# Simple Sequencers® in 6-Lead SC70

Data Sheet

# ADM1085/ADM1086/ADM1087

## FEATURES

- Provide programmable time delays between enable signals
- Can be cascaded with power modules for multiple supply sequencing
- Power supply monitoring from 0.6 V
- Output stages
  - High voltage (up to 22 V) open-drain output (ADM1085/ADM1087)
  - Push-pull output (ADM1086)
- Capacitor-adjustable time delays
- High voltage (up to 22 V) enable and $V_{IN}$ inputs
- Low power consumption (15 µA)
- Specified over −40°C to +125°C temperature range
- 6-lead SC70 package

## APPLICATIONS

- Desktop/notebook computers, servers
- Low power portable equipment
- Routers
- Base stations
- Line cards
- Graphics cards

## FUNCTIONAL BLOCK DIAGRAMS

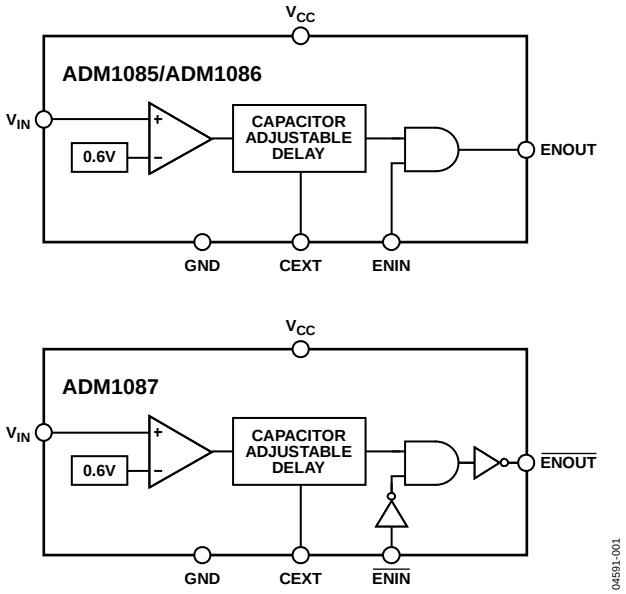


*Figure 1.*

## GENERAL DESCRIPTION

The ADM1085/ADM1086/ADM1087 are simple sequencing circuits that provide a time delay between the enabling of voltage regulators and/or dc-dc converters at power-up in multiple supply systems. When the output voltage of the first power module reaches a preset threshold, a time delay is initiated before an enable signal allows subsequent regulators to power up. Any number of these devices can be cascaded with regulators to allow sequencing of multiple power supplies.

Threshold levels can be set with a pair of external resistors in a voltage divider configuration. With appropriate resistor values, the threshold can be adjusted to monitor voltages as low as 0.6 V.

The ADM1086 has a push-pull output stage, with active high (ENOUT). The ADM1085 has an active-high (ENOUT) logic output; the ADM1087 has an active-low ($\overline{\text{ENOUT}}$) output. Both the ADM1085 and ADM1087 have open-drain output stages that can be pulled up to voltage levels as high as 22 V through an external resistor. This level-shifting property ensures compatibility with enable input logic levels of different regulators and converters.

All four models have a dedicated enable input pin that allows the output signal to the regulator to be controlled externally. This is an active high input (ENIN) for the ADM1085 and ADM1086, and an active low input ($\overline{\text{ENIN}}$) for the ADM1087.

The Simple Sequencers are specified over the extended −40°C to +125°C temperature range. With low current consumption of 15 µA (typical) and 6-lead SC70 packaging, the parts are suitable for low-power portable applications.

**Table 1. Selection Table**

| Part No. | Enable Input | Output Stage | |
|---|---|---|---|
| | | $\overline{\text{ENOUT}}$ | ENOUT |
| ADM1085 | ENIN | | Open-drain |
| ADM1086 | ENIN | | Push-pull |
| ADM1087 | $\overline{\text{ENIN}}$ | Open-drain | |

Rev. B

Document Feedback



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## REVISION HISTORY

**5/14—Rev. A to Rev. B**

Removed ADM1088 ..... Throughout
Changes to Capacitor-Adjustable Delay Circuit ..... 9
Removed Figure 26; Renumbered Sequentially ..... 12
Changes to Ordering Guide ..... 15

**4/06—Rev. 0 to Rev. A**

Added Lead-Free Models ..... Universal
Update Outline Dimensions ..... 15
Changes to Ordering Guide ..... 15

**7/04—Revision 0: Initial Version**

# SPECIFICATIONS

$V_{CC}$ = full operating range, $T_A$ = −40°C to +125°C, unless otherwise noted.

