nX-U8/100 Datasheet
JP to EN

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You may also be looking for the nX-U8/100 Instruction Manual.

Note

The aim was to keep the important information as visible as possible. Some phrases or sentences are re-worded as an improvement upon the original machine translation. This document has also been formatted differently to the original.

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Development of an ultra-low power 8-bit microcomputer

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Casio Computer, holds the largest market share of calculators globally. Scientific calculators account for 40% of the market share. (No. 1 in the world, in terms of market share of scientific calculators). In recent years, an increasing number of countries have adopted scientific calculators as teaching materials for university entrance examinations and classes, and there is a growing tendency to incorporate them as teaching materials.

Naturally, the movement is progressing in Japan as well, and a number of educational papers have been published by prominent teachers on the merits of education incorporating calculators in subjects such as mathematics, and arithmetic in elementary and junior high schools and high schools. It is expected that the demand in the domestic market will increase in the future.

Currently, the sales of scientific calculators at Casio Computer Co., Ltd. are less than 20 million units/year, but the future market trend is that sales are expected to grow to 150% due to the expansion of the market for China. In order to capture this large scientific calculator market, Oki Electric was able to enter the scientific calculator market by developing an ultra-low power 8-bit microcomputer that exceeds the specifications of conventional low-power microcomputers.

Photo 1 Scientific calculator equipped with our product
(Left side: FX-82ES; right side: FC-200V)

Photo 1 shows a scientific calculator equipped with the product developed this time: ML610901. The scientific calculator on the left side of Photo 1 is a scientific calculator of the "Math Natural Display" series that can display mathematical formulas such as fractions and √‾ (square root) in the same way as textbooks, mainly for high school and university students in science and mathematics.

In Photo 1, to the right of the fx-82ES is the FC-200V full-scale financial calculator for certified accountants, tax accountants, securities analysts, financial planners, etc. The ML610901 is also installed in many scientific calculators for overseas markets.

Casio Computer Co., Ltd. requested our products for the development of these scientific calculators. The main specifications are shown below.

1. Built-in multi-common LCD driver

For a large display that is easier to see, and is a size larger.

2. Built-in switching function between solar cell and built-in battery

This is different from a conventional calculator with a solar cell, since even if the light is blocked during a calculation, the built-in battery preserves the contents of the memory.

3. Power supply voltage: Operation guaranteed at 1.0V

This guarantees low voltage operation, so that a malfunction does not occur when switching between the built-in battery and the solar cell.

4. Low power consumption

This extends the battery life (the battery life is 2 years for a conventional calculator product, but 3 years for this product). The purpose of this is to use solar cells with a low supply capacity.

A multi-Vt process was adopted to incorporate the above four main specifications. This process has a high withstand voltage MOS and a low voltage operation MOS, and is suitable for guaranteeing operation at 1.0V with a built-in LCD driver, as required in the specification of the scientific calculator. In addition, since the multi-Vt process already exists, this has led to a reduction in development man-hours and a shortened schedule, making it possible to comply with the development schedule presented by Casio Computer.

Compared to other companies, not only did it exceed the required specifications due to low power consumption and low voltage operation, but the excellent performance of Oki Electric's original CPU core: nX-U8 / 100 was also one of the major factors in its adoption. It can be said that this was a major factor for adoption. This section describes a LCD scientific calculator (trade name: ML610901) for Casio Computer Co., Ltd. that features an ultra-low power 8-bit microcomputer with a built-in LCD driver, by adopting a multi-Vt process.

ML610901 Overview

The ML610901 is an 8-bit microcontroller with a built-in 96-segment x 32 common LCD driver.

8-bit CPU core: The nX-U8/100 divides instructions into three phases: instruction fetch, instruction decode, and instruction execution, and processes them sequentially in the pipeline. Instructions are executed efficiently by the RISC architecture of this three-stage pipeline process.

The circuit configuration consists of memory (ROM / RAM), power supply circuit, oscillation, logic (including 8-bit CPU core), and port / LCD driver. Figure 1 shows the block diagram of ML610901, and Table 1 shows the features.

