Present Status and Prospects for Fuji Electric's IC Products and Technologies

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1. Introduction

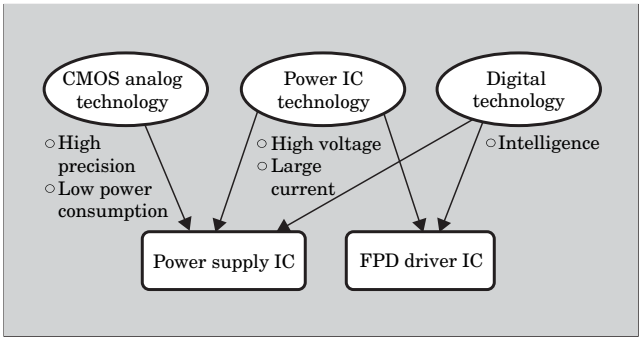
Utilizing core technologies of high voltage technology (power IC technology), high precision CMOS (complementary metal oxide semiconductor) analog technology and the associated digital control technology, Fuji Electric is expanding its offering of IC (integrated circuit) products which is concentrated on such devices as ICs for power supply units and driver ICs for FPDs (flat panel displays) (See Fig. 1).

In the fields of application for these products, small size, light weight, low power consumption and multifunctionality are required. The most important requirement is for low power consumption, which will contribute to efforts to protect the global environment. In response to these requirements, Fuji Electric has developed a low-power high-voltage CMOS analog technology, and has applied this technology to the ICs for power supply units to commercialize power supply ICs for AC adapter-use, cellular phone-use, DSCs (digital still cameras)-use, etc.

In the field of high-voltage devices, Fuji Electric is expanding its product line-up and has developed highly reliable device and process technologies for integrating a 700 V breakdown voltage power MOSFET (metal oxide semiconductor field effect transistor) into an IC device and IC production technology for fabricating an IGBT (insulated gate bipolar transistor) on an SOI (silicon on insulator) substrate.

An additional distinctive characteristic of Fuji Electric's IC devices is complex sensor technology.

Fig.1 Characteristics of Fuji Electric's ICs



This technology is being used in such applications as AFICs (auto focus ICs) for use in cameras equipped with an internal photodiode-based optical sensor and in pressure sensors for automobiles equipped with a built-in piezo-type strain gauge.

This special issue of articles will introduce new products and new technologies that leverage these special features.

2. Present Status of Fuji Electric's IC Products

2.1 Expanding line-up of products

2.1.1 Power supply ICs

Building on its base of high-voltage CMOS analog technology, Fuji Electric is concentrating on developing applications in the power IC field. Fuji has positioned the power supply IC as a top priority device and is expanding its product line. The concept behind these products is to realize low power consumption, high precision, small size and sophisticated functionality by employing proprietary technology from a perspective in which the "customer-is-number-one."

Power supply ICs can be broadly classified as either AC-DC converters that accept a commercial power source input or as DC-DC converters, which are used mainly in portable electronic devices. Fuji Electric is expanding its line of products in both of these categories. As an example, Table 1 lists Fuji Electric's line of CMOS power supply IC devices. In the AC-DC converter category, the issue of power consumption during standby has drawn attention in recent years, and there is an urgent need to lower this consumption. Fuji Electric has been advancing a series of control IC devices that support lower power consumption, and has recently developed a current-mode PWM (pulse width modulation) control IC device having a built-in high-voltage (500 V) starting circuit. By lowering the frequency during light loads, these devices aim to achieve both lower power consumption and lower output ripple voltage. In this category, higher harmonic current depression is also an important issue. Accordingly, an IC device for performing power factor correction is already in commercial production, but product development continues with the

Table 1 CMOS ICs for power supply units

(a) AC-DC category

Model name	D_{max} (%)	Circuit application			Operating mode		Protection circuit			MOS driving	Package
		Flyback	Feed-forward	PFC	Voltage	Current	OCP	OCV	OTP		
FA13842	96	○				○				○	8-pin
FA13844	48		○			○				○	8-pin
FA3641/3747	70	○			○		○	○		○	8-pin
FA5510/5511 FA5514/5515	46/70	○	○		○		○	○		○	8-pin
FA5501				○			○	○		○	8-pin
FA5502				○			○	○		○	16-pin
FA5701	70	○				○	○	○	○	Internal 700 V MOSFET	6-pin
FA5504	46		○		○		○	○		○	8-pin
FA5506/07/08	80	○				○	○	○		○	8-pin
FA5520	95	○				○		○		○	5-pin