**Table 2.**

| Parameter | Min | Typ | Max | Unit | Test Conditions/Comments |
|---|---|---|---|---|---|
| SUPPLY | | | | | |
| $V_{CC}$ Operating Voltage Range | 2.25 | | 3.6 | V | |
| $V_{IN}$ Operating Voltage Range | 0 | | 22 | V | |
| Supply Current | | 10 | 15 | µA | |
| $V_{IN}$ Rising Threshold, $V_{TH\_RISING}$ | 0.56 | 0.6 | 0.64 | V | $V_{CC}$ = 3.3 V |
| $V_{IN}$ Falling Threshold, $V_{TH\_FALLING}$ | 0.545 | 0.585 | 0.625 | V | $V_{CC}$ = 3.3 V |
| $V_{IN}$ Hysteresis | | 15 | | mV | |
| $V_{IN}$ to ENOUT/$\overline{\text{ENOUT}}$ Delay | | | | | |
| $V_{IN}$ Rising | | 35 | | µs | CEXT floating, C = 20 pF |
| | | 2 | | ms | CEXT = 470 pF |
| $V_{IN}$ Falling | | 20 | | µs | $V_{IN}$ = $V_{TH\_FALLING}$ to ($V_{TH\_FALLING}$ − 100 mV) |
| $V_{IN}$ Leakage Current | | 170 | | µA | $V_{IN}$ = 22 V |
| CEXT Charge Current | 125 | 250 | 375 | nA | |
| Threshold Temperature Coefficient | | 30 | | ppm/°C | |
| ENIN/$\overline{\text{ENIN}}$ to ENOUT/$\overline{\text{ENOUT}}$ Propagation Delay | | 0.5 | | µs | $V_{IN}$ > $V_{TH\_RISING}$ |
| ENIN/$\overline{\text{ENIN}}$ Voltage Low | | | 0.3 $V_{CC}$ − 0.2 | V | |
| ENIN/$\overline{\text{ENIN}}$ Voltage High | 0.3 $V_{CC}$ + 0.2 | | | V | |
| ENIN/$\overline{\text{ENIN}}$ Leakage Current | | 170 | | µA | ENIN/$\overline{\text{ENIN}}$ = 22 V |
| ENOUT/$\overline{\text{ENOUT}}$ Voltage Low | | | 0.4 | V | $V_{IN}$ < $V_{TH\_FALLING}$ (ENOUT), $V_{IN}$ > $V_{TH\_RISING}$ ($\overline{\text{ENOUT}}$), $I_{SINK}$ = 1.2 mA |
| ENOUT/$\overline{\text{ENOUT}}$ Voltage High (ADM1086) | 0.8 $V_{CC}$ | | | V | $V_{IN}$ > $V_{TH\_RISING}$ (ENOUT), $V_{IN}$ < $V_{TH\_FALLING}$ ($\overline{\text{ENOUT}}$), $I_{SOURCE}$ = 500 µA |
| ENOUT/$\overline{\text{ENOUT}}$ Open-Drain Output Leakage Current (ADM1085/ADM1087) | | | 0.4 | µA | ENOUT/$\overline{\text{ENOUT}}$ = 22 V |

# ABSOLUTE MAXIMUM RATINGS

$T_A$ = 25°C, unless otherwise noted.

**Table 3.**

| Parameter | Rating |
|---|---|
| $V_{CC}$ | −0.3 V to +6 V |
| $V_{IN}$ | −0.3 V to +25 V |
| CEXT | −0.3 V to +6 V |
| ENIN, $\overline{\text{ENIN}}$ | −0.3 V to +25 V |
| ENOUT, $\overline{\text{ENOUT}}$ (ADM1085, ADM1087) | −0.3 V to +25 V |
| ENOUT, $\overline{\text{ENOUT}}$ (ADM1086) | −0.3 V to +6 V |
| Operating Temperature Range | −40°C to +125°C |
| Storage Temperature Range | −65°C to +150°C |
| $\theta_{JA}$ Thermal Impedance, SC70 | 146°C/W |
| Lead Temperature | |
| Soldering (10 sec) | 300°C |
| Vapor Phase (60 sec) | 215°C |
| Infrared (15 sec) | 220°C |

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ESD CAUTION

**ESD (electrostatic discharge) sensitive device.** Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

# PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

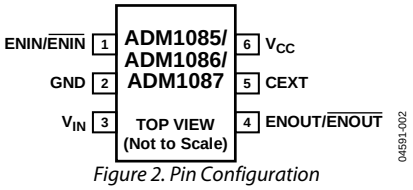


*Figure 2. Pin Configuration*

**Table 4. Pin Function Descriptions**

| Pin No. | Mnemonic | Description |
|---|---|---|
| 1 | ENIN, $\overline{\text{ENIN}}$ | Enable Input. Controls the status of the enable output. Active high for ADM1085/ADM1086. Active low for ADM1087. |
| 2 | GND | Ground. |
| 3 | $V_{IN}$ | Input for the Monitored Voltage Signal. Can be biased via a voltage divider resistor network to customize the effective input threshold. Can precisely monitor an analog power supply output signal and detect when it has powered up. The voltage applied at this pin is compared with a 0.6 V on-chip reference. With this reference, digital signals with various logic level thresholds can also be detected. |
| 4 | ENOUT, $\overline{\text{ENOUT}}$ | Enable Output. Asserted when the voltage at $V_{IN}$ is above $V_{TH\_RISING}$ and the time delay has elapsed, provided that the enable input is asserted. Active high for the ADM1085/ADM1086. Active low for the ADM1087. |
| 5 | CEXT | External Capacitor Pin. The capacitance on this pin determines the time delay on the enable output. The delay is seen only when the voltage at $V_{IN}$ rises past $V_{TH\_RISING}$, and not when it falls below $V_{TH\_FALLING}$. |
| 6 | $V_{CC}$ | Power Supply. |

