# Horn Driver Application Note

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## INTRODUCTION

Microchip CO and Smoke Detector products typically include a piezoelectric horn driver which uses the same circuit architecture as Microchip's Horn Driver products. These horn drivers are used to drive 2-terminal and 3-terminal piezoelectric horns (buzzers) for any application, but typically for smoke and CO detectors. UL217 and EN14604 require a minimum output sound pressure level, SPL, of 85 dBA at 10 ft or 3m. These horn drivers provide the necessary electrical drive to properly selected horns to meet these specifications.

This application note will provide information for both the 2-terminal and 3-terminal application.

The RE46C100 will be used throughout this application note but this applies to all products with horn drivers.

## 2-TERMINAL HORN DRIVER

The basic horn driver circuit is a digital RC oscillator shown in Figure 1.

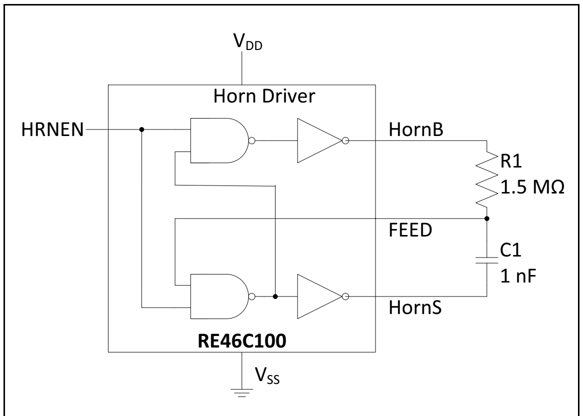


***FIGURE 1:*** *Schematic of Basic Horn Driver.*

With HRNEN low, both HB and HS are at a logic low. With HRNEN at a logic high, the oscillator function is enabled. Complimentary square waves are output at HB and HS. The FEED pin-switching threshold is set to one-half the supply voltage. If the FEED pin threshold is offset from one-half supply, the output square wave at HB and HS will not have a 50% duty cycle, which is important for achieving the 85 dBA SPL.

When HRNEN is switched high, FEED is initially low, the capacitor C1 is discharged and HB switches high. With HB switched high, capacitor C1 begins charging to one-half the supply voltage. When the FEED pin voltage reaches one-half supply, HB switches low and HS switches high. The FEED pin is now one-half the supply voltage above $V_{DD}$, e.g., FEED = 13.5V when $V_{DD}$ = 9V. The capacitor C1 now begins to discharge down to one-half the supply voltage. When the FEED pin voltage reaches one-half supply, HB switches high and HS switches low. The FEED pin is now one-half the supply voltage below $V_{SS}$, e.g., FEED = -4.5V when $V_{DD}$ = 9V and the charging cycle starts over. The horn driver voltage effectively doubles the supply voltage, $V_{DD}$, used to drive the horn when compared to a single ended horn drive.

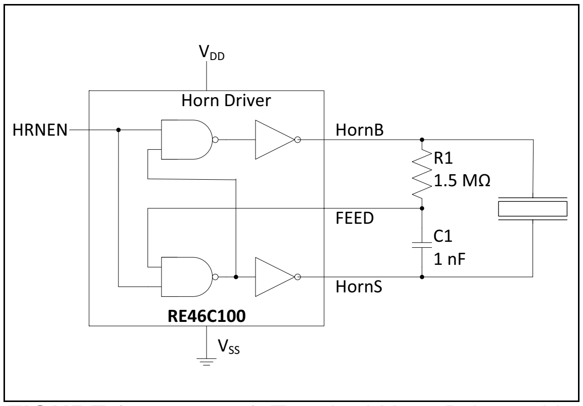


***FIGURE 2:*** *2-Terminal Horn Driver with Piezoelectric Horn.*

The frequency of operation is given by f = 1/(2.2*R1*C1). For the values shown in Figure 2, the square wave frequency is 303 Hz. If R1 is reduced to about 130 kΩ, the frequency increases to 3500 Hz. Figure 3 shows a plot of the equation versus 1/R1 and the actual performance of the RE46C100 with and without the horn.

