Development of ultra-low power 8bit microcomputer

Kazuhiro Tomita

In Casio Computer hall occupying the top share of the world's calculator, share of function calculator accounts for them of 40% (No.1 as the world's share of the scientific calculator).

In recent years, the country has a function calculator an increase in the country to adopt as a college entrance examination, and the lesson lasting included subjects, is progressing tend to incorporate as a teaching tool. Of course, the movement is progressing in the country, in subjects such as math, the number of studies of elementary and junior high school, and high school, education papers have merit Nitsu of education that incorporates a calculator [1] There, several more prominent teachers have been published, and is expected to be growing demand in the future of the domestic market. Currently, sales of scientific calculator in Casio Computer gluteal is about 20 million less than / year, as the market trend of the future of Casio Computer Co., Ltd. hall, the market expansion of the Chinese market, sales to grow to 150% predicted are doing.

In order to win this big function calculator market, Oki exceeds the specifications of conventional low-power microprocessor, performs the development of ultra-low power 8bit microcomputer, was able to enter the function calculator market.

photo1 The newly developed products in: ML610901 indicates the onboard function calculator. **photo1** Is on the left side of the function calculator, a high school and college students of science and mathematics as the main subject, fractions and √ can be displayed in the same way as the notation such as textbooks which formula of (square root) "Mathematics Natural Display" series of scientific calculator " fx-82ES " [2] It is.

Photos single commodity installation of function calculator (left: fx-82es right: FC-200V)

photo1 Right, certified public accountants and tax accountants, securities analysts, a full-fledged financial calculation calculator aimed at, such as financial planners, "FC-200V" of [3] It is. ML610901 is mounted on a number of scientific calculator as overseas friendly to other.

In developing this function calculator, showing the main specifications were asked Me than Casio Computer hall below.

① multi-common-chip LCD driver ② solar cells with built-in battery of the switching function built-in ③ power supply voltage of: operation security ④ low power consumption at 1.0V

① is to achieve a large display for easy viewing size larger. ② Unlike conventional solar cells with a calculator, even if the light is Egira in the calculation way, by the built-in battery, to protect the calculation contents. ③ ensures a low-voltage operation so that the malfunction due to the switching of the built-in battery and the solar cell does not occur. ④ the battery life long Kusuru (but battery life product was 2 years prior, 3 years in this product) [Four] . Then, it is the purpose of the use of low supply capability solar cell.

It adopted the multi-Vt process in order to capture more of the four major specifications. This process high breakdown voltage MOS, there are MOS for low voltage operation, a specification of the function calculator, it was suitable for LCD driver built, operation security at 1.0 V.

In addition, this process has allowed that you correspond to the existing order of the process, reduction of development engineering the number, and also lead to the shortening of the schedule, the development schedule presented of Casio calculator dono.

In competition with other companies, low power consumption, as well it had exceeded the specifications of low-voltage operation, Oki original CPU core: Upon also employed that the performance of the nX-U8 / 100 was excellent, one of the major factors it can be said that has become. Here, by adopting a multi-Vt process, and ultra-low power 8bit microcontroller chip LCD driver

The LS I (trade name: ML610901) for Casio Computer hall for function calculator will be described.

ML610901 Overview

ML610901 is 8bit microcontroller with an integrated LCD driver 96 segments × 32 common. 8bitCPU Core: nX-U8 / 100 is an instruction to instruction fetch, split instruction decoding, into three phases: the instruction execution, and sequential processing in a pipeline. The RISC architecture 3-stage pipeline treating this, efficiency often instructions are executed.

Circuitry, memory (ROM / RAM), a power supply circuit, oscillation, (including 8bitCPU core) logic, and a port / LCD Driver.