# TYPICAL PERFORMANCE CHARACTERISTICS

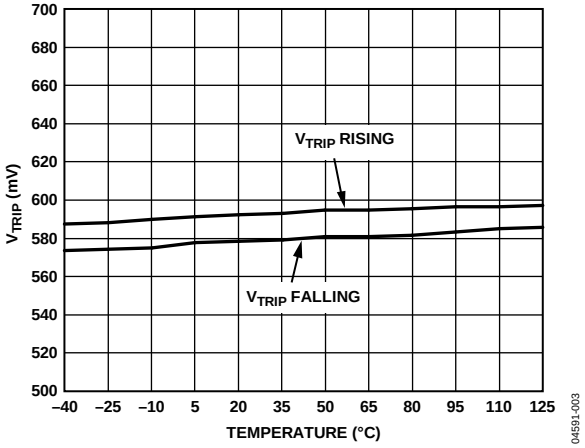


*Figure 3. $V_{IN}$ Threshold vs. Temperature*

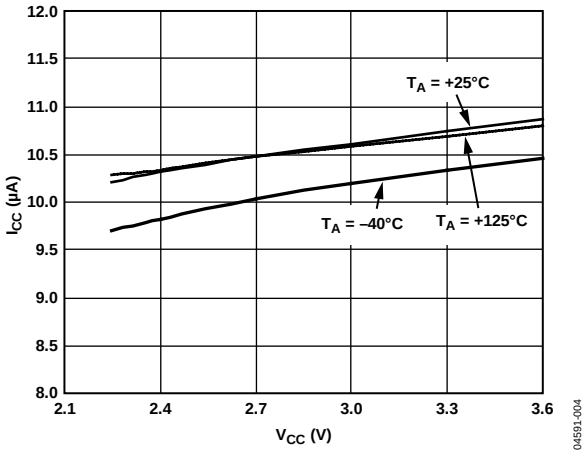


*Figure 4. Supply Current vs. Supply Voltage*

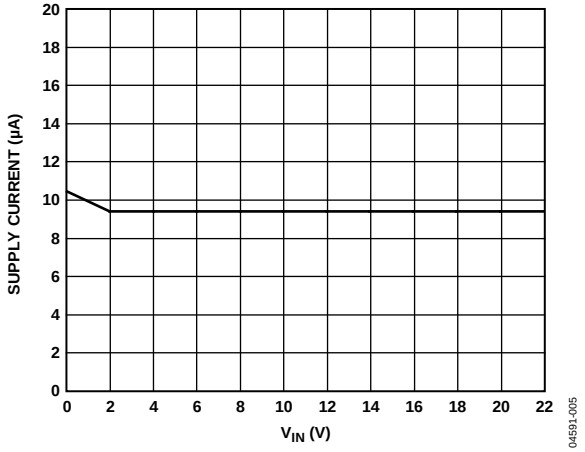


*Figure 5. Supply Current vs. $V_{IN}$ Voltage*

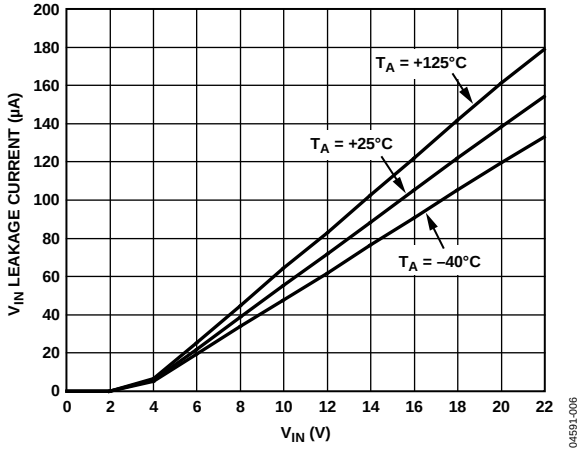


*Figure 6. $V_{IN}$ Leakage Current vs. $V_{IN}$ Voltage*

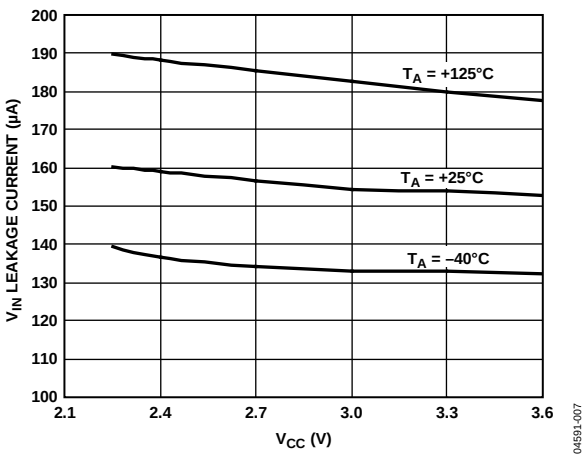


*Figure 7. $V_{IN}$ Leakage Current vs. $V_{CC}$ Voltage*

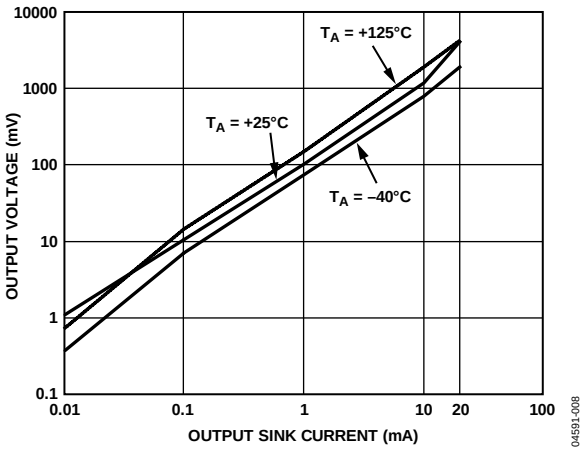


*Figure 8. Output Voltage vs. Output Sink Current*

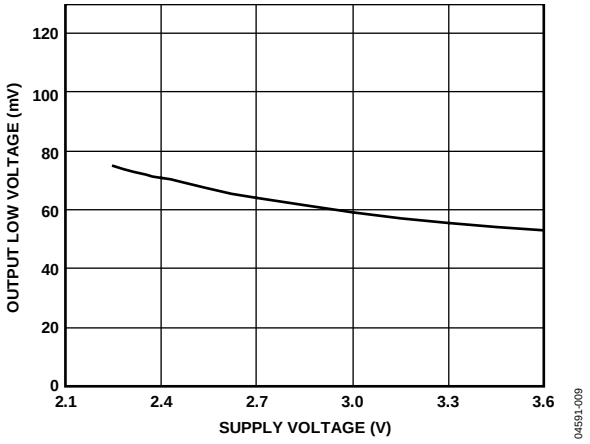


Figure 9. Output Low Voltage vs. Supply Voltage

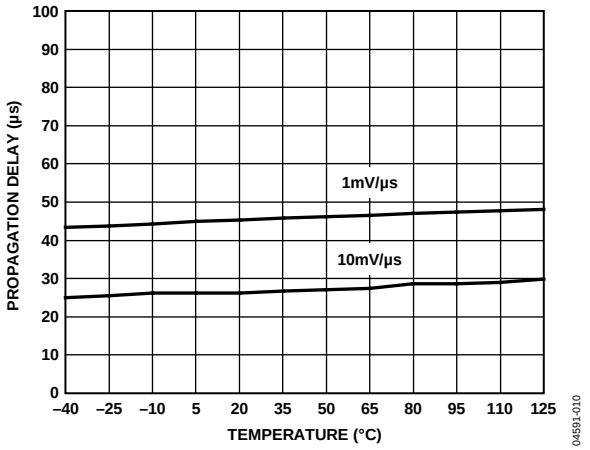