Function		ML610901
CPU		nX-U8/100
Memory	ROM	96 KB
	RAM	3584 B
	External data memory	1920 KB
Clock speed	Clock	500 kHz (system clock) 19 kHz (LCD clock)
Logic	16 bit timer	1ch
	Watchdog timer	1ch
	Time base (frequency) counter	2ch
	Interrupt	10 factors
Port / LCD drivers	LCD driver	3072 (96seg x 32com)
	Input ports	8
	Output ports	8
	I/O ports	3
	External memory interface	35
Power circuits	Power supply for logic	VDDL
	Power supply for low-speed oscillation	VXT
	Bias generation circuit **[Editor's note: this refers to the waveform/oscillation for the LCD (#288)]**	VL1~VLA
	Power switching circuit	VDD
Main electrical characteristics	Temperature range	−20°V~70°C
	Power-supply voltage	1.0V~3.6V
	Current @ STOP	0.6 μ A (Typ.)
	Current during CPU operation	0.6 μ A (Typ.)

Table 1 Features of ML610901

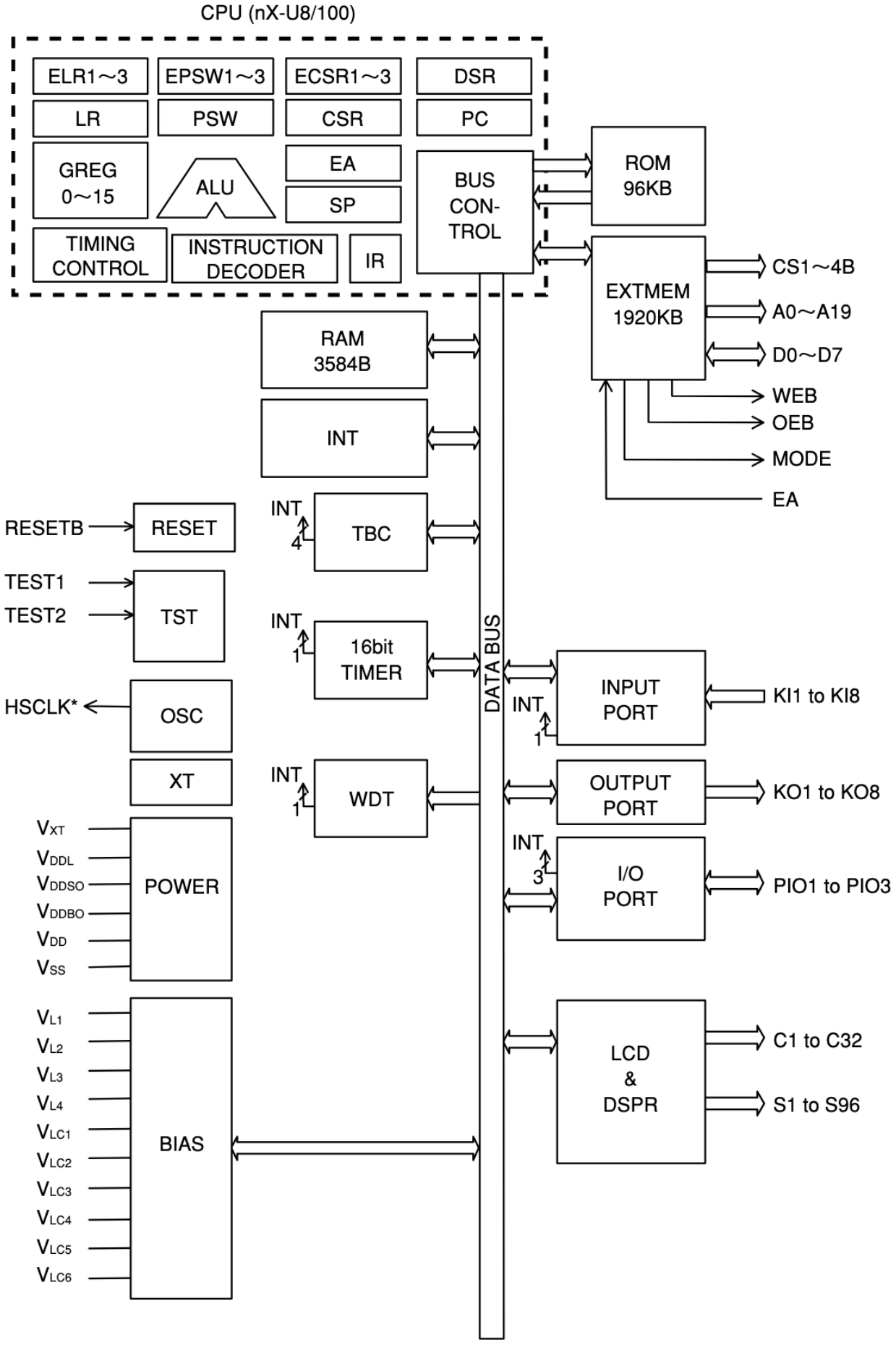

Figure 1 ML610901 block diagram

About multi-Vt

The multi-Vt process consists of the three types of MOS shown in Table 2. Taking advantage of these features, HV-MOS is used for LCD drivers, ports, and power supply circuits that require high withstand voltage, and MV-MOS is used for logic (including the 8-bit CPU core) that occupies most of the chip configuration to suppress leakage current. LV-MOS was used for the circuit part, which is a concern during low voltage operation.

	Uses	Max voltage
HV-MOS	Used in circuits that require high withstand voltage such as power supply systems	7V
MV-MOS	Used in general logic (Able to manage leakage current without issue)	4.6V
LV-MOS	Sufficient capacity is required at low voltage Partial use in some places (Leakage current is generated)	

Table 2 Multi-Vt process - MOS configuration and uses

Low power consumption & low voltage

In order to reduce power consumption, we performed the following:

1. **Lower the power supply voltage for logic**

This is the most effective measure. Table 3 shows a comparison of the logic power supply voltage between a similar conventional low-power microcomputer and the ML610901.

Power supply voltage for logic	ML610901	Conventional microcomputer
VDDL	1.16V	1.60V

Table 3 Comparison of power supply voltage for logic

Since the ML610901 lowers the voltage by about 27.5% compared to a similar conventional microcomputer, it is expected that the power consumption will be reduced by that same percentage.

