# AN-1857 LP5553 Evaluation Kit

## 1 LP5553 General Description

The LP5553 is a System Power Management Interface (SPMI) compliant Energy Management Unit for reducing power consumption of low power hand held applications such as dual-core processors and DSPs.

The LP5553 contains two advanced, digitally controlled step-down DC/DC converters for supplying variable voltages to a SoC. The device also incorporates five programmable low-dropout, low noise linear regulators for powering I/O, peripheral logic blocks, auxiliary system functions and maintaining memory retention (dual-domain) in shutdown-mode.

The LP5553 implements two SPMI non-request capable slaves. The LP5553 operates cooperatively with PowerWise® AVS technology compatible processors to optimize supply voltages adaptively Adaptive Voltage Scaling (AVS) over process and temperature variations. It also supports dynamic voltage scaling (DVS) using frequency/voltage pairs from pre-characterized look-up tables.

## 2 Evaluation Kit Overview

The LP5553 evaluation kit is based on a modular system, where the actual evaluation board is plugged on top of the USB interface connecting to a PC. The LP5553 evaluation board can also be operated standalone. The evaluation kit consists of:

- LP5553 Evaluation Board (Figure 1)
- USB Interface Board (Figure 2)
- USB interface cable
- CR-ROM including:
  - LP5553 Evaluation Software
  - LP5553 Data sheet
  - Evaluation Kit User Guide (this document)

