



A New Multi-Function Voltmeter for General Laboratory Use

HEWLETT-PACKARD voltmeters have always been valued for their accuracy, for the wide range of their measurements, and for their reliability — in short, for their all-around performance. These voltmeters now include a new multi-function voltmeter which has been designed to make measurements in both tube and transistor work. The general usefulness of the new instrument can be illustrated by the fact that its high current sensitivity permits it to measure minute currents such as leakage currents in semiconductor diodes and transistors, currents that most transistor test sets cannot measure.

SEE ALSO:
High Z voltmeter
pre-amp, p. 6

The new meter has been designed to measure the four quantities most often measured in typical bench work: dc voltage, dc current, resistance, and ac voltage. It will measure positive or negative dc voltages from 1 millivolt to 1500 volts and has an input resistance which has been made very high to permit measurement in virtually any circumstance: 100 megohms on the upper ranges and 10 megohms on the three most sensitive ranges.

The instrument will also measure positive or negative dc currents from 150 milliamperes down to 0.1 microampere. In fact, by using the three most sensitive voltage ranges as current ranges, dc currents down to 0.1 nanoampere (0.1×10^{-9} ampere) can be measured. The im-



Fig. 1. New -hp- Model 410C Multi-Function Voltmeter has been designed as a general-purpose dc-measuring instrument which can also measure ac to 700 megacycles with detachable ac probe (shown at left of 410C in center). Instrument's high current sensitivity permits measuring small currents as in above photo, where diode leakage current of 1.6 nanoamperes is being measured.

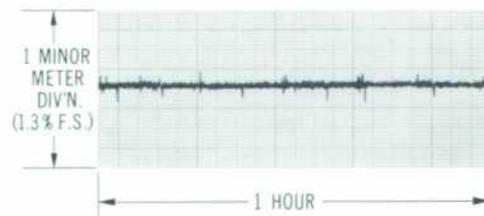


Fig. 2. High dc stability of new voltmeter has eliminated need for a dc zero control. Above recording of no-signal current in voltmeter's indicating meter demonstrates instrument's typical high stability on a much-enlarged scale. Record made on voltmeter's most sensitive range (15 mv f-s).

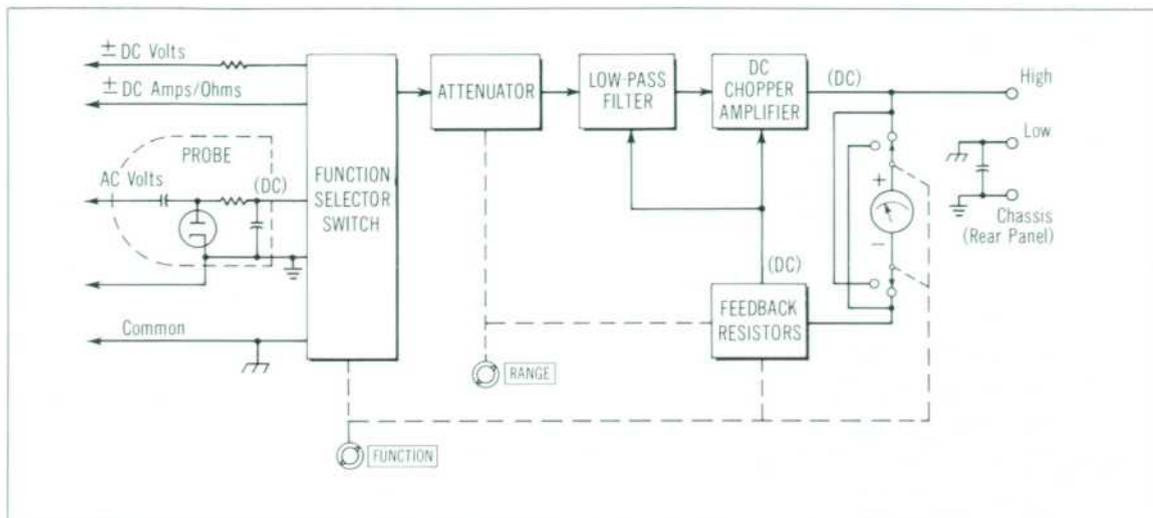


Fig. 4. Block diagram of circuit arrangement of *hp-Model 410C Voltmeter*. *Ac probe is optional.*

that the instrument can be used as a dc voltage or current amplifier.

