component news

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Distortion problem uncovered in PMI's hot new op amp

by Willie Rempfer
Analog Component Engineering

The fastest, lowest noise, precision, monolithic op amps we've seen, the OP-27 and the decompensated OP-37, will soon be announced to the industry by Precision Monolithics Inc. in the cover story of **Electronic Design's** December issue.

Component Engineering was fortunate enough to obtain samples from an early engineering run, before the time that PMI was granted this cover story. (PMI has since frozen **all** communication about the part until after December.)

Clearly, **Electronic Design's** decision to feature these parts implies their anticipation of a tremendous impact on the industry, and while our evaluation revealed outstanding performance, it uncovered a serious design flaw which could drastically degrade performance within the specified limits. Let's look first at the part's overall performance, and then concentrate on the problem found.

The good news: high performance on every front

The OP-27 does indeed provide outstanding all around performance —

1. V_{OS} and V_{OS} drift are lower than the ultra-low OP-07 (30μV and 0.4μV/°C typ).
2. I_B is comparable to the Super Beta LM308A (15nA typ).
3. Noise density is better than the NE5534 (3nV/$\sqrt{Hz}$ typ).
4. Low frequency noise is unmatched (100nVp-p, 0.1 — 10Hz typ).
5. A_V, CMRR and PSRR are all typically ~120dB (20dB better than NE5534).

continued on page 2

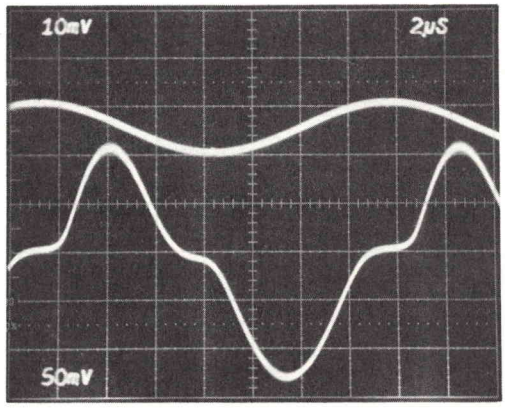


Photo 1 — Severe crossover distortion results when output sinks ~14mA. (Caused by class B element in OP-27 output stage.) Av = 100, f = 70KHz, I_{OUT} ~ 14mA.

Also in this issue

6. OP-27 bandwidth is better than the LF356 and TL072 (7MHz typ). OP-37 (A_V = 5 min) GBW is comparable to NE5534 (30MHz typ).

7. Slew rate is reasonable: OP-27 = 3V/μS typ. OP-37 = 15V/μS typ.(This is lower than BiFETs' because of the higher input stage transconductance required for precision.)

8. Specified to drive R_L = 600Ω to ±10V. This is where the design error was found. Refer to section titled "The bad news."

The above list shows an unsurpassed combination of features. This performance is achieved basically by redesigning the precision OP-07 with modifications to improve noise (simplifying input stage and running it at higher current) and bandwidth (creating zeros to cancel poles and reduce open loop phase shift).

The low frequency noise is achieved by minimizing the contribution of the second stage lateral PNPs (notorious for 1/f noise, as in the NE5534 and LM318).

These impressive features are, however, marred by a crossover distortion problem.

The bad news: crossover distortion

When the OP-27 was characterized in Component Engineering a gross dead spot was found in the open loop transfer function. This created severe crossover distortion at higher frequencies when the output was heavily loaded (see Photo 1). A parasitic collector-base junction was found in the output-driver stage which forms a **Class B element** that crosses over when the output sinks more than about 14mA (see Figure 1).

Because output swings of ±10V into 600Ω **will** cause currents in excess of this crossover current, crossover distortion will occur within the specified area of operation, as PMI has defined it (V_O = ±10V, R_L = 600Ω).

George Erdi, the OP-27 designer, was made aware of this problem and a letter was sent urging him either to modify the design and move the crossover current out of the specified region, or to change the R_L = 600Ω specification to exclude this dangerous range of currents from the specified region of operation.

