Application Report
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How to Cascade Multiple UCD90xxx Sequencers

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ABSTRACT

The UCD90xxx family of digital power supply sequencers, also known as system health monitors are flexible and powerful enough to meet users sequencing, monitoring, margining, and other needs. TI's Fusion Digital Power™ designer is a dedicated Graphical User Interface (GUI) tool that helps users configure and monitor UCD90xxx sequencers and health monitors with limited coding knowledge.

In the advanced application, the system requires more rails than a single UCD90xxx can support. Therefore, multiple UCD90xxx devices are required. This document is to describe how to cascading multiple to ensure that proper sequencing across these devices.

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Trademarks

1 Function Required for Cascading

The following features are required to implement cascading among multiple UCD90xxx devices:

1.1 Logical Controlled GPO (LGPO)

All UCD90xxx devices have a feature called logic general-purpose output (LGPO). General-purpose I/Os (GPIO) can be configured as outputs that are based on the Boolean combination of up to two ANDs, ORed together as shown in Figure 1. Inputs to the logic blocks can include the first 8 defined LGPOs, general-purpose inputs (GPI), and rail-status flags. One rail status type is selectable as an input for each AND gate.

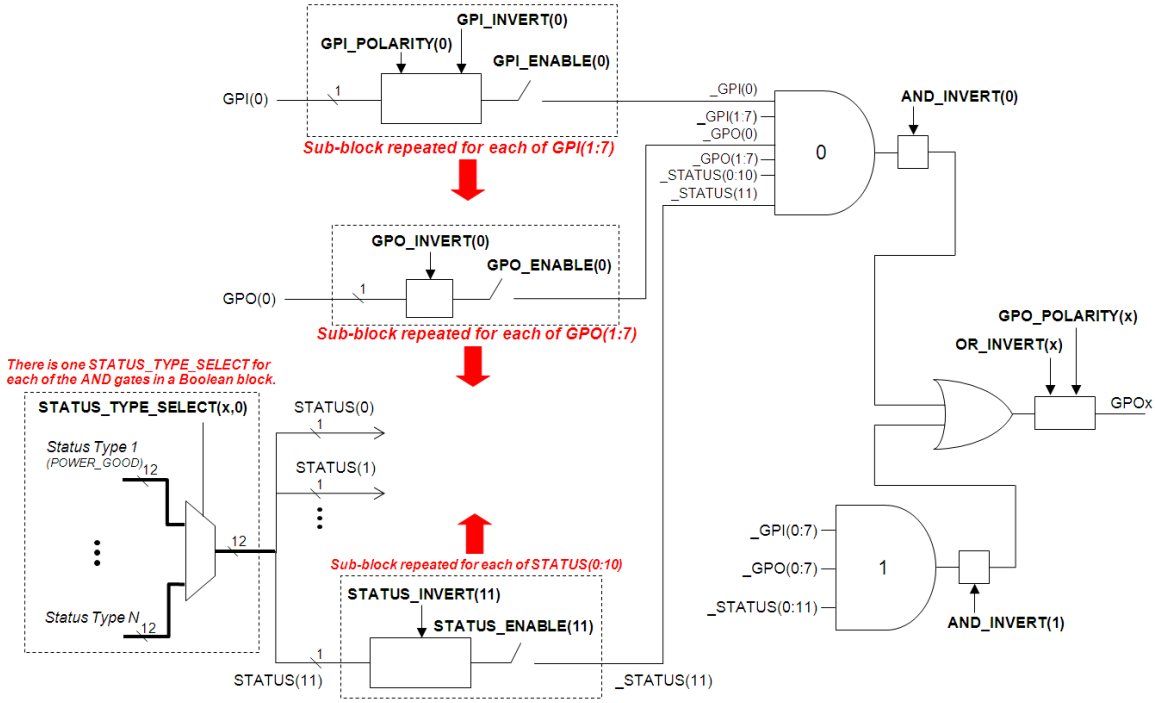

Figure 1. Boolean Logic Combination

With LGPO function, a proper signal can be generated based on the rail status from any given UCD90xxx device in the chain. So the other UCD device can determine this if the signal is connected to GPI pins. Figure 2 and Figure 3 demonstrates how to configure a GPIO to output when all rails are reaching POWER_GOOD and POWER_GOOD_OFF, respectively.