Figure 10. $V_{CC}$ Falling Propagation Delay vs. Temperature

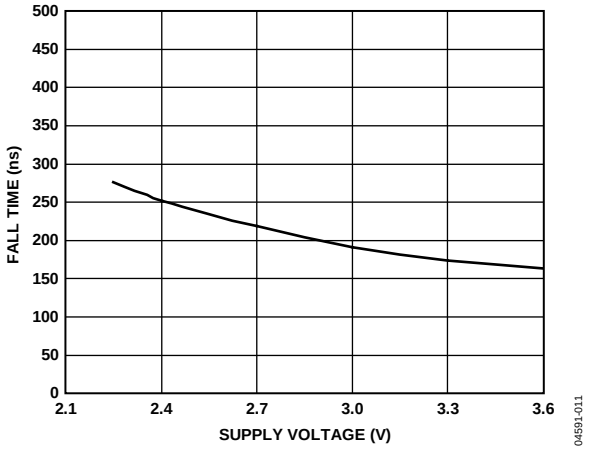


Figure 11. Output Fall Time vs. Supply Voltage

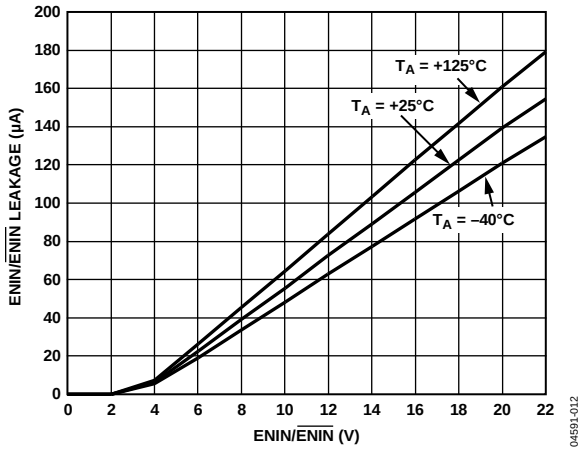


Figure 12. ENIN/$\overline{ENIN}$ Leakage Current vs. ENIN/$\overline{ENIN}$ Voltage

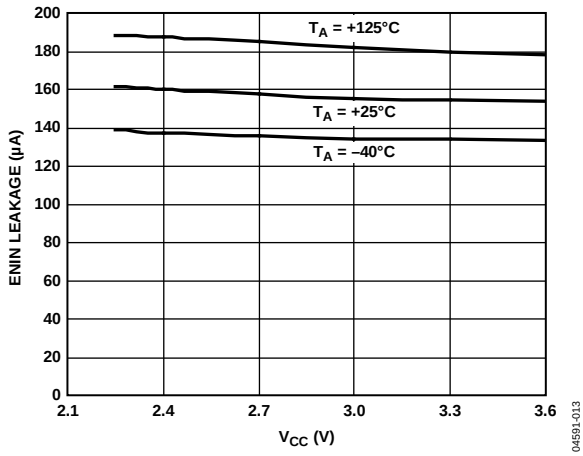


Figure 13. ENIN/$\overline{ENIN}$ Leakage Current vs. $V_{CC}$ Voltage

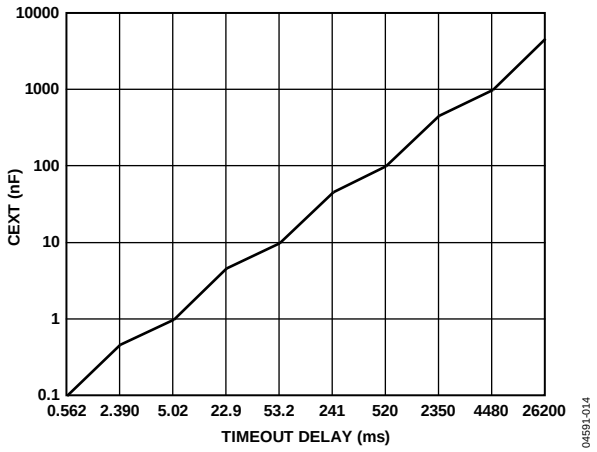


Figure 14. CEXT Capacitance vs. Timeout Delay

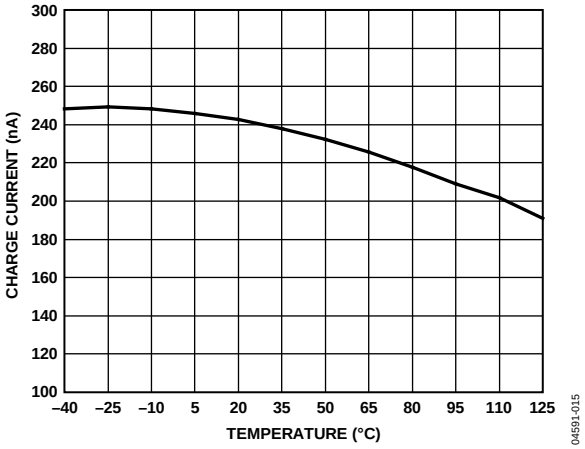


*Figure 15. CEXT Charge Current vs. Temperature*

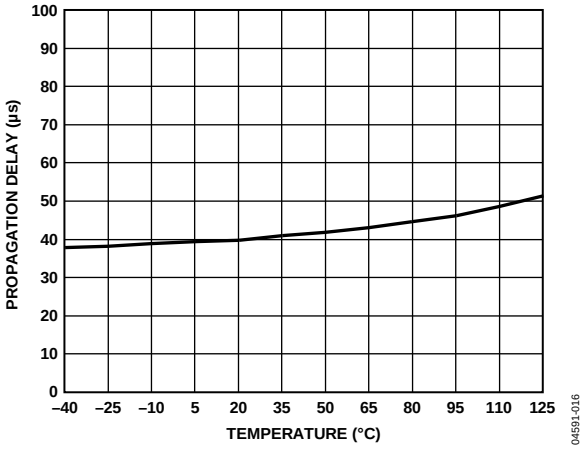


*Figure 16. $V_{IN}$ to ENOUT/$\overline{ENOUT}$ Propagation Delay (CEXT Floating) vs. Temperature*

