Avoiding Audible Noise at Light Loads When Using Leading Edge Triggered PFC Converters

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ABSTRACT

This application note applies to the TI average current mode, leading edge modulation PFC controllers. See Applicable Device Table for part numbers.

When using a leading edge triggered PFC the designer may find that the converter, under extremely light-load conditions, will encounter an audible low noise.

The unit under these conditions can go into the Over Voltage Protection (OVP) state because of the extremely light load. When this happens, the output of the current error amplifier can fall to ground because of the input offset voltage variations and the residual current from MOUT.

When the unit comes out of the OVP state, the pulse width of the converter is going to start at a maximum. Because of the integrating nature of the error amplifier, these pulses will continue for a few milliseconds. This can cause the windings of the PFC inductor to physically oscillate resulting in a periodic burst of audible noise.

A single resistor from VREF to the positive input of the current error amplifier added to the circuit is sufficient to remove this problem.

The input offset voltage of the error amplifier and the multiplier zero current (IMOUT, zero current) are given in the data sheet. Divide the offset voltage by the value of the resistor connecting the positive input of the current error amplifier to ground and add to this the multiplier zero current.

This gives the current needed through the resistor to bias the positive input high under OVP conditions. Now divide the VREF voltage by this current to get the resistor needed to connect from VREF to the positive input of the current error amplifier.

The new resistor will bias the positive input high enough to keep the current error amplifier output high during OVP and because of the integrating nature of the current error amplifier, when OVP is released the unit will gradually increase the pulse width of the pulses as the current error amplifier output falls.

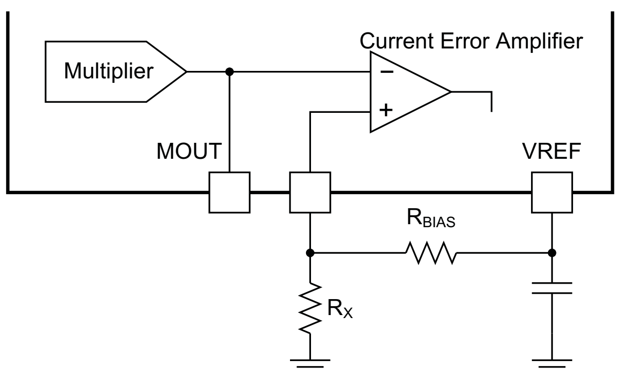

Figure 1. Schematic

Where R_X is the existing resistor from the positive input of the current error amplifier to ground,

$$I_{BIAS} = \left(\frac{V_{OFFSET}}{R_x} \right) \tag{1}$$

$$R_{BIAS} = \frac{V_{REF}}{(I_{BIAS} + I_{MOUT})} \tag{2}$$

where I_{MOUT} is at zero current

Select the nearest standard value lower than this for R_{BIAS}.

This additional resistor does add distortion at the zero crossing of the converter which might cause some problems in meeting the THD of certain designs.

With the addition of three resistors and a transistor it is possible to limit this distortion to extreme light load conditions. The schematic to accomplish this is shown below in Figure 2.

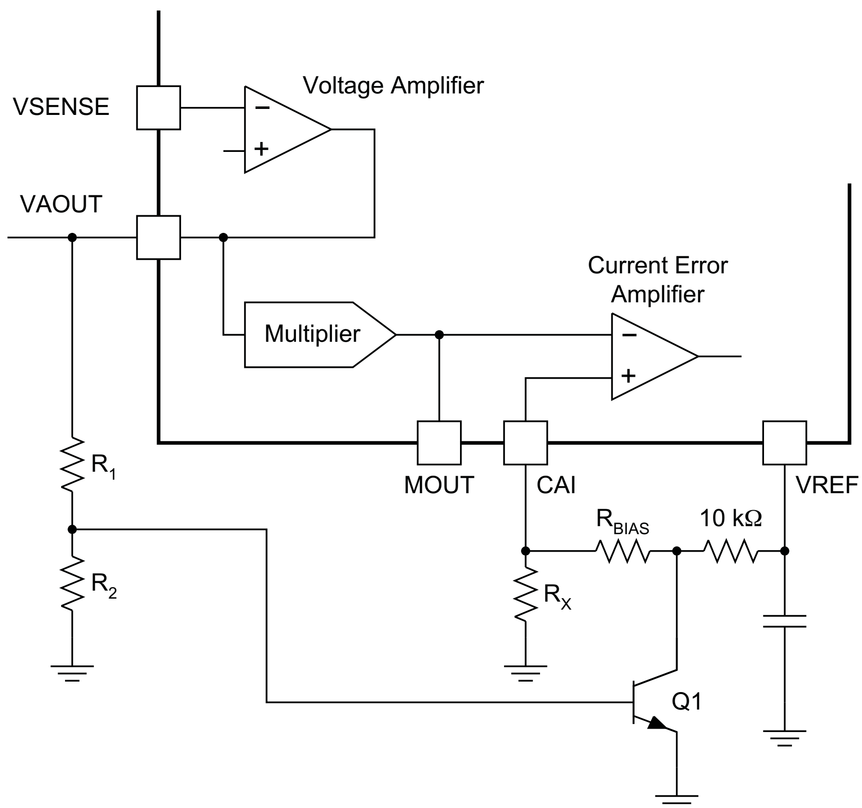

Figure 2. Circuit to Remove Chirp (without adding crossover distortion at nominal loads)

The operation of the circuit is best described with the help of the above schematic and a review of the multiplier equation.

$$I_{MOUT} = \frac{(I_{IAC} \times (V_{VAOUT} - 1))}{(V_{VFF}^{2} \times K)} \quad (3)$$

During operation as the output voltage increases the voltage on the VAOUT pin will decrease until at no load the voltage of VAOUT drops below 1 V as per the multiplier equation. At that point, from the multiplier equation, the circuit should be requiring no current.

By setting R1 and R2 so that their junction is slightly lower than the base-emitter junction voltage of Q1 with VAOUT equal to slightly greater than the 1-V level, the Q1 transistor is turned off and the collector voltage rises. This allows the application of the bias voltage to the CAI pin through the R_{BIAS} resistor.

When VAOUT goes higher as it will under any kind of significant load conditions, the Q1 transistor is turned on and the collector pulls the junction of R_{BIAS} and the 10-kΩ resistor to ground.

This removes the crossover distortion at any significant load that is present with the single resistor solution shown in Figure 1.

Table 1. Applicable Devices

BiCMOS Power Factor Preregulators		BiCMOS PFC/PWM Combination Controllers	
UCC2817	UCC2817A	UCC28500	UCC28510
UCC2818	UCC2818A	UCC28501	UCC28511
UCC2819	UCC2819A	UCC28502	UCC28512
UCC3817	UCC3817A	UCC28503	UCC28513
UCC3818	UCC3818A	UCC38500	UCC28514
UCC3819	UCC3819A	UCC38501	UCC28515
		UCC38502	UCC28516
		UCC38503	UCC28517

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