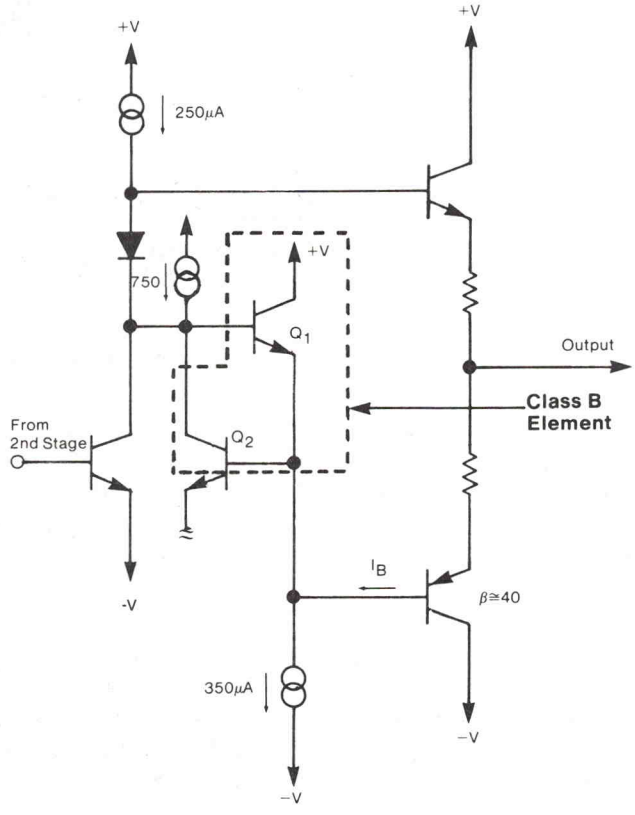


Figure 1 — Q_1 and Q_2's C-B junction form a class B driving stage for the output PNP. The class B stage crosses over when I_B = 350μA and $I_{OUT} = \beta\ I_B$ = 40(350μA) = 14mA (sinking).

It is our feeling that this problem should be resolved **before** a grand, front page, unveiling is made to the world. Although a design change seems out of the question, we have received a tentative commitment that the spec will be changed to R_L=1K, at least for the OP-27. The OP-37 is still under discussion.

continued on page 3

Usable? Yes, but avoid the danger zone!

While any component with such a glaring defect should probably be avoided or at least regarded with deep suspicion, the impressive (and unmatched) performance offered by these parts makes the OP-27 and OP-37 worth considering for precision instrumentation type applications (with the stipulation that the application avoid the dangerous current range). So, depending on the pricing (which will not be available until after December), these parts may find use in some Tek applications in the future.

If you have any further questions about this part, please contact me at 78-557, ext. 2308.

Willie Rempfer

HEXFETs part numbered

Three of International Rectifier's HEXFET power MOSFETs have been part numbered at Tek. All are N-channel parts in the popular TO-220 case. Below is a brief list of their characteristics.

Tek P/N	IR P/N	Description
151-1136-00	IRF530	100V, 0.18Ω, 10.0A
151-1137-00	IRF630	200V, 0.40Ω, 6.0A
151-1141-00	IRF730	400V, 1.00Ω, 3.5A

IR's HEXFETs are vertical DMOS transistors — a process that does not require a V-groove etched into its surface (for more details, see **Component News 267**). The "HEX" in HEXFET refers to the surface pattern of channels. For a power MOSFET to be efficient, as much channel width as possible must be crammed into a given die area. The hexagon is nearly optimum for this purpose. (IR is careful to admit that this pattern is not their invention, but was first discovered by crystals and later successfully applied in a practical structure by bees.) Other patterns, such as squares or a grid of offset squares (as bricks are laid), are used by IR's competitors — probably for no better reason that to avoid looking like imitators.