(b) DC-DC category

Model name	No. of channels	D_{max} (%)	Voltage range			Circuit application				MOS driving	Package
			2.5 to 18 V system	2.5 to 5.5 V system	10 to 25 V system	Step down	Step up	Inverter	Flyback		
FA3675F	6	Arbitrary setting	○			○	○	○	○	○	48-pin
FA3676F	6	Arbitrary setting	○			○	○	○	○	○	48-pin
FA3698F	7	Arbitrary setting	○			○	○	○	○	○	64-pin
FA3630V	2	Arbitrary setting		○		○	○	○	○	○	16-pin
FA13843	1	96					○	○	○	○	8-pin
FA13845	1	48			○		○	○	○	○	8-pin
FA3686V	2	85	○		○		○	○	○	○	16-pin
FA3687V	2	Arbitrary setting	○			○	○	○	○	○	16-pin
FA7700	1	90	○				○		○	○	8-pin
FA7701	1	100	○			○				○	8-pin
FA7703/7704	2	Arbitrary setting	○			○	○	○	○	○	16-pin
FA3629AV	3	Ch1, 87		2.5 to 5.8 V system			○		○	Internal NMOS	16-pin
		Ch2, 87					○		○		
		Ch3, 86				○					
FA3635P	1	Arbitrary setting			10 to 45 V system	○				Internal PMOS	8-pin
FA3685P	1	Arbitrary setting			10 to 45 V system	○				Internal PMOS	8-pin
FA7702	1	100			10 to 45 V system	○				Internal PMOS	8-pin
FA7706	5	Arbitrary setting	2.5 to 12 V system			○				○	48-pin
FA7707	2	Arbitrary setting	○			○		○		○	20-pin
FA7708	5	85	1.4 to 10 V system			○	○		○	○	48-pin
FA7709	6	85	1.4 to 10 V system			○	○		○	○	48-pin
FA7710	2	92			6.5 to 28 V system	○				○	24-pin
FA7711	3	Arbitrary setting	4.5 to 15 V system			○	○	○	○	○	24-pin
FA7715	2	88	1.8 to 12 V system			○	○		○	○	16-pin

(c) Miscellaneous

Model name	No. of channels	Main use	Voltage range	Circuit application				MOS driving	Package
			2.5 to 5.5 V system	Step up	Charge pump	Series regulator	Switch		
FA3721	4	RGB LED PWM control	3.15 to 5.0 V *1 2.7 to 3.2 V *2		○		○	Internal PMOS Internal NMOS	16-pin
FA3717	1	White LED Dimmer control	3.1 to 4.3 V *1 2.75 to 2.95 V *2	○				Internal NMOS	16-pin
FA3705	1	Low noise charge pump	2.7 to 4.4 V		○	○		Internal PMOS	8-pin
FA3901	1	Low power LDO	2.0 to 6.0 V			○		Internal PMOS	5-pin

*1: Power supply for power system, *2: Power supply for control system

goal of developing even easier-to-use products. Applications for an IC device with built-in 700 V power MOSFET center on AC adapter-use, and the market is growing. Although some products are already being mass-produced, Fuji Electric intends to continue to concentrate on product development and to expand its product line-up.

In the DC-DC category, the market for portable electronic devices is expanding and the trend toward use of application specific ICs is continuing. Fuji Electric has recently developed a power supply IC for use in DSCs. Because DSC applications require a different voltage for each circuit block, multi-channel technology is being promoted. Moreover, in order to extend the battery operation time, detailed power management functionality and higher efficiency of the power supply unit are required. Also, in order to support a wide variety of batteries, it is necessary to lower the low limit for operating input voltage. These requirements have been realized through application of CMOS analog technology.

To date, many of Fuji Electric's power supply ICs have been used in the power supplies that drive LCD panels. Fuji Electric has developed a specialized power supply IC for LCD monitors, which are expected to supplant CRT monitors. Capable of directly driving 3 external power MOSFETS and having a wide input voltage range (5 to 20 V), this IC is convenient to use.

