

**Application Note – Radiation Hardened
Point-of-Load Regulators,
MHP8564 / 8565 / 8566 / 8567**

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Introduction

The MHP856X are a series of Radiation Hard POL (Point-of-Load), non-isolated buck (switching) regulators. The salient features of each type are summarized in the table below. Please see the individual datasheets for exact part number and for package information.

Part Type	Salient Feature	Supply Voltage	Vout	Iout Max
MHP8565A	smallest	5 V	1 to ~4 V	3.5 A
MHP8565P *	smallest, parallelable	5 V	1 to ~4 V	3.5 A
MHP8564A	adjustable	5 V	1 to ~4 V	4.5 A
MHP8564S	parallelable	5 V	1 to ~4 V	4.5 A
MHP8564F	fixed	5 V	1 to ~4 V	4.5 A
MHP8564R	remote sense	5 V	1 to ~4 V	4.5 A
MHP8566A	quad	5 V	1 to ~4 V	18 A
MHP8567A	quad	12 V	1 to ~10 V	18 A

*Under Development

General Application Information

There are eight sections in this note. Please refer to the applicable portion for proper application information.

Section 1
MHP8565A adjustable regulator application information – Figures 1 and 2.

Section 2
MHP8564A adjustable regulator application information – Figures 3 and 2.

Section 3
MHP8564F fixed output Voltage regulator application information – Figure 4

Section 4
MHP8564R remote sense fixed output application information – Figure 5

Section 5
MHP8564S synchronizable regulator application information – Figures 6 and 2.

Section 6
MHP8566A quad parallelable 5 V regulator application information – Figures 7 and 2.

Section 7
MHP8567A quad parallelable 12 V regulator application information – Figures 8 and 2.

Section 8
Soft start application information – Figure 9.

Section 1 – Application Information, MHP8565A adjustable 3.5 Amp POL

The MHP8565A consists of a PWM integrated circuit surrounded by some of the components required for operation as a POL (Point of Load) regulator, generating output Voltages in the 1-4 Volt area from a 5 V supply. Figure 1 shows a typical application circuit.

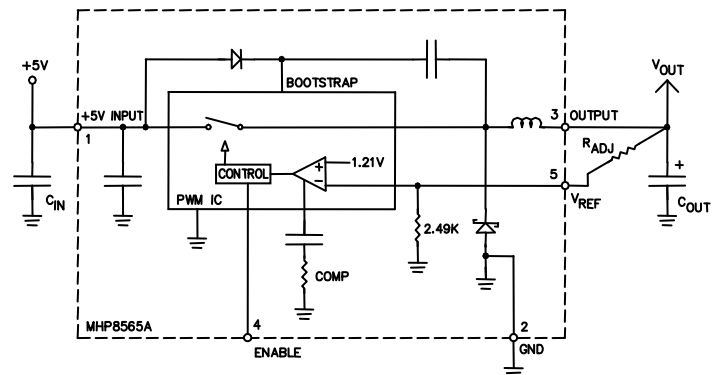
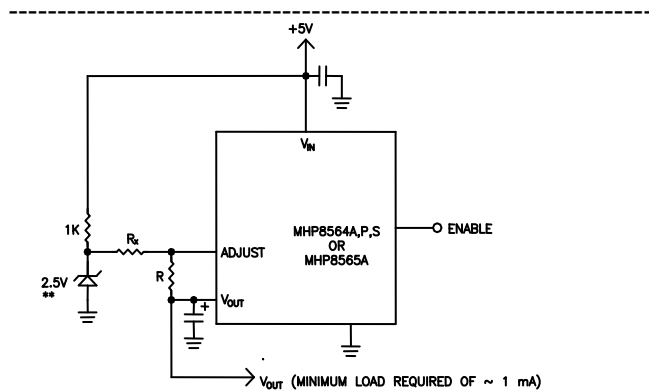


