SOLARTRON

INTEGRATING DIGITAL VOLTMETER LM 1420.2

DATA SHEET

- 2.5μV–1000V in 6 ranges.
- >150dB Common Mode Rejection.
- Integration minimises super-imposed noise.
- 0.05% d.c. accuracy.
- 33 conversions per second.
- >5,000 MΩ input resistance.
- 250 kc/s counter facility.
- BCD or Decimal printout.
- Compact, light-weight, low cost.

Digital Voltmeter LM 1420.2

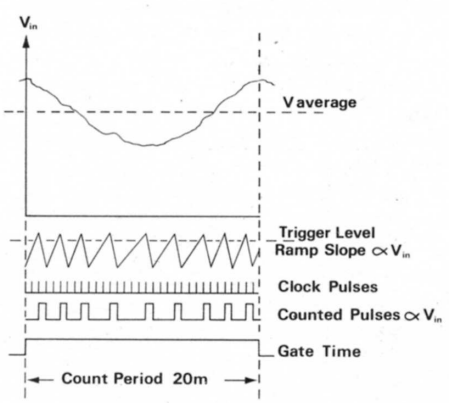
The Solartron Integrating Digital Voltmeter LM 1420.2 is a compact, high performance instrument of outstanding flexibility and low cost which uses a self-compensating, counter integrator technique (patents applied for), to achieve high accuracy and high resolution with maximum discrimination against unwanted signals.

The input circuits are completely floating with an isolation impedance greater than 10^5MΩ and less than 25 pF to mains earth, giving 150 dB rejection of common mode interference up to 500V peak. Advantage has been taken of the counters within the instrument to provide counting facilities (pulse counting, frequency and period measurements), with local or remote control. The digital readout is by neon number tubes housed behind a polaroid filter. New manufacturing methods, including automatic testing of printed circuit boards and cable looms before final assembly, ensure a high standard of reliability.

LM 1420.2 forms part of a comprehensive range of modules designed to meet every laboratory and industrial application. These include a true r.m.s. reading AC Converter a mean sensing converter and a digital resistance test set. The LM 1420.2 also forms the basis of a low cost compact logger comprising 20, 50 or 100-Channel Scanning Units, Lineariser, Thermocouple Bridge and Cold Junction Units, Punch Encoder, Range Change Unit, Digital Clock, Current Drive Unit, Off-Limit Detector and Printer Drive Unit.

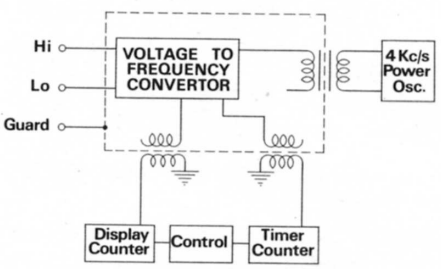
Principles of Operation

The applied signal voltage causes the output of an integrating amplifier to rise towards a preset trigger level, at which point it is reset by an accurately quantised charge. The rate of rise, and consequent number of reset charge pulses per unit time, is directly proportional to the input voltage. Digitisation is achieved by counting these pulses over a defined period thus giving a true average of the applied signal throughout that period, so minimising the effects of spurious noise. The counting period selected is normally one cycle of the mains supply frequency to give maximum rejection of fundamental and harmonics of this frequency. The timing oscillator controls the duration of the discharge pulse, as well as the count period, so that any drift of oscillator frequency will vary the timing period and pulse duration equally, hence providing automatic compensation to retain reading accuracy.



Note: Pulse Frequeny is not to scale.

The output from the counter integrator circuit is a train of pulses coupled to the counter circuit through a toroidal transformer. Power supplies are coupled to the input circuit through a similar transformer in the form of a 4kc/s square-wave, thus the input stages are completely isolated from mains earth. Input is via a 3-way plug providing 'High' and 'Low' signal pair, and a 'Guard' connection. Thus either 3-terminal guarded measurements or 2-terminal ('guard' strapped to 'low') measurements can be



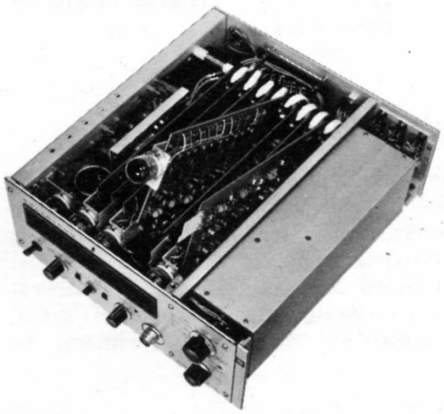
made. For most laboratory applications, 2 terminal connection to the signal source will give adequate rejection of noise. For certain applications, (e.g. data logging) the 'Guard' can be taken to the source of common mode voltage, thus virtually eliminating the common mode loop. This results in a common mode rejection in excess of 150 dB. Voltmeter sensitivity may be doubled or quadrupled by increasing the count period by ×2 or ×4. This facility may be used to increase effective resolution for inputs below ½ scale or ¼ scale respectively on any range. Inputs to both the timing and display counters are brought out to the rear of the instrument and may be used for pulse counting, frequency and period measurements, etc., with facilities for local and remote control.

