DL7100 SIGNAL EXPLORER, A HIGH-SPEED DIGITAL OSCILLOSCOPE WITH LONG RECORD LENGTH

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We have developed Signal Explorer DL7100, a digital oscilloscope with a maximum sampling rate of 1 GS/s and an analog input bandwidth of 500 MHz. The DL7100 has four channels for analog input signals and a channel for 16-bit logic input signals, along with a record length of up to 8 M words per channel. Conventional digital oscilloscopes with large memory were slow, expensive and bulky. With the development of the DSE (Data Stream Engine) which consists of three ASICs (Application Specific Integrated Circuits) for data processing, we were able to achieve a display update rate as high as 30 frames per second for a 1M-word record length.

The DL7100 features the Zoom Search function for choosing specific data from large amounts of stream data and the History Search function for choosing specific data from large amounts of captured data. These search functions facilitate the observation of complicated signals and less frequent abnormal phenomena. They are also useful for efficient troubleshooting and reducing the development period.

The development of 11 types of custom ICs for the DL7100, including the above-mentioned DSE, has allowed us to create a compact, reasonably priced oscilloscope comparable to previous models. This paper describes the configuration and functions of the DL7100.

INTRODUCTION

The market of multimedia products, such as telecommunications equipment and optical disks, is in need of high-speed, multi-channel oscilloscopes with long record lengths, in order to capture fast, complex signals. In the market of electromechanical products, such as printers and automobiles, that also require long record lengths, the signals to be measured have increased in speed, in particular those of control systems.

In 1995, Yokogawa Electric launched the DL1500 series(1) of digital oscilloscopes which featured models with a maximum record length of 2 M words. In 1996, the company also released the DL2700(2) digital oscilloscope with a maximum record length of 16 M words. These models also have an analog input bandwidth of 150 MHz and a maximum sampling rate of 500 MS/s and are in use mainly in the electromechanical market dealing with medium-speed signals.

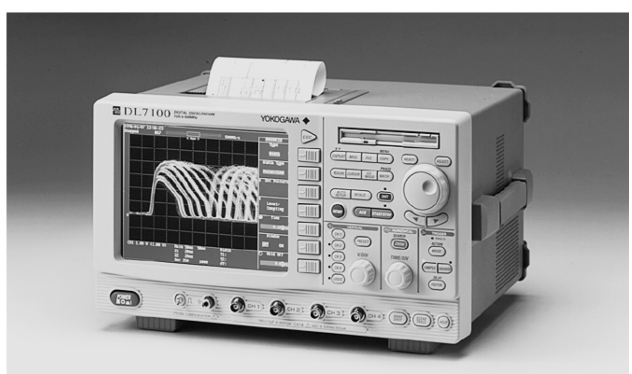

Figure 1 An External View of DL7100

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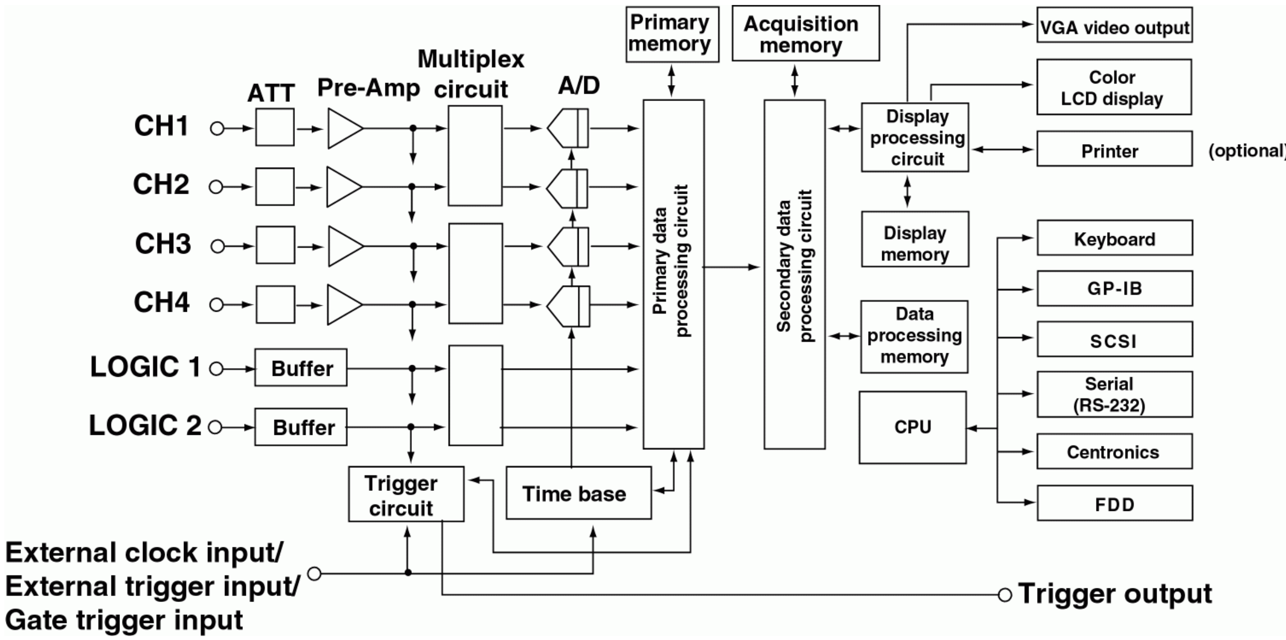

