Application Report
SLAA787–September 2017

Multi-Device Configuration for TPA32xx Amplifiers

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ABSTRACT

The TPA32xx family of parts (TPA3244, TPA3245, TPA3250, TPA3251, TPA3255, and TPA3221) comes equipped with functionality to simplify systems with multiple Class-D amplifiers. Class-D amplifiers use pulse-width modulation (PWM) switching (450 kHz – 600 kHz), which are discrete packets of energy, to deliver large amounts of output power at a very high efficiency. However, issues can arise if multiple Class-D amplifiers switch simultaneously, but are not synchronized and managed. Issues include:

- *Power Supply Overloading* resulting from all amplifiers switching on the same edge, causing the supply to droop or sag below the regulated voltage.
- *Beat Interference* or *Beat Tones* are audible tones that occur when slightly misaligned switching frequencies interact to create another frequency.

The oscillator sync pins allow multiple devices to share a common clock and draw power on different phases to improve performance. Different phases reduce power supply loading during the switch cycles. Sharing a clock improves performance by preventing beat tones.

The $\overline{\text{Clip/OTW}}$ and FAULT signal lines are configured so multiple lines can be tied together to simplify circuitry. While not required, these functionalities have several benefits that can reduce complexity and improve the performance of your audio system.

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1 Oscillator Sync Pins

The TPA32xx family has OSC_IOM and OSC_IOP pins dedicated to synchronize multiple devices on a common clock. In this setup, one device acts as a master and the rest of the devices act as slaves. In addition, a delay is applied to the positive edge of the slave device PWM.

