LW-322D Digital mV and dB Meter

(This guide was written by Jos Verstraten on 20-03-2021)

The LW-322D digital mV_{ac} and dB meter
This digital meter is specially designed for measuring very small AC voltages. With its lowest full scale range of 3.999 mV, you can accurately measure even voltages of less than 1 mV. When you add to that a specified frequency range up to 2 MHz and an accuracy of ±1.5 % up to 100 kHz, this meter seems ideal for anyone who often experiments with audio circuits.
However, what makes this meter totally irresistible is its ability to measure dB. With the 0 dB point at 1.00 V you can, according to the specifications, measure from -79 dB to +50 dB.

The scope of delivery
This digital mV_{ac}/dB meter comes well-packaged in a sturdy box with:
- a 130 cm mains cable with grounded mains plug and IEC C13 connector
- a 60 cm BNC to crocodile clip cable
- a 60 cm BNC to BNC cable
- a thin English manual

The scope of delivery of the LW-322D.

Appearance of the LW-322D mV_{ac}/dB meter
The meter is housed in a sturdy metal case measuring 220 mm by 265 mm by 85 mm, and weighs 3.3 kg. The display consists of four green seven-segment LED displays with a digit height of 13 mm. In addition, there are fifteen green LEDs for indication of:
- the measuring function (mV, V, dB, dB_m)
- one of the six measuring ranges
- overloading of the measuring range
- automatic range switching
- manual range switching
- channel 1 as input
- channel 2 as input

Next to the solid orange power switch are five small push buttons which, due to the weight of the device, are easy to operate without the device sliding backwards:
- Set range down
- Set range up
- Auto/Man
- V/dB/dB_m
- CH1/CH2

Two BNC connectors for connecting two measurement signals are provided on the right.

The appearance of the LW-322D.

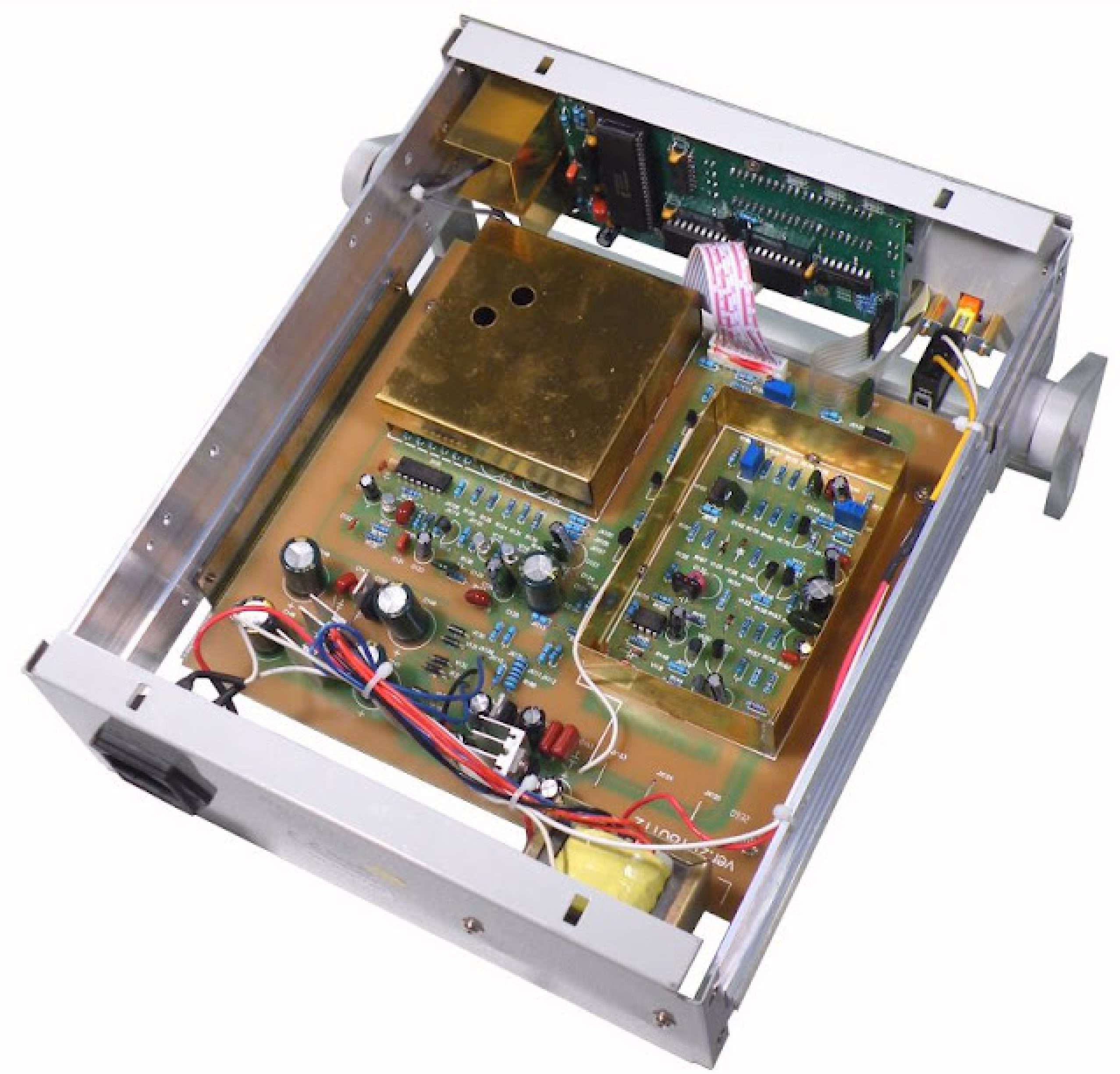
The technical specifications
According to Long Wei, the LW-322D meets the following specifications:

