OVERVIEW

- This guide walks a user through the steps to setup and configure the ISL691xx and ISL681xx Digital Multiphase products using the PowerNavigator GUI. For all other Renesas Digital Power devices, please see the Digital Point of Load user guide.

- This guide is intended for use with PowerNavigator Revision 5.4.62

- This presentation contains the following sections that can be referred to depending on the stage of the design:
  - PowerNavigator Introduction
  - Running PowerNavigator
  - Creating a new project in offline mode
  - Connecting to Hardware and loading Project files
  - Creating HEX files for production programming
INSTALLING POWERNAVIGATOR
Installing PowerNavigator

- Download the latest version of PowerNavigator from:

  www.intersil.com/powernavigator

- PowerNavigator Requires a Windows PC with Windows Vista or greater

- A driver is NOT required for the USB to PMBus adapter – it uses the built-in Windows HID driver.
Installing PowerNavigator

1. Double Click installer to begin install process.

2. Click through PowerNavigator Setup Wizard to install.

3. After installation is complete, PowerNavigator will be visible in Start Menu under “Intersil”
LAUNCHING POWERNAVIGATOR
PowerNavigator Launch Screen
PowerNavigator Launch Screen

**Connected Devices:**
- Used for telemetry monitoring only. Device configuration changes cannot be made in this mode.

**Offline Mode:**
- Used to create new projects

**Project Load:**
- Used to load an existing project or connect to existing hardware. Allows device configuration changes to be made.
Project Files

- Digital multiphase devices rely on **Project Files** for loading and editing configuration settings. *It is not possible to read back the stored configuration settings from a multiphase controller*, so proper use and maintenance of project files is critical.

**Definitions:**

- **Project File**: System level file that contains all project information, including individual configuration files.
- **Config File**: Unique file contained within the project file with the setup information for a single controller configuration.

**The project files can be found on your PC:**

- C:\USERS\User Name\Documents\Intersil\PowerNavigator\Projects
- Project files for all Digital Multiphase demo boards are available from Renesas upon request.
Digital Multiphase – Launch Screen

Connected Devices

Offline Mode

Project Load

Click on “Build New System” and then “Start”
Digital Multiphase – Main Screen

Expand Digital Multiphase section in GUI
1. Grab any device or label and drag and drop into the PowerMap.

2. Drop onto any node identified by a black square.
Digital Multiphase – PowerNavigator PowerMap

Each box or “Rail Block” on the PowerMap represents one of the device outputs. Double Click on the Rail Block to bring up the device’s design tool.
Digital Multiphase – PowerNavigator PowerMap

Example ISL68137 RailBlock (6-PH operation):

- Rail Name (customizable)
- PMBus Enable/Disable
- PGOOD Status
- Controller Type
- Number of phases assigned. 6PH in this example – each “dot” represents a phase.
- Vout/Iout Telemetry
- Address and Page info
- Online (hardware connected) or Offline indicator
Digital Multiphase – PowerMap and Rail Inspector

TIP: Make sure to configure both outputs! If an output is not used (no phases assigned) be sure to disable SVID on that output.
Digital Multiphase – Rail Inspector

Overview Screen Shows:
- Rail Name
- Device Type
- Device PMBus Address
- Rails Status
  - Enabled/Disabled
  - PMBus connected or Offline

Rail Inspector Navigation panel

Revision Register – user settable configuration revision to assist with revision tracking
### Digital Multiphase – Phase Configuration

**PWML Channel Assignments:**
- Rail 0 assigns PWM output to Loop 0
- Rail 1 assigns PWM output to Loop 1
- Drop delay sets time period for initiating phase drop when current drops below drop threshold

**Phase Add/Droop Thresholds:**
- Sets current thresholds for automatic phase add and phase drop when auto-phase dropping is enabled.
- Full digital adjustability
- Different drop and add thresholds are used to create hysteresis between add/drop set point.