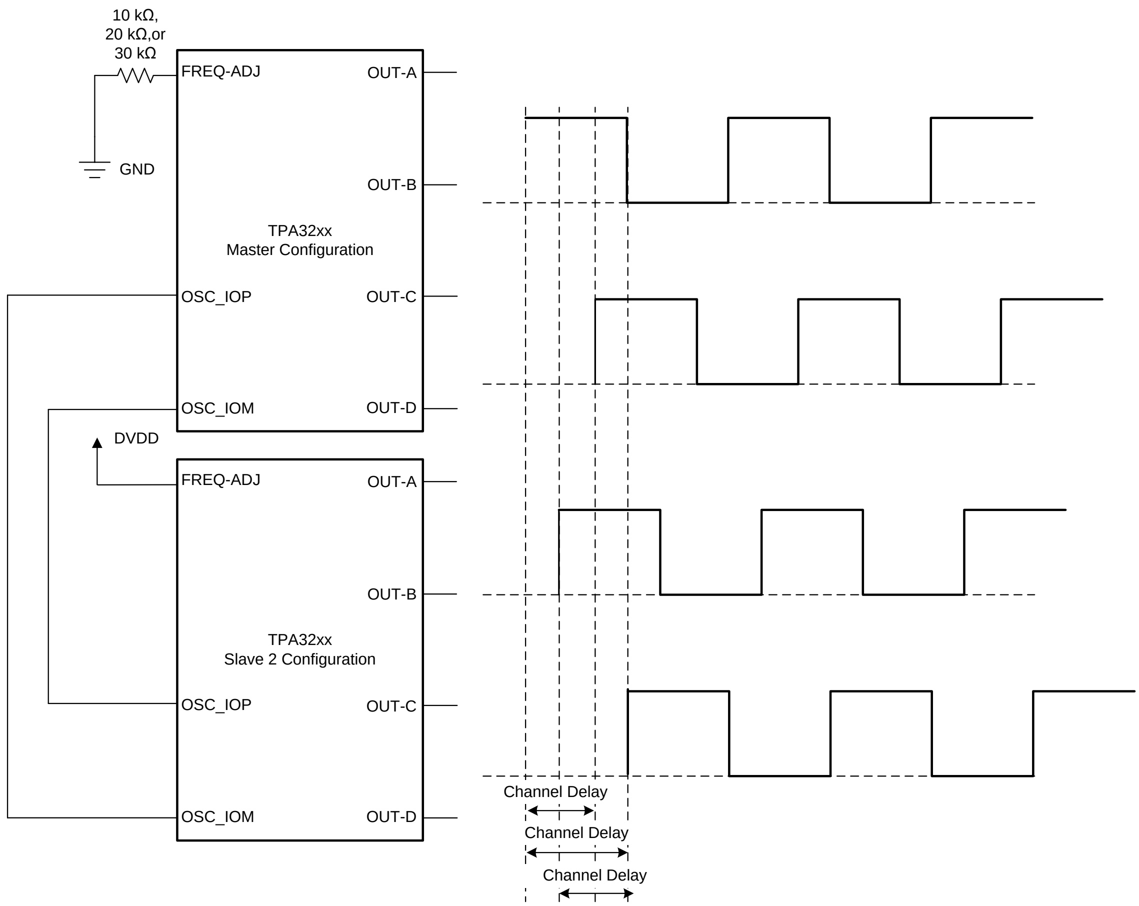

Figure 1. Oscillator Sync Pins Timing Diagram

Benefits:

By using the master and slave feature, inter-channel delay is automatically set up between the switching of the audio devices, which can be illustrated by no idle channels switching at the same time. While having no direct influence on the audio output, it will influence the switch timing to minimize noise coupling between the audio channels through the power supply. This will improve operating conditions for the power supply which, in turn, improves audio performance.

In summary: a master and slave system set up inter-channel delay between the audio channels which minimizes channels pulling power from the supply at the same time. This improves power supply performance, in turn, improving audio performance.

Implementation:

One master device is a requirement. For the master device, connect a resistor from FREQ_ADJ to GND. The values for the resistor are found in the *Recommended Operating Conditions* of the TPA32xx data sheet. As an example, Table 1 shows the values for the frequency adjust resistor for the TPA3245, TPA3251, and TPA3255.

Table 1. Frequency Adjust Resistor Value for TPA3245, TPA3251, and TPA3255

			MIN	TYP	MAX	Unit
$R_{(FREQ\_ADJ)}$	PWM frame rate programming register	Nominal; Master Mode	9.9	10	10.1	kΩ
		AM1; Master Mode	19.8	20	20.2	
		AM2; Master Mode	29.7	30	30.3	

For all slave devices, turn off the oscillator by pulling the FREQ_ADJ pin to DVDD. All slave devices will have the same PWM frame rate as the master.

The inter-channel delay will be set up for a slave device depending on the polarity of the OSC_I/O connections as follows:

- Slave 1 mode has normal polarity (master + to slave + and master – to slave –)
- Slave 2 mode has reverse polarity (master + to slave – and master – to slave +)

Table 2. Master and Slave Inter-Channel Delay Settings

		M1 = 0, M2 = 0, 2 × BTL Mode	M1 = 1, M2 = 0, 1 × BTL + 2 × SE Mode	M1 = 0, M2 = 1, 1 × PBTL Mode	M1 = 1, M2 = 1, 4 × SE Mode
Master	OUT_A	0°	0°	0°	0°
	OUT_B	180°	180°	180°	60°
	OUT_C	60°	60°	0°	0°
	OUT_D	240°	120°	180°	60°
Slave 1	OUT_A	60°	60°	60°	60°
	OUT_B	240°	240°	240°	120°
	OUT_C	120°	120°	60°	60°
	OUT_D	300°	180°	240°	120°
Slave 2	OUT_A	30°	30°	30°	30°
	OUT_B	210°	210°	210°	90°
	OUT_C	90°	90°	30°	30°
	OUT_D	270°	150°	210°	90°

For best performance, use Table 3 to select how many devices should be in Slave 1 and Slave 2. In general, try to split the devices evenly into Slave 1 and Slave 2.

For example, if you have 5 devices, put one in master (FREQ_ADJ through resistor to GND), two devices in Slave 1 (normal polarity, FREQ_ADJ to DVDD) and two devices in Slave 2 (reverse polarity, FREQ_ADJ to DVDD).