To improve the functionality and performance of cellular phones, which are typical portable electronic devices, design rules have been scaled down for the LSI (large scale integrated) ICs incorporated into these devices, and the power supply voltage has been lowered year-by-year. Cellular phones have conventionally been supplied with power from a battery power source that is fed through a series regulator. However, the series regulator method has the drawback of poor efficiency when there is a large voltage difference between the battery and power supply output. Consequently, there is a need to changeover from the series regulator method to the switching method. The switching method, however, uses a large-size external inductor for which an alternative means is desired. As one alternative, Fuji Electric has been working to develop a power supply IC device that integrates an IC and inductor onto a single chip, and has realized a 1 W-class IC that is the world's thinnest and smallest levels of the power IC device. Fuji Electric intends to consider customer needs as it accelerates development for the commercialization of these devices. Furthermore, Fuji Electric has also commercialized a new LDO (low drop out) regulator device which, when used in combination with the switching method, enables an optimal power supply path to be configured for each application.

For details of the above described products and technologies, please refer to the other articles in this special issue.

2.1.2 PDP driver ICs

The PDP (plasma display panel) is attractive for application to large-screen televisions, and the PDP market is about to enter a period of expansion. As part of the evolution of high-voltage power ICs, Fuji Electric is advancing the commercialization of driver ICs for PDPs. Among PDP driver ICs, there are medium-voltage low-current (85 V, 30 mA) address ICs and high-voltage, high-current (up to 200 V and up to 1,000 mA) scan ICs. Address ICs are being commercialized using C/DMOS (complementary/double diffused MOS) technology, and scan ICs are being commercialized using IGBT device technology on an SOI substrate. Fuji Electric's newly developed PDP driver IC is described in a separate article of this special issue.

2.1.3 AFICs

As an application of optical sensor technology, Fuji Electric is also developing AFIC devices for camera use. The camera market is transitioning rapidly from conventional film cameras to DSCs. In order to decrease the shutter release time, DSCs equipped with a Fuji Electric-made AFIC are beginning to appear in the market, and new products are being developed to accelerate this trend. The key to success, however, is the degree to which we are able to satisfy demands for smaller size and lower price. Accordingly, Fuji Electric has recently integrated a photo module with an IC chip to realize a small-size, low-cost commercial AF module. Details of this AF module are presented in "High-resolution Compact Auto Focus Module with 7 μm Pixels," a separate article in this issue.

2.1.4 Pressure sensors

Pressure sensor technology is being deployed in automobiles. In contrast to the conventional pressure sensors formed by trimming a thin film on top of a bipolar IC, Fuji Electric has newly developed a digitally trimmed pressure sensor formed by a CMOS process. These chips, provided internally with a gauge for converting pressure into strain, an amplifier, an EMI filter and a surge protection device, can be trimmed stably and with high precision. Standard product packages include a stand-alone type used to monitor the engine manifold air pressure and a self-contained cell type used for such purposes as to correct for atmospheric pressure. A vacuum reference chamber is provided inside both types of sensors to enable high precision measurement of the absolute pressure.

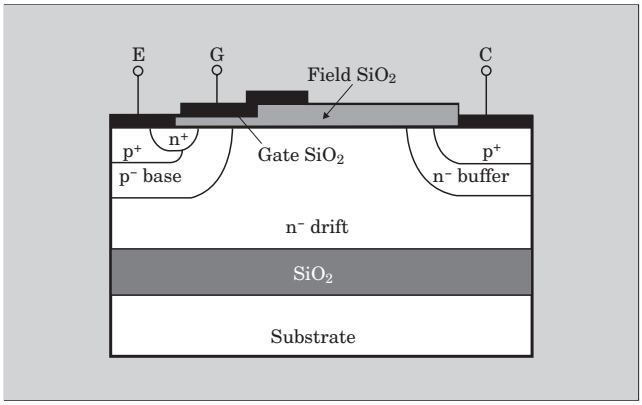
2.2 Technical development

2.2.1 Device process technology

One distinguishing feature of Fuji Electric's device process technology is a trend toward using higher voltage technology. Fuji is currently developing proprietary technology, examples of which include a highly reliable 700 V single-chip power IC device process that utilizes a dual-layer metal shield construction and a device process for PDP driver ICs that realizes a high voltage (200 V) and large current (1,000 mA) output stage by forming an IGBT device on an SOI substrate (See Fig. 2.).