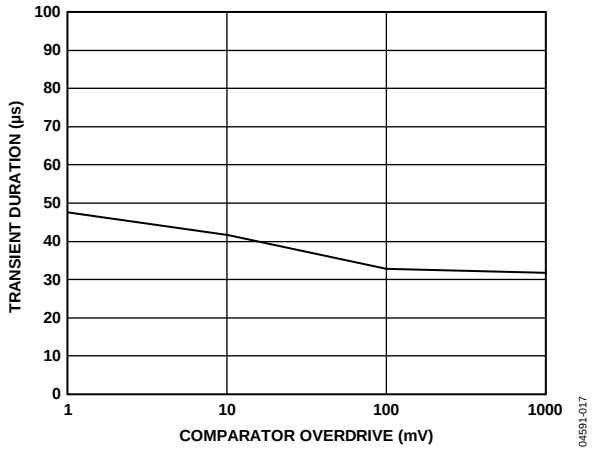


*Figure 17. Maximum $V_{IN}$ Transient Duration vs. Comparator Overdrive*

# CIRCUIT INFORMATION

## TIMING CHARACTERISTICS AND TRUTH TABLES

The enable outputs of the ADM1085/ADM1086/ADM1087 are related to the $V_{IN}$ and enable inputs by a simple AND function. The enable output is asserted only if the enable input is asserted and the voltage at $V_{IN}$ is above $V_{TH\_RISING}$, with the time delay elapsed. Table 5 and Table 6 show the enable output logic states for different $V_{IN}$/enable input combinations when the capacitor delay has elapsed. The timing diagrams in Figure 18 and Figure 19 give a graphical representation of how the ADM1085/ADM1086/ADM1087 enable outputs respond to $V_{IN}$ and enable input signals.

**Table 5. ADM1085/ADM1086 Truth Table**

| $V_{IN}$ | ENIN | ENOUT |
|---|---|---|
| $<V_{TH\_FALLING}$ | 0 | 0 |
| $<V_{TH\_FALLING}$ | 1 | 0 |
| $>V_{TH\_RISING}$ | 0 | 0 |
| $>V_{TH\_RISING}$ | 1 | 1 |

**Table 6. ADM1087 Truth Table**

| $V_{IN}$ | $\overline{ENIN}$ | $\overline{ENOUT}$ |
|---|---|---|
| $<V_{TH\_FALLING}$ | 1 | 1 |
| $<V_{TH\_FALLING}$ | 0 | 1 |
| $>V_{TH\_RISING}$ | 1 | 1 |
| $>V_{TH\_RISING}$ | 0 | 0 |

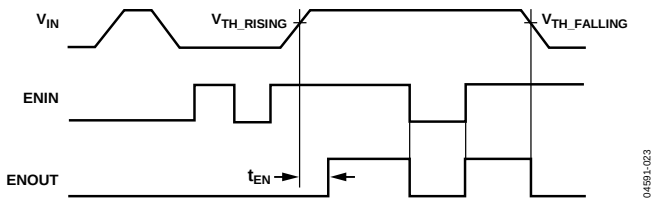


*Figure 18. ADM1085/ADM1086 Timing Diagram*

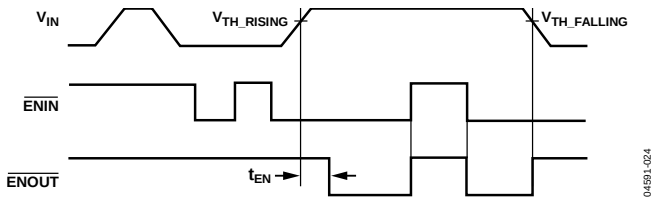


*Figure 19. ADM1087 Timing Diagram*

When $V_{IN}$ reaches the upper threshold voltage ($V_{TH\_RISING}$), an internal circuit generates a delay ($t_{EN}$) before the enable output is asserted. If $V_{IN}$ drops below the lower threshold voltage ($V_{TH\_FALLING}$), the enable output is deasserted immediately.

Similarly, if the enable input is disabled while $V_{IN}$ is above the threshold, the enable output deasserts immediately. Unlike $V_{IN}$, a low-to-high transition on ENIN (or high-to-low on $\overline{ENIN}$) does not yield a time delay on ENOUT ($\overline{ENOUT}$).

## CAPACITOR-ADJUSTABLE DELAY CIRCUIT

Figure 20 shows the internal circuitry used to generate the time delay on the enable output. A 250 nA current source charges a small internal parasitic capacitance ($C_{INT}$). When the capacitor voltage reaches 1.2 V, the enable output is asserted. The time taken for the capacitor to reach 1.2 V, in addition to the propagation delay of the comparator, constitutes the enable timeout, which is typically 35 µs.

To minimize the delay between $V_{IN}$ falling below $V_{TH\_FALLING}$ and the enable output deasserting, an NMOS transistor is connected in parallel with $C_{INT}$. The output of the voltage detector is connected to the gate of this transistor so that, when $V_{IN}$ falls below $V_{TH\_FALLING}$, the transistor switches on and $C_{INT}$ discharges quickly.

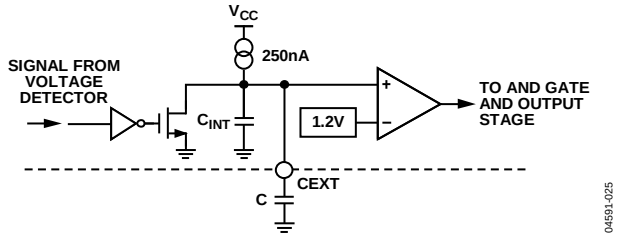


*Figure 20. Capacitor-Adjustable Delay Circuit*

Connecting an external capacitor to the CEXT pin delays the rise time—and therefore the enable timeout—further. The relationship between the value of the external capacitor and the resulting timeout is characterized by the following equation:

$$t_{EN} = (C \times 4.8 \times 10^6) + 35\ \mu s$$

where:
$C$ is expressed in farads (F), and
$t_{EN}$ is expressed in seconds (sec).

## OPEN-DRAIN AND PUSH-PULL OUTPUTS

The ADM1085 and ADM1087 have open-drain output stages that require an external pull-up resistor to provide a logic high voltage level. The geometry of the NMOS transistor enables the output to be pulled up to voltage levels as high as 22 V.