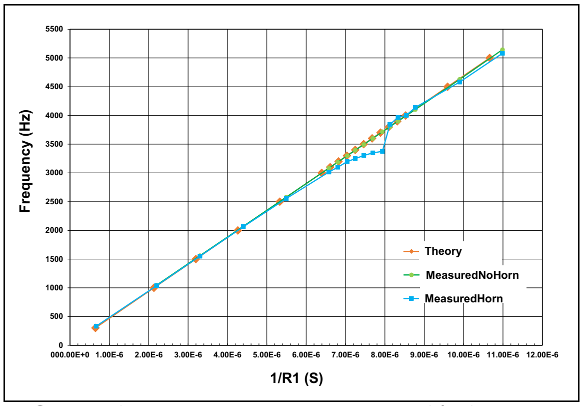


***FIGURE 3:*** *Frequency vs. 1/R1.*

When the piezoelectric horn is connected in the circuit (see Figure 2), it loads the drive circuit as the frequency is tuned closer to the horn resonant frequency. The model for a 2-terminal horn is shown in Figure 4. At series resonance, the horn exhibits its lowest resistance. The worst case on resistance of the HB and HS outputs is about 31Ω at 9V. This on resistance produces a voltage drop for large load currents, which affects the charging and discharging time of the RC network connected between HB and HS.

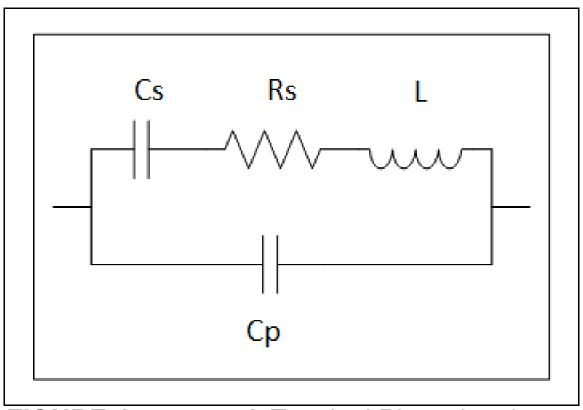


***FIGURE 4:*** *2-Terminal Piezoelectric Horn Electrical Model.*

Figure 5 shows the scope traces for the schematic in Figure 2. The horn operates at series resonance, which loads the driver outputs.

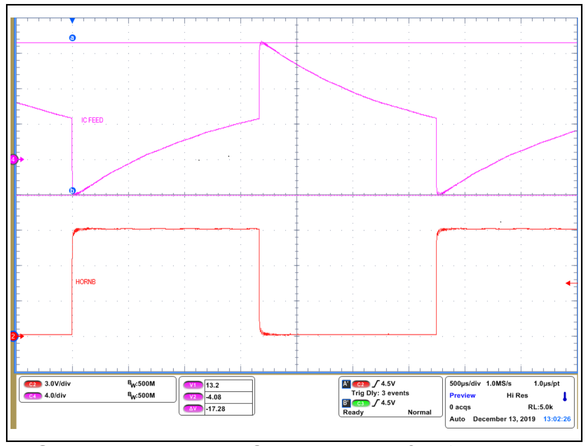

***FIGURE 5:*** *Scope Trace for 2-Terminal Operation.*

Alternatively, the FEED pin can be driven by a square wave. In Figure 6, a logic level NMOS device is used to level shift a 3.3V square wave to drive the FEED pin. R1 can be increased to reduce the current draw.