Another distinguishing Fuji Electric device and process technology is its 0.6 μm analog C/DMOS device and process technology that was developed for CMOS analog applications. This technology enables the fabrication of analog CMOS devices having a low threshold voltage for use in analog circuits, digital CMOS devices having fine design rules (0.6 μm rule) for use in digital circuits, and as high-voltage MOS devices, HV-MOS devices guaranteed to withstand 30 V and having a DMOS output stage. The application of this technology makes possible the configuration of a high performance analog circuit that can be driven at low-voltage, mixed use with a highly integrated digital control circuit such as a CPU, and the commercialization of a high performance, advanced function power supply IC.

Fig.2 IGBT structure fabricated on an SOI substrate



2.2.2 Design technology

In response to demands for IC design technology with higher levels of integration, more advanced functionality, quicker turn around time, etc., the industry is promoting the construction of automated design systems, development of highly accurate simulation technology, and the reuse of design properties. Especially for analog ICs such as power supply ICs, which are core products for Fuji Electric, analog macro cell libraries, analog circuit design verification technology, analog automated mask layout design technology, and the like are being developed and are enabling devices to be designed with higher precision, more advanced functionality and with quicker turn around time.

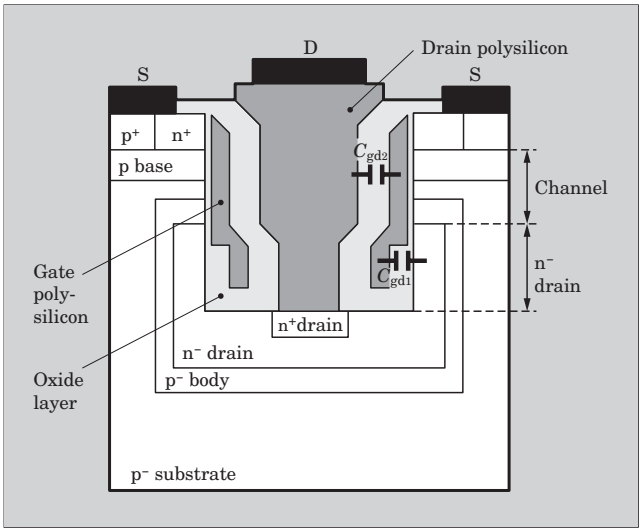
Fuji Electric also constructing a top-down design environment for digital systems. This digital design environment is being used in combination with the previously described analog design environment to achieve a higher level of sophistication in digital-analog hybrid design technology. In addition, Fuji is also developing test and automated design technology, and is forging ahead with the construction of a design environment capable of supporting the development of system power supply ICs for portable electronic devices, which are expected to becoming increasingly sophisticated in the future.

3. Future Prospects

Fuji Electric intends to continue to focus on its core technologies of high-voltage and CMOS analog technology, and to add intelligence to these technologies. Concentrating on power supply ICs, Fuji Electric aims to develop distinguished products in response to market needs.

In the power supply IC field, lower power con-

Fig.3 Structure of the trench lateral power MOSFET (TLPM)



sumption and higher efficiency are important factors in the response to environmental problems, which are only expected to become more severe. Accordingly, Fuji Electric is adopting the switching method, which has highly efficient power conversion, as its main method for supplying power. Fuji will also enhance its high-voltage, low power PWM switching technology, which has been a core technology until now and create power management technology that utilizes this switching technology effectively to develop and commercialize high-precision intelligent power supply ICs.

As for device and process technology, Fuji Electric will further develop low on-resistance device technology. Specifically, Fuji will continue to develop the unique technology described in "Low On-resistance Trench Lateral Power MOSFET Using 0.6 μm Smart Power Technology," a separate article of this special issue, and will apply that technology to products (See Fig. 3).

4. Conclusion

The present status and future prospects for Fuji Electric's IC products, which are concentrated on ICs for power supply units, have been described. Fuji Electric will continue to enhance its proprietary technologies, especially high-voltage and CMOS analog technologies, and to provide products that increase customer satisfaction.