Apart from the display tubes, semiconductors are used throughout. A special feedback arrangement achieves a very high input resistance on the three unattenuated

ranges. On the 2V range the resistance can be made virtually infinite for short periods so that accurate measurements may be made on sources of over 100 MΩ.

Mechanical Features

LM 1420.2 is small, lightweight and portable. It has a full-width carrying handle which may be used as a support for tilting the instrument. The chassis is aluminium with a Warerite faced front panel. The case is of P.V.C. clad steel. The number tube display is recessed behind a polaroid filter. All printed circuit boards are hinged at one corner to provide easy access for 'live' servicing. A specially developed type of soldered connector replaces printed circuit board edge connectors with consequent increase in reliability.



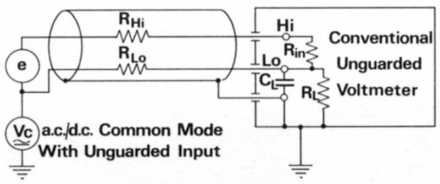
All components have been chosen for ruggedness and reliability, and nearly all (99.5%) have wide tolerances.

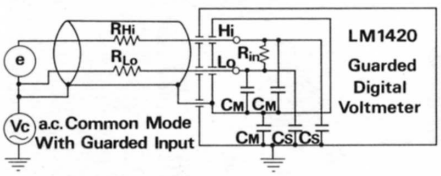
Measurement in the Presence of Noise

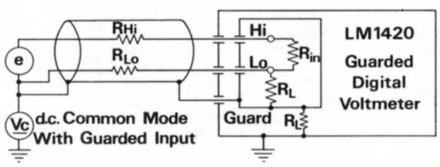
Under practical conditions, noise interference is one of the major obstacles to accurate measurement. The LM 1420.2 Integrating Digital Voltmeter employs average reading, which greatly reduces the effects of superimposed interference and the instrument incorporates an isolated and guarded input circuit to eliminate common mode noise.

Series Mode Rejection: The LM 1420.2 displays the average value of the input voltage by integration over a fixed period of 20, 40 or 80msec. Thus interference at supply frequency and related harmonics, arising in series with the measure dd.c. voltage, is virtually eliminated. This inherent rejection of 30dB can be supplemented by a switched R-C filter to give a total rejection of 60dB at 50c/s, increasing at 6dB per octave.

Common Mode Rejection: Common mode interference is an unwanted signal that simultaneously varies the potential of both the HIGH and LOW terminals of the measuring instrument with respect to earth or chassis. It may be produced by

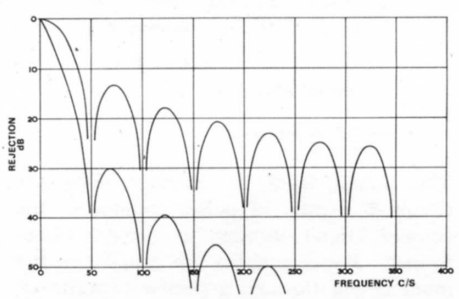




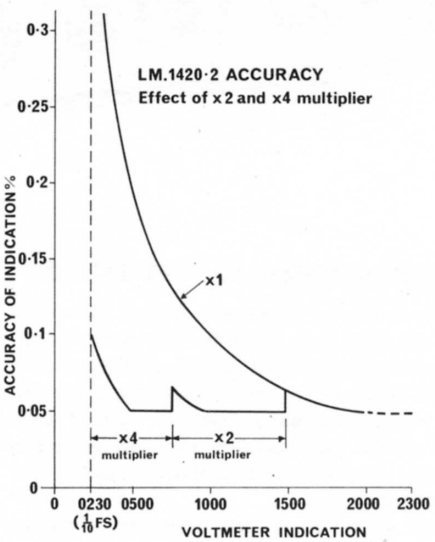


currents flowing between the voltmeter chassis earth and the earth point of the circuit under test, or it may originate from the measured voltage itself when both terminals are elevated from earth potential. The HIGH and LOW signal paths differ in impedance, therefore a series mode interference signal is produced at the voltmeter input, thus introducing errors. The magnitude of error is proportional to the current flowing in the earth loop. The solution to this problem is to increase the total impedance of the LOW signal paths to a value which reduces this current to negligible proportion. This is achieved in the LM 1420.2 by placing the isolated input circuitry within a GUARD screen which is itself isolated from the main chassis. Thus the input terminals are isolated from earth to better than 10^5 Megohms and less than 25pF. This is achieved by feeding power supplies into the converter unit and output pulses from the unit via carefully designed toroidal transformers. The screening box providing this GUARD is also mounted on high grade nylon insulators.