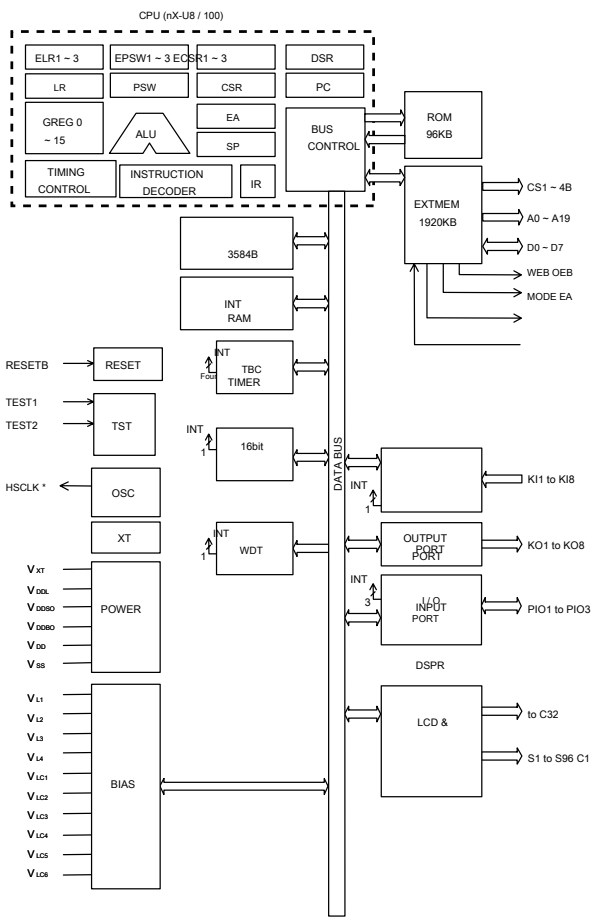**Figure 1** Block diagram of the ML610901 to, **table 1** The features in.

Figure 1 ML610901 of block

Table 1 ML610901 Features

function	ML610901
CPU	nX-U8 / 100
memory	
ROM	96K Part-Time Job
RAM	3584 Part-Time Job
External data memory 1920K Byte oscillation	
Clock generation circuit 19kHz (LCD Use clock) logic	500kHz (The system clock)
16 Bit timer	1ch
Watchdog Timer	1ch
Time base counter	2ch
interrupt	Ten Factor
port· LCD driver	
LCD driver	3072 (96seg × 32com)
Input port	8 Book
Output port	8 Book
Input and output ports	3 Book
External memory I / F	35 Book
Power circuit	
Logic for power	VDDL
Low-speed oscillation power supply	VXT
Bias generator circuit VL1 ~ VL4	
Power switching circuit VDD	
The main electrical characteristics	
Temperature range	- 20 ℃ ~ 70 ℃
Power-supply voltage	1.0V ~ 3.6V
STOP Current consumption of time 0.6 μ A (Typ.) CPU Current	
consumption during operation 50 μ A (Typ.)	

For multi-Vt process

Multi-Vt process, Table 2 It is composed of three types of MOS shown.

Utilizing these features, the required LCD drivers high-voltage, ports, and the power supply circuit HV-MOS, the logic, which accounts for most of the chip configuration (8BitCPU including core), the MV-MOS order to suppress the leakage current , a circuit portion which is concern during low voltage operation using LV-MOS.

Table 2 MOS structure of a multi-Vt process, and applications

	Use	The breakdown voltage (Max)
HV-MOS	Used in the circuit that requires a high breakdown voltage such as the power supply system 7V	
MV-MOS	Used in the logic General (Nashi problem of leakage current)	4.6V
LV-MOS	It has sufficient capacity is required at low voltage That used in the place (partial use) (Leakage current is generated)	

To the low-power efforts Five) The contents are shown below.

① (deletion of unused circuit) streamlining of ② CPU core to the power supply voltage for the logic to lower deletion of ③ built-in capacity (oscillation circuit)

Measures to reduce the ① power supply voltage for the logic are the highest quality measures. **Table 3** It shows a comparison of a conventional low-power microcontroller and the power supply voltage for logic ML610901 to.

Table 3 Comparison of the power supply voltage for the logic

Supply voltage for logic ML610901		ML610501 (Conventional products)
VDDL	1.16V	1.60V

ML610901 is about as compared with the ML610501 (conventional) Since lowering the 27.5% voltage, it is expected power consumption reduction of the ratio.