CIRCUIT ARRANGEMENT

A block diagram of the Model 410C is shown in Fig. 4. The dc amplifier uses the *hp-* developed low-noise photoconductive chopper in which the chopping action is performed by non-mechanical photoconductors. Through use of this chopper and heavy dc feedback around the amplifier, the amplifier has a high input impedance and an exceptionally low drift rate, being specified as less than 0.5% of full scale *per year* at constant temperature. The negligible drift rate and low noise (less than 0.5% of full scale on any range) allows the most sensitive dc voltage range to be 15 millivolts full scale and practical measurements to be made to below a millivolt. The dc chopper amplifier is common to all functions, all inputs being converted to dc voltages for measurement.

The low-pass filter preceding the chopper amplifier attenuates hum which may be present on the signal being measured. An active type filter² is used to obtain fast recovery from overload, without sacrificing

the high attenuation of low frequencies which is especially important for removing commonly-encountered 50 and 60 cps hum.

The photoconductive chopper (Fig. 5) is similar to those used in the sensitive *hp-* 425A microvoltmeter and 412A multifunction dc voltmeter^{3,4}. A neon relaxation oscillator alternately illuminates the two input photoconductors. Normally exhibiting high resistance, the

³J. M. Cage, "An Increased Sensitivity Micro Volt-Ammeter Using a Photo-conductive Chopper," *Hewlett-Packard Journal*, Vol. 9, No. 7, Mar., 1958.

⁴D. Norgaard, "A Precision DC Vacuum-Tube Voltmeter with Extended Sensitivity and High Stability," *Hewlett-Packard Journal*, Vol. 10, No. 11-12, July-Aug., 1959.

photoconductors have low resistance when illuminated so that the amplifier input is switched periodically between a reference level and the input dc level. The amplitude of the resulting square wave is proportional to the input dc. The dc is restored at the amplifier output by the second pair of photoconductors operating in synchronism with the input. No contact noise is generated by this type of chopping action and the circuitry is arranged so that offset voltages are negligible.

The amplifier itself combines the best advantages of tubes and transistors. One section of a dual-triode

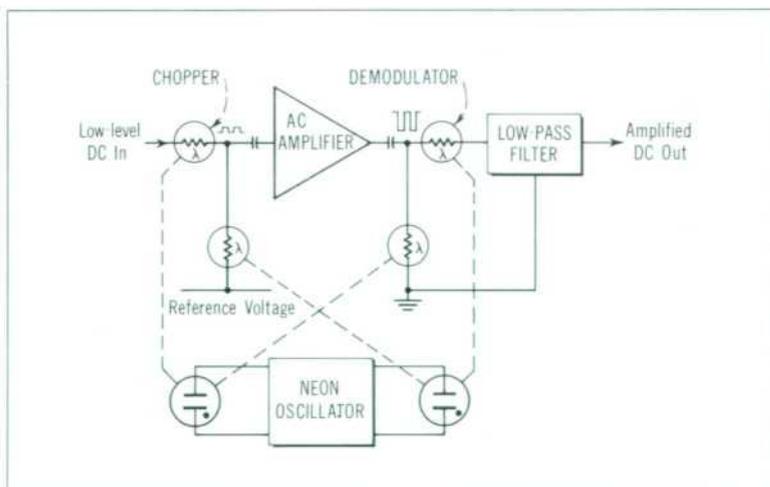


Fig. 5. Non-mechanical photoconductive chopper is used in voltmeter to obtain low-noise, high-stability amplification.

²S. McCarthy, "A Versatile Wave Analyzer for the 1 kc to 1.5 Mc Range," *Hewlett-Packard Journal*, Vol. 14, No. 5-6, Jan.-Feb., 1963.