V-groove MOSFETs, on the other hand, are nearly extinct. Efforts to avoid the chemical etching and its accompanying hazards have had very good results; and non-etched (planar) products have arrived that not only perform better, but promise better long-term reliability.

The only power FET producer still relying on V-grooving is Siliconix. Other manufacturers may still call their products VMOS, but the "V" refers only to "vertical" current conduction.

All of the HEXFETs listed previously have an alternate source in one or more of these suppliers: IR, Supertex, Motorola, Intersil/GE, Siemens and HP. At this time, only IR and Supertex have complementary P-channel parts. Many other similar power FETs are currently available, but have not been part numbered. Data sheets and samples are available.

These three HEXFETs join our growing family of power FETs. In order of power capability, they are:

151-1120-00	P-channel)	TO-92, 60V, 1A
151-1121-00	N-channel)	(complementary pair)
151-1108-00	N-channel	TO-39, 90V, 1A
151-1127-00	N-channel)	TO-220, 40V, 4A, 1.0Ω
151-1128-00	P-channel)	(complementary pair)
151-1119-00	N-channel	TO-39, 65V, 3.5A, 0.5Ω
151-1130-00	N-channel	TO-220, 40V,10A, 0.12Ω

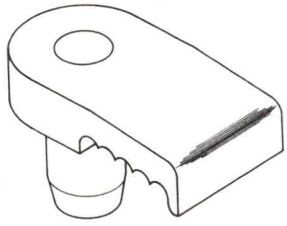
For more information on any of these FETs, please contact **Jerry Willard (78-557), ext. DR-2539.**

Tie-down clips for ribbon cables

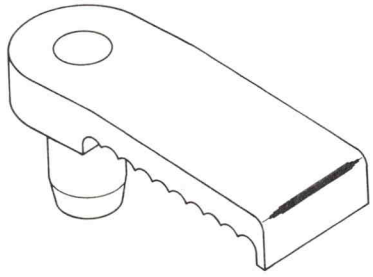
Ribbon cable has been used at Tek for many years. However, since these cables were first introduced, it has been difficult to tie the cable down on long runs.

Four ribbon cable tie-down clips have been developed for this purpose: Two clips for a cable run oriented flat to a panel, one clip for up to five wires, one for from six to ten wires in a cable, and two additional clips for a cable oriented 90 degrees to a panel.

The clips mount in #30 punched holes and are available under the part numbers as illustrated below. For additional information, please call **Casey Veenendaal, Advanced Electro Mechanical Design (50-274), ext. B-7045, or Dick Luedtke (50-274), ext. B-6636.**



346-0170-00



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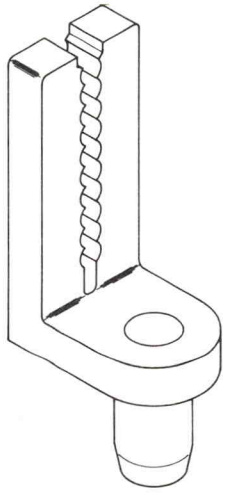


343-0843-00

Readers: we need your views!

We have been having specification problems with NEC concerning two of our high usage power transistors (P/N 151-0423-00 and -02). When these devices were part numbered in 1972, we used the Texas Instruments TIP50 specification as a model for our spec. TI shows a 1A $V_{CE(Sat)}$ parameter with a 1V maximum at a base current of 200mA, which is a forced Beta of 5. At this time, however, the TI parts are not approved because of poor quality and reliability, and no other domestic vendors can produce a reliable part either.

The root of the problem is that our present vendor's part (the NEC 2SC2333) reaches it peak h_{FE} point at a somewhat lower collector current than does the TIP50 (on which our spec is based). Figure 1 compares the h_{FE} vs. I_C for both the NEC and TI transistors.