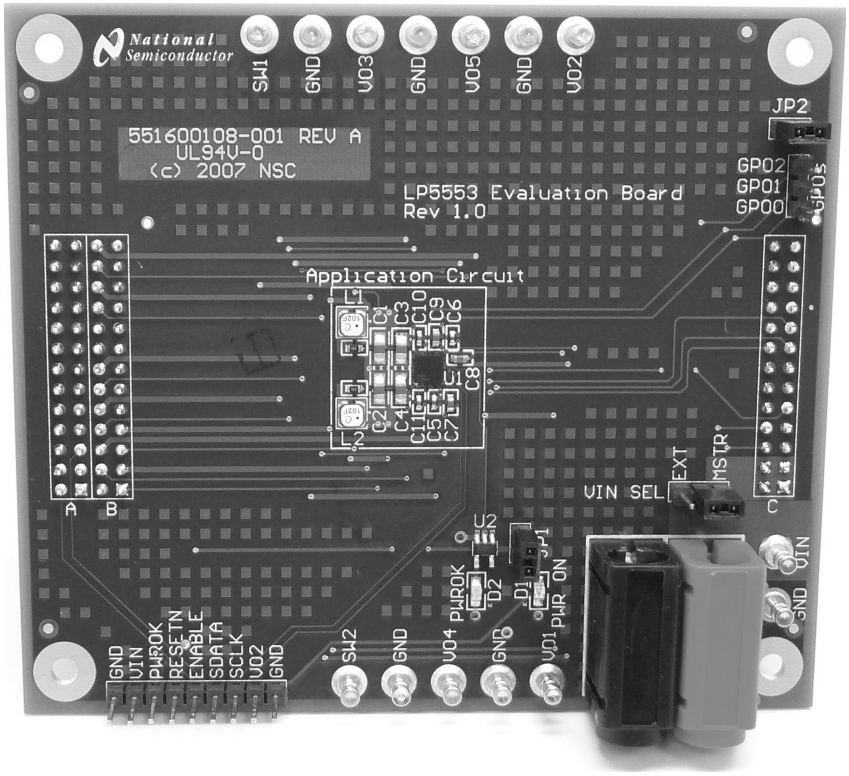


**Figure 1. LP5553 Evaluation Board**

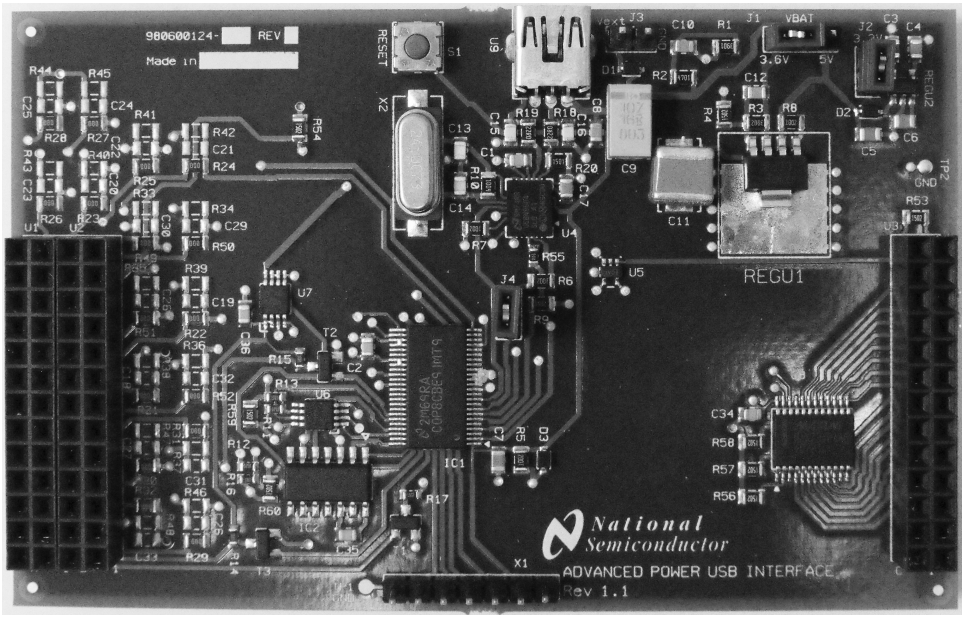


**Figure 2. USB Interface Board**

## 3 Evaluation Board

The evaluation board has the LP5553 circuit on the middle of the board with the required external components placed around it. Test posts for the pins of the LP5553 as well as the connectors for external power are placed on the edges of the board. The red LED near the power connectors indicates if the circuit is powered on and the green LED indicates the state of the PWROK signal. The LP5553 can be powered from the attached USB interface board or externally. If external power supply is used, $V_{IN}$ and GND can be connected using the banana jacks (red for $V_{IN}$ and black for GND) or VIN and GND turrets. Jumper "VIN SEL" must be set to the appropriate power source. A schematic of the LP5553 evaluation board is presented in Section 8 at the end of the document. Note that when outputs of the LP5553 are loaded, external power may be required since the maximum current from the USB port is 500mA.

| JUMPER | PURPOSE | NOTE |
|---|---|---|
| VIN SEL | Input voltage selection | MSTR: LP5553 powered from attached USB Interface board; DEFAULT |
| | | EXT: LP5553 powered from external supply |

There are two additional jumpers on the LP5553 evaluation board. They behave as follows.

| JUMPER | PURPOSE | NOTE |
|---|---|---|
| JP1 | Disconnect indicator LEDs and PWROK buffer | ON: The PWR ON and PWROK indicators are active; DEFAULT |
| | | OFF: The buffer and LEDs will remain unpowered |
| JP2 | Disconnect GPO pull-up resistors | ON: The 10K pull-up resistors are connected to the GPO pins; DEFAULT |
| | | OFF: The GPO pull-up resistors are disconnected, for use with CMOS outputs |

When LP5553 evaluation board is connected to the PC using the USB interface card and cable the SPMI commands for controlling the LP5553 are generated by the USB interface board. All signals related to the SPMI signalling environment are available on a 1x9 header on the edge of the board. If LP5553 evaluation board is operated standalone, this header allows external control of the SPMI. The pins are spaced at 100-mil intervals. The pin list is shown in Table 1. Input and output directions are with reference to LP5553. $V_{IN}$ and $V_{O2}$ are provided as reference voltages to determine the driver levels for the signals RESETN, ENABLE, PWROK, SDATA and SCLK. The external controller should drive ENABLE and RESETN between $V_{IN}$ and GND, while SDATA and SCLK should be driven between $V_{O2}$ and GND. The PWROK output will have logic-high output at $V_{IN}$.

**Table 1. Pin List**

| Pin | Function | Type | Description |
|---|---|---|---|
| 1 | GND | GND | Ground |
| 2 | $V_{IN}$ | Output | $V_{IN}$ Sense |
| 3 | PWROK | Output | PWROK |
| 4 | RESETN | Input | $V_{IN}$: Active<br>GND: LP5553 in reset |
| 5 | ENABLE | Input | $V_{IN}$: On<br>GND: Disable LP5553 |
| 6 | SPWI | Input/Output | PWI Data |
| 7 | SCLK | Input | PWI Clock |
| 8 | $V_{O2}$ | Output | $V_{O2}$ Sense |
| 9 | GND | GND | Ground |

# 4 LP5553 Evaluation Software

LP5553 evaluation software is provided to control the LP5553 evaluation board via USB connection. The evaluation software supports the SPMI commands required to control the LP5553. The evaluation software can read and write registers affecting the output voltages as well as other registers. By generating SPMI commands the evaluation software can also control the operation modes of LP5553 such as sleep, wakeup, shutdown and reset. In addition to the SPMI commands the evaluation software can control the external control inputs of the LP5553: ENABLE and RESETN. The SPMI slave address can be set through the software. The USB interface board has an ADC and uses it to measure the voltage values of the core voltages and LDOs.

