is accessible.

- LIN Mode: It is always possible to change into Command Mode via transport layer communication by sending the *START_CM* command, but this is not intended for use in a running cluster in the application.
- PWM Mode: To enter CM from PWM Mode, a *START_CM* command must be sent during the start window (nominal 30ms). During this window, both PWM pins (LOUT and HOUT) are set to the recessive level (tri-state) and can receive LIN frames (using a data dump request with service identifier B4_{HEX}). After the start window has expired, bi-communication via the LOUT and HOUT pins is no longer possible.

When changes of the registers are required, the ZSSC3170's EEPROM memory must be enabled for writing by sending the *EEP_WRITE_EN* command.

2.3. Diagnostic Mode (DM)

The ZSSC3170 detects various failures. When a failure is detected, Diagnostic Mode (DM) is activated.

- LIN Mode: The DM is indicated by error flags contained in the LIN signal that is transmitted when responding to a publisher frame in NOM, so every read-out of the sensor signal includes failure status information.
- PWM Mode: The DM is indicated by output of the recessive level. Note that the recessive level depends on the selected output driver.

During DM, LIN communication is possible via all output pins (LIN, HOUT, LOUT). This ensures that a non-configured device is accessible via LIN for end-of-line configuration. Transport layer service read-by-identifier (B2_{HEX}) with frame identifier 20_{HEX} returns an error code specifying the reason for DM activation. For more information and an error codes list, refer to the *ZSSC3170 Functional Description*.

3 Commands

If the LIN pin is accessible, the *START_CM* command can be sent at any time even if the PWM output is active. However, in order to acquire data, calibrate, or configure via the LIN interface, the PWM output must be disabled. Key commands and respective LIN frames are described in Table 3.1.

Table 3.1 LIN Commands

Command	LIN frame (ZSSC3170 specific)	Description
72 _{HEX}	LWT3c0087F05B47274FFFFFF	B4 _{HEX} – Data Dump; Start CM (to be sent with data 74 _{HEX}).
6C _{HEX}	LW_3c0087F05B46CF742FFFF	Enable EEPROM write (to be sent with data F742 _{HEX}).
01 _{HEX}	LW_3c0087F05B401FFFFFF	Start measurement cycle including initialization from EEPROM.
02 _{HEX}	LW_3c0087F05B402FFFFFF	Start measurement cycle including initialization from RAM.
-	LW_3c0087F06B220FF7FFFFFF	B2 _{HEX} – Read-By-Identifier; 20 _{HEX} – Frame Identifier; FF7F _{HEX} – Wild Card (see the “Read-By-Identifier” section in the ZSSC3170 Functional Description).

The communication protocol at all output pins is based on the LIN Data Link Layer. Note that LIN communication at the HOUT pin uses inverted signal levels compared to the LIN frame. For more information and a full list of commands, refer to the ZSSC3170 Functional Description and SSC Command Syntax.

4 Output Signal Settings

The data stored in EEPROM at addresses 0F_{HEX} to 13_{HEX} determine the configuration of the ZSSC3170.

Depending on the programmed output configuration, the corrected sensor signal is output as a PWM signal (high-side switch or low-side switch) or as digital value within a LIN frame:

- LIN interface settings can be made by programming the configuration word CFGLIN (EEPROM/RAM address 0F_{HEX}) and bit 15 of CFGAPP (EEPROM/RAM address 12_{HEX}).
- PWM signal settings can be made by programming bits [10:6] of the configuration word CFGAPP (EEPROM/RAM address 12_{HEX}).

For more information, refer to the ZSSC3170 Functional Description.

For each application, a configuration set must be established (generally prior to calibration) by programming the on-chip EEPROM for the operational modes (PWM and LIN):