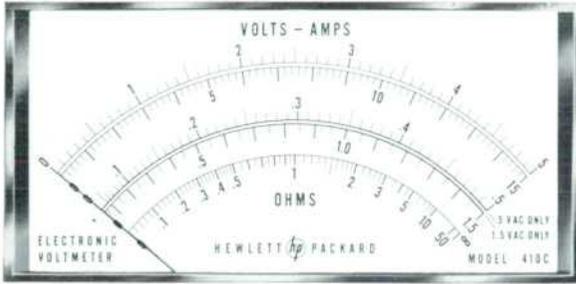


Fig. 6. Detailed view of meter scales. Meter face is calibrated by hp's automatic meter calibrator. Meter movement is of taut-band suspension type.

tube economically provides high input impedance with a low noise figure; the other section serves as the output cathode-follower. Two transistors provide high gain, the overall loop gain being 46 db at dc. Overall instrument voltage gain (in the most sensitive range) from input probe to output connector is 100.

OUTPUT CONNECTIONS

The dc amplifier connects to output terminals at the rear of the instrument, supplying a voltage proportional to meter deflection (1.5 v full scale). Negative feedback reduces the output impedance to less than 3 ohms so that up to 1 ma can be taken from this output without affecting accuracy. The instrument also may be used as a narrow-band dc amplifier (or attenuator) with voltage gains from 100 down to 10^{-3} . Frequency of the amplifier is 0.5 cps at the -3 db point.

Injection of 60 cps hum into the test circuit, a frequently overlooked problem with floating dc instruments, has been minimized in the 410C by careful attention to design of the shielded transformer and power supply. Hum injection, which arises primarily from capacitive coupling through the power transformer to the power line, is held typically to less than 2 millivolts rms or 10^{-7} ampere rms.

MILLI-, MICRO-, AND NANOAMPERE MEASUREMENTS

The voltmeter measures dc current by sensing the voltage drop across internal precision shunt resistors. Sensitivity is such that currents

of less than 1.5 microamps can be measured with a shunt resistor of only 9 kilohms on the most sensitive current range (the maximum current range is 150 ma full-scale with a 0.3 ohm internal shunt).

An alternative technique permits even smaller currents to be measured by use of the three most sensitive voltage ranges. With this technique, the dc voltage probe is used rather than the current probe, so that the voltmeter input resistance serves as the shunt for current measurement (e.g., a current of 10 nanoamps develops a voltage of 0.1 v in the 10 megohm input resistor). In this fashion, currents as low as 0.15 nanoamperes can be measured. This sensitivity is well-suited, for example, to measuring transistor or semiconductor diode reverse leakage currents which may be as small as 1 nanoampere in low-leakage units. The photo-sensitivity of some semicon-

ductor diodes, for instance, is readily demonstrated with the 410C in this current range simply by alternately shielding and exposing the diode to ambient light.

AC MEASUREMENTS

The detachable diode probe, supplied as an optional accessory, is similar to the high frequency probe used on the well-known hp-410B high frequency voltmeter⁵. The probe has a rectifying diode which converts the dc meter into a peak-responding ac voltmeter. With the probe, the instrument accurately measures sine wave signals having frequencies as high as 700 Mc, and it can be used for comparison measurements up to 3 Gc. An ac zero control is included for suppression of the thermionic diode contact potential.

The probe has a distributed shunt capacitance of only 1.5 pf, which enables it to be used on high-frequency circuits with a minimum of circuit loading. AC input resistance nominally is 14 megohms, though unavoidable dielectric losses reduce this at high frequencies (to 1 megohm at 10 Mc and to 10 k at 500 Mc). Sensitivity on ac measurements is higher than most other peak-re-

⁵J. R. Petrak, "The 700 Mc Voltmeter and Its Applications," Hewlett-Packard Journal, Vol. 2, No. 3, Nov., 1950.



Fig. 7. Type N tee enables ac measurements to be made in coaxial systems with new voltmeter's optional probe. Other coax fittings are also available.

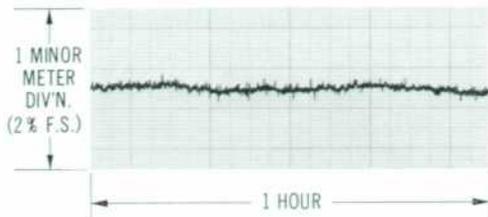


Fig. 8. Record of no-signal current in voltmeter's indicating meter on most sensitive ac range shows typical high stability of overall instrument.

sponding electronic voltmeters, the most sensitive range being 0.5 volt full scale. Special scales are provided to match the non-linear diode amp/volt characteristics on the 0.5 and 1.5 ac volt ranges; on higher ranges, the diode characteristics are essentially linear.