Since it is the resulting series mode interference signal which causes errors, the integrating property and optional use of the R-C filter give a further improvement in rejection. As a result of these precautions the LM 1420.2 provides a DC common mode

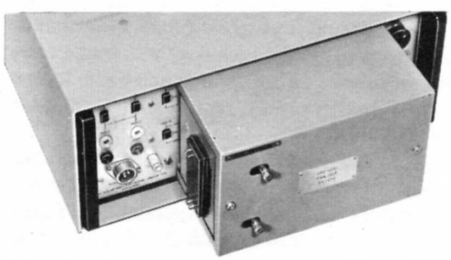


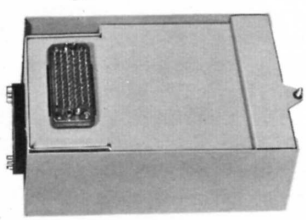
rejection of better than 150 dB and an AC common mode rejection of better than 130 dB at 50 cycles/second. A two-terminal test lead (part No. 359900010) is normally supplied with the instrument. This lead comprises two conductors for 'High' and 'Low' input connections, and a screen connected to the 'Guard'. This screen is permanently strapped to the 'Low' conductor at the test end. A three-terminal test lead (part No. 359900020) is available as an optional extra for certain applications such as data logging, to provide an independent 'Guard' connection for those cases where the common mode source is not effectively at the 'Low' test point.



Print-Out

The displayed value in modified BCD form is brought out to a rear 75-way socket, together with polarity, range and print command signals. As these signal outputs cannot be loaded, provision is made to plug 'fan-out' modules on to the rear to give





current gain, and true BCD or Decimal code. These modules are the EX 1418 for BCD and the EX 1419 for Decimal code.

SPECIFICATION

D.C. Voltage Measurements

Sensitivity: Basic sensitivity is 10μV on 20mV Range. A front panel switch gives sensitivity multiplication of ×1, ×2 and ×4 on all ranges. At ×2 multiplier setting maximum sensitivity is 5μV per indicated digit; at ×4 setting maximum sensitivity is 2·5μV per indicated digit.

Accuracy: ×1 Sensitivity Multiplier All Ranges ±0.05% of Range. i.e. ± 1 digit.
×2 and ×4 Sensitivity Multiplier. All Ranges ±0.05% of Indication OR ±1 indicated digit, which ever is the greater, up to an indication of 2999 (See Graph).
Above specification holds for mains variations of +15% to −20% of nominal setting.

Maximum Indication: 2300 on × 1 Sensitivity Multiplier. i.e. 15% over range.
2999 on ×2 and ×4 Multipliers.

Ranges

Range	Input Resistance	Sensitivity
20mV	> 50MΩ	10μV
200mV	> 500MΩ	100μV
2V	> 5000MΩ	1mV
20V	10MΩ	10mV
200V	10MΩ	100mV
1000V	10MΩ	1V

Resolution Control: 1 and 2 digit resolution control. At 2 digit resolution only even numbers are displayed.
Calibration: Internal Weston Standard Cell (unsaturated).
Operating Temperature Range: 0–50°C.
Temperature Coefficients: Typical figures, all Ranges. Volts zero ±0.6μV per degree C. Current zero $\pm 2.5 \times 10^{-11}$ A per degree C.
Scale Factor ±0.01% per degree C. The instrument may be reset to full accuracy at a given temperature (5–45°C) using front panel preset controls and internal Weston Cell.
Weston Cell Temperature Coefficient
±0.0005% per degree C.

Long Term Accuracy Stability: ±0.01% per year after calibration against internal Weston Cell.

Input Overload: The instrument will withstand an overload of 200 volts on the 20mV, 200mV and 2V ranges, and 1000 volts on the 20V and 200V ranges. Overload recovery time <500 msec.

Interference Rejection

Series Mode Rejection: The instrument displays the average value of the input over periods of 20 msec, 40 msec or 80 msec. Greater than 30dB rejection of 50c/s (or, if required 60c/s) and its harmonics is achieved. High frequency noise is also averaged out. Even at zero d.c. input, interference up to 10% of range can be tolerated.