Figure 2 Function Block Diagram of DL7100

The recently developed DL7100 digital oscilloscope inherits the features of these models, while at the same time achieving a higher speed and broader bandwidth. As the trade name "Signal Explorer" symbolizes, the DL7100 was developed under the design concepts of "easy and precise capture of complex waveforms" and "choose only the necessary information at high speeds from large amounts of captured data." For convenience of use in bench-top applications, we designed the model to be as compact as possible, focusing on depth and weight. Figure 1 provides an external view of the DL7100.

The DL7100 has the following features:

(1) A maximum sampling rate of 1 GS/s, with an analog input bandwidth of 500 MHz
(2) Four analog input channels and a 16-bit logic input channel
(3) Record length of up to 8 MS/s per channel
(4) Waveform update rate as high as 30 Hz for record length of 1 M words/channel (10 times higher, compared with previous models developed by Yokogawa Electric Corporation)
(5) Zoom Search function for choosing data necessary for waveform observation, from massive amounts of data captured into memory supporting long record lengths
(6) History Memory function for reviewing up to 2048 frames of previous waveform data and History Search function for choosing a specific waveform from among the frames
(7) A depth of approx. 340 mm and weight of approx. 9 kg.

In this paper, we will introduce the configuration and functions of the DL7100.

CONFIGURATION

Figure 2 shows the function block diagram of the DL7100. To offer a low-cost, 2 M-word/channel model, in addition to the 8M-word/channel model, the primary memory block is built as a separate printed circuit board. Furthermore, the configuration of the logic input block as a separate printed circuit board means that the simple addition of this board allows each unit of the DL7100 to be equipped with a logic input option. The DL7100 also shares the same logic probe with the DL2700. Since the logic input block contains the memory and data processing blocks, the block can be added to each unit without sacrificing the number of channels and data processing capability. The DL7100 employs a new, 8.4-in. TFT color LCD, resulting in dramatic improvements in both the viewing angle and brightness, compared with earlier models. On its rear panel the DL7100 has four power supply terminals for common use with a current probe necessary for power measurement and with an FET probe essential for observing high-speed waveforms. In addition, the DL7100 comes standard with a floppy disk drive, GP-IB interface, RS-232C serial communication interface, SCSI interface, and VGA video output. These standard features enable easy connection of the DL7100 to external equipment according to application needs. Furthermore, like earlier models the oscilloscope can be equipped with a built-in printer.

The mechanical design employed magnesium die castings for the front bezel and a shielding case in the input block to reduce weight.

ANALOG BLOCK

The analog block consists of attenuators, amplifiers, multiplex circuits and A/D converters. It features an input range of 2 mV/div to 10 V/div, frequency bandwidth of 500 MHz and dc accuracy of ±1.5%. To meet the requirements of users in every European country, the absolute maximum input voltage rating is specified as ±400 V (DC + ACpeak).

The amplifiers and multiplex circuits are newly developed custom ICs. The A/D converters are of 500-MS/s, 8-bit type and each channel has one unit. Scanning signals with the multiplex circuits gives a maximum sampling rate in the interleave method of 1 GS/s. Newly developed BiCMOS gate arrays and PWM (pulse width modulation) D/A converters are used to control the analog block.