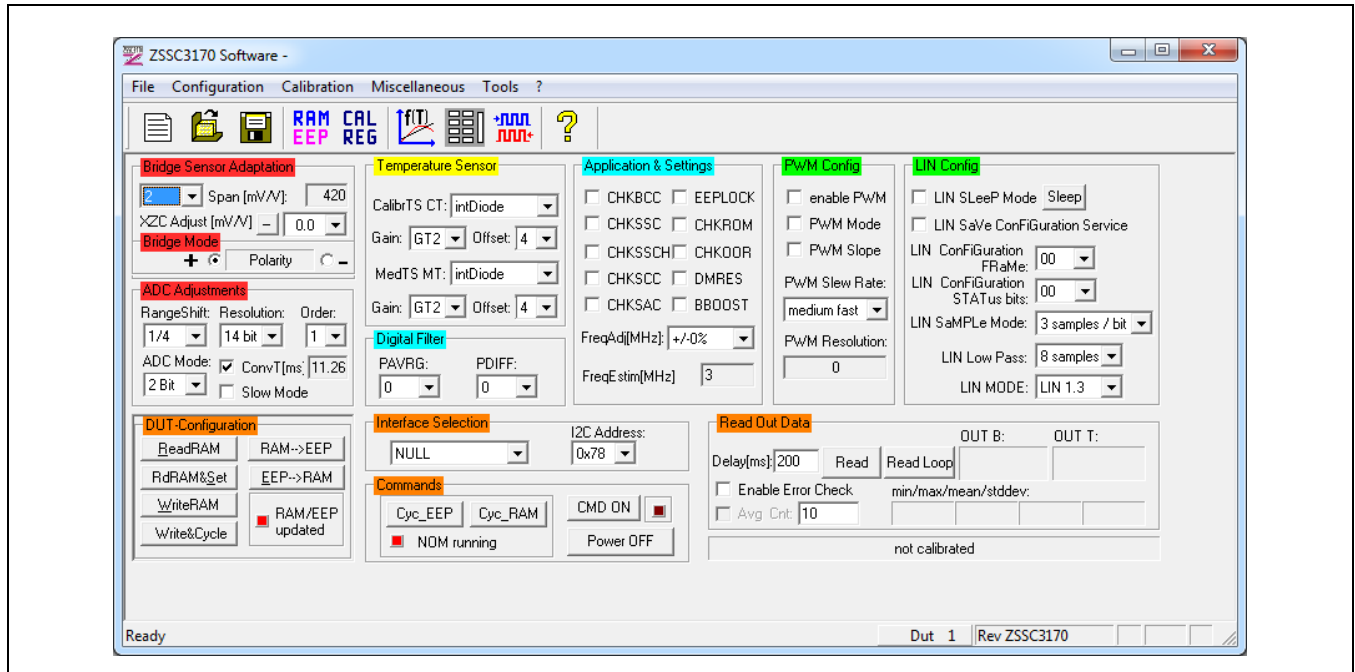
- Output Signal
- Output Mode Select PWM or LIN mode according to application requirements.
- LIN Mode Select LIN compatibility to specification package LIN2.1, LIN2.0, or LIN1.3.
- PWM Mode Select the high-side switch (HSS) output on the HOUT pin or low-side switch (LSS) output on the LOU pin.

The ZSSC3170 can be configured using the ZSSC3170 Evaluation Software, which provides read and write access to all the ZSSC3170 registers in a clear structure that hides the corresponding HEX commands behind buttons and pull-down menus. The main window of the software is shown in Figure 4.1.

The Evaluation Kit interfaces with the ZSSC3170 using I²C™ or LIN. For more information, refer to the *ZSSC3170 Evaluation Kit Description*.

Separate sections of the software set the LIN and the PWM configurations. Each has check boxes and drop-down controls that can be modified according to the target application.

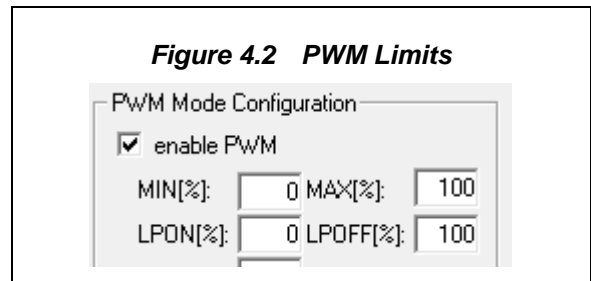
Figure 4.1 ZSSC3170 Software Main Window



After the PWM is enabled, the signal limits should be defined in percentage of the maximum and minimum output value in the "Calibration" window of the software as shown in Figure 4.2.

Note: LIN Sleep Mode should be disabled for proper PWM operation.