Table 3. Number of Master, Slave 1, and Slave 2 Devices for a Multi-Device System

Total Number of Devices	Number of Master Devices	Number of Slave 1 Devices	Number of Slave 2 Devices
1	1	-	-
2	1	1	-
3	1	1	1
4	1	2	1
5	1	2	2
6	1	3	2
7	1	3	3

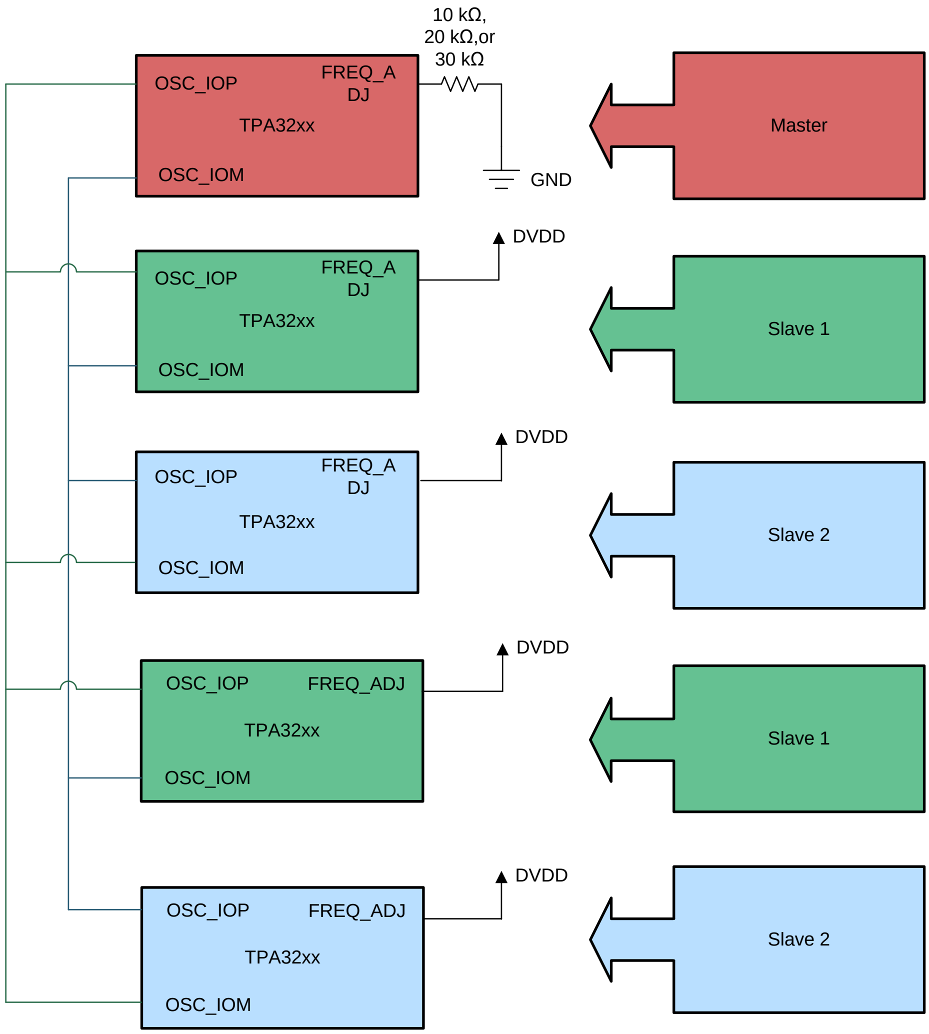

Figure 2. Master and Slave Configuration for a 5-Device System

2 Multi Device Clip/OTW and FAULT Pin

TPA32xx devices have Clip/OTW and FAULT pins to allow a system to know warning and errors occurring at the amplifier. When using multiple devices in a system, it may not be necessary to have separate Clip/OTW or FAULT signals for each device. The TPA32xx gives the option to tie these pins together across devices in order to simplify circuitry.