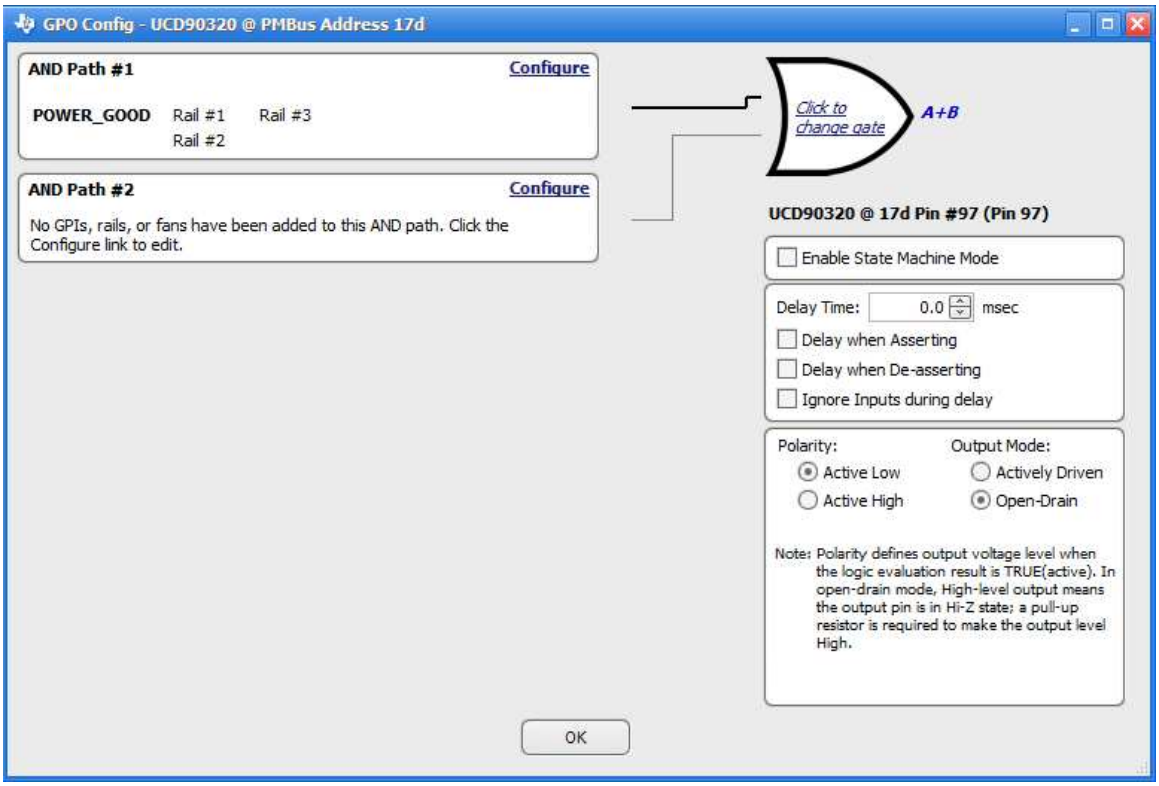

Figure 2. System POWER_GOOD Logic Builder

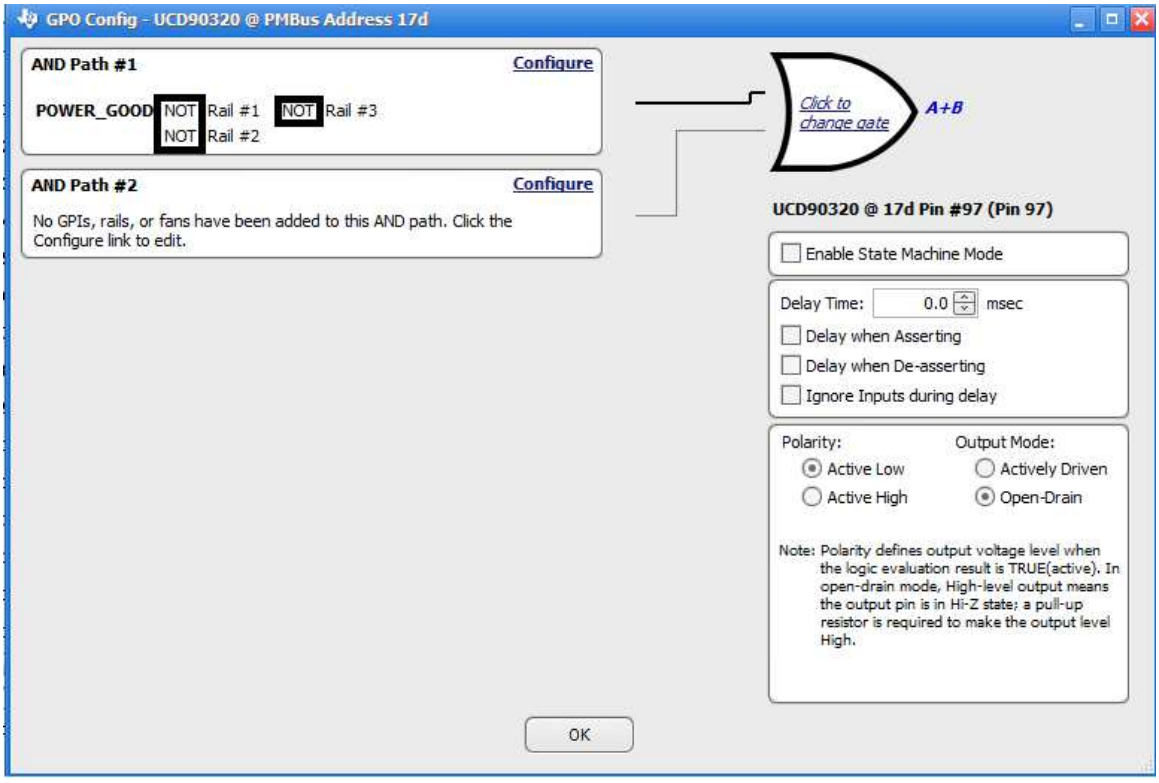

Figure 3. System POWER_GOOD_OFF Logic Builder

1.2 Sequencing On and Off Dependencies

The other important feature to cascade is the sequencing on and off dependencies (Figure 4). Those rails that have dependencies will not be on or off, unless the dependencies are met.

Table 1. Sequencing Dependencies Events

Event	Rail		GPI	LGPO
Sequence ON condition met	Voltage monitoring: Above POWER_GOOD threshold	Other monitoring: EN signal is asserted	ASSERTED(1)	The logic output is TRUE
Sequence OFF condition met	Voltage monitoring: Below POWER_GOOD_OFF threshold	Other monitoring: EN signal is de-asserted	DE-ASSERTED(1)	The logic output is FALSE

(1) The input signal is ASSERTED if it matches the defined active polarity, otherwise it is DE-ASSERTED.