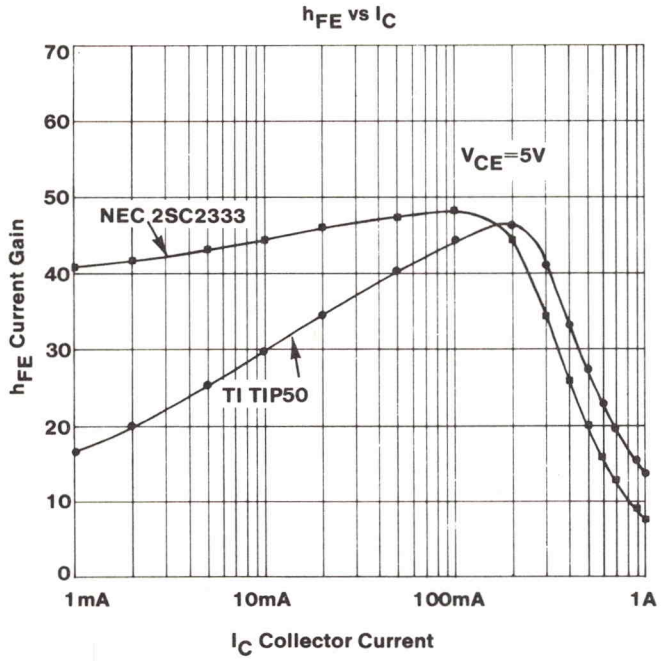
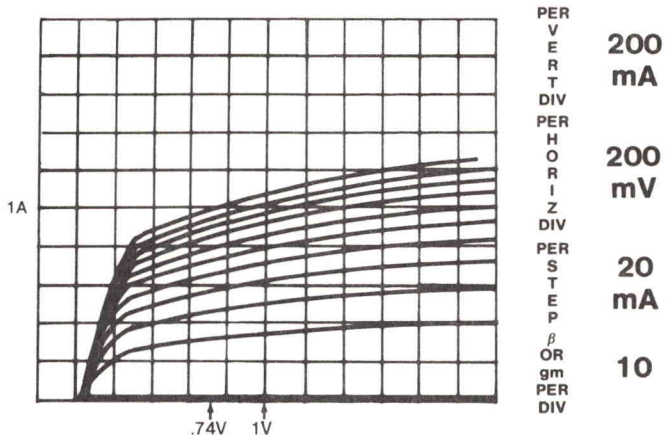
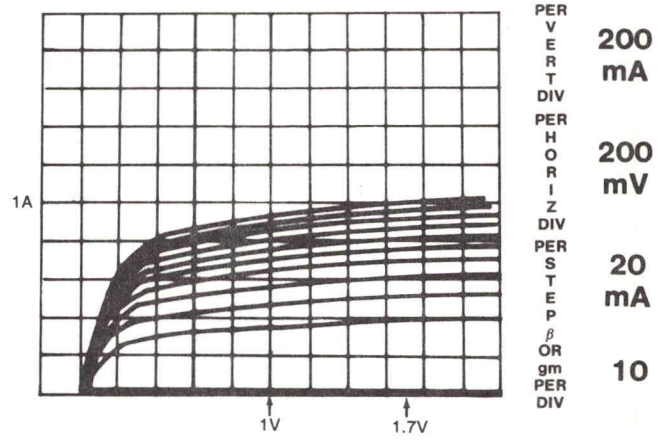


Figure 1

Figure 2 shows a curve tracer representation of this phenomenon. These displays imply an apparent high VCE(Sat), but the parts are **not** in saturation. It's just that the h_{FE} of the NEC device at the test current of 1A is low enough that the transistor is no longer in hard saturation, but is not in the active region.



TI TIP50 — "Measured" $V_{CE(Sat)} = 0.74V$



NEC 2SC2333 — "Measured" $V_{CE(Sat)} = 1.7V$

Figure 2

What is the point of all this? We need information from designers as to what collector current levels are being contemplated in new applications of these devices. This information is required to establish a meaningful $V_{CE(Sat)}$ specification that takes our present and future applications into account.