Figure 1 – 8565A Connections - With R_{ADJ} = 2670 ohms, V_{out} = 2.5V

Pin Functions, MHP8565A

- Pin 1, input Voltage- Pin 1 provides power to run the internal electronics, as well as current to be switched by the regulator’s series switch. Because this regulator runs at ~500 kHz, the on/off switch times are fast. This leads to electrically noisy operation unless leads are kept short, and low impedance capacitors are used for noise decoupling. Ceramic capacitors are recommended, 10 – 50 uF.
- Pin 2, ground. This must be connected to circuit ground with as short a connection as possible.
- Pin 3, output. The output pin supplies the output Voltage (as long as the required current is within the regulator’s capability). This pin also helps the regulator maintain stability. The ESR of the capacitor combination needs to be in the range between 50 mOhms and 200 mOhms. Two each CWR29FC227 in parallel is recommended.
- Pin 4, enable. The Enable pin must be below 130 mV in order to disable operation. On the other hand, the applied Voltage must be above 2.5 V to enable operation (<7 V max).
- Pin 5, output Voltage set.
 - For output Voltages between 1.21 V and ~ 4 V, a resistor between pin 5 and pin 3 determines the output Voltage according to the following formula.
 $V_{out} = 1.21 \times (1 + R_{adj} / 2490)$
 - For output Voltages between 1 and 1.21 V, see figure 2.



Rx Value	
Model	Rx
8564A	868Ω
8564F	N/A
8564R	N/A
8564P	1.29K
8564S	1.29K
8565A	868Ω
8565P	1.29K
8566A	1.29K
8567A	1.29K

Figure 2 – Circuit for Creating Regulated Output Voltages below 1.21 Volts

$$V_{out} = 1.21 - R \text{ (K-Ohms)}$$

Example: if R = 0.21K Ohms (210 Ohms), $V_{out} = 1.21 - 0.21 = 1.0V$, within the limits of the tolerances of the components used.

** RAD Hard Zener can be replaced with any convenient fixed voltage greater than ~ 2 volts. For any voltage other than 2.5V, resistor values would have to be adjusted accordingly.

Section 2 - Application Information, MHP8564A adjustable 4.5 Amp POL.

The MHP8564A consists of a PWM integrated circuit surrounded by some of the components required for operation as a POL (Point of Load) regulator, generating output Voltages in the 1-4 Volt area from a 5 V supply. Figure 3 shows a typical application circuit.

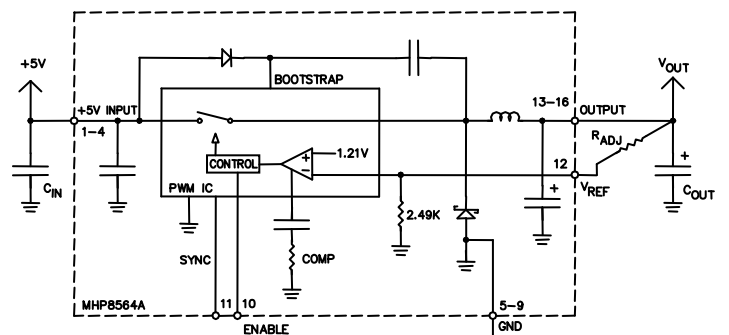


Figure 3 – 8564A Connections

With $R_{adj} = 2670$ ohms, $V_{out} = 2.5V$

Pin Functions, MHP8564A

- Pins 1-4, input Voltage- Pins 1-4 provide power to run the internal electronics, as well as current to be switched by the regulator's series switch. Because this regulator runs at ~ 500 kHz, the on/off switch times are fast. This leads to electrically noisy operation unless leads are kept short, and low impedance capacitors are used for noise decoupling. Ceramic capacitors are recommended, 10 – 50 μF .
- Pins 5-9, ground. These must be connected to circuit ground with as short a connection as possible.
- Pins 13-16, output. The output pins supply the output Voltage (as long as the required current is within the regulator's capability). These pins also help the regulator maintain stability. The ESR of the capacitor combination needs to be in the range between 50 mOhms and 200 mOhms. A single CWR29FC227 is recommended as there is an identical one inside the regulator package.
- Pin 10, enable. The Enable pin must be below 130 mV in order to disable operation. On the other hand, the applied Voltage must be above 2.5 V to enable operation (< 7 V max).
- Pin 12, output Voltage set.
 - For output Voltages between 1.21 V and ~ 4 V, a resistor between pin 12 and pin 13 determines the output Voltage according to the following formula.

$$V_{out} = 1.21 \times (1 + R_{adj} / 2490)$$
 - For output Voltages between 1 and 1.21 V, see figure 2.
- Pin 11, sync. The sync pin allows an external 5V PP logic signal to synchronize the regulator frequency, which is a nominal 500 kHz. This signal must be greater than 580 kHz but less than 1000 kHz. Above 700 kHz, caution must be

exercised due to potential waveform instability problems.