2. Slim the CPU core (remove unused circuits)

Measures were taken to suppress the generation of extra power consumption. The CPU core of a conventional low-power microcomputer is equipped with a debug function and a tool mode function, and this circuit is in the active state even while the CPU is operating, generating extra current consumption. Removing this circuit is effective in reducing power consumption.

3. Remove the built-in capacitance (oscillation circuit)

The oscillation circuit of ML610901 is a CR oscillation type with both resistance and capacitance built-in. Since the power consumption of CR oscillation depends on the charge and discharge of the capacitance, the power consumption can be reduced by reducing the capacitance value and the current. However, in the specifications of a conventional microcomputer, the resistor is externally attached, and the frequency will possibly vary due to parasitic capacitance. Reducing the built-in capacitance as a measure against power consumption, can increase the impact of parasitic capacitance even more, and would cause the frequency to vary considerably. Therefore, in the ML610901, the influence of parasitic capacitance is eliminated by incorporating a resistor in the LSI, making it possible to suppress frequency variation and hence reduce power consumption.

Achieving low voltage operation

We tuned the Vt value of existing multi-Vt processes and widened the low-voltage operation margin of CMOS transistors, to improve low-voltage operation.

In doing so, it is possible to further lower the logic power supply voltage as seen in (1) above. However, memory such as ROM and RAM has a higher operating voltage than logic components such as CPU and timer. Therefore, for ROM and RAM memory, we analyzed the conventional memory and implemented measures for low voltage operation by changing the circuit.

ROM improvements

Through analysing the operation of the ROM operation, it was found that the ROM has an effect of improving low voltage operation by reducing the bit line delay. The Y decoding section of a conventional ROM has a three-stage configuration of N-MOS. However, in the ML610901, the total ON resistance of the N-MOS can be reduced to 1/3 by making the N-MOS of the Y decoding unit a one-stage configuration, and the followability is improved.