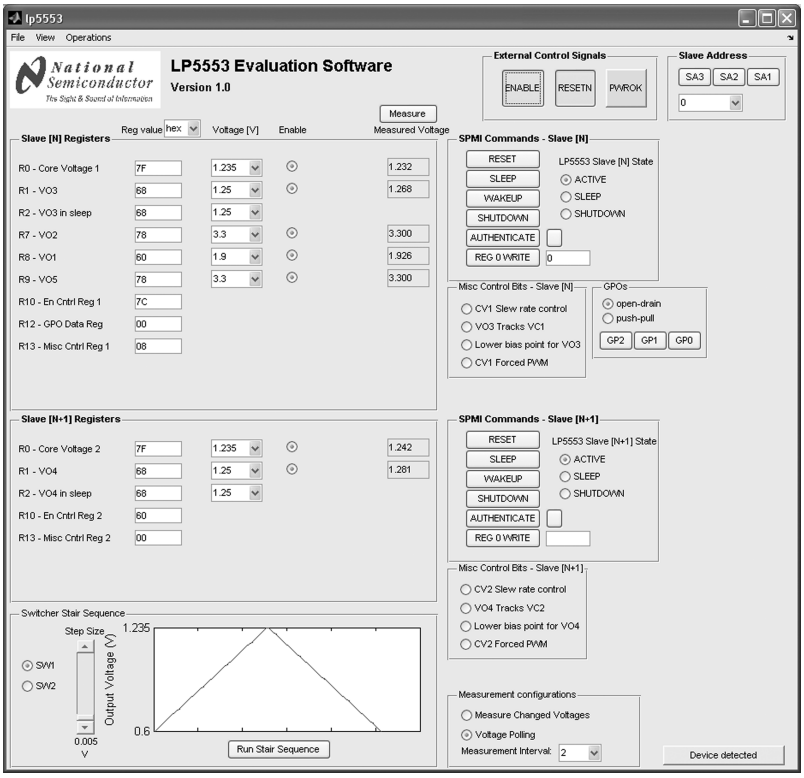


**Figure 3. LP5553 Evaluation Software (Default View)**

# 5 Getting Started

1. Unzip the LP5553 Evaluation Software to a specified folder by double-clicking the LP5553_sw_1.0.exe icon.
2. Install the MATLAB Component Runtime 7.5 to your computer by double-clicking on the MCRInstaller.exe icon in the folder where you unzipped the LP5553_sw_1.0.exe.
3. Add the following directory to your system path: <mcr_root>\v75\runtime\win32. On windows XP, this directory is automatically added to your path.
4. Connect the USB cable from the LP5553 evaluation board to the USB port of your PC. When plugging in the USB cable for the first time, operating system prompts about "new hardware found" and installs the USB driver automatically. With Win95 and Win98 operating systems the installation has to be accepted. Click "Next" several times as the installation proceeds.
5. Start LP5553 Evaluation Software by double-clicking the LP5553_GUI.exe icon. After start-up the evaluation software will automatically read the values of the registers on the LP5553 and will update the fields of the GUI. If all settings and connections are OK, the "Device detected" text should appear to the lower right corner of the evaluation software.

# 6 Evaluation Software Layout and Conventions

## 6.1 Register Control

Evaluation software has two different views to control the registers of the LP5553: Default view and button view.

The default view (Figure 3) has text fields that show the register values in hexadecimal, decimal or binary format. The format of the values can be selected using the popdown menu above the register value fields. By typing the value to the field and pressing enter, the register write command is sent to the LP5553. For the voltage registers there are also popdown menus that allows to select the target voltage. By selecting voltage from these menus the appropriate value is written to the register adjusting output voltage to selected voltage level. Setting the register value through the value field or popdown menu, the other fields of the appropriate register are updated. The radio buttons in the right side of the voltage selection popdown menus represent bits of enable control registers. Using enable buttons the corresponding output voltage can be disabled or enabled.

Selecting “Button View” from the “View” menu the evaluation software is changed to the button view (Figure 4).