- **Measuring ranges V:** 3.999 mV ~ 39.99 mV ~ 399.9 mV
- **Measuring ranges V:** 3.999 V ~ 39.99 V ~ 399.9 V
- **Zero dB measurement:** 1.0 V
- **Zero dB$_m$ measurement:** 0.775 V
- **Measuring range dB:** -79 dB ~ +50 dB
- **Measuring range dB$_m$:** -77 dBm ~ +52 dBm
- **Input impedance:** 1 MΩ // 30 pF
- **Frequency range:** 5 Hz ~ 2 MHz
- **Voltage measurement accuracy 50 Hz ~ 100 kHz:** ±(1.5 % + 8 digits)
- **Voltage measurement accuracy 20 Hz ~ 500 kHz:** ±(1.5 % + 10 digits)
- **Voltage measurement accuracy 5 Hz ~ 2 MHz:** ±(4.0 % + 20 digits)
- **dB measurement accuracy:** voltage measurement accuracy ±1 digit

An amazing amount of electronics
Today we are used to the fact that the housing of a measuring device is largely empty. This is a consequence of the miniaturisation of the components and the high degree of integration. This is not the case with the LW-322D, see the picture below. The main PCB takes up almost the entire length and width of the housing. Immediately, a number of remarkable points stand out:

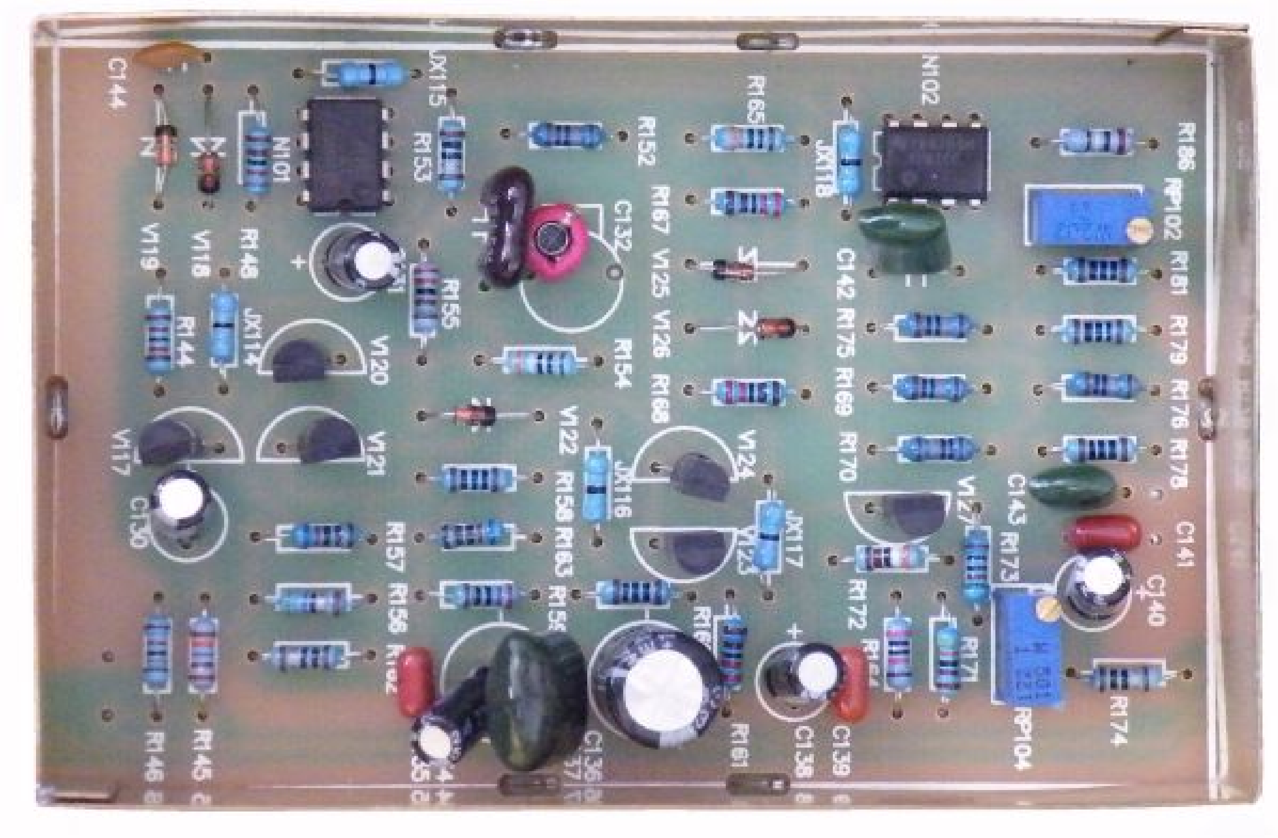
- It is clear that this meter was not designed recently, the PCB is single sided, is hand soldered and only axial components are used. It even contains a few ICs from the 74xxx TTL family!
- The advantage of such an old design is that it uses a traditional linear power supply with a 50 Hz transformer, secondary rectification, smoothing and stabilisation with 7815 and 7915 chips.
- The input amplifier on the PCB is completely built into a copper shield, both on the component side and the solder side.
- The ground of the IEC C13 chassis terminal goes only to a shield between the primary and secondary windings on the transformer. The metal housing of the meter is not earthed. The

ground of the electronics itself is also not connected to the housing.
- The wiring is neatly done with shrink tubing over all soldered connections.



The electronics in the LW-322D.

On the PCB, we discover an OP07C from Texas Instruments, a precision op-amp with a very low offset, and two LF351N chips. These two op-amps are probably in the logarithmic converter that is necessary to produce the readout in dB. The presence of the six transistors around these op-amps points a little in that direction. That part of the circuit is also in a shielded area on the PCB. Note the 0 Ω resistors that are used as wire bridges. What a cute, old-fashioned technique!



The logarithmic converter for the dB measurements.

The digital part of the circuit
On the front panel of the device, a second circuit board is mounted, on which the digital part of the circuit is present. We recognise an AT89C52 microcontroller from Atmel, a couple of TTL chips and a TC7109CP 12-bit dual slope analogue-to-digital converter. That's pretty old technology too!

Accuracy measurements with 1 kHz sine wave signals
To create the table below, we set the output voltage of our function generator until the meter needle of the PM2454 is exactly at the full scale value of the various measuring ranges. For each of the eight measuring ranges the digital readout of the LW-322D was then noted.

READ ON PM2454	READ ON LW-322D
1 mV	1.001 mV
3 mV	3.031 mV
10 mV	9.75 mV
30 mV	29.21 mV
100 mV	95.3 mV
300 mV	289.2 mV
1 V	1.026 V
3 V	3.131 V

Comparison of the readings on the PM2454 and LW-322D.

Measuring the frequency range at various voltages
As a second test, we applied voltages of 1 mV, 100 mV and 1 V at various frequencies to the input

of the LW-322D. The equality of this voltages was ensured both with the Philips PM2454 and with the cursor measurements of a 100 MHz oscilloscope.
The measurements are summarised in the table below. What we can conclude from this is that the specified accuracies are not achieved up to 2 MHz. The frequency range above 1 MHz shows a strange positive 'bump' until about 4.5 MHz. After that, the readout starts to decrease again, as is to be expected. So the LW-322D works fine up to 1 MHz, but at higher frequencies you cannot trust the readout anymore.

