CHAPTER 6. POWER SUPPLY CIRCUIT

1. Outline of the power supply

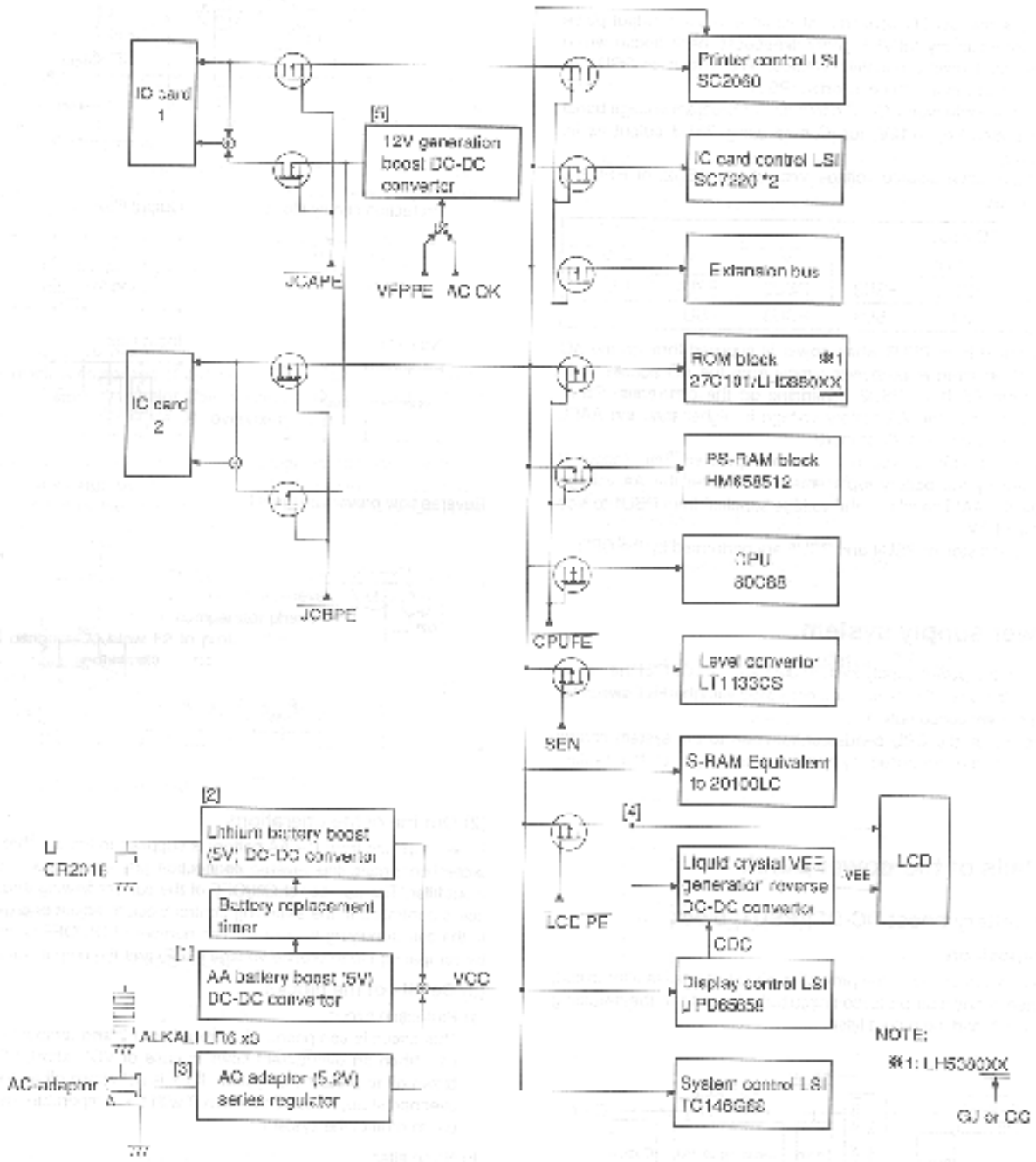


Fig. 6-1 Power supply block diagram

The power supply block is composed of five systems of input sources. The first is the pulse skip type DC-DC converter of AA battery boost type which generates +5V inputs with three U3 batteries. (PSU1)
The second is the pulse skip type DC-DC converter of lithium battery boost type which generates +5V input with a lithium battery CR2016. (PSU2)
The third is the series regulator (dropper) for AC adapter which generates +5.2V input with the DC power from the AC adapter. (PSU3)
The fourth is the DC-DC converter of variable voltage output pulse skip type for liquid crystal VEE generation/boost (back boost) which generates liquid crystal negative voltage. The output of PSU1 or PSU3 is used as input of the converter. (PSU4)
The fifth is the PWM type DC-DC converter for program voltage boost which generates Vpp (+12V) for IC card using PSU3 output as its input. (PSU5)
For the main power source voltage Vcc, PSU1, PSU2, or PSU3 is always inputed.

VCC source	AC input	○		×	
	AA input	○	×	○	×
LI input	YES	PSU3	PSU3	PSU1	PSU2
	NO	PSU3	PSU3	PSU1	×

Vcc is supplied from PSU3 when power is supplied through the AC adapter. When there is no power supply from the AC adapter, it is supplied from PSU1 or PSU2 depending on the conditions. PSU1 supplies Vcc when the AA battery voltage is higher than the AAFL leve and Vcc is kept at 4.7V or more.
PSU2 supplies +5V to Vcc only for the specified time (about 3 minutes) set by the battery replacement timer after the AA voltage falls below the AAFL level and the voltage supplied from PSU1 to Vcc falls below +4.7V.
Operations and stop of PSU4 and PSU5 are performed by the CPU.

