

M-Power 2A Series of Multi-chip Power Devices

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1. Introduction

Fuji Electric has developed highly efficient and low-noise proprietary multi-oscillated current resonant circuits for use in switching power supplies. As a custom device for this circuit, Fuji Electric has commercialized the “M-Power 2”, housed in a small package (SIP23) containing a control IC and two power MOS FETs (metal oxide semiconductor field effect transistors), and this device has been well received for use in power supplies for flat panel televisions. As a result of the trend toward increasingly larger sizes of flat panel televisions in recent years, large capacity power supplies (having an output power of approximately 400 W) are being required. To support even larger capacity power supplies, Fuji Electric has developed the M-Power 2A series of devices provided with power MOS FETs having a lower ON-resistance, and featuring improved control IC functionality.

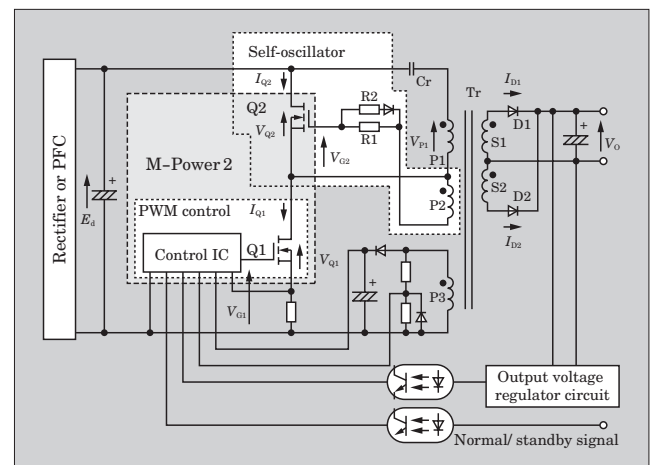
This paper introduces the M-Power 2 series and the M-Power 2A series of multi-chip power devices, and the operating principles of the multi-oscillated current resonant power supply, to which these devices are applied.

2. Operating Principles of the Multi-oscillated Current Resonant Converter

2.1 Circuit configuration

Figure 1 shows the basic circuit configuration of a multi-oscillated current resonant converter in which an M-Power 2 device is used. In the upper and lower arms, the low-side switch Q1 (power MOSFET) is separately-excited (PWM controlled) and is driven by a control IC and the high-side switch Q2 (power MOSFET) is self-excited and is driven by an auxiliary winding P2 of an isolated transformer Tr, and current resonant operation is implemented with a series resonant circuit consisting of the Tr leakage inductance and a resonant capacitor Cr. P2 and the Vcc control winding P3, which supplies power to the control IC, are designed to be tightly coupled to P1, and each generates a voltage proportional to the P1 voltage. However, the P2 voltage has the reverse phase of the P1 voltage.

Fig.1 Basic circuit configuration of the multi-oscillated current resonant converter



2.2 Basic operation

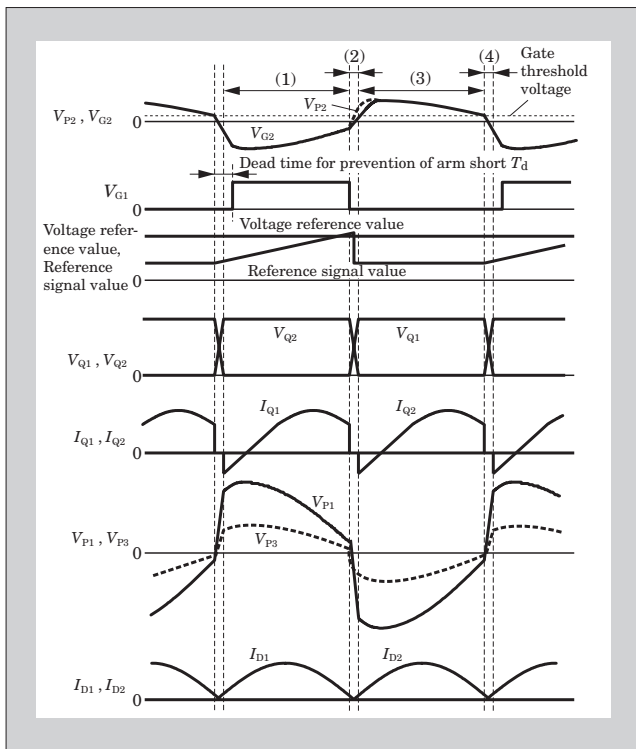
Figure 2 shows the operational timing chart.