Figure 4.2 PWM Limits

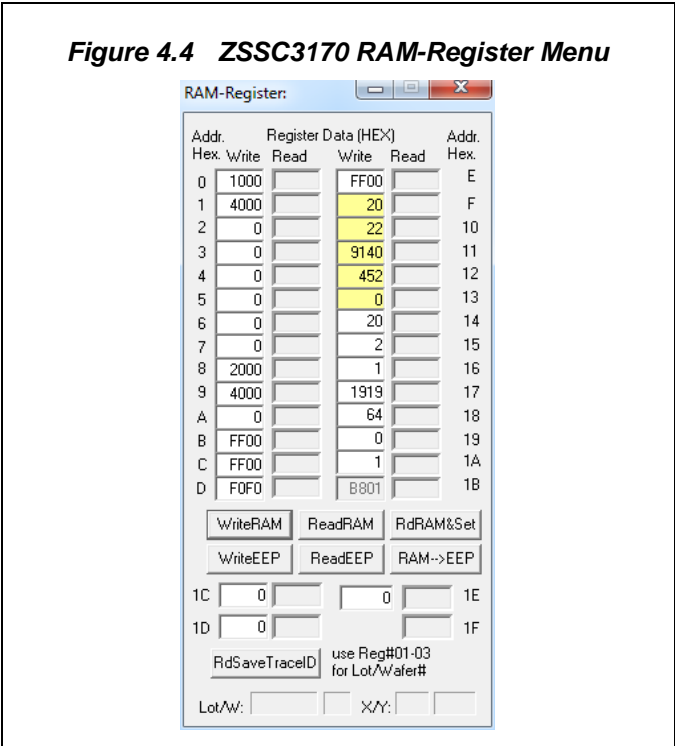
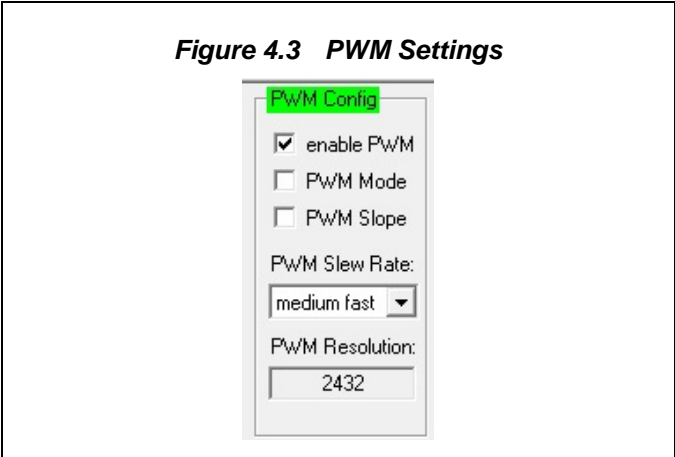


The PWM mode, slew rate, and the slope of the signal can also be configured in the main window as shown in Figure 4.3.

PWM and LIN configuration changes can be made by typing the registers values directly in the *RAM-Register* window of the software. It can be opened by pressing the **RAM EEP** icon which is shown in Figure 4.1.

This window can be used to perform read-write operations for both the RAM and the EEPROM memories. See Figure 4.4 for an example. Settings will take effect after writing them to the registers and running the NOM cycle again. After this, the ZSSC3170 will output a pulse-modulated signal. If PWM is enabled, communication via the LIN interface on the PWM pins will not be possible.

To re-establish the LIN communication, the Command Mode must be started by pressing the **CMD ON** button. This will perform a power cycle and send the *START_CM* command in the start-up window.