ACCESSORIES

Probe accessories, previously available with the -hp- 410B for extending the voltage ranges and facilitating measurements in coaxial systems, are also available for the 410C. One of these is a 100:1 capacitive divider which fits over the ac

probe tip, extending the maximum ac voltage range to 2000 v rms. Another one is a detached 1000:1 high-vacuum capacitor divider which extends the ac range to 25,000 v rms for measuring extremely high ac voltages, such as those encountered in dielectric heating applications. This unit rests on a bench or table and connects to the voltmeter through its own cable (an adapter is required to attach the cable connector to the ac probe of the 410C).

Two coaxial connectors allow the 410C to make measurements in coaxial cables. One connector is a tee

which attaches to type "N" cable connectors. This enables the probe tip to contact the center conductor of 50 ohm cables for making "bridging" measurements. The other connector fits directly on a female type "N" connector for attaching the ac probe to the end of a coaxial cable.

GENERAL

The instrument is housed in the -hp- modular cabinet occupying 1/3 of a standard 7 inch high rack-mounting combining case. It weighs less than 8 lbs. and may be used on the bench, with the tilt-up bail, or slipped into the combining case for rack use.

ACKNOWLEDGMENTS

The design group for the 410C included Rolly Hassun, Robert L. Huebner, Donald F. Schulz, and the undersigned.

-Paul G. Baird

SPECIFICATIONS -hp- MODEL 410C ELECTRONIC VOLTMETER

DC VOLTMETER:

VOLTAGE RANGES: ± 15 mv to ± 1500 v full scale in 15, 50, 150 sequence (11 ranges).

ACCURACY: $\pm 2\%$ of full scale on any range.

INPUT RESISTANCE: 100 megohms $\pm 1\%$ on 500 mv range and above. 10 megohms $\pm 3\%$ on 15, 50, and 150 mv ranges.

DC AMMETER:

CURRENT RANGES: ± 1.5 μ a to ± 150 ma full scale in 1.5, 5, 15 sequence (11 ranges).

ACCURACY: $\pm 3\%$ of full scale on any range.

INPUT RESISTANCE: Decreasing from 9 k ohms on 1.5 μ a scale to approximately 0.3 Ω on 150 ma scale.

SPECIAL CURRENT RANGES: ± 1.5 , ± 5 , and ± 15 nanoamps may be measured on 15, 50, and 150 mv ranges, using voltmeter probe, with $\pm 5\%$ accuracy and 10 megohm input resistance.

OHMMETER:

RESISTANCE RANGE: 10 ohm to 10 megohm center scale (7 ranges).

ACCURACY: $\pm 5\%$ of mid-scale reading.

AMPLIFIER:

VOLTAGE GAIN: 100 maximum.
AC REJECTION: 3 db down at $\frac{1}{2}$ cps; approximately 66 db at 50 cps and higher frequencies for signals less than 1600 v peak or 30 times full scale, whichever is smaller.

ISOLATION: Impedance between common and chassis is >10 meg in parallel with 0.1 μ f. Common may be floated up to 400 v dc above chassis for dc and resistance measurements.

OUTPUT: Proportional to meter indication; 1.5 v dc at full scale; maximum current, 1 ma.

OUTPUT IMPEDANCE: Less than 3 ohms at dc.

NOISE: Less than 0.5% of full scale on any range (p-p).

DC ZERO DRIFT: Less than 0.5% of full scale/year at constant temperature. Less than 0.02% of full scale/ $^{\circ}$ C.

OVERLOAD RECOVERY: Recovery from 100:1 overload, less than 3 sec.

AC VOLTMETER (-hp- 11036A AC PROBE REQUIRED.)

RANGES: 0.5 v to 300 v full scale in 0.5, 1.5, 5 sequence (7 ranges).