During period (1), in the state where Q1 is ON and Q2 is OFF, a current flows through Cr to P1 and supplies power to the load. Output voltage control is implemented by feeding back to the control IC the signal from the output voltage regulator circuit as a voltage reference. The control IC compares the voltage reference to a reference signal value that increases in proportion to the time elapsed since the zero-crossing of V_{P1} (from negative to positive) and performs PWM control of Q1 so that the output voltage becomes constant.

During period (2), when Q1 turns OFF, the polarity of V_{P1} inverts from positive to negative. Current for charging the Q1 output capacitance and current for discharging the Q2 output capacitance flows from Tr, and the Q1 drain voltage rises and the Q2 drain voltage drops.

During period (3), after the discharge is completed, the Q2 body diode begins to conduct. At this timing, ZVS (zero voltage switching) becomes active when Q2 turns ON. The gate voltage turn-on voltage is moderated by a resistance connected to the Q2 gate terminal, and the circuit is set such that ZVS will become active and prevent Q1 and Q2 from both turning ON simulta-

Fig.2 Operational timing chart



neously and a short-circuit current from flowing. Also, with Q2 in an ON state, a current, inverted from that of period (1), flows to P1 and supplies power to the load.

Operation during period (4) is the same as during period (2). Afterwards, the operation returns to period (1), and when discharging is completed, the Q1 body diode begins to conduct. At this timing, ZVS becomes active when Q1 turns ON. After the timing of the negative to positive zero-crossing of V_{P1} is indirectly detected by the P3 voltage, and after the time T_d, dead time for prevention of an arm short, has elapsed, Q1 is turned ON.

2.3 Features

The converter has the following features.

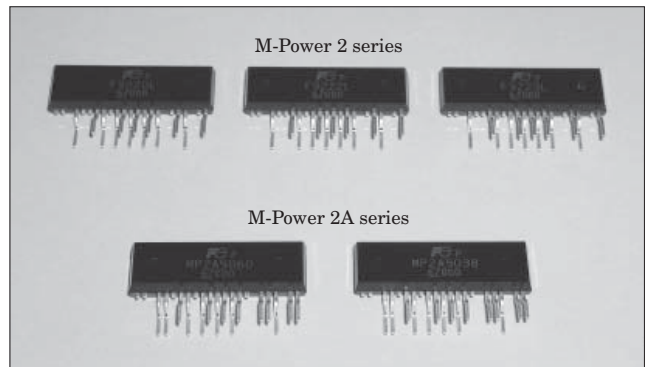
- (1) High efficiency
- (2) Low noise
- (3) No arm-short by lower frequency side operation (the resonant breakaway phenomenon)
- (4) High efficiency during light load operation

Features (1) and (2) above provide the same benefit as the conventional current resonant circuit frequency control method. However, features (3) and (4) are difficult to achieve with the frequency control method, and a significant advantage of the present method is the ability to provide these countermeasures and improvements easily.

3. Overview of the M-Power 2A Series

Figure 3 shows the appearance of the M-Power 2

Fig.3 Appearance of M-Power 2 and M-Power 2A series devices



and M-Power 2A series devices. These devices use the same package construction. The M-Power 2A series features improved control IC functionality, and its pin layout differs from that of the M-Power 2 series.

3.1 Structure

Internally, the M-Power 2A has an all-silicon multi-chip configuration, and the M-Power 2A houses a control IC and two power MOSFETs (Q1 and Q2) in a SIP package having a height of 10 mm and width of 30 mm, which is suitable for application to low-profile power supplies.

3.2 Control IC functions

The control IC, which was developed specially for multi-oscillated control, has some general functions. One is a computation function to control the PWM (pulse width modulation) operation of the Q1 according to the indicated value for the secondary side output voltage. The other is a protection function by latched shutdown against the overcurrent, load short-circuit, overheat, overvoltage and undervoltage lockout. Also, the latched shutdown function of the overcurrent protection and the overheat protection is provided with a timer setting.

3.3 Power MOSFET

The power MOSFET used is a SuperFAP-G series power MOSFET having the characteristics of low-resistance and high switching speed, and aims to reduce loss.

4. Improvements to the M-Power 2A and Differences from the M-Power 2 Series

The improvements to the M-Power 2A and differences from the M-Power 2 series are as listed below.

4.1 Structural improvements

Compared to the lead frame structure of the M-Power 2, the M-Power 2A has a larger mounting area for the power MOSFETs (Q1 and Q2), and enables the mounting of power MOSFETs having lower ON-

resistance (in order to ensure sufficient current capacity, the provision of two main current terminals). As a result, the MP2A5038 (500 V/0.38 Ω) is well suited for application to output switching power supplies of approximately 400 W.

4.2 Control IC function and performance improvements

Table 1 compares the functions of the M-Power 2 and the M-Power 2A.