Section 3 - Application Information, MHP8564F fixed output Voltage 4.5 Amp POL

The MHP8564F consists of a PWM integrated circuit surrounded by some of the components required for operation as a POL (Point of Load) regulator, generating output Voltages in the 1-4 Volt area from a 5 V supply. Figure 4 shows a typical application circuit.

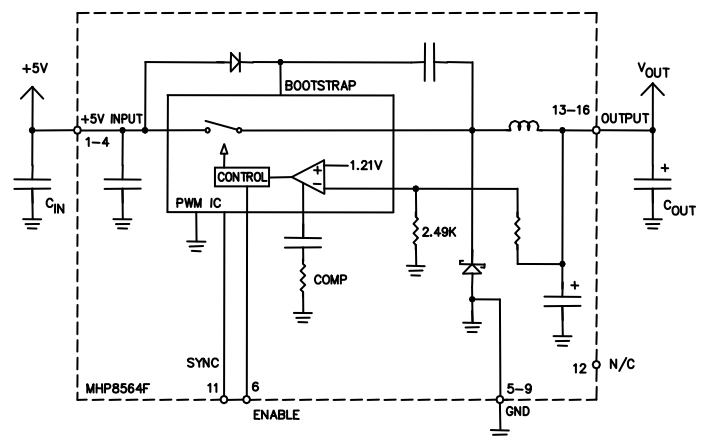


Figure 4 – 8564F Connections

Pin Functions, MHP8564F

- Pins 1-4, input Voltage- Pins 1-4 provide power to run the internal electronics, as well as current to be switched by the regulator's series switch. Because this regulator runs at ~ 500 kHz, the on/off switch times are fast. This leads to electrically noisy operation unless leads are kept short, and low impedance capacitors are used for noise decoupling. Ceramic capacitors are recommended, 10 – 50 μF .
- Pins 5-9, ground. These must be connected to circuit ground with as short a connection as possible.

- Pins 13-16, output. The output pins supply the output Voltage (as long as the required current is within the regulator's capability). These pins also help the regulator maintain stability. The ESR of the capacitor combination needs to be in the range between 50 mOhms and 200 mOhms. A single CWR29FC227 is recommended as there is an identical one inside the regulator package.
- Pin 10, enable. The Enable pin must be below 130 mV in order to disable operation. On the other hand, the applied Voltage must be above 2.5 V to enable operation (<7 V max).
- Pin 12, N/C
- Pin 11, sync. The sync pin allows an external 5V PP logic signal to synchronize the regulator frequency, which is a nominal 500 kHz. This signal must be greater than 580 kHz but less than 1000 kHz. Above 700 kHz, caution must be exercised due to potential waveform instability problems.

Section 4 - Application Information, MHP8564R remote sense 4.5 Amp POL

The MHP8564R consists of a PWM integrated circuit surrounded by some of the components required for operation as a POL (Point of Load) regulator, generating output Voltages in the 1-4 Volt area from a 5 V supply. Figure 5 shows a typical application circuit.