ACCURACY: $\pm 3\%$ of full scale on sinusoidal ac voltages at a calibrating frequency of 400 cps.

FREQUENCY RESPONSE: At 20 cps, 0 to -10% ; at 400 cps, 0%; at 100 Mc, -3 $\pm 2\%$; at 700 Mc, $\pm 10\%$.

FREQUENCY RANGE: 20 cps to 700 Mc.

INPUT IMPEDANCE: Input capacity, 1.5 pf; input resistance, greater than 10 megohms at low frequencies. At high frequencies, impedance drops off due to dielectric loss.

SAFETY: Probe body grounded to chassis at all times for safety. All ac measurements are referenced to chassis ground.

METER: Positive peak-resounding, calibrated in rms volts for sine wave input.

GENERAL:

MAXIMUM INPUT: on dc, 100 v on 15, 50, and 150 mv ranges, 500 v on 0.5 to 15 v ranges, and 1600 v on higher ranges. AC: 100 times full scale or 450 v peak, whichever is less, to 50 Mc, decreasing at higher frequencies to 75 v peak at 500 Mc.

POWER: 115 to 230 v $\pm 10\%$. 50 to 1000 cps, 13 watts (20 watts with 11036A AC Probe).

DIMENSION: 6 $\frac{1}{2}$ in. high, 5 $\frac{1}{2}$ in. wide, 11 in. deep behind panel.

WEIGHT: Net 8 lbs, shipping 14 lbs.

ACCESSORY FURNISHED: Detachable power cord, NEMA plug.

ACCESSORIES AVAILABLE

-hp- 11036A AC PROBE: \$60.00

-hp- 11039A CAPACITIVE AC VOLTAGE DIVIDER (requires -hp- 11018A

Probe Adapter @ \$25.00)

Division ratio: 1,000:1.

Maximum voltage: 25,000 v ac at low frequencies, decreasing to 7000 v at 20 Mc.

Frequency range: ± 25 cps to 20 Mc.

Accuracy: within 3%.

Input capacity: 15 ± 1 pf.

Price: \$150.00.

-hp- 11040A CAPACITIVE AC VOLTAGE DIVIDER

Division ratio: 100:1.

Maximum voltage: 2000 v ac to 50 Mc, decreasing to 100 v ac at 400 Mc.

Frequency range: 10 kc and above; can be used below 10 kc with correction curve.

Accuracy: within $\pm 1\%$.

Input capacity: Approx. 2 pf

Price: \$30.00

-hp- 11042A PROBE COAXIAL "T" CONNECTOR

Residual VSWR: 1.1 @ 500 Mc; 1.2 @ 1,000 Mc

Connectors: one male and one female type "N". \$40.00

-hp- 11043A PROBE COAXIAL TYPE "N" CONNECTOR

Mates with female type "N" connector. \$30.00

-hp- 11045A DC VOLTAGE DIVIDER (for -hp- model 410C only)

Division ratio: 100:1.

Input Impedance: 10,000 megohms.

Maximum voltage: 30,000 v dc

Maximum current drain: 3 μ amps dc

Accuracy: within $\pm 5\%$

Price: \$50.00

PRICE: -hp- Model 410C. \$300.00

OPTION 01: -hp- 11036A AC Probe calibrated with instrument, add \$50.00

Prices f.o.b. factory

Data subject to change without notice

A GUARDED AMPLIFIER FOR INCREASING DIGITAL VOLTMETER SENSITIVITY

ACCURATE dc voltage measurements in the presence of high hum and noise have been made possible by the Dymec DY-2401A Integrating Digital Voltmeter¹. Unlike other digital voltmeters, the integrating voltmeter is little influenced by hum and noise on the voltage being measured. This capability derives from a voltage-to-frequency conversion measuring technique which generates pulses at a repetition rate proportional to the dc voltage being measured and counts them to indicate the measured voltage.