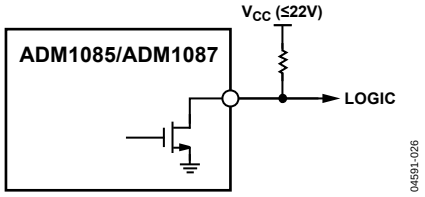


*Figure 21. Open-Drain Output Stage*

The ADM1086 has a push-pull (CMOS) output stage that requires no external components to drive other logic circuits. An internal PMOS pull-up transistor provides the logic high voltage level.

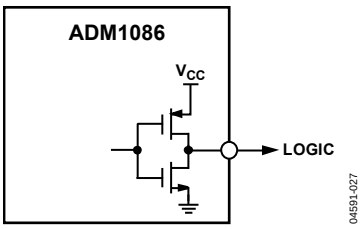


*Figure 22. Push-Pull Output Stage*

# APPLICATION INFORMATION

## SEQUENCING CIRCUITS

The ADM1085/ADM1086/ADM1087 are compatible with voltage regulators and dc-to-dc converters that have active high or active low enable or shutdown inputs, with a choice of open-drain or push-pull output stages. Figure 23 to Figure 25 illustrate how each of the ADM1085/ADM1086/ADM1087 simple sequencers can be used in multiple-supply systems, depending on which regulators are used and which output stage is preferred.

In Figure 23, three ADM1085s are used to sequence four supplies on power-up. Separate capacitors on the CEXT pins determine the time delays between enabling of the 3.3 V, 2.5 V, 1.8 V, and 1.2 V supplies. Because the dc-to-dc converters and ADM1085s are connected in a cascade, and the output of any converter is dependent on that of the previous one, an external controller can disable all four supplies simultaneously by disabling the first dc-to-dc converter in the chain.

For power-down sequencing, an external controller dictates when the supplies are switched off by accessing the ENIN inputs individually.