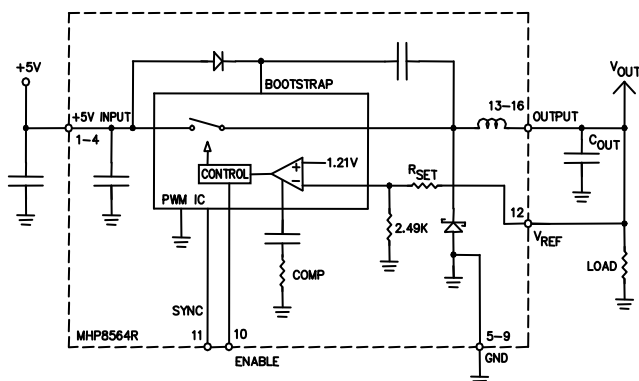


Figure 5 – 8564R Connections

Pin Functions, MHP8564R

- Pins 1-4, input Voltage- Pins 1-4 provide power to run the internal electronics, as well as current to be switched by the regulator's series switch. Because this regulator runs at ~500 kHz, the on/off switch times are fast. This leads to electrically noisy operation unless leads are kept short, and low impedance capacitors are used for noise decoupling. Ceramic capacitors are recommended, 10 – 50 uF.
- Pins 5-9, ground. These must be connected to circuit ground with as short a connection as possible.
- Pins 13-16, output. The output pins supply the output Voltage (as long as the required current is within the regulator's capability). These pins also help the regulator maintain stability. The ESR of the capacitor combination needs to be in the range between 50 mOhm and 200 mOhms. A single CWR29FC227 is recommended as there is an identical one inside the regulator package.
- Pin 10, enable. The Enable pin must be below 130 mV in order to disable operation. On the other hand, the applied Voltage must be above 2.5 V to enable operation (<7 V max).
- Pin 12, output Voltage remote sense.
- Pin 11, sync. The sync pin allows an external 5V PP logic signal to synchronize the regulator frequency, which is a nominal 500 kHz. This signal must be greater than 580 kHz but less than 1000 kHz. Above 700 kHz, caution must be exercised due to potential waveform instability problems.

Section 5 - Applications information, MHP8564S synchronizable 4.5 A POL

The MHP8564S consists of a PWM integrated circuit surrounded by some of the components required for operation as a POL (Point of Load) regulator, generating output Voltages in the 1-4 Volt area from a