Benefits:

When multiple are used in a system, the engineer has the option of tying the warning and error signal lines together in order to simplify the system. This can simplify a circuit by reducing the number of pins to monitor or the number of GPIOs needed on a microcontroller or processor as well as reduce the number of pullup resistors. This comes at the cost of making debug potentially harder. The ability to monitor each device and determine which device is faulting or entering Clip/OTW will be lost. Tying these signals together is equivalent to using an OR gate. For example, one could tie all of the Clip/OTW pins together and if just one device reached clipping, the Clip/OTW signal would go LOW (it is an active HIGH signal). If multiple devices went into clipping, the Clip/OTW signal also goes LOW. Up to 30 devices can have the Clip/OTW or FAULT pins tied together according the TPA32xx datasheet.

Implementation:

To keep signals to a minimum, all of the Clip/OTW pins could be tied together as well as all of the FAULT pins.

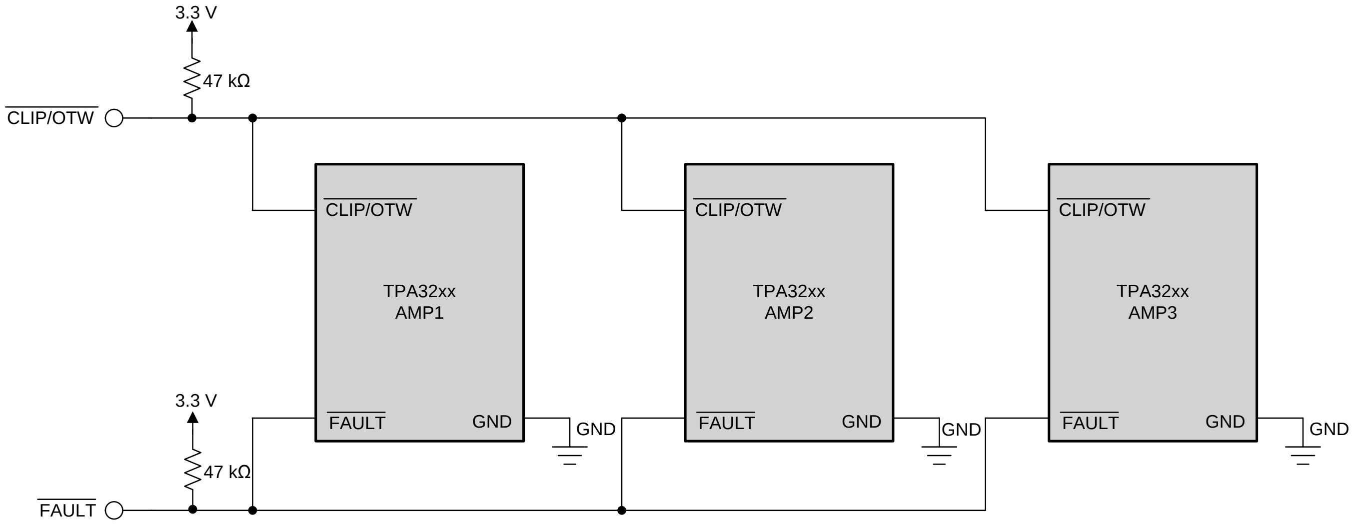

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Figure 3. Configuration 1: All Clip/OTW Pins Tied Together, all FAULT Pins Tied Together

The Clip/OTW pins can be separated so one can diagnose which device is going into clipping or having an overtemperature warning. The FAULT pins can be tied together because you do not need to know when a particular device is going into FAULT.

