APPLICATION INFORMATION

lamp characteristics / PZT operation

A cold cathode fluorescent lamp has a relatively constant voltage across it when lit. The lamp's intensity (lumens) is roughly proportional to lamp current, where lamp voltage remains somewhat constant over the operating range. The lamp voltage is dependant on the diameter and length of the lamp used in the application. The lamp impedance decreases with increasing lamp current, resulting in a negative incremental impedance. This lamp impedance affects the gain of the piezoelectric transformer (see Figure 9) and thus the operating frequency of the system.

Ceramic piezoelectric transformers were first proposed by C. A. Rosen in 1956. Unlike magnetic transformers that rely on electromagnetic coupling, the PZT uses electromechanical coupling (see Figure 6). This effect results in mechanical motion when an electric potential is applied to the piezoelectric material.

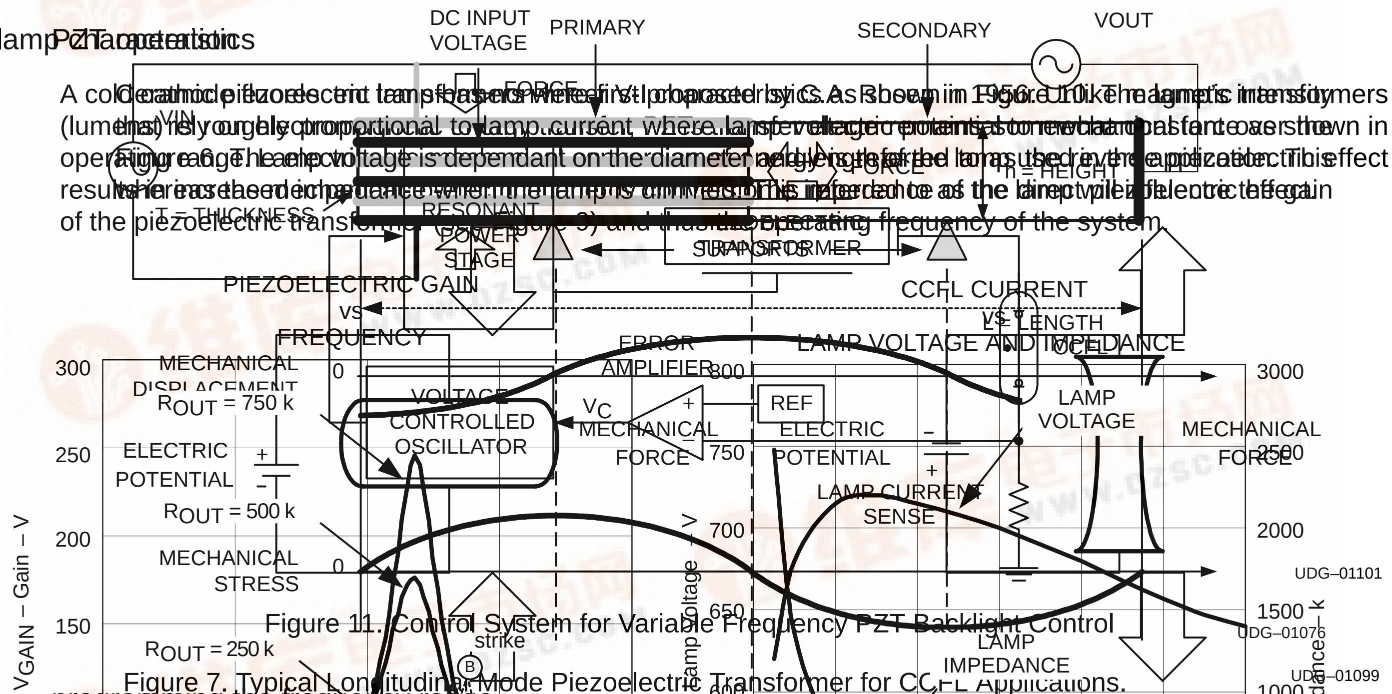


Figure 6. Piezoelectric Effect

Figure 7. Typical Longitudinal Mode Piezoelectric Transformer for CCFL Applications.

