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FAST COMPENSATION EXTENDS POWER BANDWIDTH

In all IC operational amplifiers the power bandwidth depends on the frequency compensation. Normally, compensation for unity gain operation is accompanied by the lowest power bandwidth. A technique is presented which extends the power bandwidth of the LM101A for non-inverting gains of unity to ten, and also reduces the gain error at moderate frequencies.

In order to achieve unconditional stability, an operational amplifier is rolled off at 6 dB per octave, with an accompanying 90 degrees of phase shift, until a gain of unity is reached. Unity gain in most monolithic operational amplifiers is limited to 1 MHz, because the lateral PNP's used for level shifting have poor frequency response and exhibit excess phase shift at frequencies above 1 MHz. Hence, for stable operation, the closed loop bandwidth must be less than 1 MHz where the phase shift remains below 180 degrees.

For high closed loop gains, less severe frequency compensation is necessary to roll the open loop gain off at 6 dB per octave until it crosses the closed loop gain. The frequency where it crosses must, as previously mentioned, be less than 1 MHz. For closed loop gains between 1 and 10, more frequency compensation must be used to insure that the open loop gain has been rolled off soon enough to cross the closed loop gain before 1 MHz is reached.

The power bandwidth of an operational amplifier depends on the current available to charge the frequency compensation capacitors. For unity gain operation, where the compensation capacitor is largest, the power bandwidth of the LM101A is 6 kHz. Figure 1 shows an LM101A with unity gain

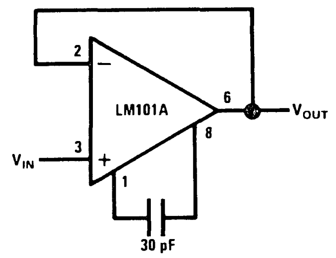

FIGURE 1. LM101A With Standard Frequency Compensation.

compensation and Figure 3 shows the open loop gain as a function of frequency.

A two-pole frequency compensation network, as shown in Figure 2, provides more than a factor of two improvement in power bandwidth and reduced gain error at moderate frequencies. The network consists of a 30 pF capacitor, which sets the unity gain frequency at 1 MHz, along with a 300 pF capacitor and a 10k resistor. By dividing the ac output voltage with the 10k resistor and 300 pF capacitor, there is less ac voltage across the 30 pF capacitor and less current is needed for charging. Since the voltage division is frequency sensitive, the open loop gain rolls off at 12 dB per octave until a gain of 20 is reached at 50 kHz. From 50 kHz to 1 MHz the 10k resistor is larger than the impedance of the 300 pF capacitor and the gain rolls off at 6 dB per octave. The open loop gain plot is shown in Figure 3. To insure sufficient drive to the 300 pF capacitor, it is connected to the output, Pin 6, rather than Pin 8. With this frequency compensation method, the power bandwidth is typically 15–20 kHz as a follower, or unity gain inverter.

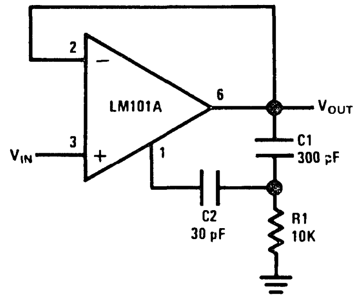

FIGURE 2. LM101A with Frequency Compensation to Extend Power Bandwidth.

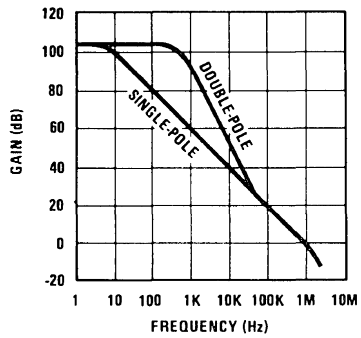

FIGURE 3. Open Loop Response for Both Frequency Compensation Networks.

This frequency compensation, in addition to extending the power bandwidth, provides an order of magnitude lower gain error at frequencies from DC to 5 kHz. Some applications where it would be helpful to use the compensation are: differential amplifiers, audio amplifiers, oscillators, and active filters.