Application Briefs

VECTOR DIFFERENCE $\sqrt{V_a^2 - V_b^2}$ WITH THE AD531

The square-rooting properties of 3-variable analog multiplier-dividers, such as the AD531 and the 433*, by the feedback solution of an implicit equation (e.g., the RMS circuit, page 13), have led to some interesting uses in vectorial combination. Vector sums were discussed at length in *Dialogue*, Vol. 6, Nos. 2 & 3. The key to the scheme: if $u^2 + v^2 = w^2$, then by subtraction and factoring, $u^2 = (w + v)(w - v)$. Dividing both sides of the equation by $(w + v)$, one can easily recognize an implicit solution for the vector sum, w, that can be embodied with an XY/I device and 2 op amps. If instead, both sides of the equation are divided by u, a solution for the vector *difference* appears:

$$u = \frac{(w+v)(w-v)}{u} = \sqrt{w^2 - v^2}$$

A practical circuit that embodies this equation simply with the monolithic AD531 is shown in Figure 1. Since the X input of the AD531 is a differential input—and the sum can be obtained passively—the only necessary external operational amplifier is an AD741, to convert the fed-back output from a voltage to a current.

When properly calibrated and adjusted for less than 100mV error at full scale, the output will differ from the theoretical value by less than ±100mV for any pair of input voltages over an output dynamic range between 10V:0.3V and 10V:0.1V. Bandwidth is DC to 100kHz for best accuracy, and 600kHz for -3dB.

CALIBRATING THE CIRCUIT

Step	Condition	Adjust	For
1.	CAL. $V_a = V_b = 0V$	E_0 BAL	$E_0 = 0V$
2.	CAL. V_a = 20Vp-p, 10Hz, $V_b = 0V$ Pin 13 (AD531) grounded Scope sensitivity 50mV/cm(V), 100ms/cm(H)	Y BAL	Min. E_0 swing
3.	CAL. $V_a = V_b = 0$, 20Vp-p to pin 13 Scope sensitivity as in (2)	X BAL	Min. E_0 swing
4.	OPERATE. $V_a = 10.00V$, $V_b = 0V$	GAIN	$E_0 = 10.00V$
5.	OPERATE. $V_a = 1.00V$, $V_b = 0V$	"Low end"	$E_0 = 1.00V$
6.	OPERATE. $V_a = V_b = 0V$	E_0 BAL	$E_0 = 0V$

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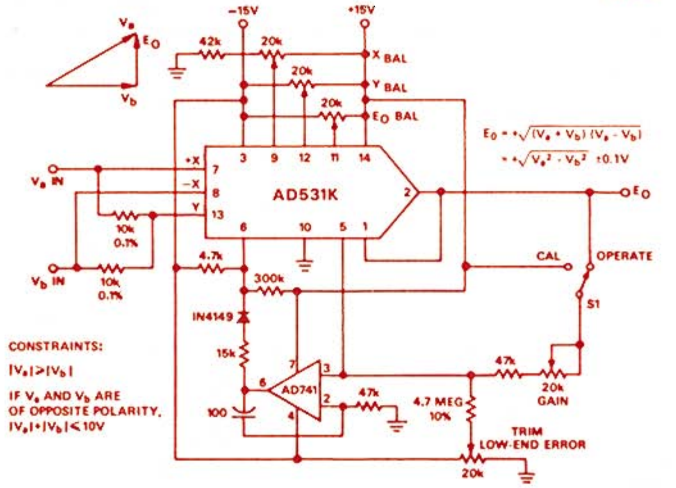


$$E_0 = +\sqrt{(V_a + V_b)(V_a - V_b)} = +\sqrt{V_a^2 - V_b^2} \pm 0.1V$$

Figure 1. Vector-Difference Circuit Using AD531

*For technical information on Model 433, use the reply card. Request **J13**.

A LOW-NOISE, LOW-DRIFT FET-INPUT AMPLIFIER DESIGN

If you want a low-drift-and-noise operational amplifier for low-frequency, high-impedance applications at minimal cost, is it better to make your own or buy a complete, fully-guaranteed unit? It would be hard for us to make a judgment, unless we know your aptitudes and cost structure. On the other hand, you can know both your own capabilities and our price. In any event, we are equally gratified if the choice is between our 43K (best drift-and-noise vs. price), 40J, or AD503 (low price), and an amplifier that you can build with an AD840 dual-FET, an AD301A op amp*, and a small handful of components.

Yes, you can build a rather formidable amplifier at low cost.

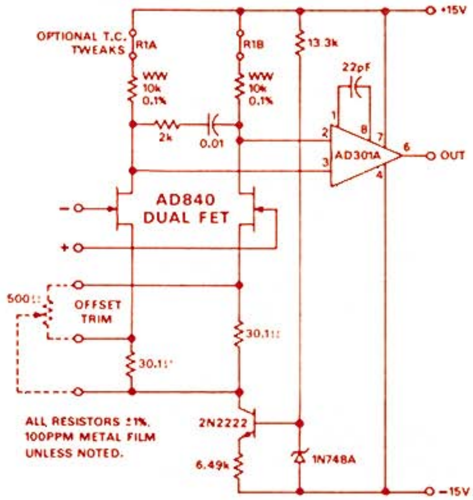
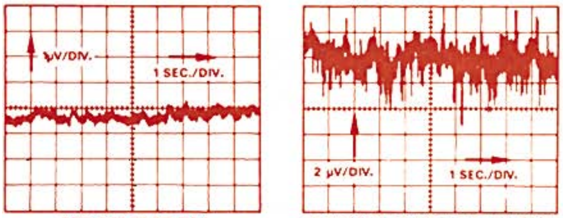


Figure 1. Low Noise Low Drift FET Input Amplifier Using AD840 Dual FET

How do these characteristics sound?

Offset vs. temperature: 5μV/°C (tweakable to 1μV/°C)
Noise: 1μVp-p (0.1 to 10Hz), 8μVrms (5Hz to 10kHz)
Bias current: 10pA, either input
CMR: 80dB (-10V to +9V)
Bandwidth: 700kHz (small-signal, unity gain), 15kHz fp
Full-power output: ±10V @ ±5mA

They describe the performance of the amplifier shown in Figure 1. The photographs (Figure 2) compare its low-frequency noise with that of a popular I.C. FET-input amplifier that happened to be on the bench. The key to the excellent performance is the AD840 dual FET, with its 3μV/°C *max* temperature-drift nonlinearity, introduced in Vol. 6, No. 3 of *Dialogue*. ▶▶▶



AMPLIFIER OF FIGURE 1

COMMERCIALLY-AVAILABLE LOW-COST FET-INPUT OP AMP

Figure 2. Typical Noise Waveforms DC to 10Hz

*For technical and price information on all of these devices, request **J14**.