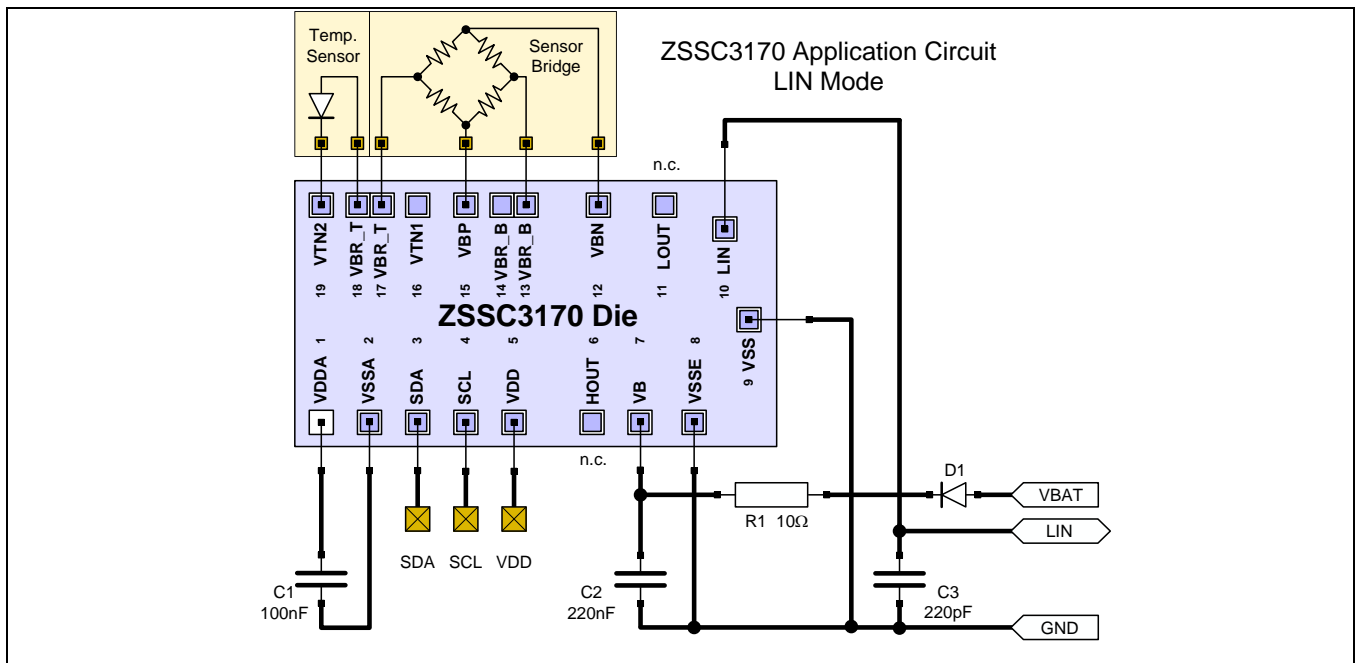


5 Application Circuits

The basic application circuits for each output signal are described in this section.

5.1. LIN Output Signal

Figure 5.1 LIN Application Circuit



The ZSSC3170 can be directly connected to the battery in this application via the protective diode (D1) and current limiting resistor (R1) in applications where the maximum voltage drop does not exceed 1V. This circuit also requires a few external capacitors for noise immunity. In this schematic, the LOUT and HOUT pins are not connected and not used. The LIN interface requires a ground connection to the VSS pin.

All necessary LIN settings can be configured after entering the Command Mode (CM) via the LIN interface or the I²C™ interface (if connected). The ZSSC3170 Evaluation Kit Software can also be used to configure the ZSSC3170 as described in the *ZSSC3170 Evaluation Kit Description*.

After starting the ZSSC3170 Evaluation Software, simply choose “LIN – CB – USB” interface from the “Interface Selection” section and make all necessary changes for the LIN modes, frames, filters, and other services in the “LIN Config” section. Then update the RAM and EEPROM registers by clicking the **Write RAM** and **RAM-->EEP** buttons.