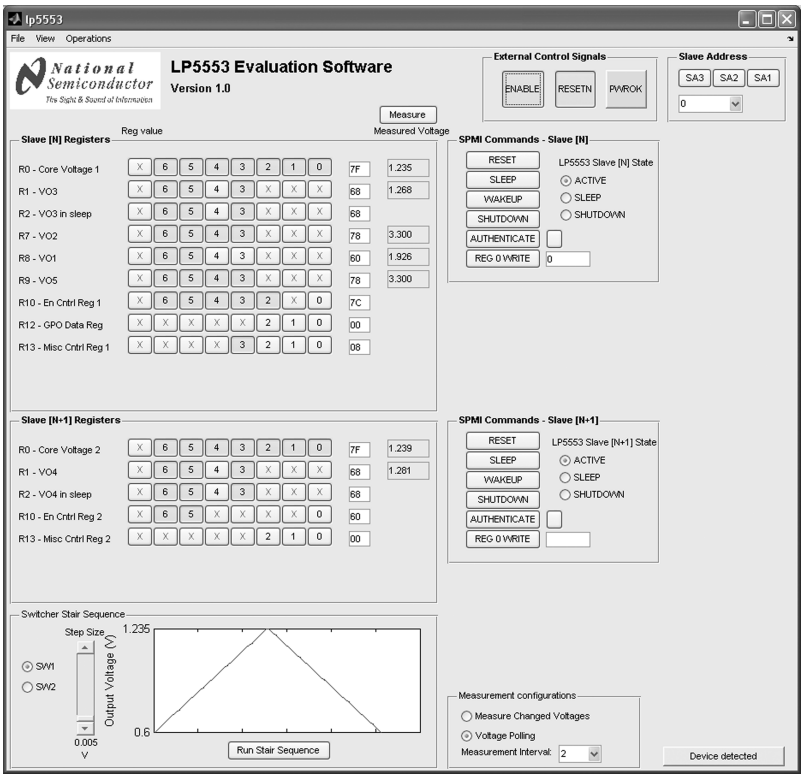


**Figure 4. LP5553 Evaluation Software (Button View)**

In the button view the register bits are shown as buttons. Register value is written whenever a button is pressed. The two-digit HEX-numbers in the right side of the buttons show the content of each register.

The output voltages can be measured by using ADCs in both views. On the right side of the register panels are fields for the measured output voltages. Voltages are measured when the Measure button above the fields is pressed.

At the bottom right corner is a Measurement Configurations panel. By selecting the Measure Changed Voltages option, the appropriate voltages are measured whenever the register value is changed. If “Voltage Polling” option is selected the voltages are measured at intervals that can be selected using the “Measurement interval” popdown menu on the bottom of the panel.

## 6.2 SPMI Commands

On the right side of the register panel are panels for SPMI commands for both slaves (Figure 5).

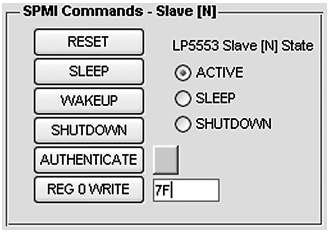


**Figure 5. SPMI Commands panel**

"Reset", "Sleep", "Wakeup", "Shutdown", "Authenticate" and "Register 0 Write" SPMI sequences are sent when the command button is pressed. Slave operating states are represented on the right side of the command buttons.

- SPMI Commands:
  - Reset: Sending the reset command initializes the SPMI slave and sets its registers to default
  - Sleep: Sending the sleep command activates the sleep sate of the SPMI slave. In the sleep state core voltage is 0V, memory voltage VO3/VO4 is controlled by its retention value (R2) and the other voltages retain their programmed values.
  - Shutdown: Writing the shutdown command will cause the SPMI slave to switch of all regulators, thus causing all output voltages to go to zero. However LDO1, LDO2 and LDO3 act as shared resource between two slaves of the LP5553 and they will remain on when slave 'N' is in shutdown state as long as slave 'N + 1' is in active or sleep state. If only one of the slaves is in shutdown state it can be placed to active state by sending reset command to it. If both slaves are in shutdown, toggle 'ENABLE' or 'RESETN' to activate the outputs.
  - Wakeup: Sending the wakeup command changes the SPMI slave from sleep state to active state. The core voltage returns to the default value and memory voltage tracks the core voltage (if VO3/4 tracks CV1/2 option is selected) or returns to the value determined by register R1.
  - Authenticate: the authenticate command is a nine-frame sequence consisting of the authenticate-command followed by four challenge/response frame sequences. If authentication succeeds, the colour of the box in right side of the authenticate button will change to green.
  - Register 0 write: This command adjusts the core voltage directly. Pressing the button, the hexadecimal value written to the text field will be written to the register R0. Command is also sent when enter is pressed after typing the value to the text field. This command has the same effect as executing a register write to the register R0. However this command requires only one frame, while register write command needs two frames to execute. New value of register R0 is also updated to the register panel.