- (1) Improved output voltage dropout characteristics at sudden change in load

In the case of unloaded burst operation as shown in Fig. 4 for a power supply equipped with an M-Power 2 device, if the load is suddenly changed to a near maximum loaded condition, a phenomenon occurs in which the output voltage drops significantly. The voltage drop occurs because after a sudden load change (from no load to maximum load) during burst operation, even if the output voltage reference value, COMP voltage (FB (feedback) voltage in the case of the M-Power 2A), rises, switching does not restart unless the CB (burst operation frequency) oscillation reaches its lower limit. Thus the M-Power 2A has been devised such that switching restarts soon after the point in time when the FB voltage rises, and therefore there is almost no drop in output voltage, and a dramatic improvement is realized.

- (2) Surge voltage prevention of the overvoltage protection

The M-Power 2's overvoltage protection operates to instantaneously implement a latched shutdown when an excessive voltage (overvoltage) is input. However, it is desired that latched shutdown does not occur for an overvoltage pulse having an extremely narrow width, such as a lightning surge. Therefore, with the

Table 1 Functional comparison of M-Power 2 and M-Power 2A

Item	M-Power 2	M-Power 2A
Input power at standby (when $P_o = 0$ W)	0.6 W (burst operation)	0.41 W (burst operation)
	Built-in standby mode	External standby circuit
Switching restart timing	Minimum of CB oscillation	FB voltage reaches V_{thFB}
Dead time for prevention of arm short	Fixed	Adjustable
Circuit to prevent audible noise at light load	External circuit	Built-in
Overvoltage protection (OV)	1 shot latch	Timer latch at 270 μ s
Overcurrent protection (OC)	Plus detection (+900 mV)	Minus detection (-171 mV)
	Timer latch at 100 ms	Timer latch at 36 ms
Short circuit protection (SC)	Plus detection (+1,500 mV)	No function
	1 shot latch	

M-Power 2A, the overvoltage protection function is provided with a 270 μ s timer, and does not react to narrow width overvoltage pulses.

- (3) Less resistive loss for overcurrent protection detection

With the M-Power 2 series, overcurrent protection circuit has an operating voltage of 900 mV, the current detection resistance loss increases as the power supply output power increases, and increasing the size of the detection resistor results in greater heat generation. On the other hand, the M-Power 2A has a lower operating voltage of 171 mV, and achieves reduced detection resistance loss. The following improvements have been made in the M-Power 2A.

- (a) The current detection method has been changed from plus to minus, and the influence of the power MOSFET's drive current has been eliminated.
- (b) The current detection terminal is separated from the power MOSFET's source terminal, and an externally attached filter can be designed freely in accordance with the power supply specifications.
- (c) Two GND terminals (PGND and SGND) are provided, the influence of noise on the control IC lessened, and the pattern layout has been made easier to design.
- (4) Built-in compensation circuit for light load burst