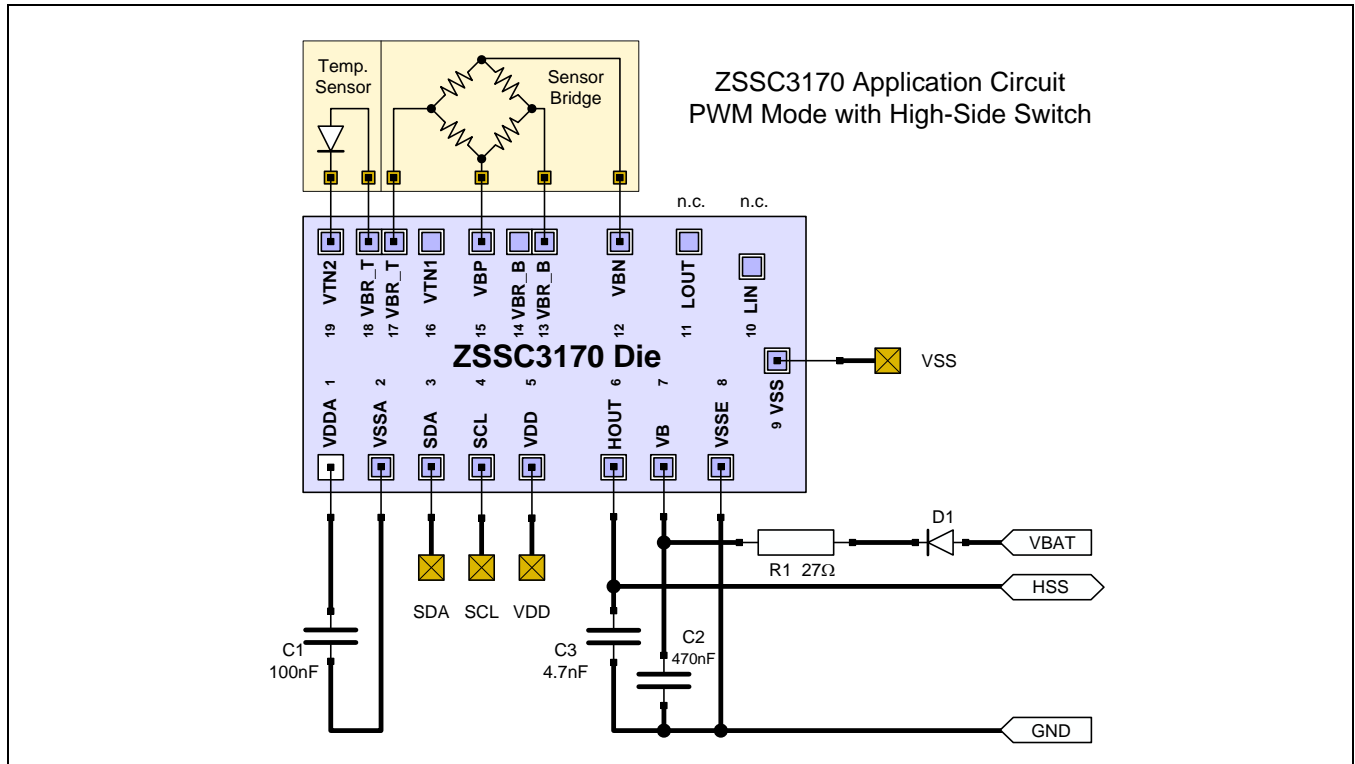
Note that **enable PWM** should not be checked; otherwise, the output signal will be directed to HOUT or LOUT respectively after starting the NOM.

The LIN interface is now configured, and the ZSSC3170 calibration and application settings can be made with the target application or for the end-of-line calibration and data acquisition.

5.2. HSS and LSS Output Signals (PWM Mode)

As shown in Figure 5.2 and Figure 5.4, for PWM applications, the LIN and VSS pins are not connected. There is an extra capacitor on the HOUT or LOUT pins for filtering. Its value depends on the target application signal line and the EMC environment.

Figure 5.2 High-Side Switch Application Circuit



To setup and configure the ZSSC3170, the Command Mode must be entered during the startup window (30ms). Note that the HSS output on the HOUT pin has inverted signal levels due to the internal pull-down resistor.

When using the Evaluation Kit Software, all necessary settings can be made before starting the NOM and starting the data acquisition.

First, the PWM signal should be enabled by checking the **enable PWM** box shown in Figure 5.3. Limits and other settings can be adjusted in the “Calibration” window of the software as well as the PWM off-value percentage difference and off-filter parameter.

Note: LIN Sleep Mode should be disabled for proper PWM operation.