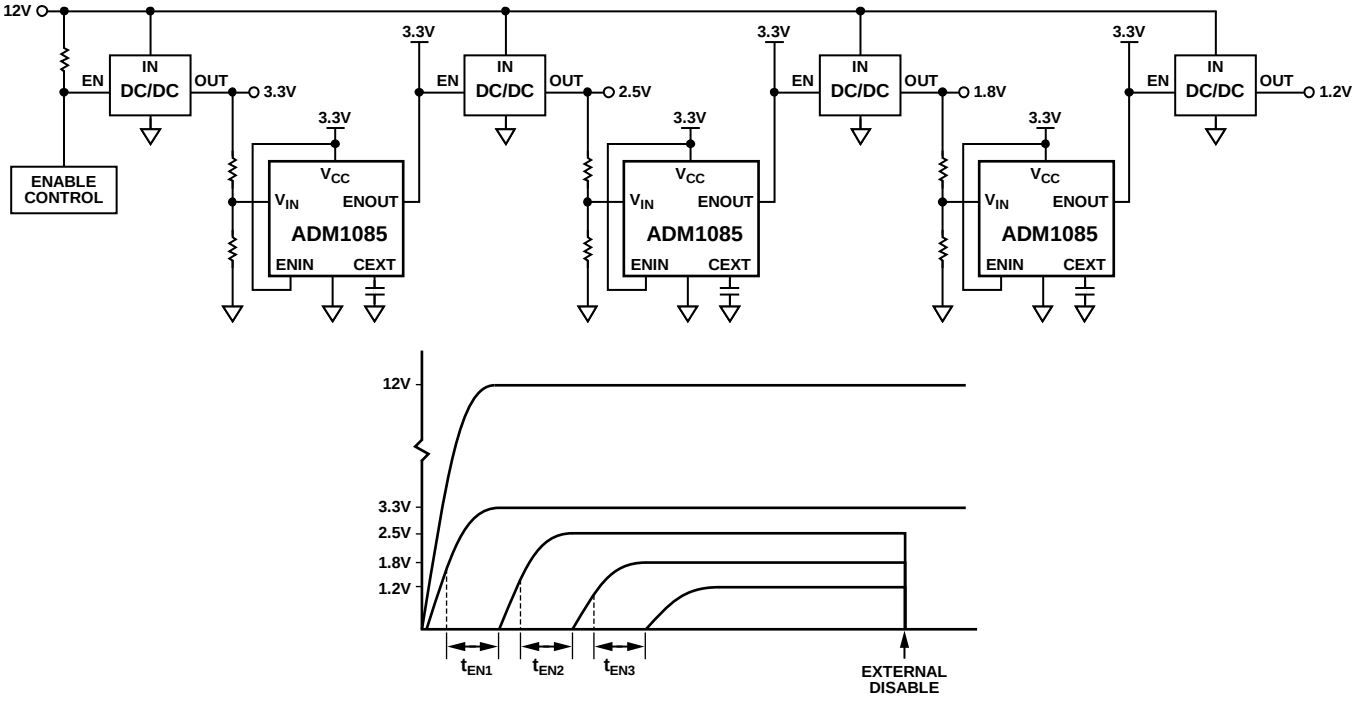


*Figure 23. Typical ADM1085 Application Circuit*

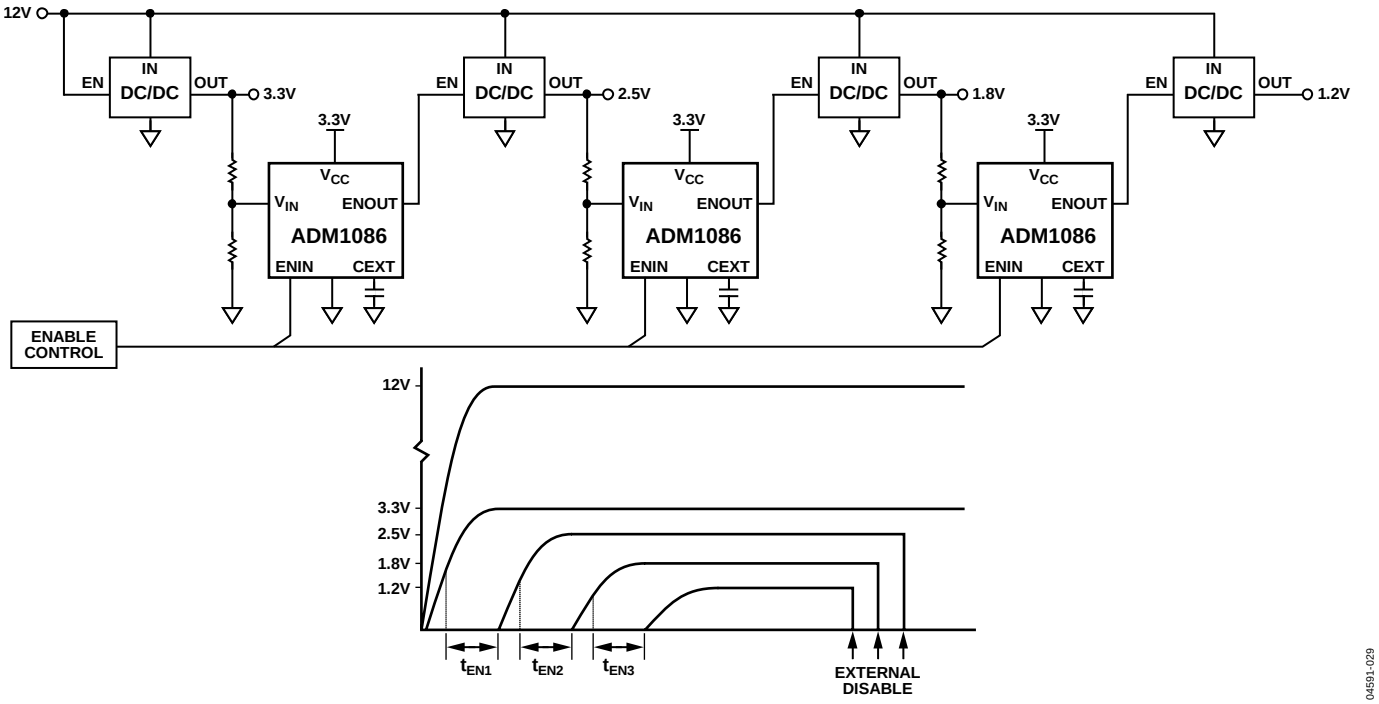


*Figure 24. Typical ADM1086 Application Circuit*

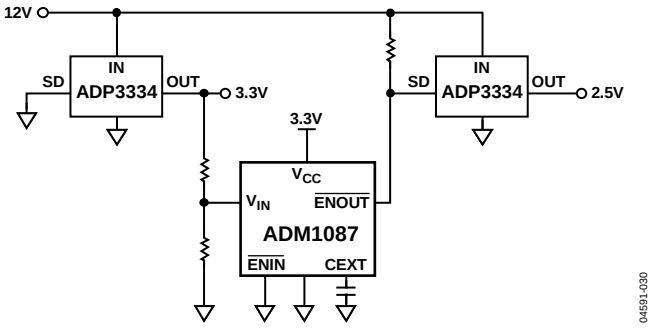


*Figure 25. Typical ADM1087 Application Circuit Using ADP3334 Voltage Regulators*

## DUAL LOFO SEQUENCING

A power sequencing solution for a portable device, such as a PDA, is shown in Figure 26. This solution requires that the microprocessor power supply turn on before the LCD display turns on, and that the LCD display power-down before the microprocessor powers down. In other words, the last power supply to turn on is the first one to turn off (LOFO).

An RC network connects the battery and the $\overline{SD}$ input of the ADP3333 voltage regulator. This causes power-up and power-down transients to appear at the $\overline{SD}$ input when the battery is connected and disconnected. The 3.3 V microprocessor supply turns on quickly on power-up and turns off slowly on power-down. This is due to two factors: Capacitor C1 charges up to 9 V on power-up and charges down from 9 V on power-down, and the $\overline{SD}$ pin has logic high and logic low input levels of 2 V and 0.4 V.

For the display power sequencing, the ADM1085 is equipped with Capacitor C2 to create the delay between the microprocessor and display power turning on. When the system is powered down, the ADM1085 turns off the display power immediately, while the 3.3 V regulator waits for C1 to discharge to 0.4 V before switching off.

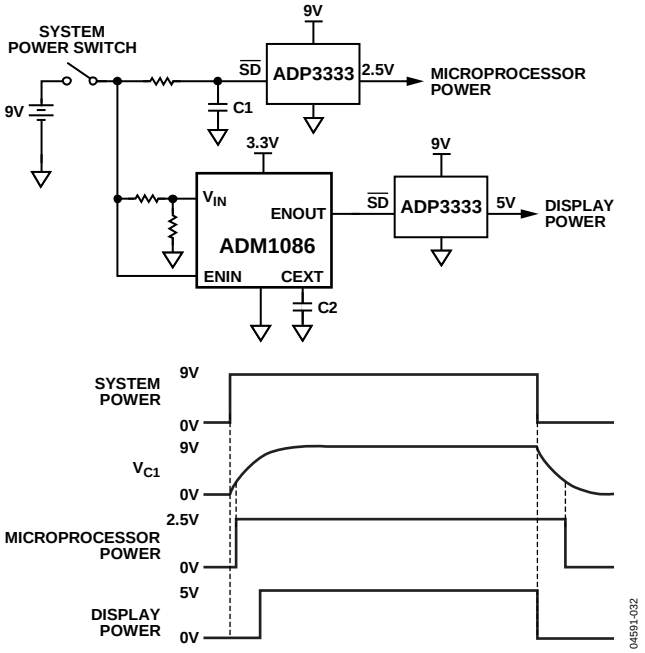


*Figure 26. Dual LOFO Power-Supply Sequencing*

## SIMULTANEOUS ENABLING

The enable output can drive multiple enable or shutdown regulator inputs simultaneously.