5 V supply. Figure 6 shows a typical application circuit.

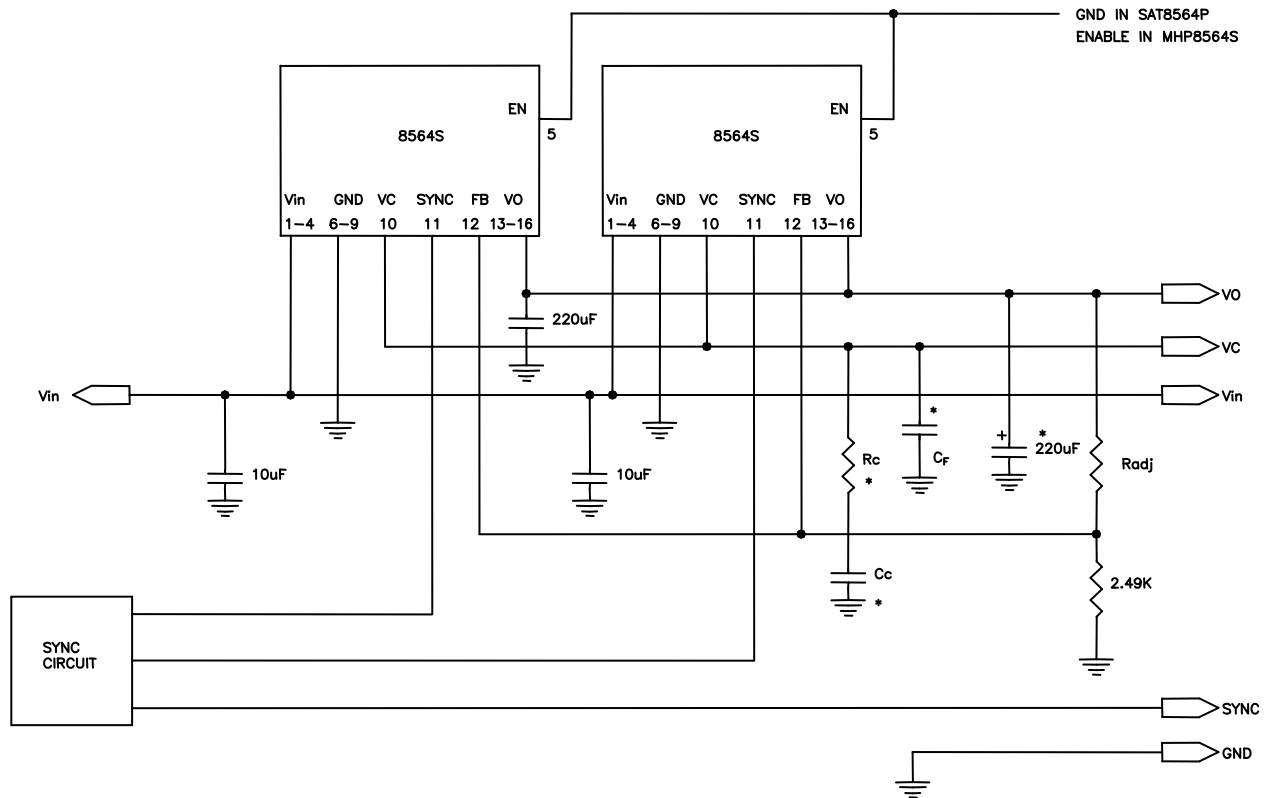


Figure 6 – Parallel Operation, 8564S

- When employing only electrolytic output capacitors, the simplest compensation is a capacitor whose value is $1.5nF$ times the number of paralleled units. However, a slightly more complex compensation of a resistor (R_c) of value $1.6 k\Omega$ divided by the number of units in parallel, in series with a capacitor (C_c) of value $3900pF$ times the number of units in parallel, all of which is in Parallel with a capacitor (C_f) of value $1000pf$ times the number of units in parallel, generally leads to smoother output transitions with less turn on overshoot. Output capacitors should be as shown in Figure 3, one ea CWR29FC227 per regulator.
- When employing ceramic output capacitors, the simplest compensation is a capacitor whose value is $22nF$ times the number of units in parallel. This may, however produce an overshoot at turn on. User should check to see that output turn-on, steady state, and transient behavior is acceptable with any chosen compensation scheme.

Pin Functions, MHP8564S

- Pins 1-4, input Voltage- Pins 1-4 provide power to run the internal electronics, as well as current to be switched by the regulator's series switch. Because this regulator runs at $\sim 500 kHz$, the on/off switch times are fast. This leads to electrically noisy operation unless leads are kept short, and low impedance capacitors are used for noise

decoupling. Ceramic capacitors are recommended, 10 – 50 uF.

- Pin 5, enable. The Enable pin must be below 130 mV in order to disable operation. On the other hand, the applied Voltage must be above 2.5 V to enable operation (<7 V max).
- Pins 6-9, ground. These must be connected to circuit ground with as short a connection as possible.
- Pins 13-16, output. The output pins supply the output Voltage (as long as the required current is within the regulator's capability). These pins also help the regulator maintain stability. The ESR of the capacitor combination needs to be in the range between 50 mOhms and 200 mOhms. A single CWR29FC227 per regulator is recommended as there is an identical one inside each regulator package.
- Pin 10, Vc, Compensation pin, but also used for paralleling. In this version of the MHP8564, the compensation components are not included internally, so they must be added externally. See figure 6.
- Pin 12, output Voltage set (feedback).
 - For output Voltages between 1.21 V and ~4 V, a resistor between pin 12 and pin 13

determines the output Voltage according to the following formula.

$$V_{out} = 1.21 \times (1 + R_{adj}/2490)$$

- For output Voltages between 1 and 1.21 V, see figure 2.
- Pin 11, sync. The sync pin allows an external 5V PP logic signal to synchronize the regulator frequency, which is a nominal 500 kHz. This signal must be greater than 580 kHz but less than 1000 kHz. Above 700 kHz, caution must be exercised due to potential waveform instability problems.

Section 6 - Application Information, MHP8566A quad 4.5 Amp POL for 5 V supplies.

The MHP8566A consists of four independent POL (point of load) regulators, each of which is essentially equivalent to an MHP8564S, generating output Voltages in the 1-4 Volt area from a 5 V supply. Each of these four regulators is parallelable with others in any combination required. Figure 7 shows a typical application circuit. The internal synchronizer triggers each of the four POLs at 90 degree intervals. Nominal PWM frequency is 583 kHz.

$$V_{out} = V_{ref} \times (1 + R_{adj} / 2490), \text{ with } V_{ref} \sim 1.21 \text{ Volts}$$