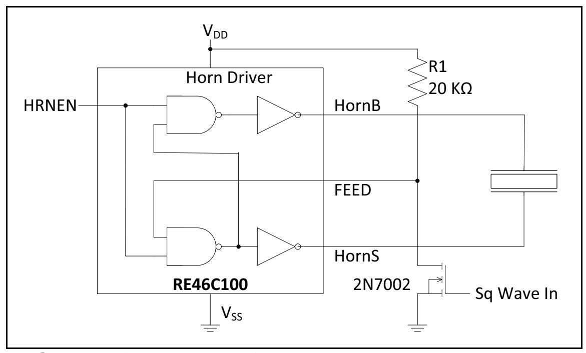


***FIGURE 6:*** *2-Terminal Horn Driver with NMOS Level Shifter.*

## 3-TERMINAL HORN DRIVER

The 3-terminal horn driver is shown in Figure 7. The horn G terminal must connect to the HornB pin and the horn M terminal must connect to the HornS pin. The G terminal is the metal plate where the ceramic material is deposited. The M terminal is the metal film contact on top of the ceramic material. The F terminal of the horn provides a feedback signal that affects the charging and discharging of the capacitor, C1.

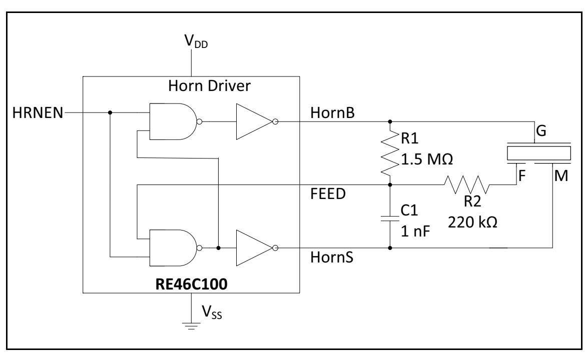

***FIGURE 7:*** *3-Terminal Horn Driver.*

At power-up R1 and C1 start the oscillator running. In particular, R1 is chosen to minimize its interaction with the charging/discharging cycle once the oscillator is running at the resonant frequency.

In Figure 8, when HORNB switches low, the initial R1 current is IC FEED/R1, which is approximately 9 µA (IC FFED = ~13.5V) and the initial R2 current is (HORN FEED – IC FEED)/R2, which is approximately 98.2 µA ((HORN FEED – IC FEED) = 21.6V). HORN FEED is the horn F terminal voltage. The larger charging/discharging current flowing through R2 controls the charging/discharging cycle for C1.

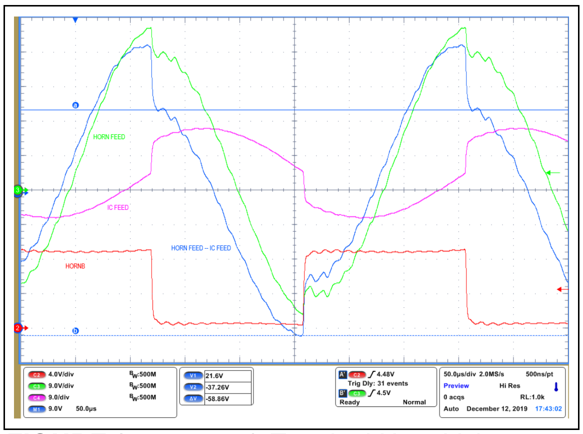


***FIGURE 8:*** *3-Terminal Horn Voltage Waveforms.*

The waveforms in Figure 8 show the optimum resonance condition. When HORNB switches, the HORN FEED voltage is at its peak. Finding the best R2*C1 product produces this result. There is no simple equation for calculating this product. It is easier to experimentally adjust the value of C1 and R2 to achieve optimum resonance. Using R2*C1*F0 = 0.75, where F0 is the resonant frequency of the horn, provides a reasonable initial estimate of the R2 *C1 product.

## REFERENCE

1. RE46C100 Data Sheet, “*Piezoelectric Horn Driver Circuit*”, DS20002166B, Microchip Technology Inc, 2014.

2. “*AVX Piezoelectric Acoustic Generators*”, Kyocera.

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