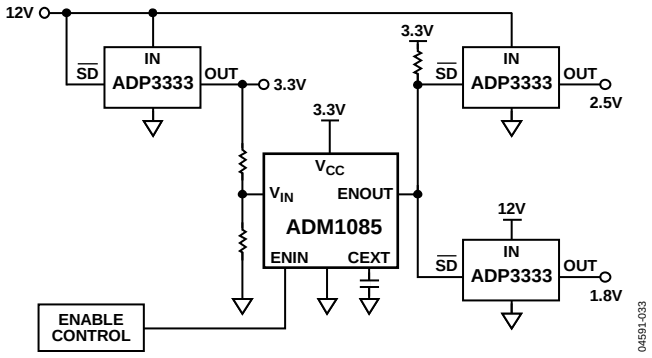


*Figure 27. Enabling a Pair of Regulators from a Single ADM1085*

## POWER GOOD SIGNAL DELAYS

Sometimes sequencing is performed by asserting power good signals when the voltage regulators are already on, rather than sequencing the power supplies directly. In these scenarios, a simple sequencer IC can provide variable delays so that enabling separate circuit blocks can be staggered in time.

For example, in a notebook PC application, a dedicated microcomputer asserts a power good signal for North Bridge™ and South Bridge™ ICs. The ADM1086 delays the South Bridge signal, so that it is enabled after the North Bridge.

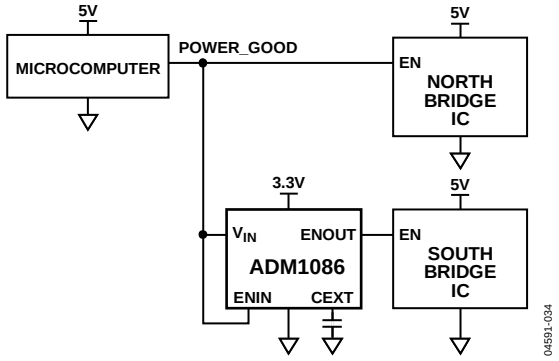


*Figure 28. Power Good Delay*

## QUAD-SUPPLY POWER GOOD INDICATOR

The enable output of the Simple Sequencers is equivalent to an AND function of $V_{IN}$ and ENIN. ENOUT is high only when the voltage at $V_{IN}$ is above the threshold and the enable input (ENIN) is high as well. Although ENIN is a digital input, it can tolerate voltages as high as 22 V and can detect if a supply is present. Therefore, a simple sequencer can monitor two supplies and assert what can be interpreted as a power good signal when both supplies are present. The outputs of two ADM1085s can be wire-AND'ed together to make a quad-supply power good indicator.

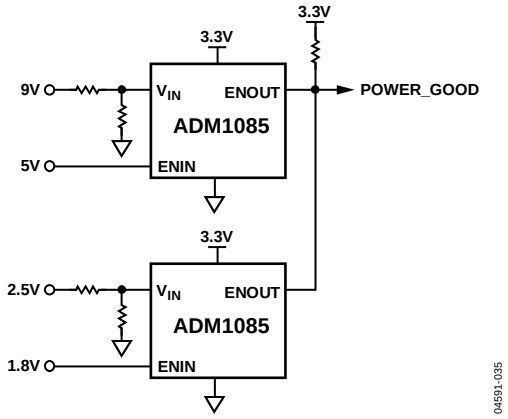


*Figure 29. Quad-Supply Power Good Indicator*

## SEQUENCING WITH FET SWITCHES

The open-drain outputs of the ADM1085 and ADM1087 can drive external FET transistors that can switch on power supply rails. All that is needed is a pull-up resistor to a voltage source that is high enough to turn on the FET.

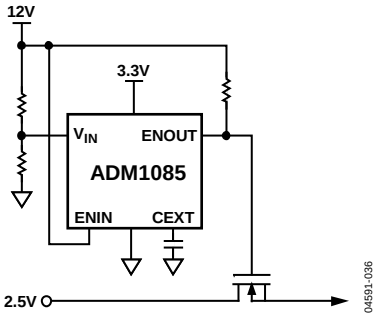


*Figure 30. Sequencing with a FET Switch*

# OUTLINE DIMENSIONS

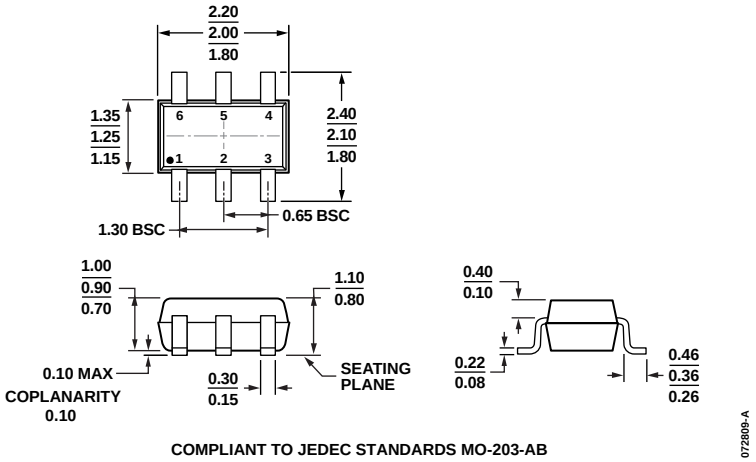


*Figure 31. 6-Lead Thin Shrink Small Outline Transistor Package [SC70]*
*(KS-6)*
*Dimensions shown in millimeters*

## ORDERING GUIDE

| Model[1] | Temperature Range | Ordering Quantity | Package Description | Package Option | Branding |
|---|---|---|---|---|---|
| ADM1085AKSZ-REEL7 | −40°C to +125°C | 3k | 6-Lead Thin Shrink Small Outline Transistor Package (SC70) | KS-6 | M7R |
| ADM1086AKSZ-REEL7 | −40°C to +125°C | 3k | 6-Lead Thin Shrink Small Outline Transistor Package (SC70) | KS-6 | M8M |
| ADM1087AKSZ-REEL7 | −40°C to +125°C | 3k | 6-Lead Thin Shrink Small Outline Transistor Package (SC70) | KS-6 | M7S |
| EVAL-ADM1087EBZ | | | Evaluation Board for the ADM1087 device. This board can also be used to evaluate the other devices in the family. Sample can be ordered separately. | | |

[1] Z = RoHS Compliant Part.

## NOTES


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