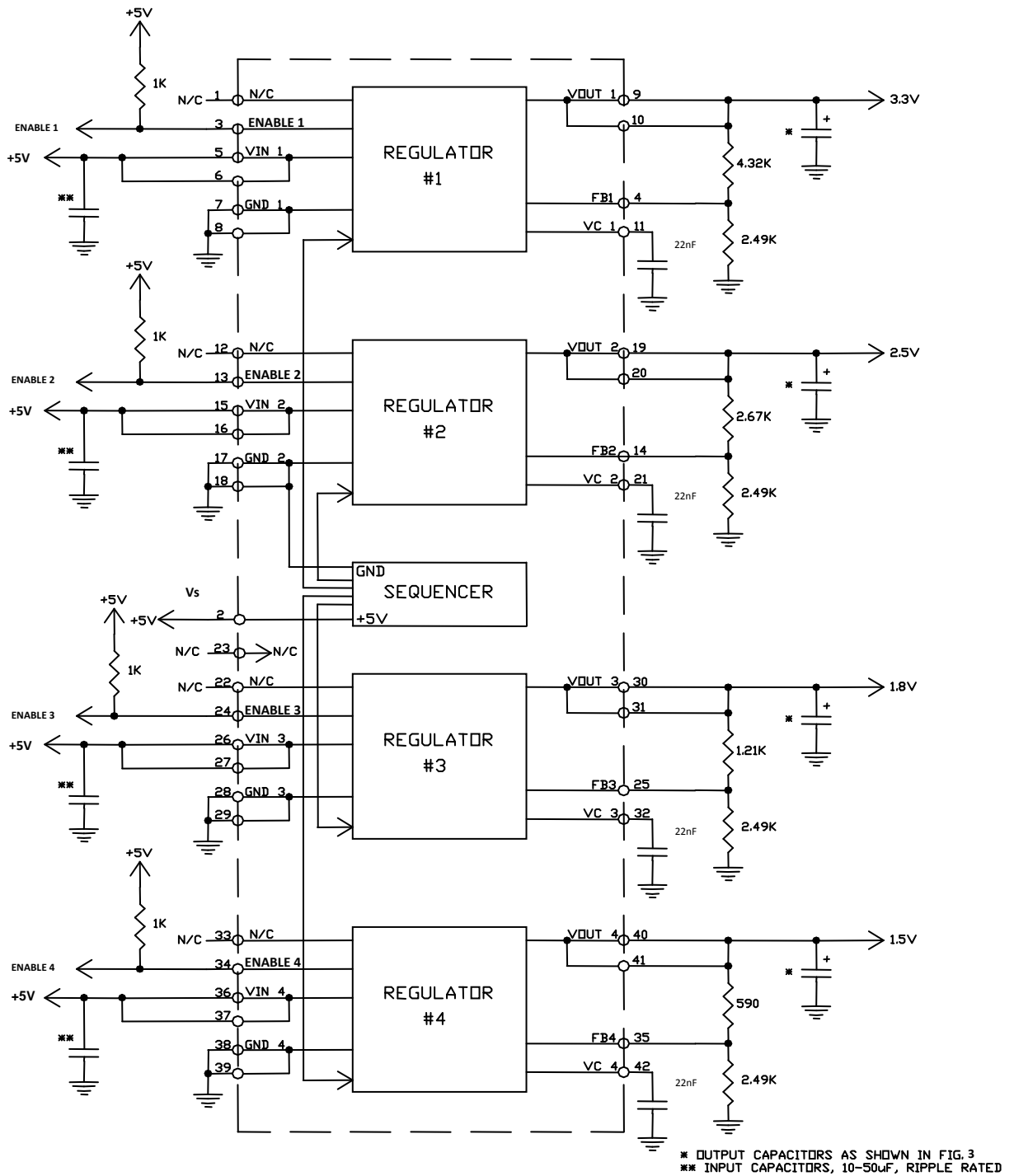


Figure 7 – 8566A Connections

Section 7 - Application Information, MHP8567A quad 4.5 Amp POL for 12 V supplies.

The MHP8567A consists of four independent POL (point of load) regulators, each of which is essentially equivalent to an MHP8564S, generating output Voltages in the 1-10 Volt area from a 12 V supply.