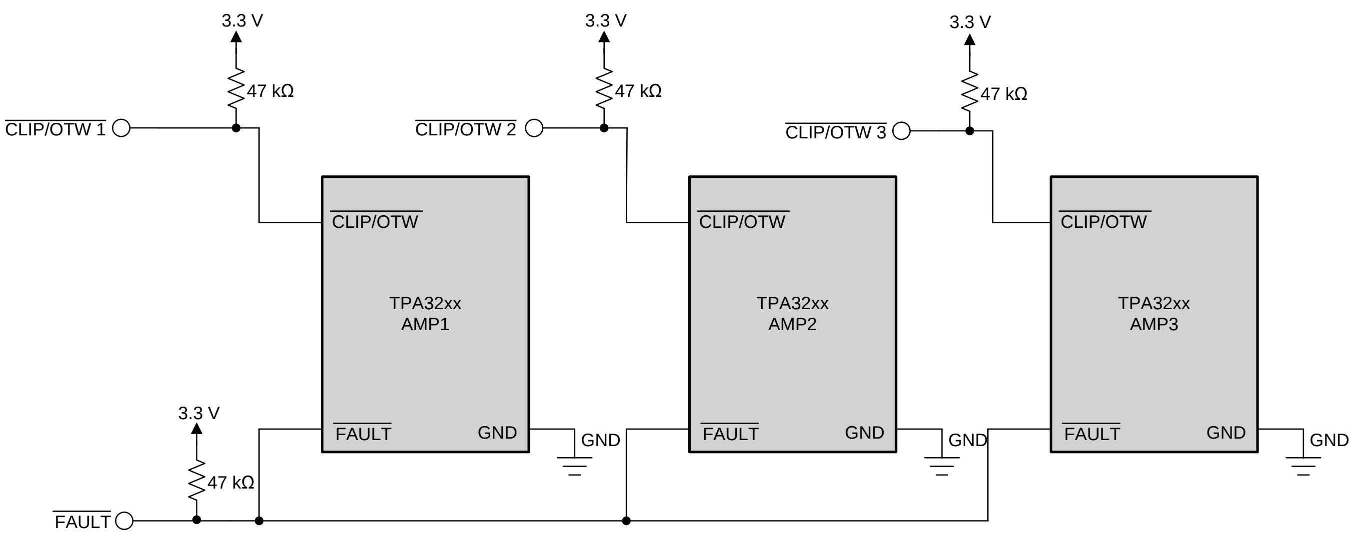

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Figure 4. Configuration 2: All Clip/OTW are Separate, all FAULT Pins Tied Together

The Clip/OTW pins can be tied together because you do not need to distinguish when a particular device is going into clipping or has an OTW warning. The FAULT pins are separated so one can determine which device is going into FAULT.

