The LCR Meter IM3536 is an LCR meter that can measure electronic components using measurement signals that span a broad range of frequencies, from 4 Hz to 8 MHz. It provides superior speed and precision compared to previous products and is well suited to use in a diverse range of fields and applications, from production lines to research and development. This paper describes the product’s functionality, features, architecture, and other characteristics.

I. INTRODUCTION

Electronic components such as capacitors and inductors are operating at increasingly high frequencies and levels of precision. For example, manufacturers are turning to higher switching frequencies to enable more compact designs for the power inductors that are used in mobile phone power supplies, and capacitors used as power supplies for high-speed CPUs demand low equivalent series resistance (ESR). As a result of these trends, the instruments that measure these electronic components must deliver higher-frequency, higher-precision performance.

In addition, manufacturers of measuring instruments find themselves under pressure to lower the costs of their products in the face of falling prices for electronic components.

Hioki developed the high-speed, high-stability, and multifunctional LCR Meter IM3536 to meet these needs.

II. OVERVIEW

More than 10 years have passed since Hioki developed the LCR HiTester 3532-50, which offered measurement frequencies ranging from 42 Hz to 5 MHz, in 2001. During that time, the precision of electronic components has risen even as their prices have fallen, pushing the manufacturers of the instruments used to measure these electronic components to deliver faster speeds and higher precision. It was in response to these trends that Hioki developed the IM3536.

The IM3536 supports the broad frequency band of 4 Hz to 8 MHz. Whereas the previous 3532-50 offered a maximum frequency of 5 MHz when used as a four-terminal LCR meter, the IM3536 delivers four-terminal-pair measurement at higher frequencies. In addition, whereas the 3532-50’s accuracy guarantee applied only to values of 10 mΩ or greater, the IM3536’s guarantee starts at 1 mΩ to facilitate high-precision measurement.

To enable its use in a production setting, the IM3536 delivers measurement times as short as 1 ms (representative value) and features the first four-terminal contact check function of any megahertz-class LCR meter in order to boost measured value reliability.

The IM3536 can be used in a broad range of fields and applications, from production lines to research and development.

III. FEATURES

The IM3536 delivers the following features:

A. Broad Range of Measurement Frequencies and Levels

The IM3536 lets users vary measurement conditions across a broad range of possibilities with measurement frequencies from 4 Hz to 8 MHz and measurement levels from 10 mV to 5 V. These capabilities make it possible to carry out measurement and evaluation under conditions that closely approximate actual operation in research and development, for example measurement of increasingly high-frequency power inductors and evaluation of samples that exhibit a high degree of signal dependence.

B. High-Precision Measurement

The IM3536 delivers repeatability that is an order of magnitude greater than that of previous products. Repeatability is especially improved for measurement of low-inductance samples, making the instrument ideal for use in low-ESR measurement of electrolytic capacitors and in impedance measurement of power supply coils. In addition, accuracy is guaranteed over measurement cable lengths of up to 4 m in order to facilitate embedding in automated equipment, and the instrument is available with 0 m, 1 m, 2 m, and 4 m cables.
LCR Meter IM3536

C. **High-Speed Measurement**

The IM3536 is capable of measurement at up to 1 ms. Thanks to work to optimize the internal structure of the instrument’s software, processing times have been reduced compared to those of previous systems as illustrated in Fig. 1 when using the panel load function (to load measurement settings and conditions) with its handler interface. In this way, processing time from trigger input to the completion of measurement has been dramatically reduced by approximately 40% compared to previous systems, allowing the IM3536 to help improve productivity.

D. **Guaranteed Accuracy Range Starting at 1 mΩ**

Fig. 2 illustrates the IM3536’s impedance Z measurement range. The instrument provides guaranteed accuracy from 1 mΩ, broadening the range of measurement targets with which it can be used compared to previous products.

E. **Contact Check Function**

The IM3536 verifies proper contact between the probes and measurement sample by means of a contact check during four-terminal measurement and a High-Z reject function during two-terminal measurement. In this way, the instrument delivers improved measurement and more reliable sorting.

F. **Sequential Measurement**

The IM3536 can make sequential measurements using up to 60 different sets of measurement conditions. Fast switching between measurement conditions enables a single instrument to be used to measure targets under multiple sets of conditions.

G. **Comparator Function**

The IM3536 can generate HI (higher), IN (within a range), LO (lower), and AND (a logical conjunction results in true) results as external output for two parameters.

H. **BIN Function**

The IM3536 can perform BIN measurement for two parameters across up to 10 categories, simplifying sorting of measured components.

I. **Internal DC Bias Function**

The IM3536 can apply DC bias of 0 V to 2.5 V, allowing it to be used in measurement of components with polarity, for example electrolytic capacitors.

J. **Measured Value Memory**

The IM3536 can store up to 32,000 measured values in its internal memory. Stored data can be saved collectively on a USB flash drive or downloaded to a computer.

K. **Interfaces**

The IM3536 ships standard with USB, RS-232C, LAN, and GP-IB interfaces.

L. **Handler Interface**

The IM3536 ships standard with a handler interface for outputting measurement complete and judgment results signals and controlling the instrument using input such as a measurement trigger signal.