Each of these four regulators is parallelable with others in any combination required. Figure 8 shows a typical application circuit. The internal synchronizer triggers each of the four POLs at 90 degree intervals. Nominal PWM frequency is 583 kHz.

$$V_{out} = V_{ref} \times (1 + R_{adj} / 2490), \text{ with } V_{ref} \sim 1.21 \text{ Volts}$$

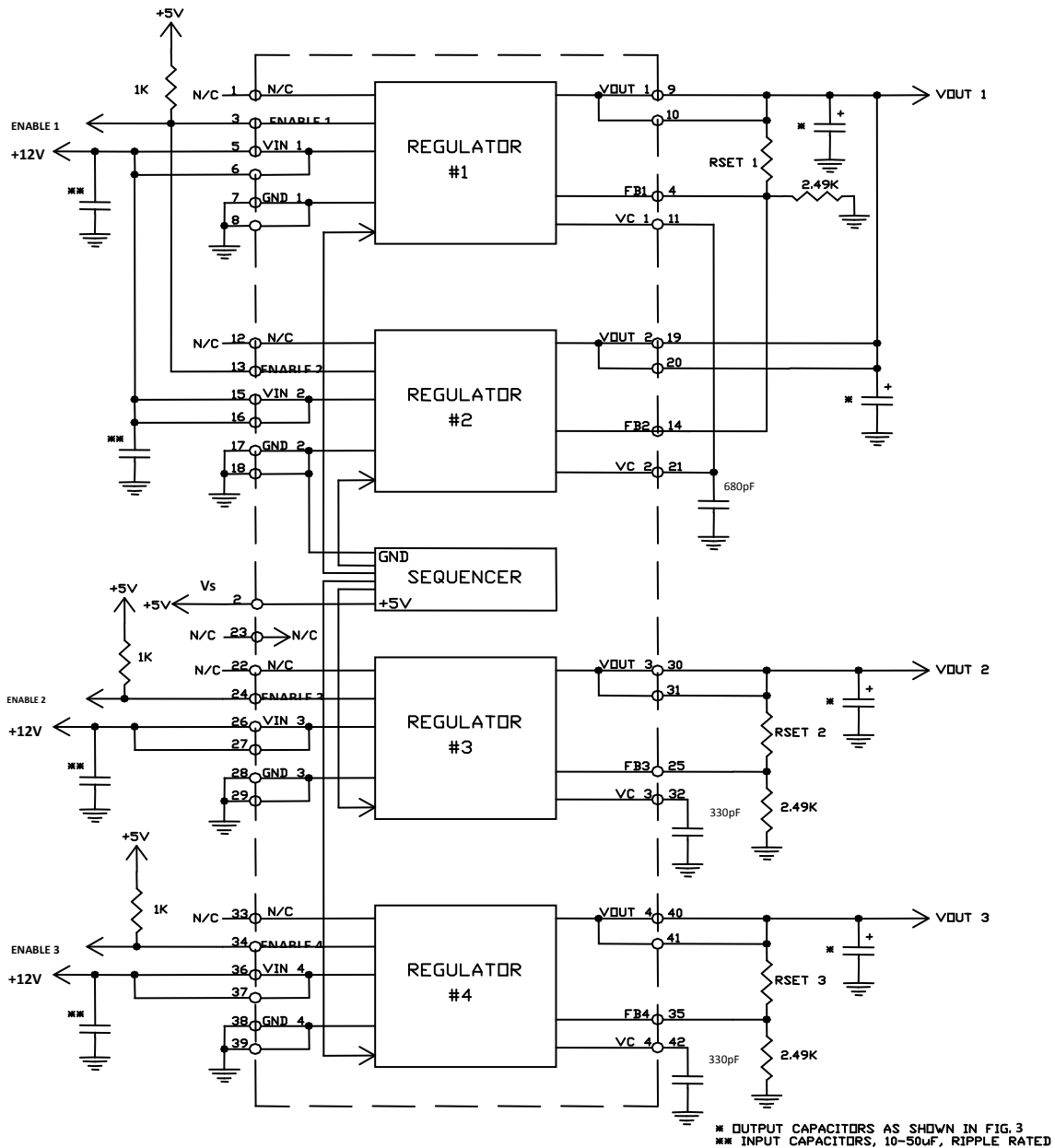