TIMEBASE AND TRIGGER BLOCKS

The timebase block employs a PLL, where the clock is switched between 1 GHz and 800 MHz. The clock frequency is then pre-scaled with a high-speed ECL logic IC for distribution to each channel. In interleave mode, clock signals on channels 2 and 4 are delayed by 1 ns against those on channels 1 and 3. The T/V (time/voltage) converter developed for the DL4100[3] is also used with the DL7100 to measure marginal time lengths, i.e., the phase difference between the trigger and sampling clock necessary for equivalent sampling or other purposes.

The trigger block consists of comparators, a high-speed trigger logic IC, a and pulse width detector. All these devices are newly developed custom ICs and have a 500-MHz bandwidth. The block provides a wide choice of trigger sources, including the four analog channels in addition to the external 100-MHz trigger input on the rear panel, the logic input and the commercial power line.

For trigger functions, we added a function for setting the upper and lower limits of pulse width and triggering the oscilloscope at a specific pulse width, as required in particular by the multimedia market. The pulse width is configurable in a 1-ns resolution.

DATA PROCESSING BLOCK (DSE)

In normal applications, the DL7100 updates waveforms using only the dedicated data processing hardware called a data stream engine (DSE), without working with the CPU. The DSE is divided into three blocks: a primary data processing circuit, a secondary data processing circuit, and a display processing circuit. All these circuits are created with newly developed gate arrays. Two channels are paired and two pairs (or three pairs, if the model is equipped with a logic input option) are assigned to the primary and secondary data processing circuits for parallel data processing. This design strategy has achieved a screen update rate as high as 30 Hz for a record length of 1 M words/ channel.

For the primary data processing circuit, we have developed a BiCMOS gate array (RBC) comprising 93,000 gates. The RBC applies such processes as decreasing bit density, enveloping and "box averaging" to the outputs of the A/D converters and records the results in the primary memory. For the primary memory, high-speed SRAM is used. The RBC transfers the recorded data to the secondary data processing circuit according to a given trigger address.

For the secondary data processing circuit, we have developed a CMOS gate array (AMI) comprising 440,000 gates. The AMI receives data from the RBC, applies such computations as averaging to the data, and stores the results in the acquisition memory. For the acquisition memory, synchronous DRAM is used. The AMI applies such processes as compression and interpolation to the stored data and converts the results to display data. This data is then transferred to the display processing circuit according to a given display cycle. In addition to these functions, the AMI has such arithmetic functions as addition, subtraction, multiplication, differentiation and integration, as well as an auxiliary function for automatically measuring waveform parameters.

For the display processing circuit, we have developed a CMOS gate array (GCP) comprising 310,000 gates. The GCP synthesizes the data stored in the graphic and character memory to produce a brightness signal for output to the display. For the graphic and character memory, synchronous GRAM and high-speed SRAM are used, respectively. The GCP, by using the waveform data it reads to display waveforms and other waveform data transferred by the AMI, applies an overwriting process to the data and writes the results back to the graphic memory. The resulting data is converted to waveforms for viewing at the next display cycle. The GCP also controls the printer.

ZOOM SEARCH AND HISTORY SEARCH

Zoom Search

When using an oscilloscope with a long record length, users often desire to view a close-up of part of a captured waveform. To do this, they usually search for the part they want to observe by moving the center of the enlarged area. If the amount of captured data is extraordinarily large, this work requires a great deal of time. Work efficiency is improved with the Zoom Search function.

Figure 3 is an example of an application in which a specific serial pattern is searched for. In a serial pattern search, there is a choice of two methods: a synchronous method that uses an arbitrary channel as the clock and an asynchronous method that requires specifying a bit-to-bit time interval. A search pattern should comprise 64 bits, each being defined as a symbol H, L or X. The serial pattern search permits evaluation of serial communication components, such as an I^2C bus widely used for electric home appliances and multimedia controllers, which was difficult with conventional oscilloscopes. This search function is also useful when searching for a specific pattern of PWM waveforms.

As the search condition of the Zoom Search function, users can choose from a rising edge (or falling edge), pulse width and parallel pattern, in addition to the serial pattern discussed above.