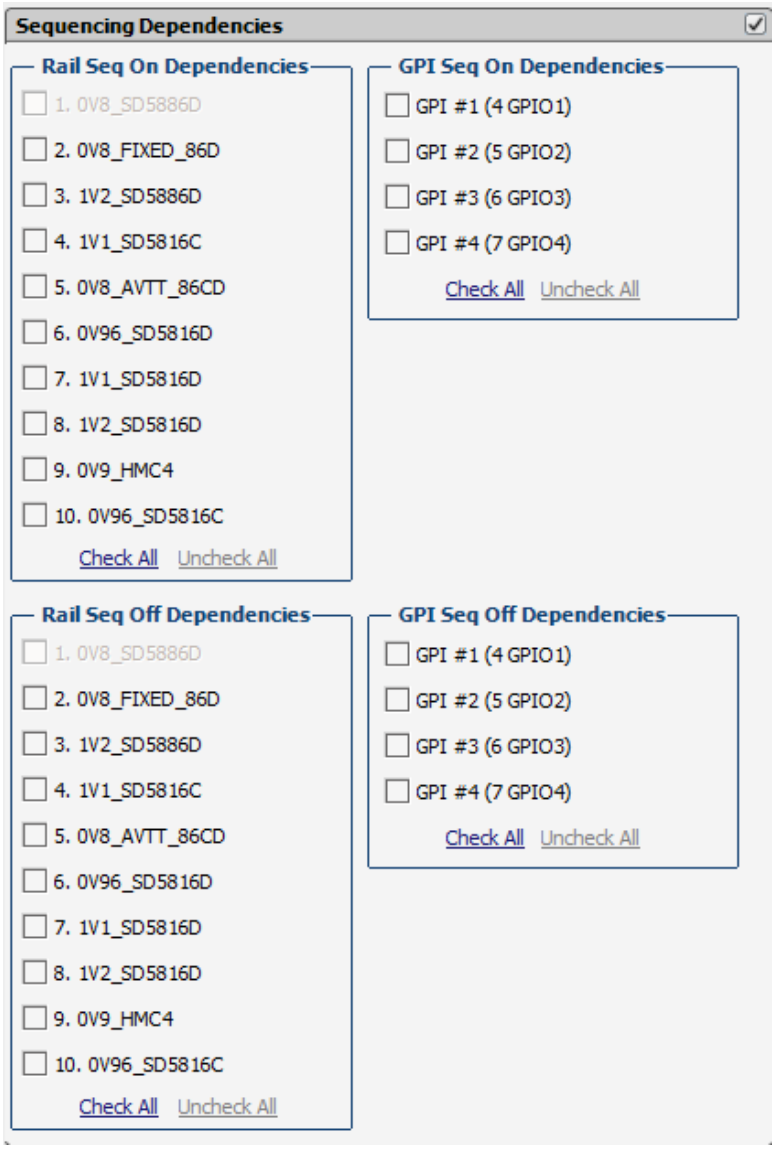

Figure 4. Sequencing On and Off Dependencies

1.3 UV, GPI Fault Response

All analog Monitor pin can be used to monitor digital signal such as POWER_GOOD output from other devices. A proper external voltage divider is required to meet the ADC reference. The de-assertion of a POWER_GOOD output can trigger a UV fault of the next device. When device detects the UV fault, the UV fault response of the rail can be configured to shut down other rails controlled by the same UCD90xxx device via setting other rails as fault shutdown slaves of the faulted rail.

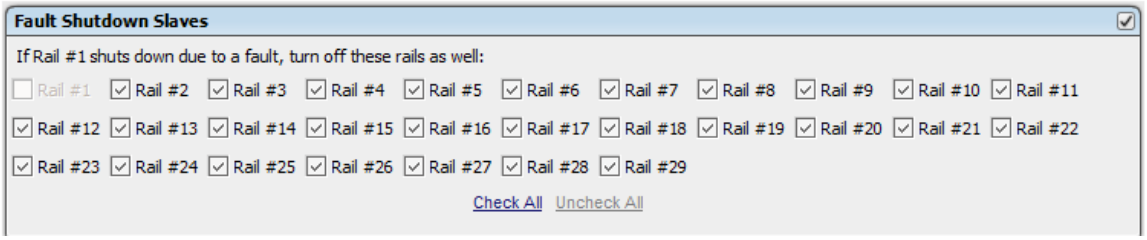

Figure 5. Fault Shutdown Slaves

The UCD9090A, UCD90160A, UCD90240, and UCD90320 devices support GPI fault response; therefore, the POWER_GOOD output signal can be connected to GPI instead of MON to save the MON for normal monitoring. The de-assertion of the POWER_GOOD output can trigger GPI fault on the next device. The fault response of the GPI fault can be configured to shut down rails controlled by the same device. Configure the GPI fault response as shown in the following paragraphs. There are some differences to set the GPI fault response between the UCD9090A, UCD90160A and the UCD90240, UCD90320.

For the UCD9090A and UCD90160A, the Fault response is centralized at GPI configure as shown in Figure 6. Only one GPI can be assigned to have Fault response.

But for UCD90240 and UCD90320 devices, the Fault response is separated into two places. The user first must enable the GPI Fault Enable feature on the GPI Configure as shown in Figure 7. Next, select the corresponding response for the given rail as shown in Figure 8. All GPI can be assigned to have the fault response function.