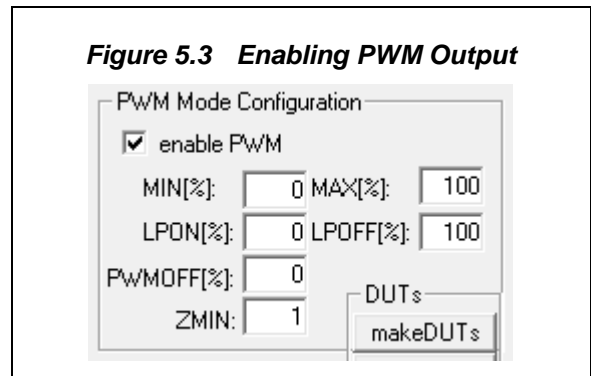
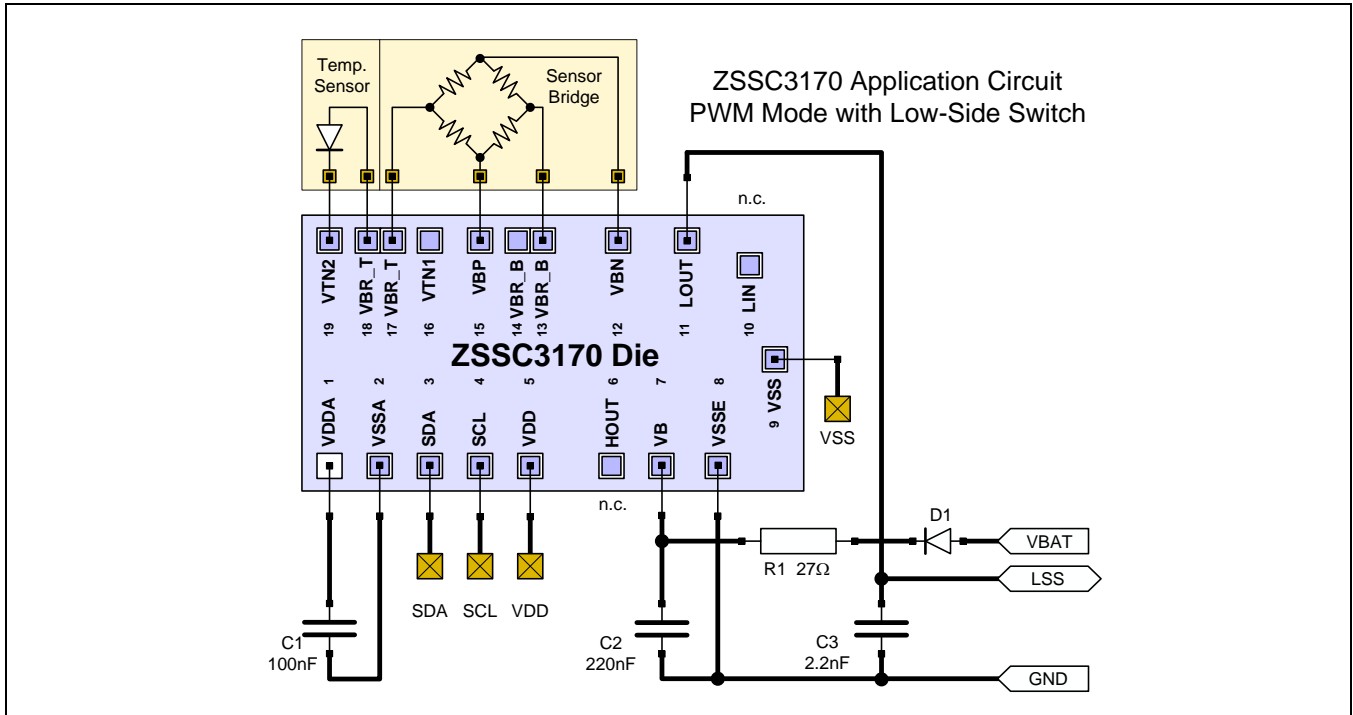


Figure 5.4 Low-Side Switch Application Circuit



The PWM output signal depends on the following settings:

- ADC resolution, mode, and order: The output signal is synchronized with the measurement cycle and ADC conversion time. The resulting PWM maximum resolution is displayed in the “PWM Config” section.
- **PWM Mode**: High or low side switch.
- **PWM Slope**: The slope of the PWM signal is controlled by monitoring either the voltage or the current at the PWM output. If checked, voltage control is activated. If not checked, current control is activated.
- **PWM Slew Rate**: Primarily used to set the slew rate for certain EMC requirements.

Next, settings can be written into the registers by clicking **Write RAM** and **RAM-->EEP**, and NOM can be started by clicking **Cyc_EEP** or **Cyc_RAM**.

6 Related Documents

Document
<i>ZSSC3170 Data Sheet</i>
<i>ZSSC3170 Functional Description</i>
<i>SSC Command Syntax Spreadsheet</i>
<i>ZSSC3170 Evaluation Kit Description</i>
<i>ZSSC3170 LIN Interface Description</i>
<i>ZSSC3170 High Voltage Protection Description</i>
<i>ZSSC3170 Technical Note – Dice and Package Dimensions</i>

Visit www.IDT.com/ZSSC3170 and www.IDT.com/ZSSC3170KIT or contact your nearest sales office for the latest version of these documents.

7 Glossary

Term	Description
ADC	Analog-to-Digital Converter
AFE	Analog Front End
DAC	Digital-to-Analog Converter
MUX	Multiplexer
PGA	Programmable Gain Amplifier
PWM	Pulse Width Modulation

8 Document Revision History

Revision	Date	Description
1.00	December 31, 2012	First release
1.10	August 28, 2013	PWM operation and LIN Sleep mode incompatibility notes added.
1.20	April 21, 2014	SSOP package removed. Sales and support contacts updated. Related documents updated.
	March 31, 2016	Changed to IDT branding.

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