Driving Capacitance With the THS4001

Application Brief

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Driving Capacitance With the THS4001

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ABSTRACT

Operational amplifiers (op amps) are often used to drive devices that have significant input capacitance such as analog-to-digital converters, cables, MOSFETs, filter networks, etc. The effect of the capacitance is extra phase shift in the loop gain of the amplifier. This phase shift erodes the phase margin of the amplifier and may lead to instability. At high frequency, even a very small capacitance is detrimental.

This paper reports a simple method for restoring amplifier stability while driving capacitive loads with the THS4001.

1 Introduction

A typical technique used to compensate for output capacitance is to isolate it with a resistor. The question is, how much resistance to use.

This report outlines the test setup and resistor values required to stabilize the THS4001 while driving various load capacitors. Refer to application report *Effect of Parasitic Capacitance in Op Amp Circuits*, literature number SLOA013, for an in-depth presentation of the effects of output capacitance on circuit operation and compensation methods.

2 Test

Figure 1 shows the test circuits that determine the minimum value of isolation resistance required for stable operation.

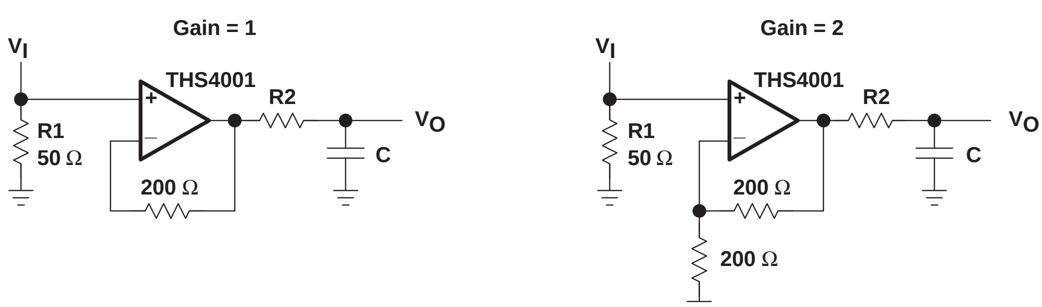

Figure 1. Test Circuits

The input signal is a square pulse with rise time and fall time of 10 ns, and the amplitude adjusted for ±2 V on the output of the op amp. The amplifier's power supply voltage is varied between ±5 V and ±15 V. The signal source is a LeCroy model 9210 pulse generator with the 9211 variable edge output module. The output signal is probed using a Tektronix P6217 4 GHz probe with input load of 0.4 pF and 100 kΩ. The signal is then displayed on a Tektronix TDS 794D oscilloscope.

The test circuit is built using the THS4001 EVM, #SLOP119. The load capacitor is soldered across the terminal pins of output connector, J2, on the solder side of the EVM. The circuit power is applied, the input signal is applied, and resistor (R2) adjusted until a square pulse with less than 2% overshoot and undershoot is obtained.

3 Data

Figure 2 shows the graphs of the required resistor values and the rise/fall time variations with the resistor and output capacitance for gain = 1 and gain = 2. Graph A is a plot of resistor (R2) vs capacitance (C), and graph B is a plot of the rise/fall time vs capacitance (C) (with R2). Graph A is plotted with log-log scales to show the log relationship of resistor (R2) to capacitor (C). Rise/fall time is the average of the rise time and the fall time.