Fig.4 Schematic drawing of operation at sudden load change

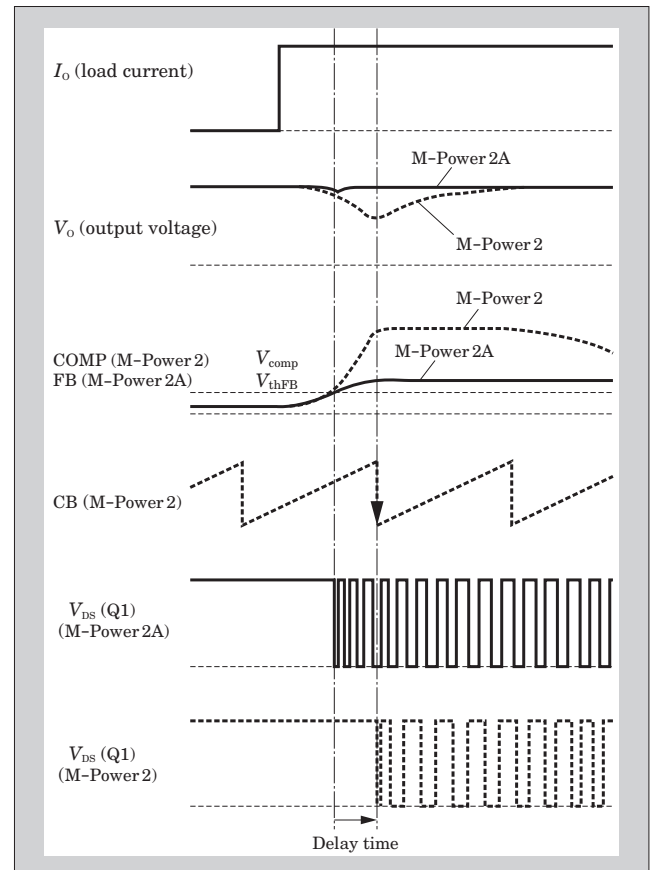


Fig.5 External standby circuit

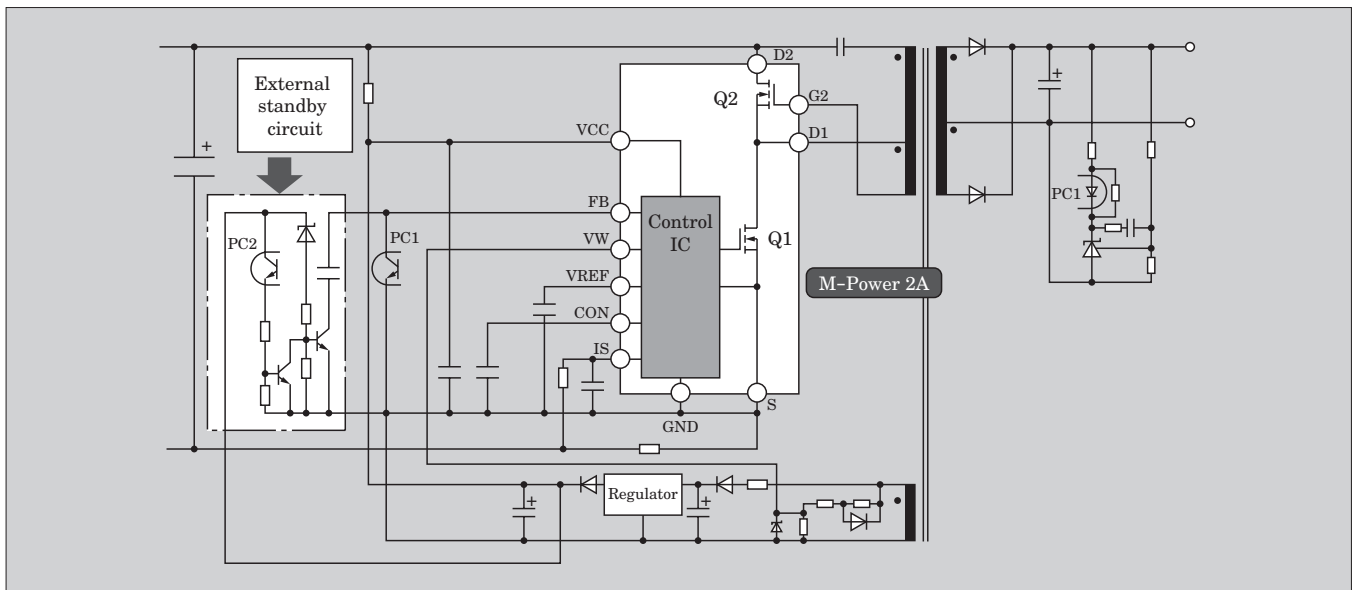


Table 2 Fuji Electric's M-Power 2A series product lineup

Model name	MOSFET (Q1, Q2)		Control IC		Package
	V_{DS}	$R_{DS(ON)}$	$V_{CC(ON)}$	$T_{j(OFF)}$	
MP2A5038	500 V	0.38 Ω	16.5 V	125 to 150°C	SIP23
MP2A5050		0.50 Ω			
MP2A5060		0.60 Ω			
MP2A5077		0.77 Ω			
MP2A5100		1.0 Ω			
MP2A5135		1.35 Ω			

operation

With the M-Power 2, the operation is burst during a light load, and in cases where an audible burst operation sound from Tr creates a problem, it is recommended that a circuit be attached externally to provide a solution. On the other hand, with the M-Power 2A, a compensation circuit for burst operation is built-in, thereby enabling a reduction in the number of externally attached components.

(5) Reduced power consumption of control IC

The M-Power 2 has a built-in standby function, but the M-Power 2A eliminates this function in order to reduce the consumption of electrical power by the control IC. However, in the case where a standby function is required in one converter, a standby function circuit can be attached externally. (See Fig. 5.)

5. Conclusion

This paper has introduced the newly developed M-Power 2A series of products that feature an improved control IC for power supplies in flat panel televisions and the like (Table 2). Accordingly, the M-Power 2A series of devices are well suited for application to large capacity power supplies for use in large screen flat panel televisions and the like. In the future, Fuji Electric plans to expand the product lineup to support various other requests. Fuji Electric also intends to strive to develop power supply systems and to commercialize custom power devices in order to support requests for even more sophisticated power supplies.