② was taking measures to prevent the occurrence of excessive power consumption by the streamlining of the CPU core (deletion of unused circuit). CPU core of a conventional low-power microcomputer, debugging features, and tools mode function is mounted, this circuit is in operating CPU is in the active state, excess current consumption has occurred. Deletion of this circuit portion is effective as reducing power consumption.

③ to explains how to delete the built-in capacity of (oscillation circuit). Oscillator circuit ML610901 is of the type incorporated in the resistor-capacitor both in CR oscillator.

Power consumption of the CR oscillator, the charge of the capacitor, because it depends on the disk charge, to reduce the capacitance value, the effect of reducing power consumption by no less current. However, in the conventional product specifications, the resistance is in the external, there is a characteristic in which the frequency varies due to the influence of the parasitic capacitance. Power consumption measures, reducing the internal capacity, the influence of the parasitic capacitance becomes more dominant, a factor which fluctuated greatly frequency. Therefore, eliminating the influence of the parasitic capacitance by Rukoto to internal resistance in ML610901 to LSI, it made it possible to reduce power consumption and variation characteristics of frequency.

improved low-voltage operation of the ROM

Efforts to low voltage operation, to tune the Vt value of the existing multi-Vt process is to extend the low voltage operation margin of the CMOS transistor. By this initiative, it is possible to take measures to lower the top Symbol logic supply voltage of ①.

However, ROM, and a memory such as the RAM, CPU and, compared with the logic, such as a timer, the operating voltage is high. For this reason, ROM, memory RAM analyzes the conventional memory, and also carried a low-voltage operation measures by the circuit changes.

Method of realizing the

Results of the analysis of ROM operation, ROM is that there is the effect of improving the low-voltage operation by reducing the delay of the bit line has been found. Y decode unit of the conventional ROM was composed of 3 stages N-MOS. However, by the one-stage configuration of the N-MOS of the Y decode unit in ML610901, it is possible to reduce the total **ON resistance of the N-MOS to 1/3, and better follow-up performance. Figure 2 A conventional ROM configuration, Figure 3 To show the ROM configuration of ML610901.**
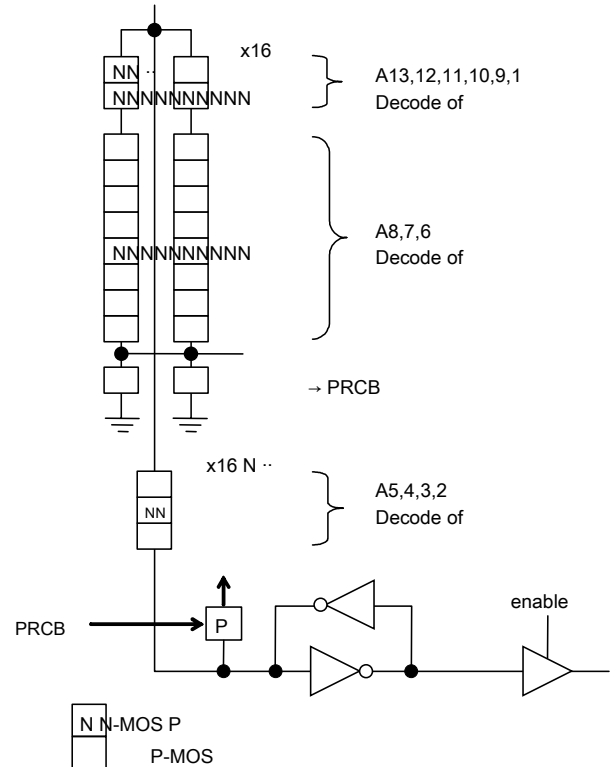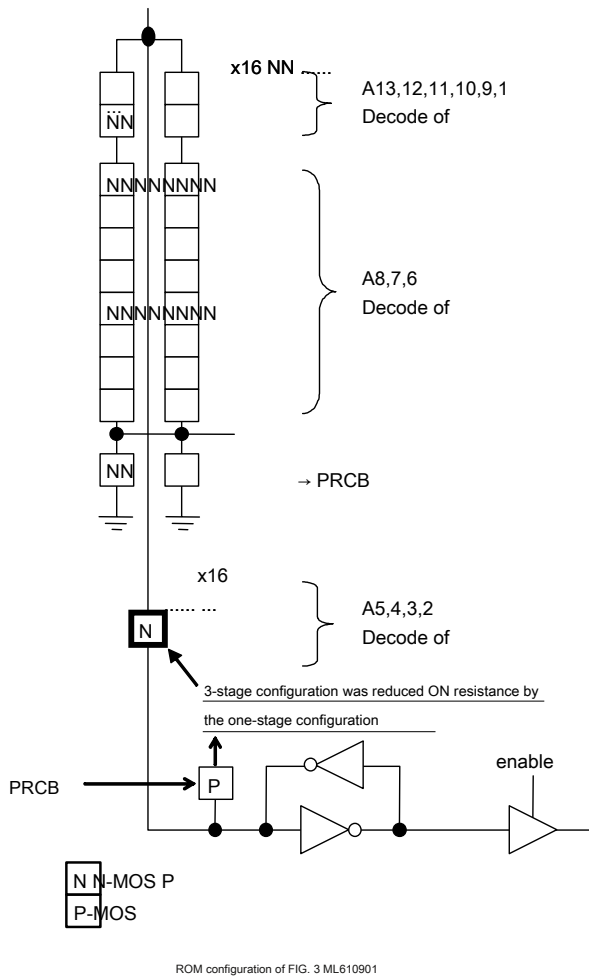