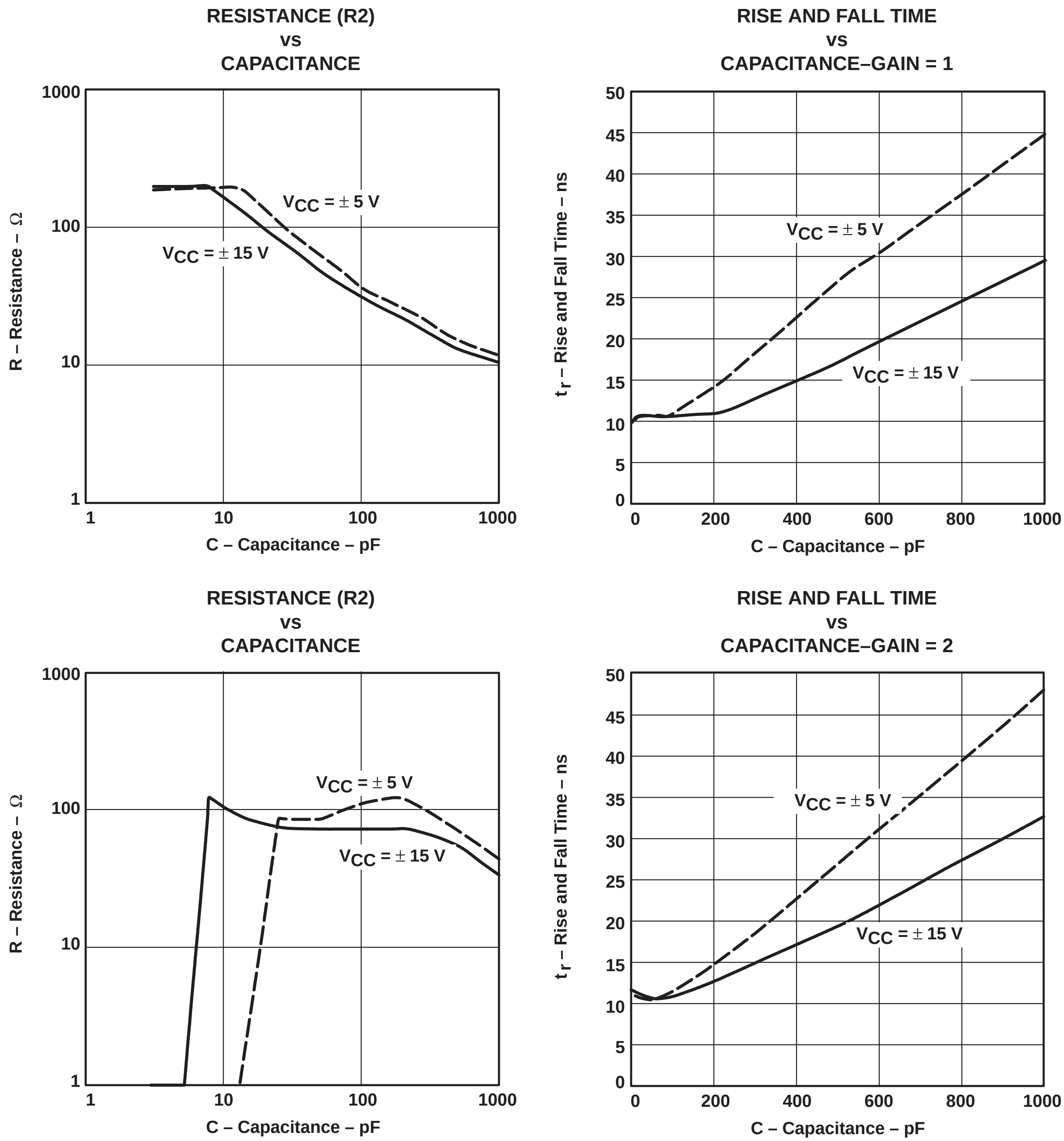

Figure 2. R2 and Rise Time vs Capacitance

4 Summary

In general with V_{CC} = ±5 V, slightly higher resistor values are required and the rise/fall time is longer.

Evaluating the data for the unity gain circuit and solving for a straight-line approximation, a formula for estimating the required resistor value for load capacitance above about 10 pF is found to be: $R = \frac{1}{\sqrt{C}} \times 450$, where C is the in pF.

With gain = 2, the required resistor value is approximately 20 Ω to 30 Ω across the range of load capacitance tested, except at the extremes.

Optimum performance is obtained from the THS4001 with V_{CC} = ±15 V. The output is much more distorted while driving capacitance greater than 200 pF with V_{CC} = ±5 V than with V_{CC} = ±15 V.

The data presented here is to help in estimating component values. The exact value of circuit components needs to be verified by the user during testing.