Common Mode Rejection: (With or without earth referenced print out device).

> 150 dB at d.c.
> 130 dB at 50c/s

} With 1kΩ unbalance between input leads and filter in use.

Maximum permissible common mode is 500V peak with respect to chassis.

Filter: A simple R–C filter with a time-constant of 100 msec. may be switched in. This gives an additional attenuation of 30dB at 50c/s increasing at 6dB per octave.

Input: The instrument is supplied with a 3-way shielded connector attached to a 2-core screened cable. The screen is taken to the internal screening box.
The input is completely isolated with $> 10^5$MΩ shunted by 25pF between low and chassis, and $> 10^4$MΩ shunted by 150pF between screening box and chassis.
The input capacitance between signal high and signal low is 0.02μF approximately on the 20mV, 200mV and 2V ranges, and approximately 200pF on the 20V, 200V and 1,000V ranges.

Polarity Indication: The polarity of the input is sensed and automatically displayed as a + or − sign.

Measurement Speed

Automatic Mode: 33 readings per second on ×1 Sensitivity Multiplier, 20 per second and 11 per second respectively on ×2 and ×4 Sensitivity Multipliers.
Manual Sample Mode: 22 readings per second Monopolar or Programmed Polarity Operation. 8 readings per second Bipolar Operation.
Remote Control: Sampling may be controlled by either remote contacts or a pulse. The pulse must be a 6–10V positive-going edge of rise time <1μsec.

Print-Out

The displayed value is available in modified B.C.D. form at a rear 75-way socket. Other outputs include polarity, range and print command signals.
"Fan-out" modules which give current gain and true parallel B.C.D. or decimal code are available as extras. They bolt on to the rear panel and the print information is supplied via a 50-way connector on the EX 1418 (B.C.D.) and 75-way connector on EX 1419 (Decimal) Fan out unit. The units are approx. 7½" wide by 5" high, the EX 1418 is 2½" deep and the EX 1419 is 4" deep.

Signalling Levels from Fan-Out Units

	ON	OFF
Numerical Information	−6V at 4mA load −10V into o/c	 0V
Polarity	−6V at 3mA load −10V into o/c	 0V
Range Information	−12V at 1mA load	0V

Digitise Command: 6–10V positive going pulse of rise time <1μsec or contact closure.
Print Command:
12V negative going pulse of approximately 200μsec duration, and waveform changing from −12V during digitise to 0V during display. } In Sample mode only

Frequency and Time Measurement: The two internal counters (Timer and Display) are made available for use at the rear panel. By suitable combinations of input signals and count time, the instrument may be employed as either a simple stop watch, or to determine the frequency or period of unknown events. Counting can be controlled locally on the front panel, or remotely by signals and contact closures.
Frequency: The maximum inputs are: Timer Counter 600kc/s Display Counter 300kc/s.
Sensitivity: Minimum input to both counters: 3V r.m.s.
Control Signals: Start and stop signals can be applied to two separate sockets. By commoning these sockets, the signals can be applied sequentially. A 6–10V positive-going edge of rise time <1μsec is required in each case.
Timer Ratios: The division ratio of the Timer Counter may be set to 10^3, 2×10^3, 4×10^3, 10^4, 2×10^4 or 4×10^4.

Operating Modes

Manual: The front-panel push-button is used to Reset-and-Start, and to Stop.
Remote: External pulses can be used to stop and start. The push-button is used to reset. At either Manual, or Remote, a count period may bedefined by using the Timer Counter. An external signal may be fed in, or the internal 500kc/s clock may be employed.
Single: The instrument totals the signals received during one count period only. Subsequent periods are ignored.
Multiple: The instrument displays the accumulated total of pulses received during successive count periods.

General

Display: End-viewing cold-cathode number tubes mounted behind a polaroid filter. The decimal point is positioned automatically by the range switch. The filter allows the display to be easily read under all conditions of ambient lighting.
Overall Dimensions:
Height: 6½ in. (16.5cm)
Width: 14¼ in. (36.2cm)
Depth: 16¼ in. (41.3cm)

LM1420.2R
Height: 5¼ in. (13.4cm)
Width 19 in. (48.2cm)
Depth 15 in. (38.1cm) from front panel face
16 in (40.6cm) Overall

Weight: 25lb. (11.3kg).
Power Input: 117V/234V+15%–20%, 50–60c/s; 50VA.

INTEGRATING DIGITAL VOLTMETER LM 1420.2

DATA SHEET

SOLARTRON

Alternative Versions of LM 1420.2

LM1420.2R: (Rack mounting) comprises a standard LM 1420.2 to which is bolted a mechanical extension unit enabling it to be mounted in standard 19-inch racking. A full-width dust cover is also included.