Figure 2 shows the configuration of a conventional ROM, and Figure 3 shows the ROM configuration of the ML610901.

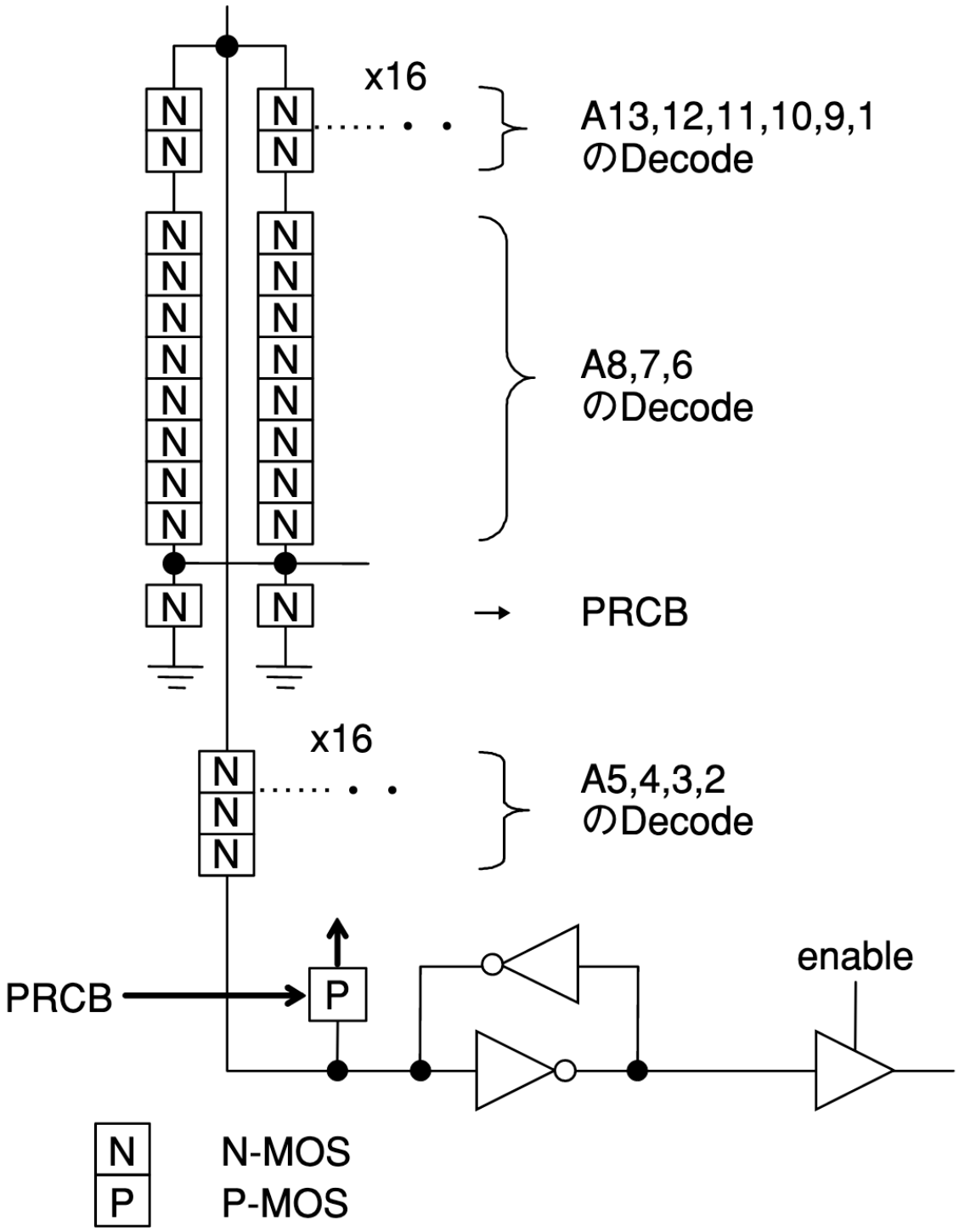

Figure 2 Conventional ROM configuration

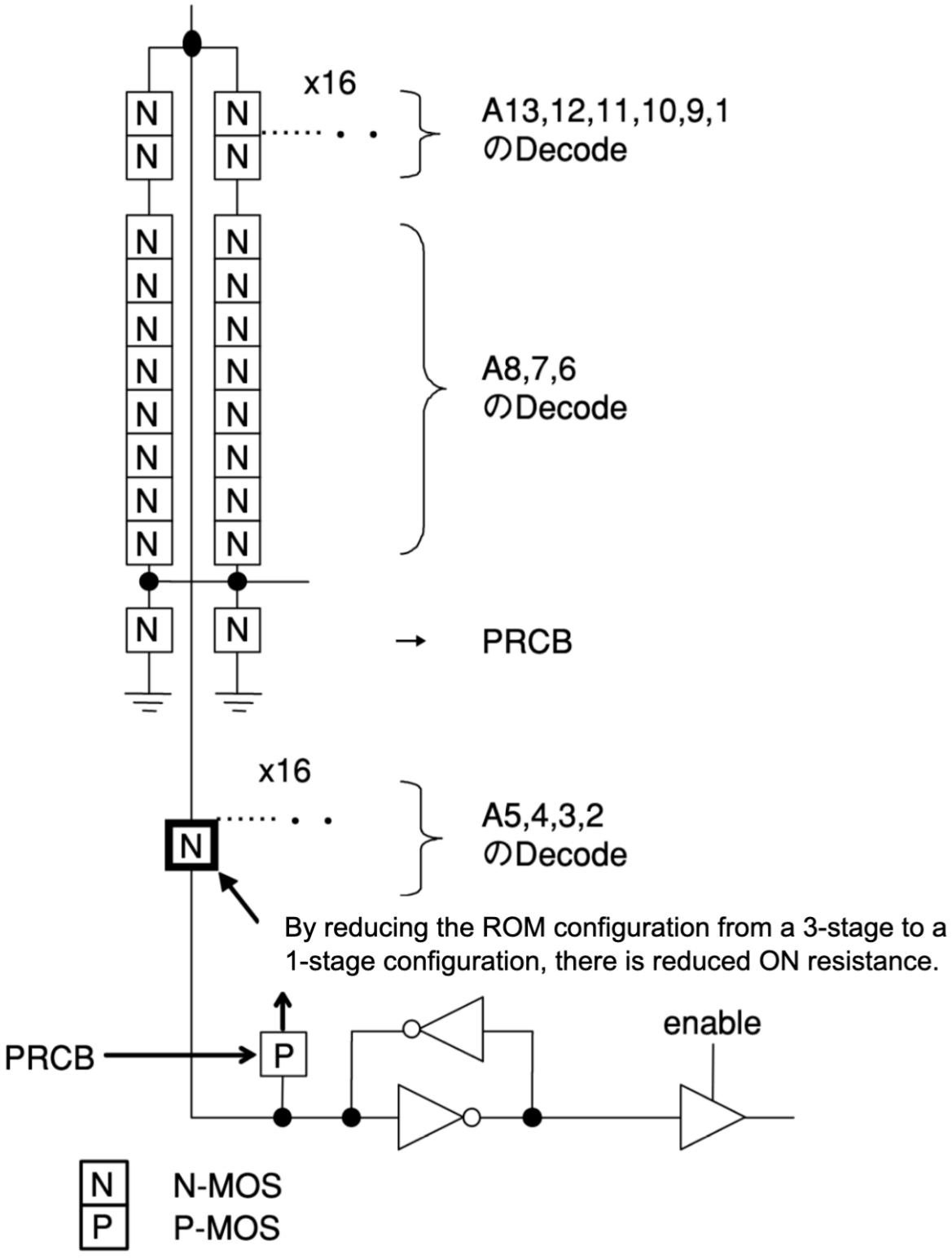

Figure 3 ML610901 ROM configuration

RAM improvements

Analysing the operation of RAM shows that the RAM has a delay each at:

- the column switch;
- before going to the next cycle for the read operation; and
- at the transfer gate of the write data for the write operation.