Radio buttons on the right side of the SPMI command panels show the states of the slaves.

## 6.3 External Control Signals

- Control Inputs:
  - RESETN: controls hardware reset pin, active low, default = 1.
  - ENABLE: controls hardware enable pin, active high, default = 1.
- Status Outputs:
  - PWROK: if the evaluation board is correctly powered and at least one of the slaves is in active or sleep state, PWROK will be high and the color of this button will be green; otherwise it will be red.

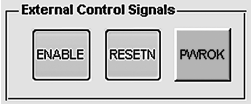


**Figure 6. External Control Signals panel**

## 6.4 Slave Address

The slave address can be set with the buttons or selecting the address from popdown menu in “Slave address” panel (Figure 7) on the upper right corner of the GUI.


**Figure 7. Slave Address setting panel**

## 6.5 Misc Control Bits

The Misc Control Bits panels (Figure 8) of both slaves (visible in default view) allow control the Misc Control Register bits (2:0):

- SW1/SW2 Slew Control
- LDO3/LDO4 Tracking Select
- LDO3/LDO4 Low IQ Bit

And bit 0 of the Enable Control registers:

- Forced PWM Mode

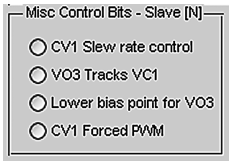


**Figure 8. Misc Control Bits panel**

Toggling of the radio buttons updates the appropriate bit to the registers in Registers panels.

## 6.6 GPOs

Buttons of GPO panel (visible in default view) (Figure 9) affect the bits of GPO register (slave 'N'). Open-drain and push-pull radio buttons affect the bit 3 of Misc Control Register 1.

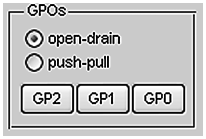


**Figure 9. GPOs panel**

## 6.7 Measurement configurations

If the Measure Changed Voltages radio button is toggled on, the appropriate voltages will be measured through ADCs, when register value is changed. If Voltage Polling is toggled on, all voltages will be measured at intervals selected by the “Measurement Interval” popdown menu.

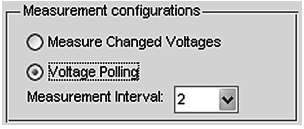


**Figure 10. Measurement configurations panel**

### 6.8 Switcher Stair Sequence

Pressing Run Stair Sequence will run a stair sequence for the core voltage. Affected core voltage can be selected from left side of the panel. Step size of the stair sequence can be adjusted using the slider. Graph on the right side of the panel shows the effect of the step size.

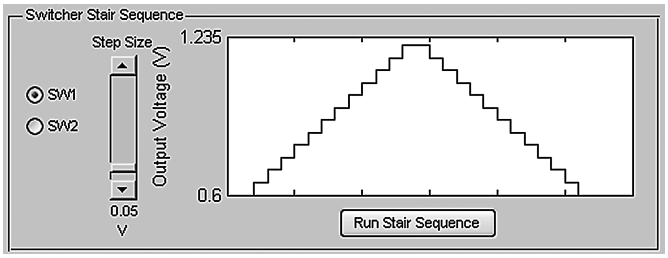


**Figure 11. Switcher Stair Sequence panel**

## 7 Menus

Menus of the GUI provide various operations and settings of the GUI.

### 7.1 File

- Open Profile: open a profile to overwrite the current settings of the LP5553 registers. This will open the “Select File to Open” dialog that allows select the text file containing the values of the registers. When file is opened the values from the file will be written to the registers.
- Save Profile: save the current register values to a text file
- Export Profile: creates a text file including names, addresses and values of each register as well as voltage values of core voltage and LDO outputs
- Exit: close the GUI


**Figure 12. File menu**

### 7.2 View

From View menu you can select the register view:

- Default View: register values presented in hexadecimal, decimal or binary format and voltage registers also as voltage values.
- Button View: register bits presented as buttons.