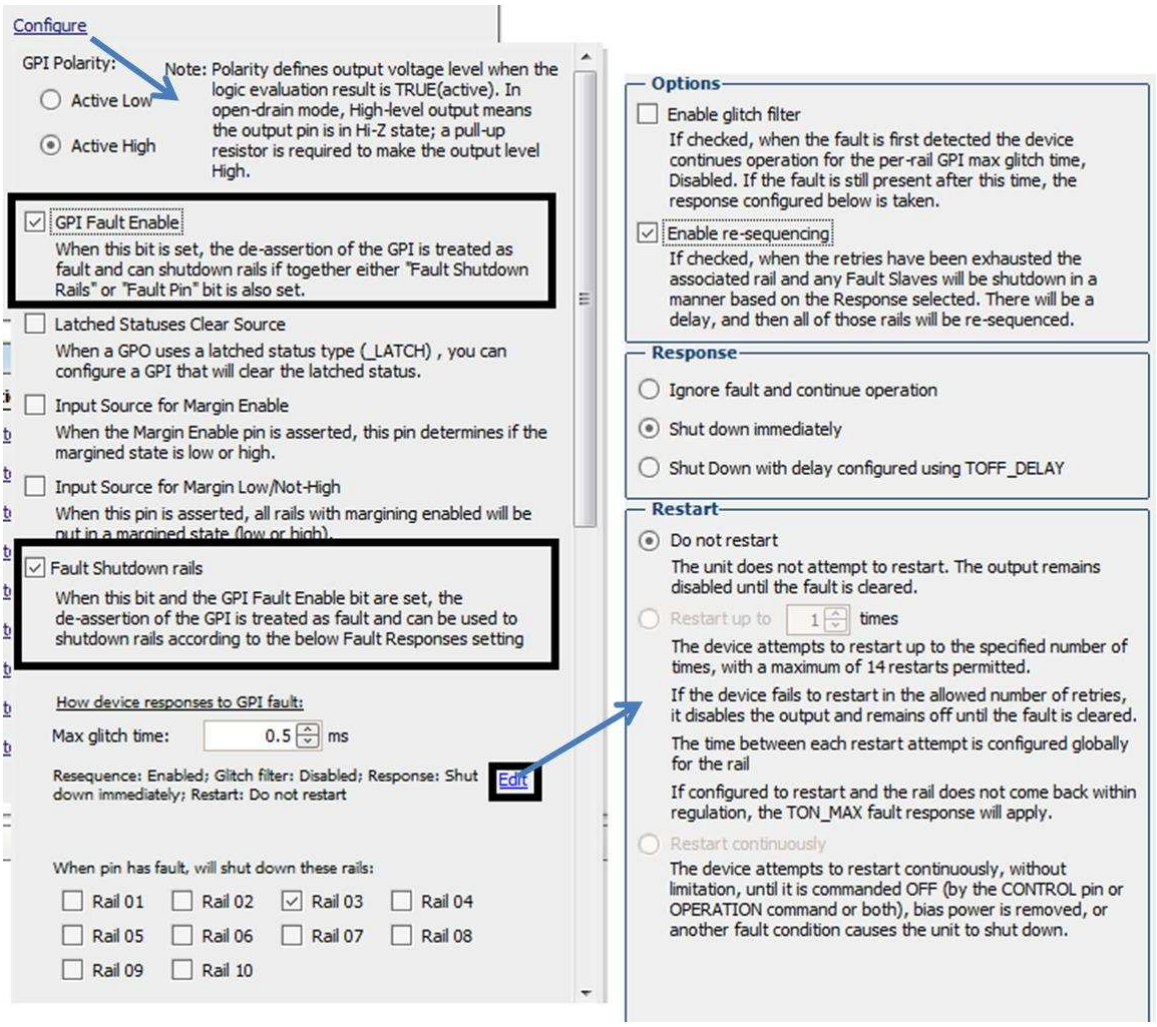

Figure 6. GPI Fault Response for UCD9090A and UCD90160A

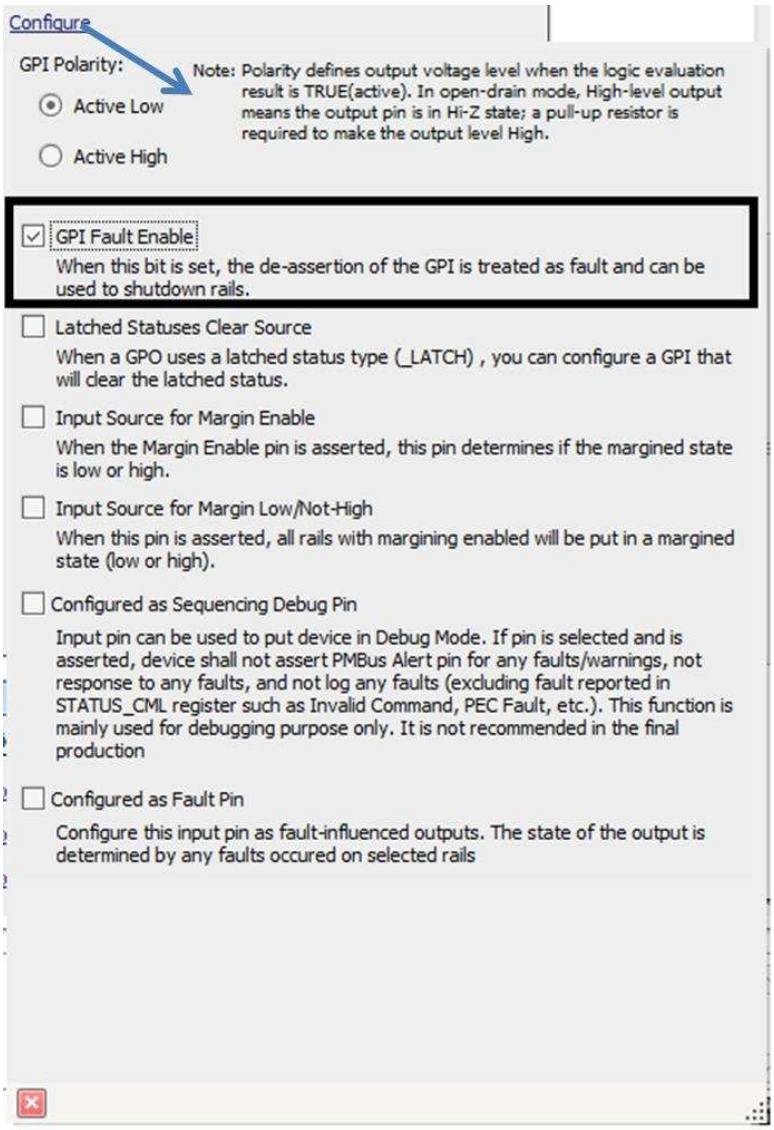

Figure 7. GPI Fault Response For UCD90240 and UCD90320 - Step 1

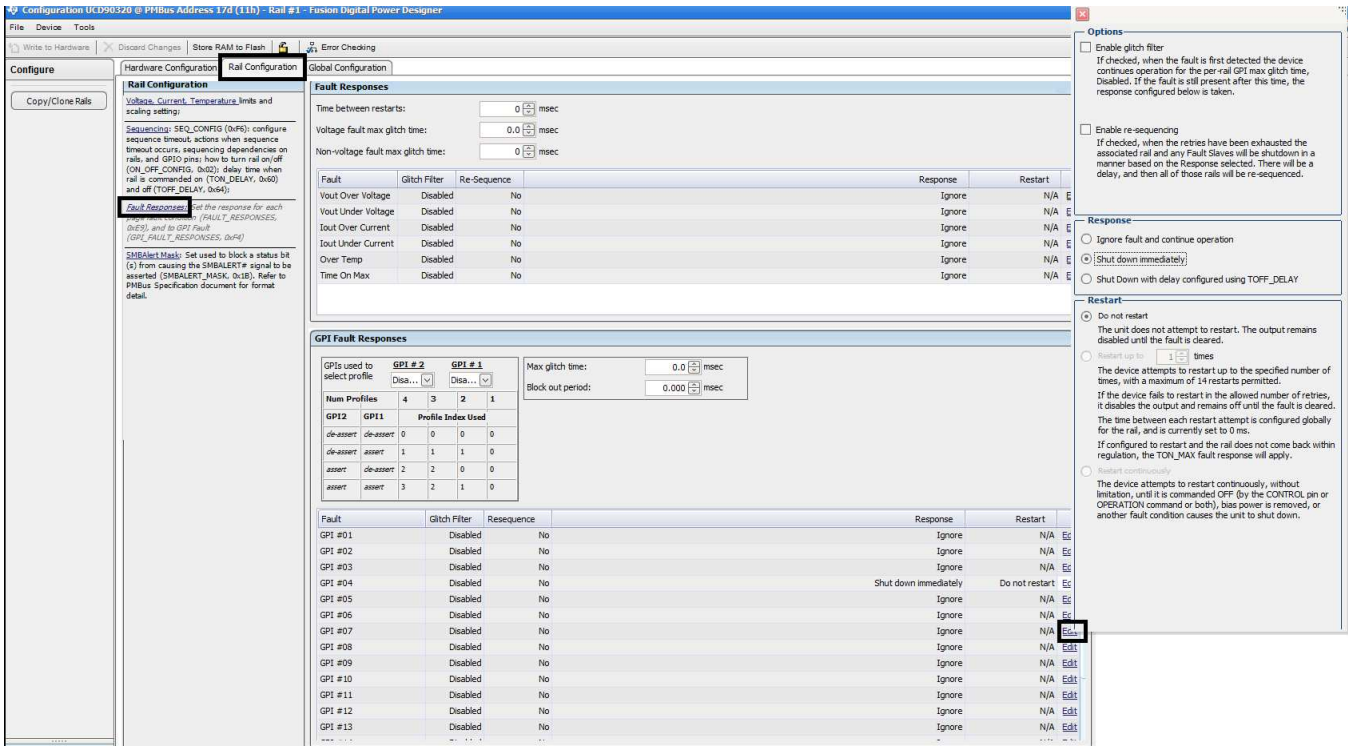

Figure 8. GPI Fault Response for UCD90240 and UCD90320 - Step 2

1.4 Fault Pin

The UCD9090A, UCD90160A, UCD90240, and UCD90320 devices support the FAULT PIN feature. Fault pin is a bi-directional signal and can form a fault bus when pulled up to 3.3 V. When there is no fault on a Fault Bus, the Fault Pins are digital input pins and respond to the Fault Bus. When one or multiple UCD devices detect a rail fault, the corresponding Fault Pin is turned into active driven low state, pulling down the Fault Bus and communicating to all other UCD devices of the corresponding fault. This way, a coordinated action can be taken across multiple devices. After the fault is cleared, the state of the Fault Pin of the given device is turned back to an input pin. There are some differences to set GPI fault response between the UCD9090A, UCD90160A devices and the UCD90240, UCD90320 devices.

For the UCD9090A and UCD90160A devices, only one GPI pin can be assigned as FAULT PIN, the configuration of the fault pin is shown in Figure 9. For the UCD90240 and UCD90320 device, the fault pin configuration is separated at three places. Please follow Figure 10 to enable the GPI fault and Fault Pin (UCD90320 Only). Figure 11 demonstrates how to configure a Fault pin, for UCD90240, the Fault pin selection is done at this step. Once previous two steps, please follow Figure 8 to configure the corresponding fault response for the fault pin.