**Rail 1**

<table>
<thead>
<tr>
<th>Hardware Phase Assignment</th>
<th>Rail 1 Thresholds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phases on Rail 0</td>
<td>APD Enable</td>
</tr>
<tr>
<td>Phases on Rail 1</td>
<td>Minimum Phase Count</td>
</tr>
<tr>
<td>Unused Phases</td>
<td>Fast Phase Threshold</td>
</tr>
<tr>
<td>Manual Hardware Phase Assignments</td>
<td>Drop Delay</td>
</tr>
<tr>
<td>Loop 0</td>
<td>Off</td>
</tr>
<tr>
<td>Loop 1</td>
<td>On</td>
</tr>
<tr>
<td>Phase 0</td>
<td>Rail 0</td>
</tr>
<tr>
<td>Phase 1</td>
<td>Rail 0</td>
</tr>
<tr>
<td>Phase 2</td>
<td>Rail 0</td>
</tr>
<tr>
<td>Phase 3</td>
<td>Rail 0</td>
</tr>
<tr>
<td>Phase 4</td>
<td>Rail 0</td>
</tr>
<tr>
<td>Phase 5</td>
<td>Rail 0</td>
</tr>
<tr>
<td>Phase 6</td>
<td>Rail 0</td>
</tr>
<tr>
<td>Phase Add/Droop</td>
<td>One phase</td>
</tr>
<tr>
<td></td>
<td>Two phases</td>
</tr>
<tr>
<td></td>
<td>Three phases</td>
</tr>
<tr>
<td></td>
<td>Four phases</td>
</tr>
<tr>
<td></td>
<td>Five phases</td>
</tr>
<tr>
<td>Thresholds</td>
<td>15.0 A</td>
</tr>
<tr>
<td></td>
<td>27.0 A</td>
</tr>
<tr>
<td></td>
<td>39.0 A</td>
</tr>
<tr>
<td></td>
<td>51.0 A</td>
</tr>
</tbody>
</table>

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Digital Multiphase – Device Setup

- **VOUT_MAX** sets upper line of output voltage. Any **VOUT_COMMAND** above **VOUT_MAX** will be ignored.
- Vout and Vout OV/UV fault limits thresholds
- Check “track PMBus Vout” to have fault levels track the Vout command based on percentage
- Per phase switching frequency
Digital Multiphase – Power Train Configuration

- Selects current sense scheme – Inductor DCR or SPS.
- Displays max current measurement per phase before Isense ADC clips.
- Default IMON output for ISL99226/7 SPS. Adjust as needed to dial in load line accuracy.
- Power stage UFET and LFET Rds(on). Use typical values from datasheet.
- Ceramic Capacitance used at load.
- Output inductance and DCR (per phase). Use typical values from inductor datasheet. This information is REQUIRED for proper operation.
- Approx. resistance of PCB planes between output inductors and Load.
- Bulk Capacitance or ceramic capacitance by output inductors.
- Approx. resistance of PCB planes between output inductors and Load.

Output inductance and DCR (per phase). Use typical values from inductor datasheet. This information is REQUIRED for proper operation.

Default IMON output for ISL99226/7 SPS. Adjust as needed to dial in load line accuracy.
Digital Multiphase – Control Loop Configuration


Filter to reduce High Frequency Jitter in P-gain path.

Integral Gain block.

TIP: Default P and I settings can be used for initial board bring-up, then dialed in during transient testing.
Digital Multiphase – Diode braking

- **Start if ΔV rise > Threshold**
  - VOUT is monitored for fast rising conditions and suppression will be initiated if the fast rising magnitude exceeds this threshold.

- **Stop if ΔV fall < Threshold**
  - Vout is monitored for falling condition and suppression will be halted if the falling magnitude exceeds this threshold. It must be smaller than the rise threshold.

**TIP:** Diode braking should only be enabled after other loop settings have been optimized.

**Enabled/Disabled Diode Braking**

Settings to determine when to apply diode breaking to prevent LFET overheating. Default values are a good starting point. See tuning guide for more info.

Vout excursion during load release required before diode breaking is engaged. Lower values result in more aggressive braking.

Used by current estimator to mode diode breaking behavior. Typical range: 0.3V to 0.7V.
Digital Multiphase – Dynamic Voltage Change Tuning

Sets TON_DELAY (delay from enable to Vout ramp), TON_RISE (Vout soft-start ramp time), TOFF_DELAY (delay from enable low to disable) and TOFF_FALL (Vout soft-stop time, if used)

Dynamic voltage change performance optimization. Two Gain Settings:

Transition Up Gain to improve dynamic performance from a lower to higher Vout.

Transition Down Gain to improve dynamic performance from a higher to lower Vout.

Follow graphic to adjust gain settings.