Floated and guarded input circuitry is used in the voltmeter to reject common mode voltages, contributing further to a reduction in the effects of noise. As diagrammed in the typical measuring set-up of Fig. 2, both ac and dc potentials can exist between two widely separated earth grounds, so that common-mode currents may circulate through the loop composed of the transducer bridge arms, signal leads, and capacitance (shown lumped as C_d). A guard shield (Fig. 3) breaks this loop by effectively preventing common mode potential from appearing across C_d . The guard shield com-



Fig. 1. Dymec Model DY-2411A Guarded Amplifier (upper unit) increases sensitivity of DY-2401A Integrating Digital Voltmeter by 10 times, permitting measurements to below 10 microvolts. Amplifier has input impedance above 10,000 megohms, here enabling stable measurement to be made on standard cell which is very sensitive to current drains even of microamperes. Reading is 1,019.17 millivolts with first digit off scale to left.

pletely surrounds the input circuitry and connects to signal ground only through the connecting cable shield. No ground loops involving the input circuit are therefore formed by other earth ground points elsewhere in the system.

The measurement information is coupled out of the guard in the form of pulses. Since voltages existing between guard and chassis, as a result of ground loop pickup, have no effect on operation of the pulse counting circuits, there is no need to float the rest of the instrument. A single-ended output with one terminal tied to chassis ground therefore is available, an important feature in digital data acquisition systems which incorporate other grounded equipment.

10,000-MEGOHM PREAMPLIFIER

The sensitivity of the integrating voltmeter can now be increased ten-fold by the addition of a new

companion amplifier. The amplifier-voltmeter combination permits measurements to be made to below 10 microvolts and is thus well-suited to thermocouple and strain gage bridge transducer measurements. In addition, the amplifier also has an exceptionally high input impedance of 10,000 megohms, which enables measurements to be made in the most demanding situations (Fig. 1).

The new Dymec DY-2411A Guarded Data Amplifier has floating, guarded circuitry from input to output so that the signal guard is maintained all the way from the transducer output to the voltmeter input. Negligible zero drift and low internal noise in the amplifier allow full use to be made of the digital voltmeter's high accuracy, making it possible to measure voltages as low as a few microvolts (see Table p. 8). The amplifier also serves as an excellent buffer because of its high input resistance.

¹R. A. Andersen, "A New Digital Voltmeter Having High Rejection of Hum and Noise," Hewlett-Packard Journal, Vol. 13, No. 6, Feb.,

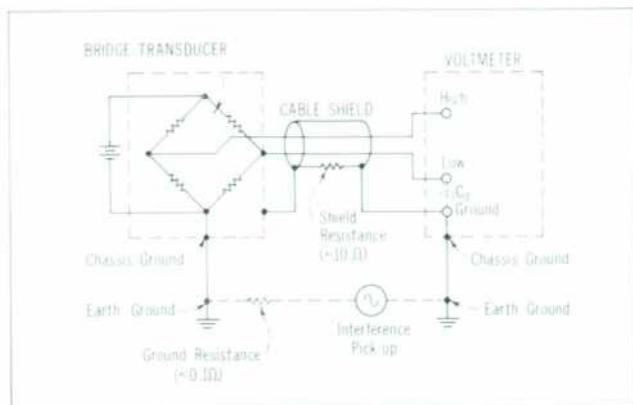


Fig. 2. Diagram showing how hum pick-up typically impresses hum voltage across an unguarded voltmeter's input impedance. Ground loop (common mode) current flows through the arms of the bridge and C_d . DY-2401A Voltmeter is designed to avoid this problem, as shown in Fig. 3.

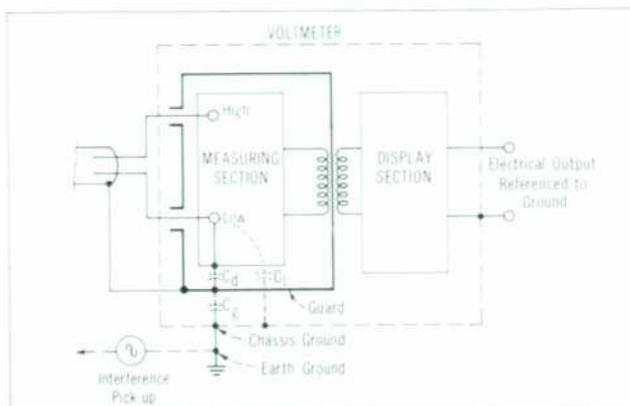


Fig. 3. Basic input circuit arrangement of DY-2401A Integrating Digital Voltmeter. Input and measuring circuits are guarded (and floated) to reduce stray capacity C_L to a very small value, thus opening hum-circuit loop and giving effective common mode rejection of 134 db or more.