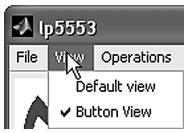


**Figure 13. View Menu**

### 7.3 Operations

- Read All Registers: read the register values from the LP5553 using read register SPMI commands.
- Registers to Default: sets all the register values to default
- Regulators to Max: sets values of the registers that affect to output voltages to max
- Regulators to Min: sets values of the registers that affects to output voltages to min


**Figure 14. Operations menu**

## 8 Evaluation Board Schematic

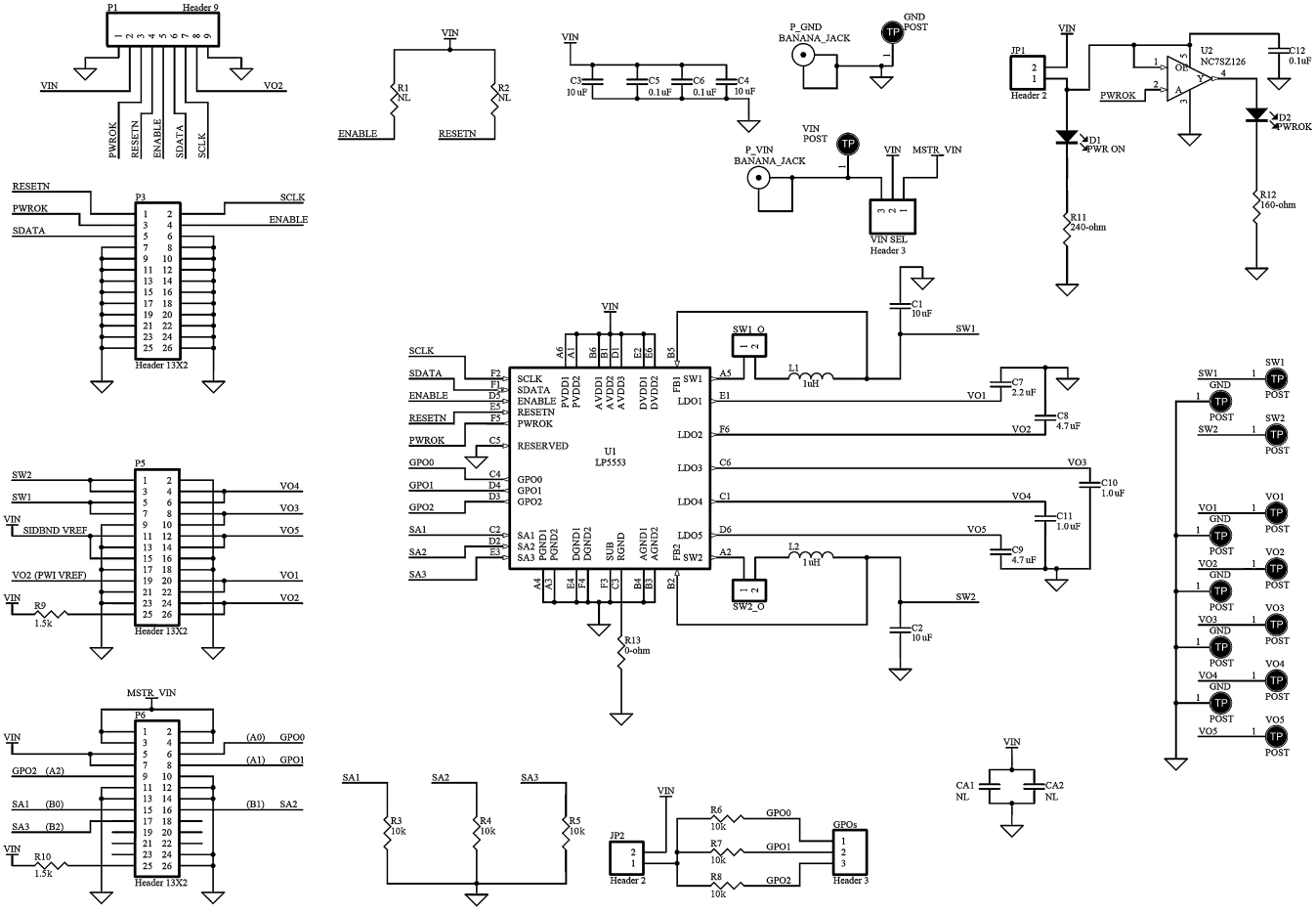


**Figure 15. LP5553 Evaluation Board Schematic**

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