TIP: Dynamic Voltage Gain performance should be dialed in after optimizing control loop performance.
Digital Multiphase – Temp Sense Setup

Used to select temperature sense scheme. Use “SPS” setup when using smart power stage – TMON output from SPS is directly connected to TEMP monitoring pin. Temp compensation is not required when using SPS.

Example diode temp sense scheme. Use diode sense when using inductor DCR for current sense. Temperature compensation must be enabled for DCR temp co. compensation.

Primary/Aux Diode Enable: diode temp sense allows the use of two sensing diodes per TEMP pin. Use these settings to enable/disable Aux or Primary diode.
Digital Multiphase – Global Fault Setup

De-assert PowerGood: If a fault is set to ignore, these configure the device to still pull PGOOD low.

For example, if Vout Under-Voltage fault is set to ignore, but the De-assert PowerGood box is checked, when a UV fault occurs, the controller will continue to regulate, but PGOOD will be pulled low.

If the controller is set to act on a FAULT, PGOOD will always be pulled low and the controller will latch off when the fault occurs.
Digital Multiphase – Vout Fault Configuration

Sets VOUT Under Voltage fault limit, relative to VID setting. If box is unchecked, fault will be ignored and controller will continue to attempt to regulate.

Sets VOUT Over Voltage fault limit, relative to VID setting. If box is unchecked, fault will be ignored and controller will continue to attempt to regulate (Not Recommended).

Protect OV Fault when Disabled: If Vout exceeds 3.2V when output is disabled, controller will clamp output voltage to protect load if this box is checked.
Digital Multiphase – Current Fault Configuration

- **Input current OC protection limit.** \( I_{in} \) is calculated using current estimator hardware.

- **Sets Peak Over and Under current per phase (includes inductor ripple current).** Peak settings should not be set above max measured current from Power Train page. Count = number of consecutive switching cycles with a peak trips before a fault is declared. Peak per phase current will be limited to this value.

- **Fast Sum OC:** Average OC protection of the summed phase current

- **Slow Sum OC:** Slow average OC protection of the summed phase current

- **Disables output if SPS internal OC trips or per phase current sense ADC clips.** Recommend to leave this enabled.
Digital Multiphase – Temp Fault Configuration

Internal Temp Sensor OT limit fault limit. When box is checked (recommended), controller will latch off if OT limit is exceeded.

External Smart Power Stage OT/UT fault limit. When box is checked (recommended), controller will latch off if OT or UT limit is exceeded.
Digital Multiphase – Black Box Setup

Enable Black Box: Enables/Disables Black Box function

Write Black Box Data to OTP: If enabled, when a Black Box event is triggered, Black Box information is written to OTP. There are 10 OTP saves – when OTP is full, no more Black Box events can be stored in OTP. If disabled, Black Box events are only stored in RAM, and will be lost if controller 3V3 input is cycled.

Single NVM Write per POR: When enabled, only a single Black Box event will be stored between device power cycles (POR). This prevents multiple Black Box event triggers from the same fault.

Black Box Slot: Selects where to read Black Box Data from. Two options: RAM or one of 10 Black Box OTP slots.
Digital Multiphase – Device PMBus Address Select

**TIP:** If project device address is not set to hardware device address, PowerNavigator will not be able to download settings to hardware – make sure the address is correct!

After configuring both outputs with Rail Inspector, set PMBus address to match intended PMBus address in actual design.
Offline Project Is Now Complete!

After reaching the NVM configuration screen on BOTH outputs, your offline project is now complete! Return to PowerNavigator main screen and save.
CONNECTING TO HARDWARE
Connecting to Hardware

- Once the project file is complete, Renesas’s USB to PMBus adapter (ZLUSBEVAL3Z) can be used to connect to hardware.

- To connect to the controller’s PMBus interface, only SCL, SDA and GND connections from the adapter to the board are required.
Digital Multiphase – Connecting to Hardware

Connected Devices

Connected devices show up in Device Scan.

Offline Mode

Click on saved project in “Open Existing Project” window, then click “Start”

Project Load

Create a new project by using one of the other two options.
Digital Multiphase – Connected PowerMap

Project settings are automatically downloaded into device

Monitor View shows real time telemetry read back from both outputs

"OFFLINE" indicator is gone, indicating hardware is connected

Connected Rails show up in PowerMap
Using the Monitor View screen, all device telemetry is automatically read back and displayed in real time.