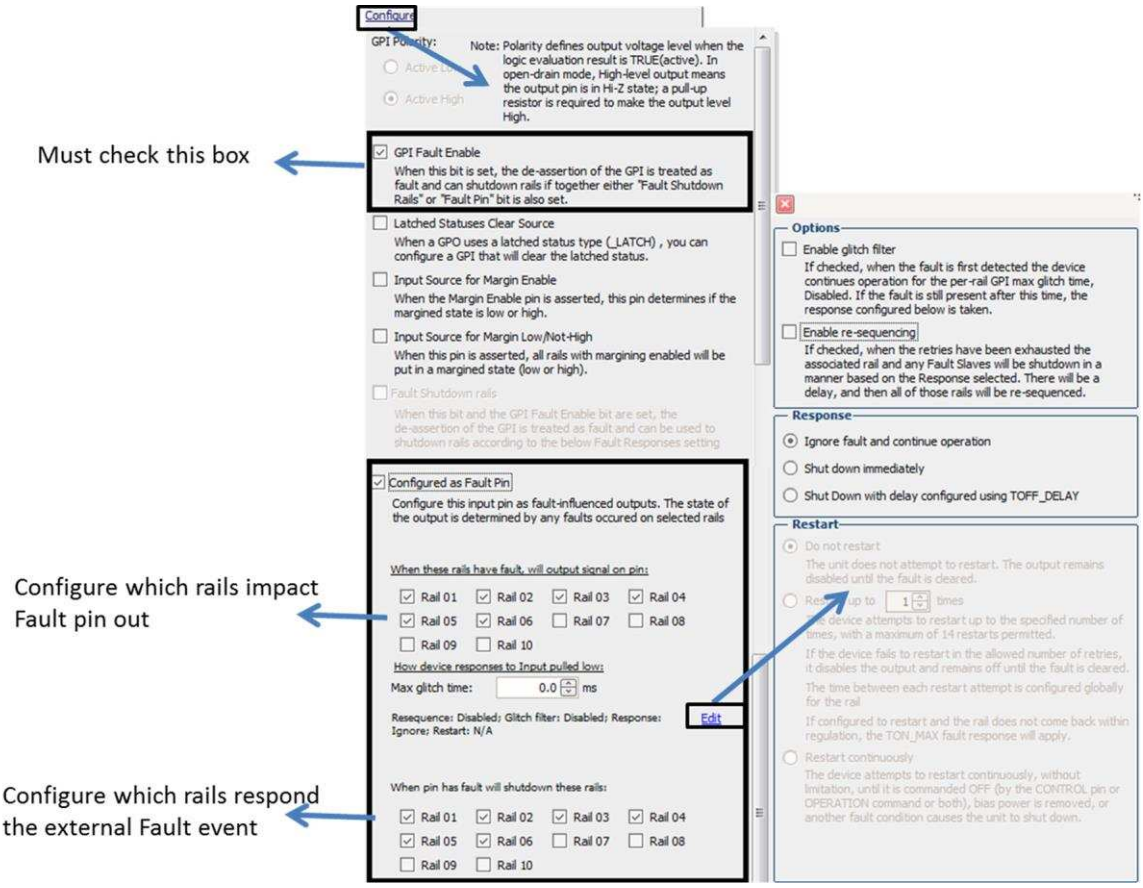

Figure 9. Fault Pin Configuration for UCD9090A and UCD90160A

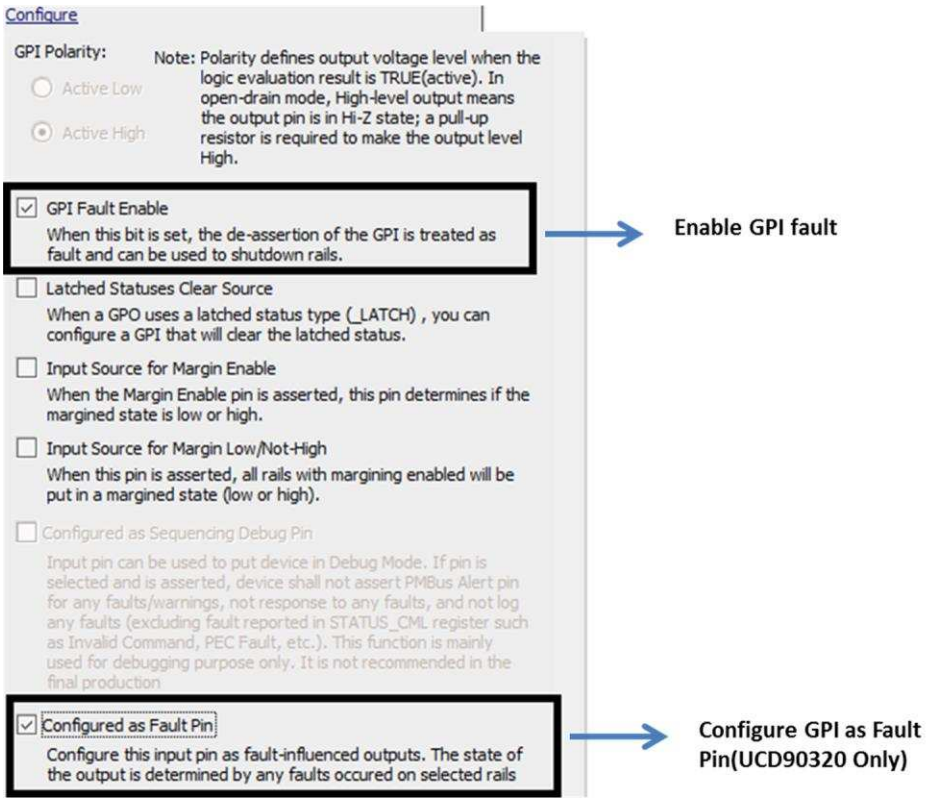

Figure 10. Configure Fault Pin UCD90240 and UCD90320 - Step 1

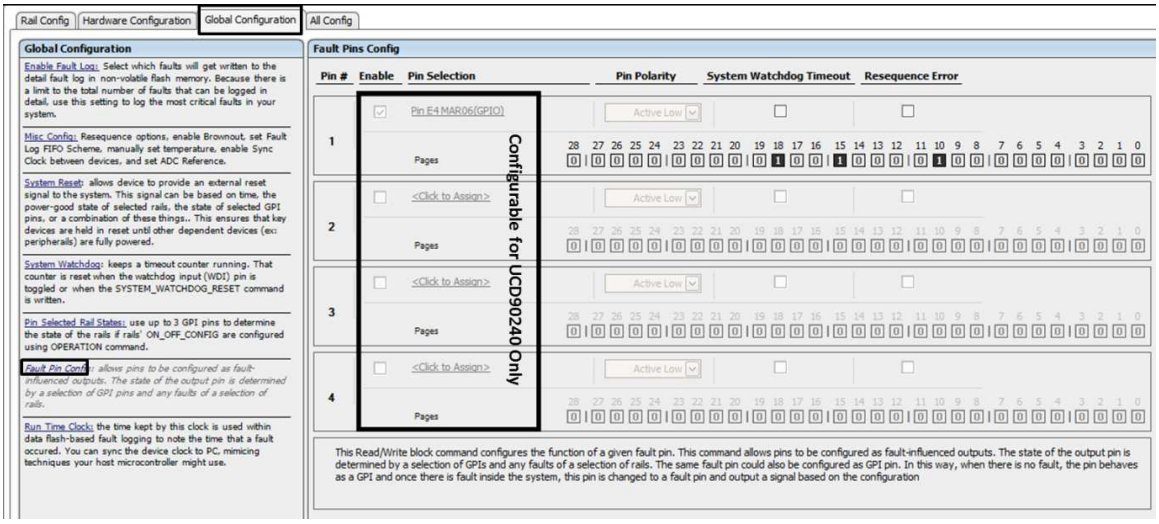

Figure 11. Configure Fault Pin UCD90240 and UCD90320 - Step 2

2 Cascading Multiple UCD90xxx

There are many different ways to cascade multiple UCD90xxx devices, which is up to system power sequencing requirements.

2.1 Only Power On Sequencing is Required

For systems where only the power-on sequencing among multiple UCD90xxx devices is a concern, the following connection description works well.

An LGPO pin can be used to coordinate multiple controllers by using it as a POWER_GOOD output from one device and connecting it to the PMBUS_CNTRL pin of another. Connect the POWER_GOOD signal of the last UCD in the chain back to either MON/GPI pin of the first UCD. This imposes a master and slave relationship among multiple devices. During startup, the slave controllers initiate their start sequences after the master has completed its start sequence and all rails have reached regulation voltages. During shutdown, as soon as the master starts to sequence-off, it de-asserts the POWER_GOOD signals to its slaves. A shutdown on one or more of the master rails can initiate shutdowns of the slave devices. The master shutdowns can be initiated intentionally or by a fault condition. This method works to coordinate multiple controllers. The fault on slaves cannot only shutdown its own rails, but also de-assert the POWER_GOOD signal to shutdown the rails of other slaves. For the last devices in the chain, when there is a fault, it de-asserts the POWER_GOOD signals. The