It was found that reducing the delay of precharge operation as in the case of reed has the effect of improving low voltage operation. The conventional RAM circuit section uses MV-MOS, and by changing this from MV-MOS to LV-MOS, the ON resistance of the MOS becomes smaller and the followability is improved.

Figure 4 shows the RAM configuration of the ML610901. The MOS circled is the part where MV-MOS is changed to LV-MOS. As for the device characteristics, the minimum operating voltage was improved from 1.00V to 0.89V by tuning the Vt value and changing the circuit, and the minimum power supply voltage of 1V (the target specification) was guaranteed. Through these efforts, ML610901 completed mass production start-up in June 2004.

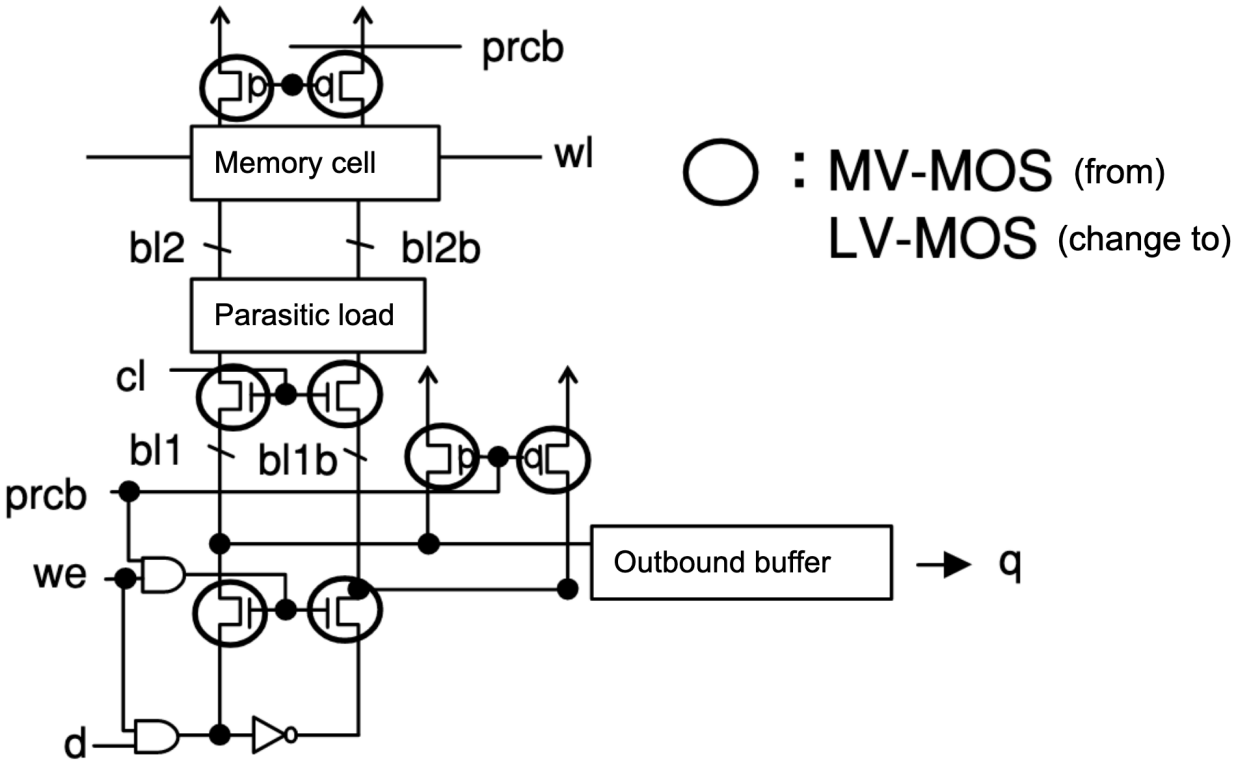

Figure 4 RAM configuration of ML610901

Conclusion

The ultra-low power (low voltage operation) technology in the development of ML610901 is a technology that could be achieved by the combined power of design which makes the best use of the features of the multi-Vt process and the process technology that supports it. In the future, we would like to continue to open up the technology and commercialize it with our comprehensive strength, in response to the demand for lower voltage operation and lower power consumption.

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