In LCR mode, it is possible to switch between judgment results signal and binary coded decimal (BCD) signal output. In BCD mode, measured values for the first and third parameter are output as a BCD signal.
**M. Application Software**

The IM3536 ships standard with application software for saving measurement data as Microsoft Excel and text files (CSV format) using its USB, RS-232C, LAN, or GP-IB interface. Since measurement data can be acquired by sweeping through multiple frequency, voltage, and current values, the software is useful in evaluating samples that exhibit signal dependence.

**IV. Architecture**

**A. Analog Circuitry**

Fig. 3 illustrates the architecture of the IM3536’s analog circuitry.

1) **Signal generation circuit:** The signal generation circuit uses a direct digital synthesizer (DDS) to generate sine wave measurement signals at frequencies ranging from 4 Hz to 8 MHz. A 12-bit DAC and constant-current circuit are used to vary the DDS reference current, allowing the level to be controlled from 10 mV to 5 V at a maximum resolution of 1 mV. In addition to applying an internal DC bias voltage of 0 V to 2.5 V, the DC bias application circuit can be used to generate DC resistance measurement signals.

2) **Detection circuit:** Broadly speaking, the IM3536’s detection circuit consists of voltage detection and current detection components. The voltage detection circuit detects the voltage across the measurement sample using a differential amplification circuit, while the current detection circuit detects the current flowing to the measurement sample using an I-V conversion circuit. A low-pass filter (LPF) for rejecting noise and a measurement range amplification circuit are connected downstream of these circuits. When using DC bias, the DC voltage component is canceled by the DC bias rejection circuit that follows the differential amplification circuit.

3) **A/D converters:** The IM3536 uses 16-bit, 1 MS/sec. successive approximation type A/D converters to convert analog signals to digital signals by means of either direct sampling for measurement frequencies of up to 400 kHz or undersampling (with a sampling frequency that is less than twice the measurement frequency) for measurement frequencies greater than 400 kHz.

Generally speaking, folding noise (aliasing noise) caused by undersampling and sampling clock jitter (fluctuation) noise degrade the signal-to-noise ratio (SNR) in the high-frequency domain, reducing measurement repeatability. However, the IM3536 delivers improved repeatability by incorporating an anti-aliasing filter tuned to measurement frequency to address folding noise and using a low-jitter sampling clock and synchronizing operation with the measurement signal generation circuit to address jitter noise.

**B. Digital Circuitry**

Fig. 4 provides a block diagram for the IM3536’s digital circuitry.

The instrument uses a 32-bit RISC CPU to deliver excellent computational performance, power consumption, and other characteristics. The CPU’s principal peripheral circuitry consists of display, program, and working memory. Analog circuits such as the A/D converters, DDS, and D/A converters as well as other devices are controlled by a field programmable gate array (FPGA).

**V. Performance and Functionality**

**A. Wideband Performance**

The I-V conversion circuit’s terminal resistance is switched according to the connected measurement cable length, impedance range, and measurement frequency, broadening the measurement frequency band to a maximum of 8 MHz. The maximum frequency that can be used varies with the cable length: 8 MHz when using a directly connected fixture or 1 m cable, 2 MHz when using a 2 m cable, and 1 MHz when using a 4 m cable. Fig. 5 and Fig. 6...
compare the measurement error for the 3532-50 and IM3536 when using a 1 m measurement cable (sample: 2.49 kΩ resistor).

The IM3536 delivers reduced measurement error compared to the 3532-50 while broadening the frequency band to 8 MHz.

B. Improved Precision for High- and Low-Impedance Measurement

Enhancements including the addition of a 50× amplifier to the amplification circuit, optimization of the LPF, and a redesigned power supply circuit give the IM3536 better repeatability than previous products for low- and high-impedance measurement. In addition, since the output resistance can be switched from its normal value of 100 Ω to 10 Ω during low-impedance measurement, the magnitude of the current flowing to the sample can be increased for even higher repeatability. Fig. 7 illustrates the results of a comparison of repeatability between the IM3536 and the previous 3532-50 during 100 mΩ measurement. Similarly, Fig. 8 illustrates the results of a comparison of repeatability during 1 MΩ measurement. Both sets of results indicate repeatability that is an order of magnitude higher than that of the previous product.

C. Improved Precision During High-Frequency Measurement

In addition to the improvements described in “3) A/D converters” in Section IV-A, adoption of consistent characteristics for the A/D converters used in voltage and current detection and in peripheral circuits, reduced noise in the measurement signal generation unit, and other enhancements yielded increased repeatability. Fig. 9 illustrates the results of a comparison of repeatability between the IM3536 and the previous 3532-50 when using a 5 MHz measurement frequency. The results indicate that repeatability has improved by an order of magnitude.

D. Residual Charge Protection

Sometimes charged capacitors are erroneously connected to LCR meters on capacitor production lines. The IM3536 incorporates a residual charge protection function to ensure...
internal circuitry will not be damaged in the event of such an error, making it more resistant to residual charges than the previous 3532-50. Fig. 10 compares the new instrument with the previous model (assuming measurement of a charged capacitor).

VI. CONCLUSION
The IM3536 is an LCR meter that delivers high speed, high precision, and high stability. Hioki expects it to be used in a wide range of fields and applications, from production lines to research and development.

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