first (master) device in the chain will treat this as a UV fault (connected on the MON pin). A proper fault response could be set to shutdown rails. The other option here is to use GPI instead of the MON pin. GPI fault response is available on the UCD9090A, UCD90160A, UCD90240, and UCD90320. Therefore, GPI can be used for those devices to achieve the same function if there are not enough MON pins left. For this configuration the power-off sequencing is not ensured since all rails controlled by multiple UCDs will be sequenced off together. If there is a requirement for the power down sequence to cross different devices, this configuration may not be applicable.

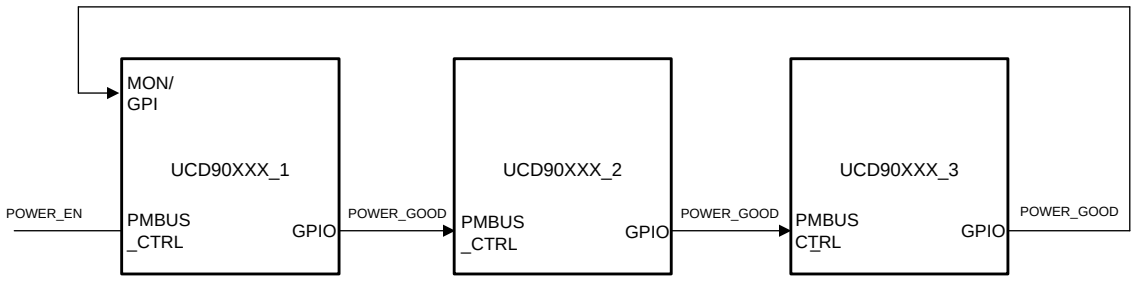

Figure 12. POWER_GOOD Cascading Case 1

Another method to cascade multiple devices is to connect the power-good output of the first device to a MON/GPI pin of the second device; connect the power-good output of the second device to a MON/GPI pin of the third device, and so on. Optionally, connect the power-good output of the last device to a MON pin of the first device. The rails controlled by a device have dependency on the power-good output of the previous device. This way, the rails controlled by multiple devices can be sequenced. Also, the de-assertion of a power-good output can trigger a UV fault of the next device. The UV fault response can be configured to shut down other rails controlled by the same device. This way, when one rail has a fault shutdown, rails controlled by other devices can be shut down accordingly. Optionally, connect to the GPI pin instead of the MON pin if the UCD9090A, UCD90160A, UCD90240, and UCD90320 devices are used in the cascading method to save the MON pin for other uses.

