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## Use of NCP81172 for Extended Output Voltage Range



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### Introduction

The NCP81172 is a general-purpose two-phase synchronous buck controller, which has a typical application circuit as shown in Figure 1 if PWM-VID function is not employed. In Figure 1, the voltage  $V_{REFIN}$  at REFIN pin is the reference voltage for regulation of output voltage  $V_{OUT}$ , i.e.  $V_{OUT} = V_{REFIN}$ .  $V_{REFIN}$  is always lower than the voltage  $V_{REF}$  having a typical value of 2 V. As a result of

### APPLICATION NOTE

that,  $V_{OUT}$  cannot be higher than 2 V. To support applications with extended output voltage range, an application solution is illustrated in this application note.

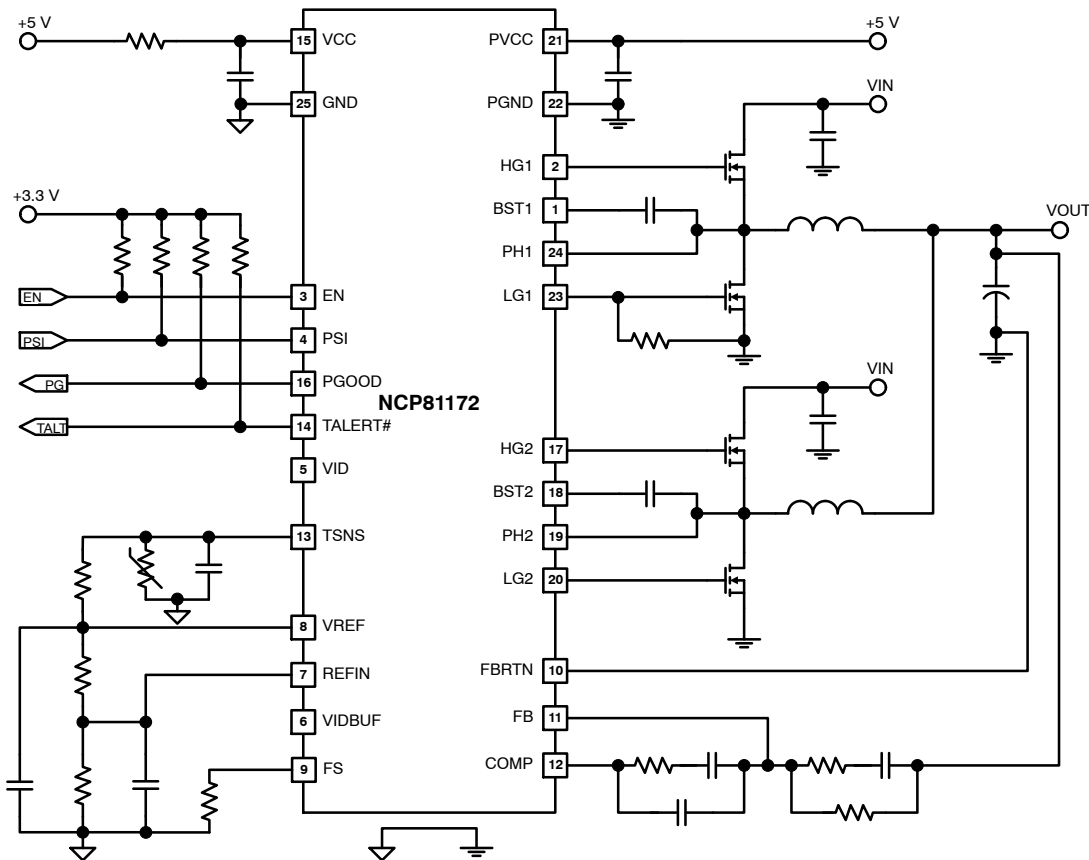


Figure 1. Typical Application Circuit for  $V_{OUT} < 2$  V

### Solution Description

Figure 2 shows a proposed solution for extended output voltage range. The major difference from the solution of Figure 1 is that an additional resistor  $R_{FB2}$  is applied between FB pin and FBRTN pin, which boosts output voltage to be higher than the voltage set at REFIN pin.