- Rail Name(s)
- Pin or PMBus Enable Selector
- Vout Telemetry
- Vin Telemetry
- Iout Telemetry
- Iin Telemetry
- Internal Temp Telemetry
- External Temp Telemetry
- Pout Telemetry
- Pin Telemetry
Digital Multiphase – Railscope

RailScope Displays Telemetry information from multiple rails at the same time

- Double click slots to add rails to RailScope
- Select up to 4 telemetry parameters per device
- RailScope controls
- Enable/disable logging
- Adjust Plot size
Digital Multiphase – PhaseScope

PhaseScope Displays Detailed Telemetry information from one rail (ex – per phase current)

Select what phases to display telemetry for

PhaseScope controls

Enable/disable logging

Adjust Plot size

Per-phase current information displayed
**Digital Multiphase – Monitor/Current Balance**

Quick view of device telemetry and status

- View of per phase current. Individual phase offsets can be used to manually adjust current balance among phases.
- Total Iout offset adjustment for each output. Can be used to manually calibrate offsets at no load.
- Iin tuning for each channel. Can be used to adjust input current offset errors.
Digital Multiphase – Fault Reporting

TIP: If a rail is having start-up issues, or shutting down during board bring-up, check fault bits first to help debug issue.
ADVANCED FEATURE SET: AVSBUS
AVSBus Overview

- AVSBus is an interface designed to facilitate and expedite point-to-point communication between an ASIC, FPGA, or other logic, memory, or processor devices and a POL control device on a system for the purpose of adaptive voltage scaling.

- This bus provides a focused set of functionality for the purpose of high speed rail control. All other configurations and settings must be done through the GUI or through PMBus.

- The AVSBus commands can always be read, but they cannot be written unless the device is configured to operate via AVSBUS in the PMBus command OPERATION.

- 2 New Panels are visible using the PowerNavigator GUI to facilitate AVSBus testing
  - AVSBUS Basic
  - AVSBUS Advanced

- Require dedicated Renesas-developed AVSBus dongle to support device testing. Refer to the EVK users guide for details on dedicated hardware developed.

*Available only on ISL68137, ISL68134 devices
* Compliant to latest AVSBUS 1.3x04 Spec defined by System Management Interface Forum (PMBUS part III)
Digital Multiphase – AVSBus

Overview
- Configuration
  - Phase Configuration
- Loop
  - General
  - Power Train
  - Transient
  - Diode Braking
  - Ramp Timing
  - Temperature Sense
- Faults
  - Global Settings
  - Voltage
  - Current
  - Temperature
  - Black Box
- Memory Config
  - Save to NVM
- Advanced

AVSBus Basic
- AVSBus Advanced
- Debug
- Telemetry
- Monitor
- Fault
- Phase Scope
- Command Tools
- New

AVSBus Host Interface Configuration
- Vout Mode
- VDDIO Voltage
- Bus Speed

Bus Speed – Adjust AVSBus speed on AVSBus adapter. Max 50MHz

AVSBus Commands – read/write single AVSBus commands to device.
Digital Multiphase – AVSBus

Drag and drop AVSBus commands to “queue” up a sequence of AVSBus commands to AVSBus dongle buffer. Up to 100 commands can be queued at a time.

Delays can be added to the sequence, allowing the AVSBus commands to be precisely sequenced.

Once queued up, the command loop can be run and the AVSBus commands will be executed.

Checking the Loop button allows the command sequence to be repeated.
AVSBus – Example Vout Set Point Change

Using the AVSBus interface, 300mV change in Vout takes <20us, enabling rapid changes in CPU power states.
SAVING SETTINGS TO NVM
Digital Multiphase NVM Stores

- Renesas Digital Multiphase controllers contain OTP (one time programmable) NVM memory for storing device configuration settings.

- Up to 8 different configurations (Configuration ID’s) can be stored in the device, using 1 of 8 available NVM “slots”
  - Once a NVM slot is used, it cannot be erased or reprogrammed.
  - Multiple versions of the same Configuration ID can be stored in NVM – the controller will always use the most recent version.