Figure 9

Figure 10

Figure 11. Control System for Variable Frequency PZT Backlight Control

programming the frequency range

A typical PZT with longitudinal mode geometry is shown in Figure 7, a single layer design would have similar construction without the layering on the primary. AC voltages applied to the V_{IN} electrodes causing mechanical expansion and compression in the thickness direction. This displacement on the primary is transferred to the secondary in the longitudinal direction. Supports at ½ wavelength provide a means for a standing wave to be generated at a resonant frequency as shown. Mechanical resonance occurs at multiple standing wave frequencies (n) based on the transformer's length and material velocity (v).

The frequency range of the UCC397x family is programmed with external components R_{OSC}, C_{OSC} and R_{ANGE}. The oscillator charge time (t_{CHG}) is on the order of 500 ns. The decay time (t_{DISCH}) is determined by the value of C_{OSC} and the discharge currents generated in R_{OSC} and R_{ANGE}. The nominal discharge time at OSC is set by R_{OSC} and C_{OSC} (see equation [8]), the frequency range is programmed by adjusting the discharge time with the R_{ANGE} resistor and the COMP voltage (see equation [9]).

$$f_n = \frac{n\,v}{2\,length} \quad (1)$$

Voltage gain is a function of the PZT material coefficient gL, 1, the number of primary layers, the thickness of the material and the overall length as follows:

$$V_{GAIN} \propto gL \times \frac{length \times layers}{thickness} \quad (2)$$

$$t_{DISCH(nominal)} = R_{OSC} \times C_{OSC} \times \ln(1.7 / 0.7) \quad (8)$$

An electrode at V_{OUT} is used to recover the amplified electrical potential at the secondary.

variable frequency control system

A simplified block diagram of a PZT based backlight converter is shown in Figure 11. The PZT is driven by a resonant power stage whose amplitude is proportional to input voltage. The PZT then provides the voltage gain necessary to drive the lamp. A control loop is formed around the error amplifier that compares average lamp current to a reference signal (REF) allowing the intensity of the lamp to be regulated. The resulting control voltage V_C drives a VCO that determines the operating frequency of the resonant power stage.

PZT electrical model

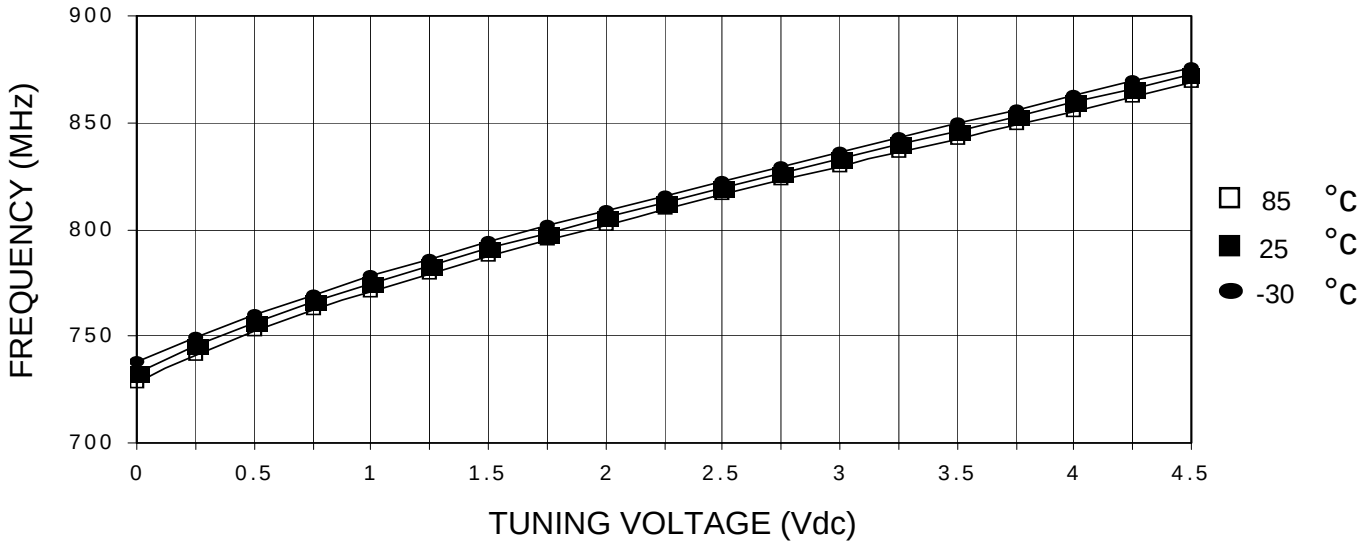
In order to predict PZT performance in a system, it is useful to develop an electrical circuit model. The model shown in Figure 8 is often used to describe the behavior of a PZT near the fundamental resonant frequency. Many PZT manufacturers will provide component values for the model based on measurements taken at resulting frequency with lamp loads and output loads.