In steady-state operation, the voltage difference between REFIN and GND is equal to the voltage difference between FB and FBRTN. Hence, the output voltage  $V_{OUT}$  is given by

$$V_{OUT} = V_{REFIN} \cdot \frac{R_{FB1} + R_{FB2}}{R_{FB2}} \quad (\text{eq. 1})$$

where the REFIN voltage  $V_{REFIN}$  is set by the resistor divider at REFIN pin:

$$V_{REFIN} = V_{VREF} \cdot \frac{R_{VREF2}}{R_{VREF1} + R_{VREF2}} \quad (\text{eq. 2})$$

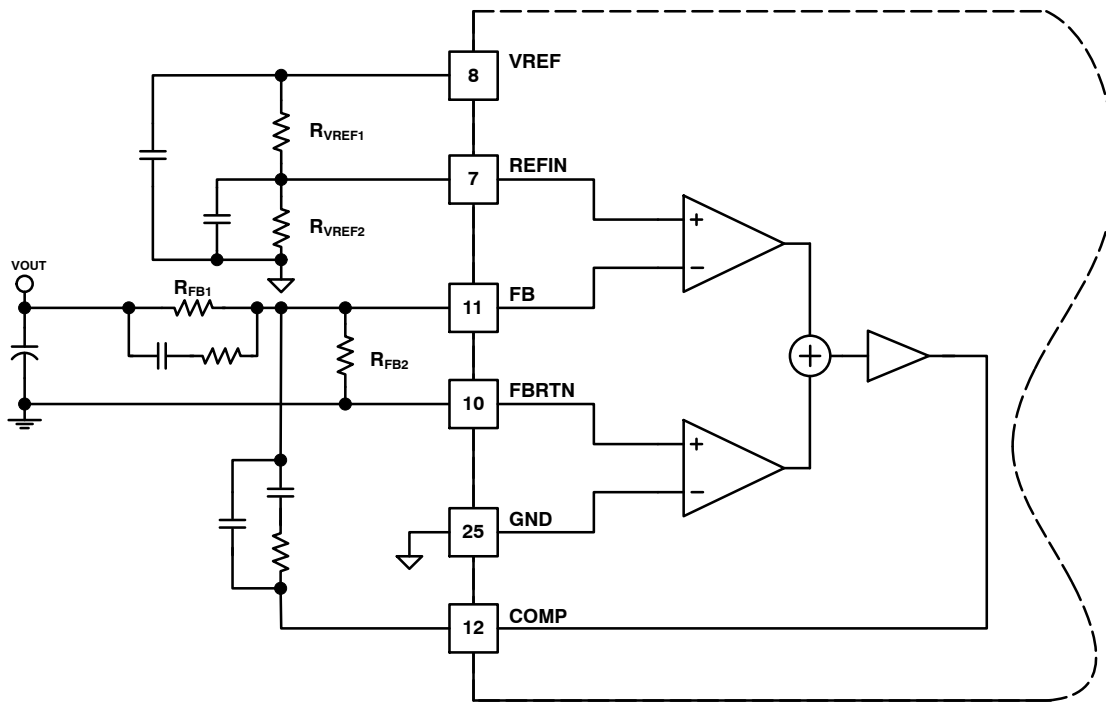


Figure 2. Application Circuit for Extended Output Voltage Range

One thing needs to mention, the NCP81172 is not designed for 2-phase applications in which conversion ratio  $V_{OUT}/V_{IN}$  is over 0.45. In another word,  $V_{IN}$  has to be higher than about 2.3 times of  $V_{OUT}$  in 2-phase mode to assure stable operation. However, the 1-phase operation does not have this limitation.

### Design Guideline

#### 1. REFIN Voltage Programming

The NCP81172 has an output over voltage protection function, which is based on voltage detection at FB pin. The over voltage threshold is equal to VREF having a typical value of 2 V. The maximum acceptable REFIN voltage can be defined by a predetermined over voltage threshold  $K_{OV}$ , e.g. 130%.

$$V_{REFIN} = \frac{V_{VREF}}{K_{OV}} \quad (\text{eq. 3})$$

Select resistance values for  $R_{VREF1}$  and  $R_{VREF2}$  to get the appropriate REFIN voltage, and make the total resistance value of the two resistors in a range from 5 k $\Omega$  to 50 k $\Omega$ .