LM 1420.2B: (Bench mounting) is of similar mechanical construction to LM 1420.2R housed in a 19″ bench case. The dust cover is therefore not required. A Standard LM 1420.2 may be converted for rack mounting or may be housed in a 19″ bench case by the addition of the appropriate extension units.

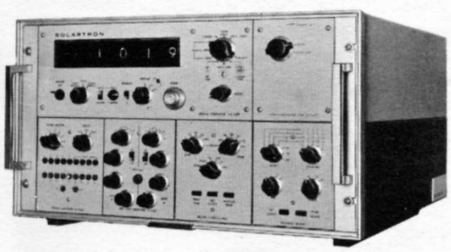
LM 1420.2C: (Command Range Version). The command range facility enables remote range selection for 20mV, 200mV, 2V, 20V and 200V and remote control of x1 x2 or x4 sensitivity.

LM 1420.2A: (DC plus True RMS and Mean AC measurement). This unit provides true RMS and means sensing of AC input voltage irrespective of its waveform as well as DC measurement.

LM 1420.2M: (DC plus Means AC sensing). The mean AC sensing unit is scaled to indicate the RMS value of a sinusoidal input, having a much wider frequency range than the LM 1420A.

LM 1420.2C, LM 1420.2A or LM1420.2M are manufactured as complete units. They are 17″ wide and are suitable for 19″ rack mounting or may be housed in a 19″ bench case.

Associated Equipment



Compact Logger: This system is a complete data logger based on the LM 1420.2 and makes use of additional compatible units including – System Pin Board, 20, 50 or 100-Channel Scanners LU 1461 or LP 1132, Printer Drive Unit LU 1466, Punch Encoder LU 1718, Typewriter Drive Unit LU 1469, Digital Clock LU 1463, Off-Limit Detector LU 1464, Resistance Thermometer Unit LU 1462, Lineariser LU 1465 and Thermocouple Unit LU 1468.

Resistance Digital Test-Set LM 1621: This unit uses an LM 1420.2 to measure the out of balance voltage in a wheatstone bridge circuit. It may be used in one of two ways—

(a) to give a digital display of the percentage deviation of an unknown resistor from any nominal value.

or (b) as a high accuracy absolute resistance bridge using the LM 1420.2 as the null detector.

The unit is completely self-contained and measures resistance in the range 10Ω – 10MΩ.

Accessories

Test Leads: Part No. 359900010. Two-terminal lead with Guard connected to Low. Part No. 359900020. Three-terminal lead with independent High, Low and Guard connections.

Valve and Semi-Conductor Complement

Semi-conductors

Diodes

Type No.	Manufacturer	No. Off.
OA91	Mullard	188
OA95	Mullard	4
OA200	Mullard	4
OA202	Mullard	6
OAZ241	Mullard	5
OAZ243	Mullard	2
OAZ245	Mullard	2
OAZ240	Mullard	1
ZD599A	Lucas	1
BYX22–200	Mullard	4
BYX22–400	Mullard	2
BAY31		11
1S120	Texas	4
RAS310AF	Plessey	2

Transistors

Type No.	Manufacturer	No. Off.
ACY17	Mullard	1
ACY20	Mullard	3
XK505	S.T.C.	15
D535	Texas	83
GET885	Mullard	13
OC35	Mullard	3
SA203	Sprague	2
SA201	Sprague	2
3N72	Sperry	1
2S303	Texas	1
49496A	Lucas	1
A1778	Fairchild	36
2S501	Texas	1

Valves: Neon display tubes

ZM1020	Mullard	4
ZM1021	Mullard	1

Ordering Code

LM 1420.2 refers to the basic digital voltmeter in a small bench case 14¼ in. (36.2 cm) wide. When ordering LM 1420.2 in combination with associated equipment the code numbers given in the following table should be used.

Combination Description		Order Code No.
LM 1420.2 plus Blank Panel Unit	19 in. Rack Mounting Unit	1420 R
	19 in. Bench Case	1420 B
LM 1420.2 plus Command Range Unit	19 in. Rack Mounting Unit	1420 RC
	19 in. Bench Case	1420 BC
LM 1420.2 plus AC Converter Unit	19 in. Rack Mounting Unit	1420 RA
	19 in. Bench Case	1420 BA
LM 1420.2 plus Mean AC Converter Unit	19 in. Rack Mounting Unit	1420 RM
	19 in. Bench Case	1420 BM
BCD Fan-Out Unit		EX 1418
Decimal Fan-Out Unit		EX 1419

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