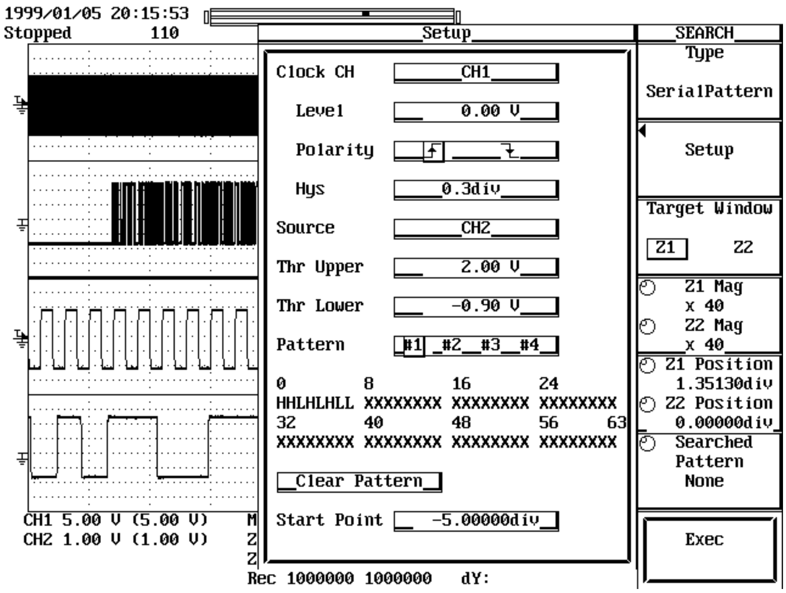

Figure 3 Setup Screen for Serial Pattern Search

History Search

When troubleshooting digital circuits, users may want to capture less frequent abnormal phenomena. These phenomena are difficult to verify since their waveforms are readily updated as soon as they appear on the display. The History Search function of the DL7100 is designed to meet this application need. The allocated memory is partitioned into blocks, where waveforms are accumulated block by block and then retrieved to overwrite on-screen waveforms when an abnormal phenomenon comes to a stop. This function has been incorporated in every model of the recent DL series of digital oscilloscopes.

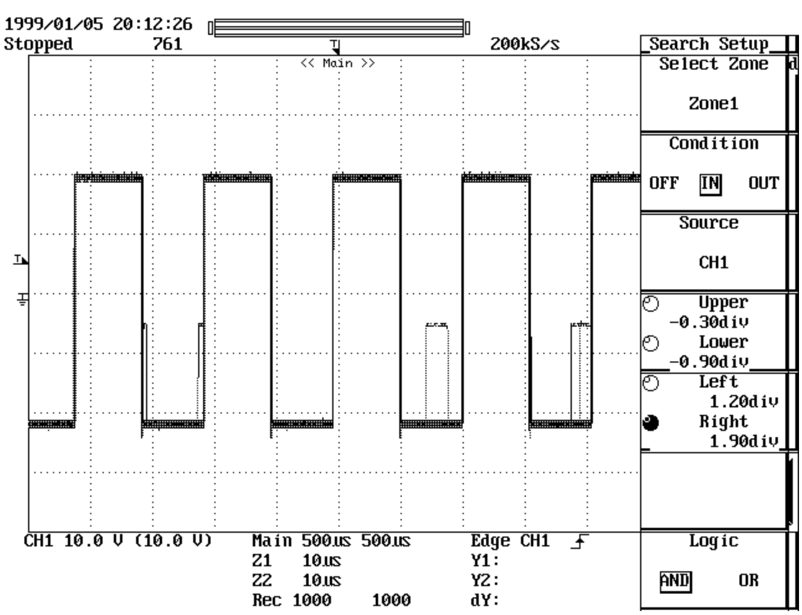

Figure 4 History Search Screen

Although the DL7100 can store as many as 2048 frames of waveforms, it is extremely time-consuming to choose a desired waveform by recalling frames of waveforms one after another. We have solved this problem by adding the new History Search function to the DL7100.

Using the History Search function, users set a zone on a full-wave overwrite screen, as shown in Figure 4. Consequently, they can isolate only those waveforms that pass (or do not pass) through the zone, from among all captured waveforms. An advanced search is also possible since the History Search function permits a maximum of four search conditions. Furthermore, any automatically measurable waveform parameter can also be used as a search condition.

CONCLUSION

In this paper, we have presented an overview of the configuration and functions of the DL7100. The DL7100 is the result of reviewing the most fundamental yet important functions of digital oscilloscopes, as well as making efforts to develop a truly easy-to-use waveform measuring instrument. We are confident engineers in a wide range of industrial fields will find the DL7100 to be a tool that increases efficiency in product development ◆

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