The best approach is to set our spec to the standard NEC test point of 1V maximum at a collector current of 0.5A, and a base current of 100mA — again a forced Beta of 5. This will give us a good chance of having uninterrupted deliveries of these much-used power transistors.

Please contact me at 78-557, ext. DR-2552, with your comments or questions.

Jim Williamson
Analog Component Engineering

ComponentNewsNewComponents

This column is designed to provide timely information regarding new components, vendors, availability and price. "New Components" can also be used as an informal update to the Common Design Parts Catalogs. Samples may or may not be available in Engineering Stock.

Vendor	Number	Description	When Available	Tek P/N	Engineer to contact, ext.
		analog devices			
Fuji	ESAD83-004	Rectifier, Dual Rect. 25A, 40V, Plastic TO-3	now	soon	G. Sargeant, DR-2540
Fuji, I.R.	12CTQ040	Dual Rect. 10A, 40V, TO-220	now	soon	G. Sargeant, DR-2540
		optoelectronic and passive devices			
Panasonic	LS	Capacitor, aluminum electrolytic, 33μF, 160VDC, single-ended, 0.53" dia. x 1.06" 140mA ripple current	now	290-0947-00	D. Anderson, DR-2545
Panasonic	LS	Capacitor, aluminum electrolytic, 100μF, 50VDC, single-ended, 0.41" dia. x 0.67", 300mA ripple current	now	290-0950-00	D. Anderson, DR-2545
3M	—	Cable assembly, 3.75" long, 50 conductor, socket/socket	now	175-3881-00	E. Doolittle, DR-2309
3M	—	Cable assembly, 2.25" long, 26 conductor, socket/P.C. Board	now	175-3971-00	E. Doolittle, DR-2309
3M	—	Cable assembly, 12.00" long, 50 conductor, PC Board/PC Board	now	175-3975-00	E. Doolittle, DR-2309
3M	—	Cable assembly, 1.50" long, 40 conductor, socket/socket	now	175-3974-00	E. Doolittle, DR-2309
3M	—	Cable assembly, 9.00" long, 50 conductor, socket-socket	now	175-3882-00	E. Doolittle, DR-2309
Belden	—	Cable, 4 twisted pairs – individually shielded, 24AWG	now	175-3151-00	E. Doolittle, DR-2309

Cable ties have ID tags

Component News 284 (page 10) reported on the many advantages of using cable ties instead of Type Kord for lacing harness assemblies. Now, the STS Prototype group at Walker Road has gone one step further, and part numbered cable ties with identification tags for their 179-XXXX-XX cable harnesses.

Two styles of cable ties are available — 346-0187-00, a 4½-inch tie with a flag that can be heat stamped with a part number; and 346-0189-00, an 8-inch cable tie with a label that wraps around the harness itself. The ties should help alleviate confusion in Kit Prep and rebatching areas, as well as making replacement easier for our customers and service technicians.

These two ties will be used on all new STS instruments, and mods are underway to convert to these ties in many existing instrument lines.

If you have any questions about cable ties, please contact **Georgia Brune (08-054), ext. V-7268.**

Anna Krout
94-512, ext. WR-1116

TECHNICAL STANDARDS

The function of Technical Standards is to identify, describe, and document standard processes, procedures, and practices within the Tektronix complex, and to ensure these standards are consistent with established national and international standards. Technical Standards also provides a central repository for standards and specifications required at Tektronix.