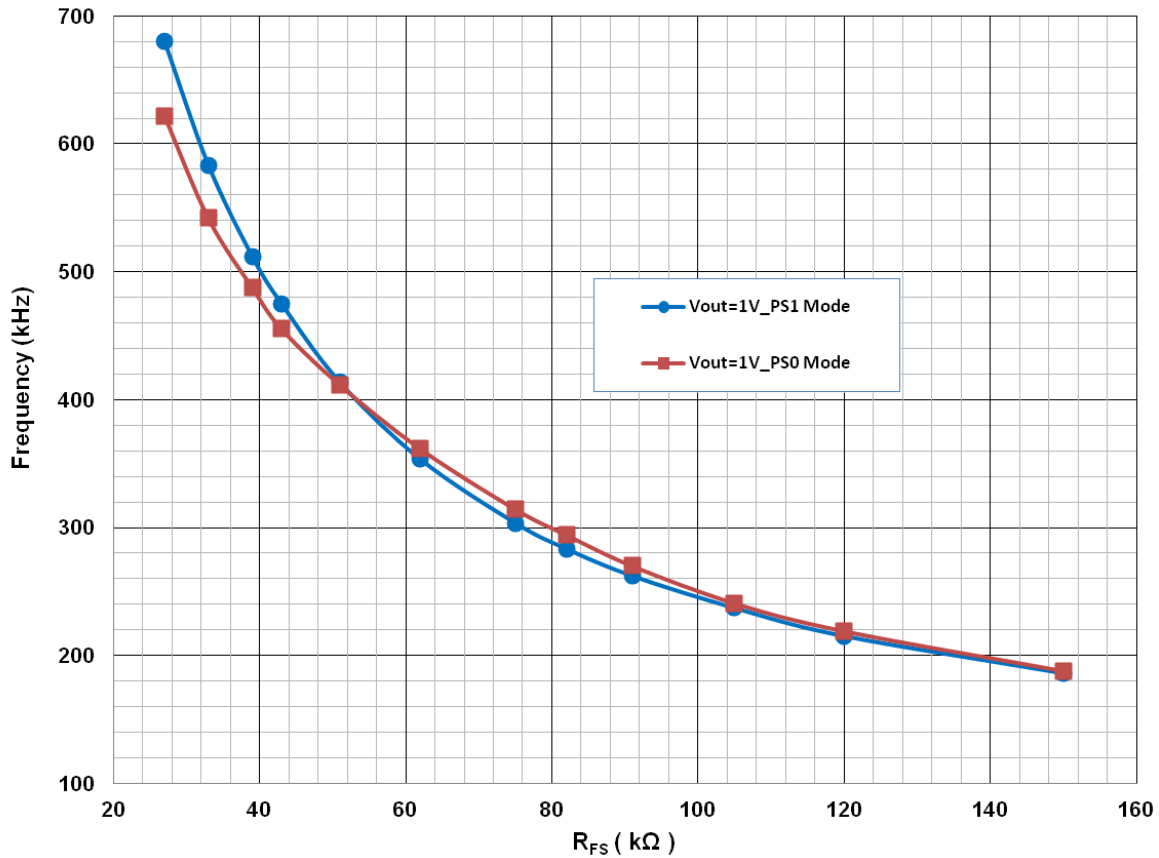
#### 2. Output Voltage Programming

After REFIN voltage is defined, the output voltage programming can be done by designing the feedback divider comprised of  $R_{FB1}$  and  $R_{FB2}$ . Usually  $R_{FB1}$  is arbitrarily selected in a range from 1 k $\Omega$  to 50 k $\Omega$ , and then  $R_{FB2}$  can be obtained by

$$R_{FB2} = R_{FB1} \cdot \frac{V_{REFIN}}{V_{OUT} - V_{REFIN}} \quad (\text{eq. 4})$$

#### 3. Switching Frequency Programming

Switching frequency of the NCP81172 is programmed by a resistor  $R_{FS}$  applied from FS pin to ground. The typical switching frequency range is from 200 kHz to 800 kHz. Figure 3 shows a measurement based on a typical application under a condition of  $V_{IN} = 12$  V,  $V_{OUT} = V_{REFIN} = 1.0$  V,  $I_{OUT} = 20$  A for PS0 mode operation (2-phase) and  $I_{OUT} = 10$  A for PS1 mode operation (1-phase).