The frequency range of the VCO must include the strike and operating frequencies of the PZT with some tolerance included for component variation. Minimizing the programmable range improves the control response of the feedback loop. For example, a frequency range of 67 kHz to 77 kHz might be used for the PZT in Figure 9. The gain of the PZT must guarantee sufficient lamp voltage at minimum input voltage to ensure that the control loop will always operate on the right-side of resonance.

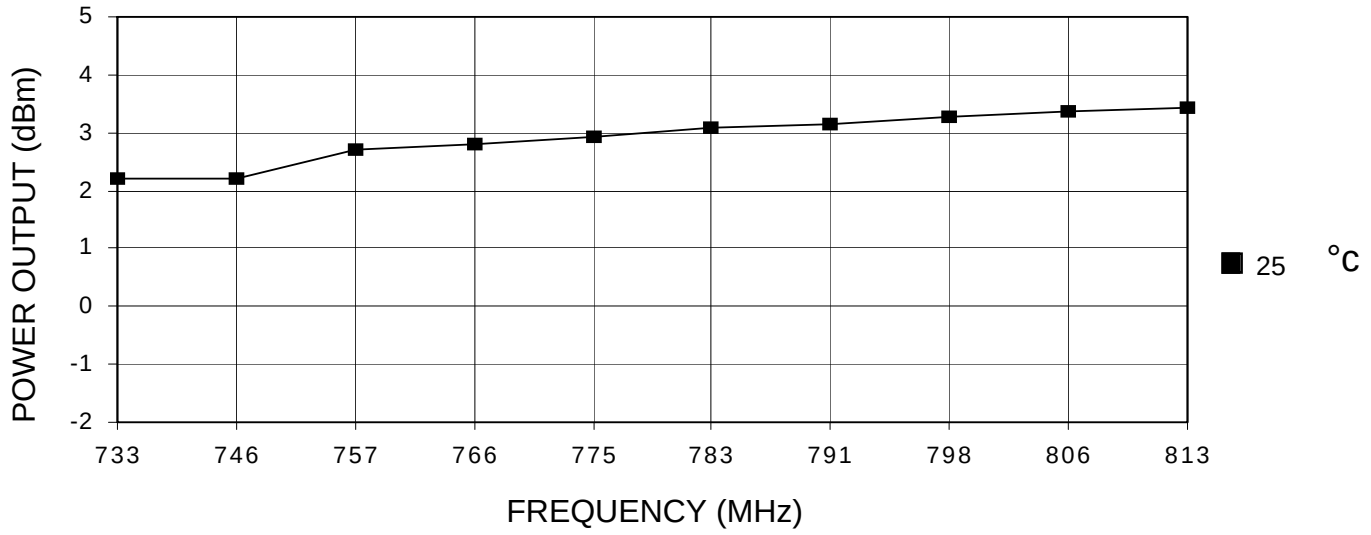
$$t_{DISCH} = R_{OSC} \times R_{ANGE} \times C_{OSC} \times \ln\left(\frac{1.7}{0.7}\right) \ldots \quad (9)$$

$$Frequency(V_{COMP}) = \frac{1}{t_{CHG} + t_{DISCH}(V_{COMP})} \quad (10)$$

TUNING CURVE, typ.



POWER CURVE, typ.



PHYSICAL DIMENSIONS