Fixed amplifier gain settings of +1, +10*, and bypass may be selected manually or by remote contact closures.

The amplifier-voltmeter combination has 6 voltage ranges, extending from 10 mv to 1000 v full scale (the amplifier is bypassed when the input voltage exceeds ± 10 v); 300% over-ranging on the 5 lower ranges increases resolution to a maximum of 3 parts in 10^6 . This means that on the 10 mv range, for example, the amplifier-voltmeter reads input volt-

ages up to 30 mv with the most significant digit moved to a non-existent sixth place to the left of the 5-digit display.

Fast settling time, to within 0.01% of final value in 100 μ sec, insures that the amplifier assumes a new voltage level with full accuracy prior to a new measurement in spite of fast commutating rates. For instance, the Dymec 2010G low-level data acquisition system, which incorporates the new amplifier, is able to make a measurement within 100 milliseconds, including channel switching time and recording on punched paper tape.

The DY-2411A guarded data amplifier uses the stable dc amplifier circuitry of the Dymec DY-2460A operational amplifier, recently described in these pages². This amplifier capitalizes on a long-lived, physically rugged photoconductive chopper which is inherently quiet and stable.

OVERLOAD CIRCUITRY

Overload protection is incorporated in the amplifier to eliminate the possibility of amplifier saturation. Saturation is undesirable in a digital data acquisition system because slow recovery from saturation affects the output voltage, providing erroneous readings of transducer measurements which follow an overload. Level sensing circuitry in the DY-2411A reacts when the amplifier output voltage exceeds ± 10.5 volts, activating relays to disconnect the amplifier circuitry from the signal line while providing a bypass for the signal.

REMOTE PROGRAMMING

The overload relays also function as part of the control circuitry to bypass signals automatically during measurements of quantities not re-

*Although the gain setting multiplies rather than adds to the gain, a plus sign (+) is used to signify that there is no signal polarity inversion.



Fig. 4. Panel view of DY-2411A Guarded Amplifier with DY-2401A Integrating Digital Voltmeter. Inter-connections are at rear.

²R. J. Strehlow, "A Solid-State Operational Amplifier of High Stability," Hewlett-Packard Journal, Vol. 14, No. 3-4, Nov.-Dec., 1962.



Fig. 5. DY-2401A Voltmeter and new DY-2411A Amplifier are incorporated in Dymec DY-2010G Thermocouple and Strain Gage Measuring System. System measures up to 200 inputs at 5-place full-scale sensitivity of $\pm 10,000$ millivolts. Measurements are recorded on paper tape by high-speed punch (open panel) for computer processing.

NOISE AND STABILITY RATINGS OF DY-2401A/2411A VOLTMETER-AMPLIFIER COMBINATION FOR MOST-SENSITIVE RANGES

| VOLTMETER SAMPLING TIME | VOLTMETER RANGE SETTING | VOLTMETER FULL-SCALE READING ⁽¹⁾ ⁽²⁾ ⁽³⁾ (DY-2411A SET TO +10) | NOISE ⁽⁴⁾ | 24-HOUR STABILITY |
|-------------------------|-------------------------|---|--------------------------------|--------------------------------|
| 1 sec | 0.1 v 1 | 9.9999 mv 99.999 mv | $\pm .002$ mv $\pm .003$ mv | $\pm .004$ mv $\pm .010$ mv |
| 0.1 sec | 0.1 v 1 v | 10.000 mv 100.00 mv | $\pm .005$ mv $\pm .015$ mv | $\pm .004$ mv $\pm .010$ mv |

⁽¹⁾Assumes M20 decimal point modification incorporated in voltmeter; otherwise decimal point shifted one place to right.

⁽²⁾Polarity sensed and indicated automatically

⁽³⁾Over-ranging to 3 times full scale

⁽⁴⁾Reading-to-reading fluctuation with steady input signal

quiring the amplifier. Other relays switch the resistors to set the amplifier in the +1 or +10 mode. The relays, all of which are reliable reed types, may be operated by the front panel switch or activated remotely by contact closures to ground.