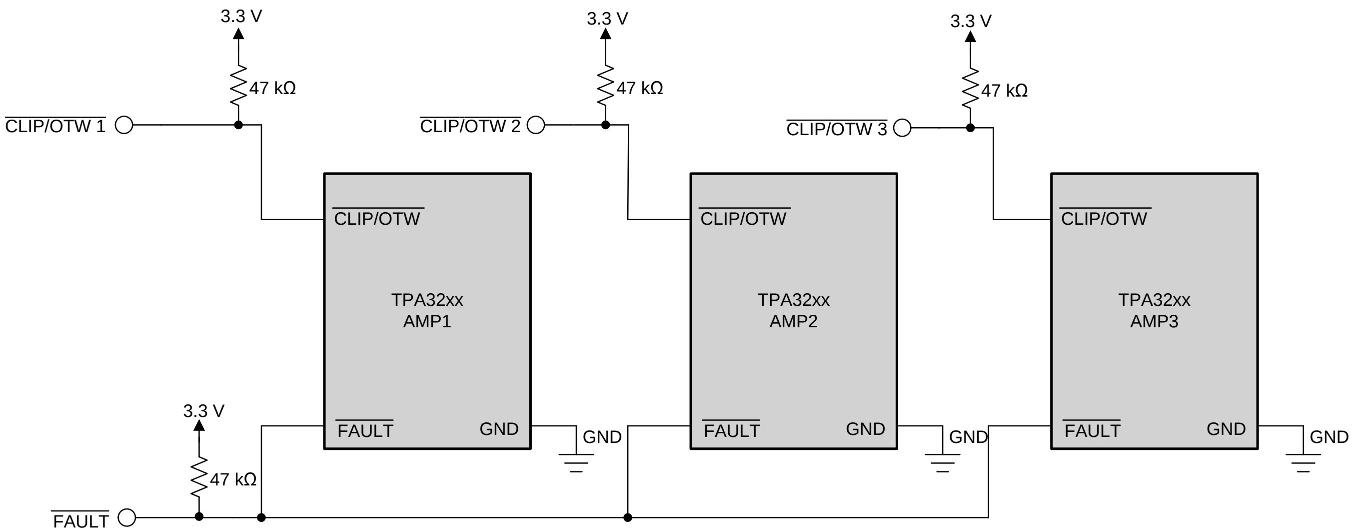

Figure 5. Configuration 3: All Clip/OTW are Tied Together, all FAULT Pins are Separate

One can also use separate Clip/OTW and FAULT for each device. This slightly complicates the circuit, but it allows you to see which device is causing each signal to go LOW.

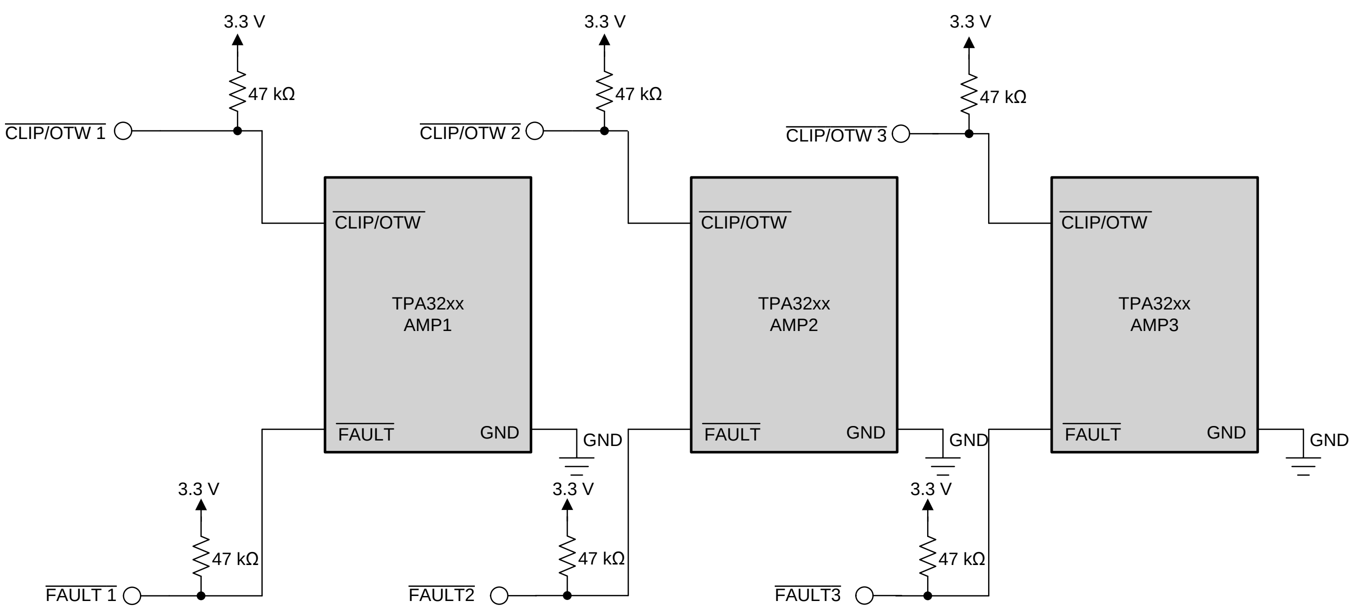

Figure 6. Configuration 4: All Clip/OTW are Separate, all FAULT are Separate

There is no requirement that all signals be tied together or separated. Any combination is possible. It is up to the engineer to determine what the best way to configure the system is.

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