FREQUENCY	1 mV ON PM2454	100 mV ON PM2454	1 V ON PM2454
10 Hz	1.001 mV	95.4 mV	1.022 V
50 Hz	1.004 mV	94.8 mV	1.016 V
100 Hz	1.004 mV	95.1 mV	1.027 V
500 Hz	1.003 mV	95.1 mV	1.027 V
1 kHz	1.002 mV	95.3 mV	1.018 V
5 kHz	1.001 mV	95.3 mV	1.013 V
10 kHz	1.001 mV	95.2 mV	1.014 V
50 kHz	1.000 mV	95.2 mV	1.014 V
100 kHz	0.998 mV	95.3 mV	1.022 V
500 kHz	0.995 mV	95.5 mV	1.028 V
1 MHz	1.010 mV	97.1 mV	1.046 V
2 MHz	1.116 mV	108.5 mV	1.158 V
3 MHz	1.115 mV	134.3 mV	1.391 V
4 MHz	1.480 mV	150.9 mV	1.463 V
5 MHz	0.942 mV	102.6 mV	0.890 V

Checking the bandwidth of the LW-322D.

Checking the dB measurements
The LW-322D is calibrated with a reading of 0 dB at a voltage of 1.00 V. As is well known, if you decrease the voltage from that position to 300 mV, 100 mV and so on, the reading decreases by 10 dB. Since our Philips PM2454 also has such a range switch, it is easy to check the accuracy of the LW-322D's dB scale. Each new full scale reading on the PM2454 should make a 10 dB difference. The results are summarised in the table below and are very impressive.

SET ON PM2454	READ ON LW-322D AT 1 kHz	READ ON LW-322D AT 1 MHz
1 mV	-60.0 dB	-59.9 dB
3 mV	-50.4 dB	-50.1 dB
10 mV	-40.2 dB	-40.1 dB
30 mV	-30.7 dB	-30.5 dB
100 mV	-20.4 dB	-20.2 dB
300 mV	-10.8 dB	-10.5 dB
1 V	+0.2 dB	+0.3 dB
3 V	+9.9 dB	+10.1 dB

Checking the accuracy of dB measurements.

Checking the dB_m measurements
A power of 1 mW generated in a 600 Ω resistor is assumed to be 0 dB_m. From this you can easily calculate that this corresponds to a voltage of 0.7745 V. Because of this strange voltage value, it is not so easy to check the accuracy of the LW-322D when measuring dB_m. Fortunately, the Philips PM2454 also has such a scale, and that is why we can make the table below.
As signal source we use a Philips PM5109S RC generator, which has buttons of -10 dB, -20 dB and -30 dB that can be used in combination to attenuate the signal. The measurements are performed with a sine wave voltage with a frequency of 1 kHz. These results also leave nothing to be desired!

READ ON PM2454	READ ON LW-322D
+10 dB_m	+10.4 dB_m
0 dB_m	+0.2 dB_m
-10 dB_m	-10.2 dB_m
-20 dB_m	-20.3 dB_m
-30 dB_m	-30.1 dB_m
-40 dB_m	-40.2 dB_m
-50 dB_m	-49.9 dB_m

Checking the accuracy of dB_m measurements.

Note on the automatic range switching
This function works perfectly for most measurements. However, if you apply a voltage to the meter that is only slightly larger than the maximum value of the range, for example 405 mV, things go wrong. Then the meter doesn't know which range to choose and flips back and forth between the ranges 399.9 mV and 3.999 V. Switching to manual range setting is the only solution.

Pay attention to the input impedance!
An important point that is often forgotten in practice is the influence of the parallel input capacitance on the measurements. This capacitance is specified by the manufacturer as maximum 30 pF. It stands in parallel with the input resistance of 10 MΩ.

For low frequencies, those in the audio range, this does not bother you much. For higher frequencies, the impedance of this small capacitance plays an increasingly important role. At 100 kHz, the impedance of a 30 pF capacitor drops to 53 kΩ and at 1 MHz even to 5.3 kΩ. This means that, as the frequency increases, the LW-322D will become an increasingly heavy load for the point at which you are measuring. This can completely corrupt the accuracy of the measurements! So, always consider the point at which you are measuring and the influence this impedance may have on that point.
This is a point that applies to all measuring equipment. For comparison: our Philips PM2454 has an input capacity of maximum 25 pF, so not much less.