The DY-2411A uses all solid-state

circuitry for maximum unattended reliability in data acquisition systems. The amplifier is housed in the -hp- modular cabinet so that it may be used in a standard 19 in. rack, with supplied adapters, or put to use as a manually-operated bench unit.

—Donald H. Jenkins

SPECIFICATIONS

DYMEC DY-2411A

GUARDED DATA AMPLIFIER

NOISE REJECTION: Effective common mode rejection when used with guarded DY-2401A Digital Voltmeter is 134 db min. at all frequencies, 154 db at dc (0.1 sec sample).

GAIN: +1 and +10 (non-inverting). Gain setting and bypass mode selected manually or remotely.

GAIN ACCURACY: (into 100k) +1: $\pm .002\%$; includes temperature effects, 10° to 50°C +10: $\pm .007\%$; temp coeff. 0.0005%/°C

LINEARITY: $\pm .001\%$ of full scale, either gain setting.

ZERO DRIFT:

CONSTANT TEMP: 1 μ v/week max. with 2-hour warmup.

TEMP. COEFF: 0.5 μ v/°C max. with 2-hour warmup.

ZERO ADJUSTMENT: ± 30 μ v. Zero shift on change of gain setting or switch to bypass is less than 3 μ v.

NOISE: Noise and stability figures for DY-2411A/DY-2401A combination for most popular voltmeter settings are shown in chart (valid for source resistance of 100 k or less) (see table at top of page.)

INPUT CIRCUIT:

TYPE: Floated and guarded signal pair. Signal pair and guard may be operated up to 500 v above chassis ground.

INPUT RESISTANCE: 10^{10} ohms, for relative humidity up to 95% at 40°C.

LEAKAGE RESISTANCE: Low to guard: $>10^8$ ohms. Guard to chassis: $>10^8$ ohms.

INPUT CAPACITANCE: 180 pf nominal (140 pf in bypass mode.)

FULL-SCALE INPUT: ± 10.5 v^(*) for +1 gain.

± 1.05 v^(*) for +10 gain.
 ± 1000 v in bypass mode.

CONNECTORS: Front panel binding posts (3/4" centers) for HI, LO, and Guard. Also special guarded connector on rear panel.

OUTPUT CIRCUIT:

OUTPUT RESISTANCE: <1.5 ohms.

MIN. LOAD IMPEDANCE: 10 k.

MAX. OUTPUT: ± 10.5 v (see full scale input).

CONNECTOR: Special guarded connector on rear panel.

SETTLING TIME: Output settles to within .01% of final value in 100 μ s. (Minimum encode delay time of DY-2401A is 6.66 ms.)

PROGRAMMING:

RANGE SELECTION: +1, +10, and bypass selected by external contact closures to ground, applied to rear Winchester connector.

OVERLOAD RESET: Range selection takes less than 6 ms. Positive-going 15 v pulse, applied to programming input connector. Instrument resets in less than 6 ms.

(*) If input exceeds this, amplifier switches automatically to bypass mode. Overload indicated by front panel lamp; reset by pushbutton or remote signal.

PROGRAMMING OUTPUT: Programming commands (contact closures to ground) normally received from system scanner at programming input connector and routed through to voltmeter at separate rear connector. DY-2411A generates contact-closure to ground when switched to +10 range, permitting correct decimal point indication on DY-2401A-M20.

OPERATING CONDITIONS: 10° to 50°C ambient temperature range; up to 95% relative humidity at 40°C.

POWER REQUIRED: 115/230 v $\pm 10\%$, 50 to 1000 cps, 16 watts approx.

DIMENSIONS: 16 3/4 w x 3 1/2 h x 13 1/4 d.

WEIGHT: Net 17 lb.; shipping 26 lb.

ACCESSORIES FURNISHED: Signal Input Connector; mates with rear guarded connector.

Signal Output Cable; mates with rear guarded connector, other end terminated with spade lugs.

Programming Input Mating Connector.

PRICE: MODEL DY-2411A Guarded Data Amplifier, \$1,150.00.

DYMEC

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