Chuck Sullivan, manager (41-260)

New standards available

MIL-C-24308A	**Connectors,** Electric, Rectangular, Miniature, Polarized Shell, Rack and Panel, General Specification
MIL-S-46163	Sealing, Lubricating, and Wicking Compounds: Thread-Locking, Anaerobic, Single-Component
MIL-STD-45662 A	**Calibration** Systems Requirements
Fed-Spec QQ-R-566B	Federal Specification Rods and Electrodes, **Welding** Aluminum and Aluminum Alloys
MIL-I-28947A	Illustrations for **Technical Repair Parts** Publications: Preparation of
MIL-F-55561B	Foil, Copper, Cladding for **Printed Wiring Boards**
MIL-P-46112B	Plastic Sheet and Strip, Polymide
MIL-M-7298C	Manuals, Technical: Commercial Equipment
MIL-E-55585D	**Electronics Equipment** and Parts, Packaging of
MIL-W-47192(MI)	Amendment I — **Welding** Rod and Wire, Nickel Alloy High Permeability Shielding Grade
MIL-I-46865A(MI)	**Insulating Compound,** Electrical Epoxy, Colloidal Silica Filled for Potting and Encapsulation
MIL-I-46877(MI)	**Insulating Compound,** Electrical
MIL-V-47006	**Varnish,** Insulating, Electrical, Unmodified Epoxy Base **Amendment 2**
MIL-R-47191	Amendment I — Rod, Welding, High Strength
MIL-R-39017C	Supplement IA — **Resistors,** Fixed Film (Insulated) Established Reliability General Specification for
MIL-STD-1353B	Electrical **Connectors,** Plug-In Sockets and Associated Hardware, Selection and Use of
MIL-STD-199B	**Resistors,** Selection and Use of — Notice 6
MIL-STD-1587A	Materials and Process Requirements for Air Force Weapon Systems
ANSI/ASTM D 523	Standard Test Method for **Specular Gloss**
IEEE STD 488A	Supplement to IEEE Standard Digital Interface for Programmable Instrumentation

For information on any of these standards, call ext. TC-241.

Notice: Call ext. TC-241 regarding the following items

All Tek people designing, or considering the design of plug-in transformer units should know about UL 1310 Draft Standard for Direct Plug-In Transformer Units.

All Tek people working on/with the RS-232 Interface can get information on 2500 volt testing from FCC Rules and Regulations, Part 6F.

FCC information is now available on Environmental Testing for Vibration, Temperature, Humidity and Shock.

COMPONENT CHECKLIST

The "Component Checklist" is intended to draw attention to problems or changes that affect circuit design. This listing includes: catalog and spec changes or discrepancies; availability and price changes; production problems; design recommendations; and notification of when and how problems were solved. For those problems of a continuing nature, periodic reminders with additional details will be included as needed.

Tek P/N	Vendor	Description of part	Who to contact, ext.
156-1257-00	Intel	8291A GPIB chip	Jim Howe, WI-3589

The D-step version of the 8291A has been received and studied here at Tek. The device seems to be fully functional with the exception of the problem handling Service Request as noted in **Component News 283,** page 14.

Intel has verbally confirmed that the problem with the timing of the interrupt for Serial Poll will be designed out of the chip. Assuming that the redesign is completed successfully, the 8291A will become the device of choice for Talker/Listener GPIB applications.

The reason for this is that the 8291A is significantly enhanced in usability compared to the original 8291. Problems in the interrupt status register behavior have been eliminated, as have problems in handling output transfers. A new ACDS-holdoff function for receipt of <Device Clear> or <Group Execute Trigger> has been added.

The result is that the 8291A is very competitive with the TI 9914 in Talker/Listener applications. The 8291A has an end-of-string compare register which is very convenient, especially for DMA-driven applications. The 8291A also has on-board generation of Parallel Poll response message, which greatly simplifies the implementation of the parallel poll response. However, it cannot be used if more than one address can be recognized.

The 8291A will have a **functional** Service Request facility which implements the auto clearing of the "rsv" local message.

The Intel device consumes only about ½ to ⅔ of the power of the TI device, and costs only about ⅔ as much. Production quantities of the 8291A are expected in March, 1981.

Because of numerous problems in the 8291 versus the availability of the 9914, many designers have chosen the latter. However, the 8291A should be seriously considered as an alternative for Talker/Listener applications. The two devices are similar enough both in pinout and function that some products which have already settled on the 9914 may still be able to change to the 8291A.

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