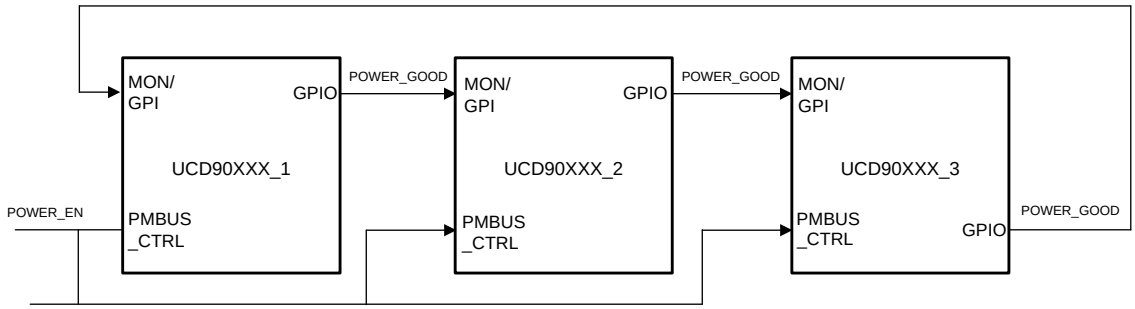

Figure 13. Power Good Cascading Case 2

2.2 Both Power On and Off Sequencing Are Required

The 2 use-cases in Section 2.1 do not ensure the power down sequence since there is no such information communicated among the devices. To ensure that the first rail on is the last one off among multiple devices, an additional LGPO pin is required. The new LGPO pin outputs a POWER_GOOD_OFF when all the rails controlled by the same devices are below the POWER_GOOD_OFF threshold, indicating that the rails are properly shutdown. The upstream UCD can take this signal from downstream UCD as sequencing off dependencies via the GPI pin. When the hosts de-assert the POWER_EN pin to power down the whole system, the rails controlled by the last UCD in the chain will be off first. All rails controlled by the first (master) UCD start shutting down its rails when all slave rails are off. This can ensure a proper shutdown sequence.

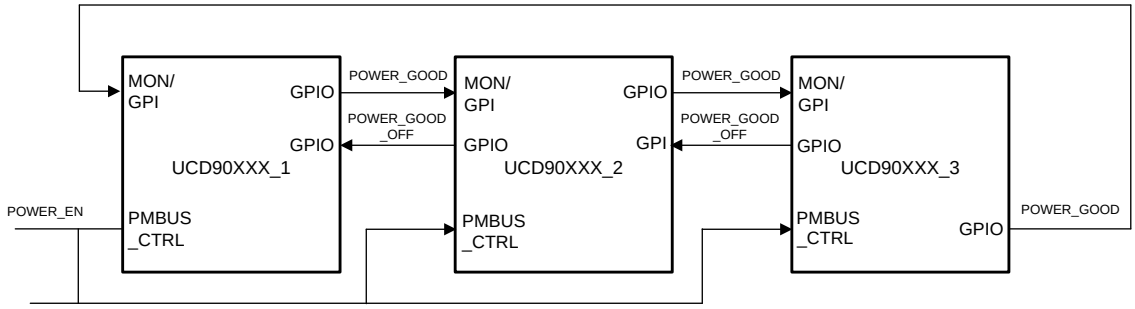

Figure 14. POWER_GOOD and POWER_GOOD_OFF Cascading

2.3 Fault Pin Cascading

The UCD9090A, UCD90160A, UCD90240, and UCD90320 devices have a new feature “Fault Pin”.

The Fault pin is a bi-directional signal and can form a fault bus when pulled up to 3.3 V. When there is no fault on a Fault Bus, the Fault Pins are digital input pins and listen to the Fault Bus. When one or multiple UCD devices detect a rail fault, the corresponding Fault Pin is turned into active driven low state, pulling down the Fault Bus and informing all other UCD devices of the corresponding fault. This way, a coordinated action can be taken across multiple devices. The action is programmable. After the fault is cleared, the state of the Fault Pin is turned back to an input pin. The fault pin cascading connection does not provide power on or power off dependencies among multiple UCD devices, but it lets multiple devices response to the same fault event.

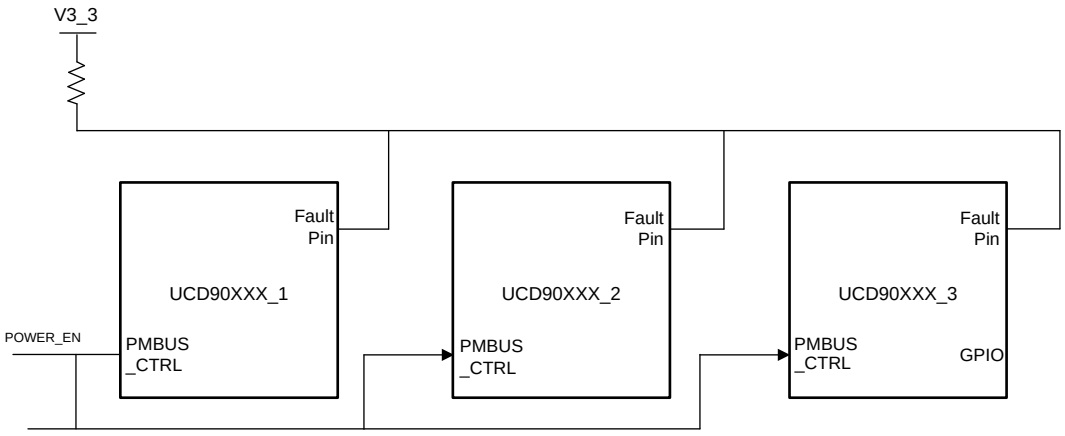

Figure 15. Fault Pin Cascading

3 Conclusion

The UCD90xxx family provides versatile approaches for users to implement cascading multiple devices. The best approach can be selected based on the power requirements and sequencer solution of the system.

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