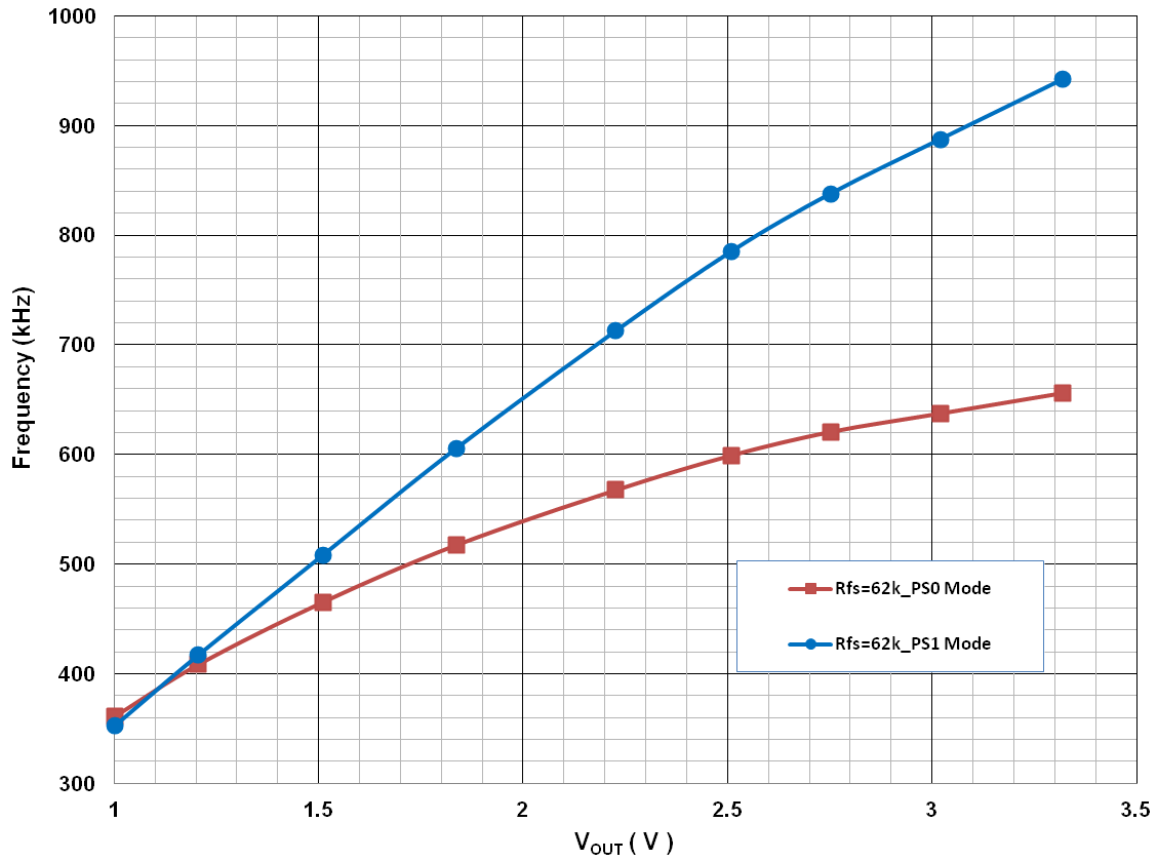


**Figure 3. Switching Frequency Programmed by  $R_{FS}$  under Condition of  $V_{OUT} = V_{REFIN} = 1.0$  V**

The PWM control of the NCP81172, ramp pulse modulation (RPM), is one kind of ripple regulators. The three major determinant factors for the average PWM on time are input supply voltage  $V_{IN}$ ,  $REFIN$  voltage  $V_{REFIN}$ , and frequency programming resistor  $R_{FS}$ . The NCP81172 has a built-in  $V_{IN}$  feedforward function in internal ramp signal in order to reduce frequency variation caused by variable supply voltage, and it is not a concern in this application note. In applications with  $V_{OUT} = V_{REFIN}$ , PWM on time is proportional to  $V_{OUT}$  such that frequency maintains quasi constant when  $V_{OUT}$  changes if  $R_{FS}$  is fixed. Due to this reason, Figure 3 can be used as a frequency

programming reference for applications with  $V_{OUT} = V_{REFIN}$ .

However, situation changes in applications where  $V_{OUT}$  regulation level is higher than  $V_{REFIN}$  level, i.e.  $V_{OUT} > V_{REFIN}$ . The PWM on time does not change much over  $V_{OUT}$  level programming by means of adjusting  $R_{FB}$  at FB pin without any change in either  $R_{FS}$  or  $V_{REFIN}$ , therefore, the higher  $V_{OUT}$  level the higher switching frequency. Figure 4 shows an exemplary measurement under a condition of  $V_{REFIN} = 1.0$  V,  $R_{FS} = 62$  k $\Omega$ , and  $V_{OUT}$  changing from 1.0 V to 3.3 V by adjusting  $R_{FB}$ .




**Figure 4. Switching Frequency Changes with V<sub>OUT</sub> Programming under Condition of V<sub>REFIN</sub> = 1.0 V and R<sub>FS</sub> = 62 kΩ**

To provide a guide for frequency programming in applications with V<sub>OUT</sub> > V<sub>REFIN</sub>, the switching frequency in PS0 mode operation (2-phase) can be estimated by

$$F_{SW(kHz)} = 6500 \cdot R_{FS(k\Omega)}^{-0.7} \cdot \left( \frac{V_{OUT}}{V_{REFIN}} \right)^{0.5} \quad (\text{eq. 5})$$

and the switching frequency in PS1 mode operation (1-phase) can be estimated by

$$F_{SW(kHz)} = 8500 \cdot R_{FS(k\Omega)}^{-0.77} \cdot \left( \frac{V_{OUT}}{V_{REFIN}} \right)^{0.83} \quad (\text{eq. 6})$$

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