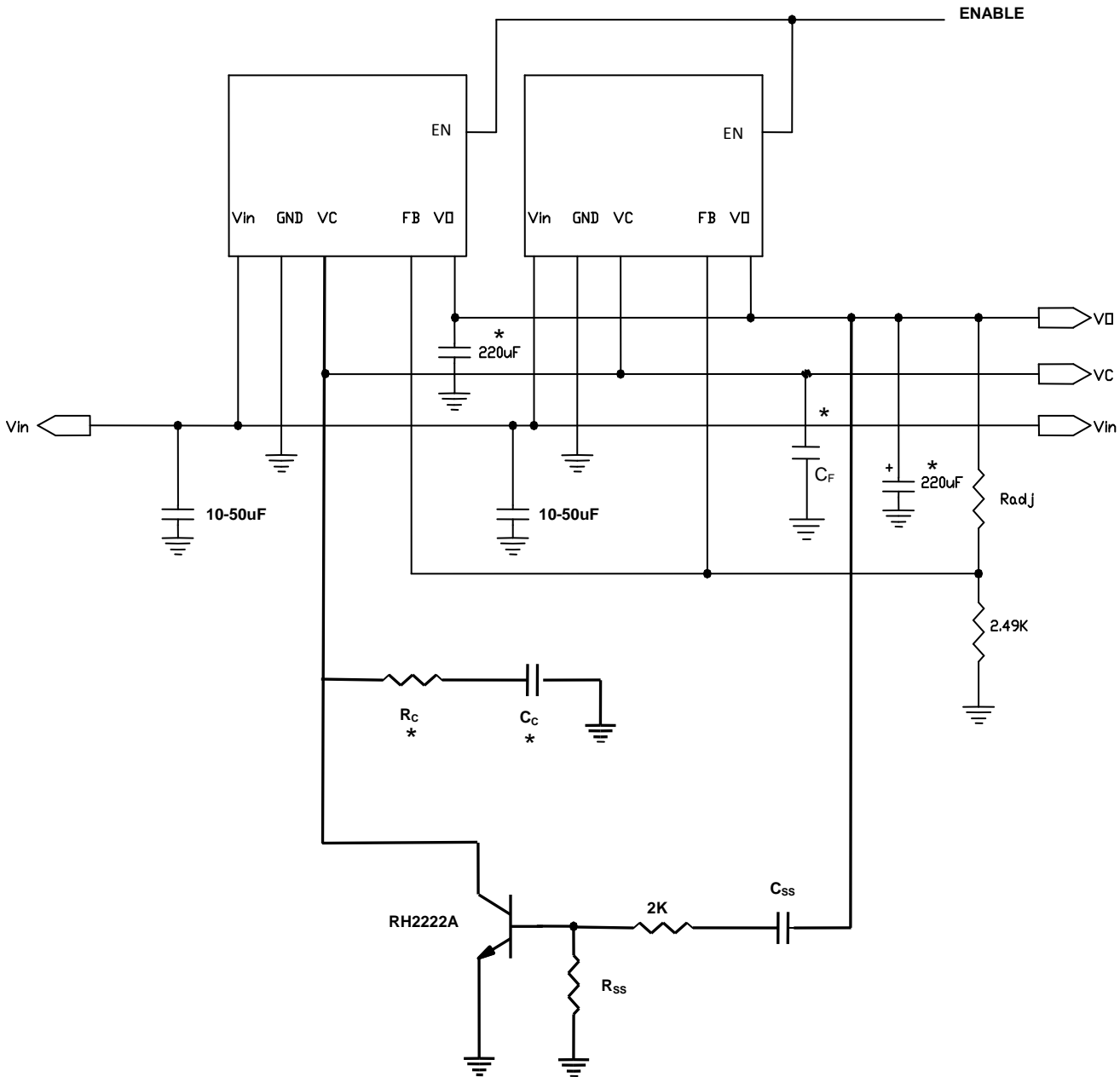


Figure 8 – 8567A Connections



* Consult applicable datasheet for values of these components. Some models have Rc and Cc included inside the package, and some do not.

$$\text{Rise Time} = \frac{(R_{ss})(C_{ss})(V_{out})}{0.7}$$

Example: with R_{ss} = 47K and C_{ss} = 15nF, Rise Time = 2.5ms for 2.5V output.

Figure 9 – Soft Start Implementation