- At start-up, an external pin-strap resistor tells the controller which of the stored Configuration ID’s to use
  - The resistor does not point to a NVM slot, but rather to a CONFIGURATION_ID
Example Configuration Stores

Example: Storing Configs
- A 4+0 design configuration is first stored as Config ID 1
- The 4+0 design is then updated due to design change (ex. Vboot change), resulting in a new Config ID 1 store.
- A 3+1 design configuration is stored as Config ID 4

In this example:
- 2 CONFIG IDs are stored in OTP
- 3 OTP slots are used, however. CFG1 (Rev 0) uses a slot, but is not accessible since it has been replaced by CFG1 (Rev 1)

Upon Power Up
- A 1800 Ohm Rconfig will result in Cfg1 (Rev 1) to be used. Only the latest revision will ever be loaded
- A 3300 Ohm Rconfig will result in Cfg4 (Rev0) to be used

<table>
<thead>
<tr>
<th>R CONFIG (Ω)</th>
<th>CONFIG ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>6800</td>
<td>0</td>
</tr>
<tr>
<td>1800</td>
<td>1</td>
</tr>
<tr>
<td>2200</td>
<td>2</td>
</tr>
<tr>
<td>2700</td>
<td>3</td>
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<td>3300</td>
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<tr>
<td>3900</td>
<td>5</td>
</tr>
<tr>
<td>4700</td>
<td>6</td>
</tr>
<tr>
<td>5600</td>
<td>7</td>
</tr>
</tbody>
</table>
Saving Settings to NVM

To save the current config to the on-board memory in the device that is connected.

First click on the “Save to NVM” in the Rail Inspector

If the project has not been saved since the most recent changes, the “Refresh” button will be enabled and the “Save” buttons for the configuration IDs will be disabled.
Saving Settings to NVM

After project has been saved, “Refresh” will gray out, indicating the latest settings have been saved. “Save Project” is enabled if the project has unsaved changes. “Save” options will now be active, allowing the project to be saved to 1 of 8 available CFG ID’s.
Saving Settings to NVM

Once the configuration has been saved, input power to the part should be cycled.

Re-loading the NVM screen will show that there are now 7 saves remaining. In addition, the NVM contents will show a match to the project in your directory.

Clicking on the “Match Found” button will show information for the matching project.
Digital Multiphase HEX File Export

- To support production programming, Digital Multiphase controllers support a HEX export utility.
  - Once a design has been finalized, the exported HEX file is used to program devices on high speed production programmers.

- The HEX export utility is available under the “Utilities” menu on the main PowerNavigator screen.

- Using this utility, multiple projects can be combined into a single HEX file
  - Each project is assigned one of 8 available CONFIG_IDs
  - An external resistor is then used to select the proper CONFIG_ID
Digital Multiphase – Saving A Project

Select “Save” from File Menu. Be sure to save revision information in project name.
Digital Multiphase – Exporting HEX File

After saving, select “Multiphase Hex Exporter” from Utilities Menu.
Digital Multiphase – Exporting HEX File

In Multiphase Hex Exporter, select controller part number from drop down box.
Digital Multiphase – Exporting HEX File

After part number is selected, the Hex Exporter tool will scan the PowerNavigator Projects folder for all project IDs with that part number.

After scanning is complete, all projects using that part number will be displayed.

Select project, then Click and drag project into desired Config ID.

Set programming address to match address of controller in programming environment.
Digital Multiphase – Exporting HEX File

After all projects have been loaded, click “Export Hex File.”

In resulting pop-up window, select save location and file name for Hex file. To ease Hex file management, be sure to include version numbering in Hex file.
Digital Multiphase – Configuration Vs. HEX File

**Configuration File**

```
# DigitalPhase_2-0_0.hex
# Set-up text here.

PAGE 0x00 # 0x00
"Esprit" # 0x01
"setup" # 0x02
"end" # 0x03
```

**Hex File**

```
0x00000000 0x01000000 0x02000000 0x03000000
... (similar pattern for hex values)
```

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Digital Multiphase – Project Compare

Select “Project Comparison” from Utilities menu
Digital Multiphase – Connecting to Hardware

Click “Load Project”

In resulting pop-up window, navigate to project you wish to compare.
**Digital Multiphase – Connecting to Hardware**

After projects have been loaded, expand to show individual rails.

Drag and drop rails into compare window.
Digital Multiphase – Connecting to Hardware

Scan List for differences, OR click “Export to Excel XML”
Digital Multiphase – Connecting to Hardware

After clicking “Export to Excel XML”, name comparison and select save location.
Digital Multiphase – Connecting to Hardware

Differences will be automatically highlighted in RED