Figure 2 conventional ROM configuration

RAM configuration of FIG. 4 ML610901

○ : Change from MV-MOS to the LV-MOS

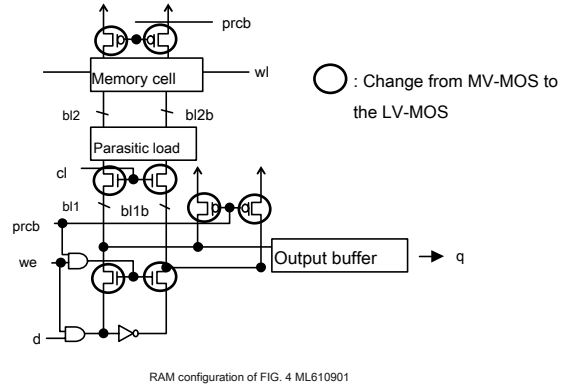ROM configuration of FIG. 3 ML610901

Improvement of RAM

As a result of the analysis of the RAM operation, RAM is, in respect to the read operation, and the delay in the column switch, delay of the precharge operation before going on to the next cycle, with respect to the write operation, and the delay in the transfer gate of La Itodeta It was found to have the effect of improving the low-voltage operation by reducing the delay of the precharge operation similarly to lead.

Circuit portion of a conventional above RAM is using the MV-MOS, the MOS of the ON resistance by changing the MV-MOS in LV-MOS is reduced, and good trackability.

Figure 4 To show the RAM configuration of ML610901. ○ MOS surrounded by is where you change from MV-MOS to the LV-MOS. Device characteristics by tuning the circuit changes Vt value, the minimum operating voltage is improved to 0.89V from 1.00 V, it could be realized minimum supply voltage 1V guarantees a target specification.

As a result of these efforts, ML610901 completed the mass production start-up in June 2004.

Conclusion In recent

Ultra-low-power (low-voltage operation) technology in the development of ML610901 is, and design capabilities that take advantage of the capabilities of the multi-Vt process, is a technology that was able to achieve in the overall strength of the process technology to support the Re it. We will further low-voltage operation, also in response to a request of the low power consumption of, in this way open turn off the technology in the comprehensive strength, I want to go to commercialization. ◆◆

■ References

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5) Kurita other: low-power design of the LSI, Oki Technical Review 188 No., Vol.68 No.4, pp.36-39, 10 May 2001

● I introduce

Kazuhiro Tomita:. Kazuhiro Tomita Co., Ltd. Oki Micro Design LSI design center LSI design part circuit design team