2. Power supply system

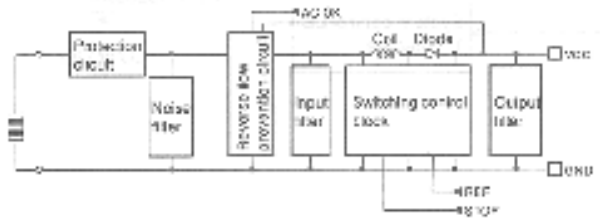
As shown in the power supply system diagram, ON/OFF of the power supplies to the operation blocks are controlled with the FET switch for reducing current consumption.
To control FETs, the CPU sends control code to the system control LSI, or FETs are controlled by the hardware logic of the system control LSI.

3. Details of the power block

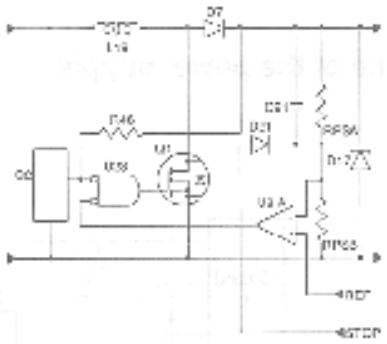
[1] AA battery boost DC-DC (PSU1) block

(1) Composition

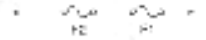
This block is composed of the protection circuit, the noise filter circuit, the reverse connection protection circuit, the input filter, the switching control circuit, and the output filter.



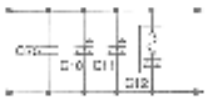
Switching control block



Protection circuit block

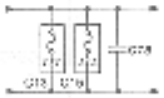


Output filter

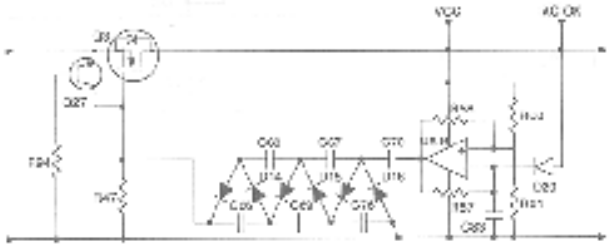


Noise filter

Input filter



Reverse flow prevention circuit



(2) Outline of the operations

Power supplied from the AA battery is supplied to the coil through the protection circuit, the reverse connection protection circuit, and the input filter. The number of ON/OFF of the current flowing through the coil is controlled in the switching control block to adjust energy stored in the coil, supplying the output. The number of ON/OFF is controlled by comparing the reference voltage (REF) and the output voltage.

(3) Details of the blocks

(a) Protection circuit

This circuit is composed of current fuse F2 and temperature fuse F1. When an overcurrent flows in case of VCC short, F2 will be blown off to protect the system. If F2 is not blown off under output overload state, F1 will be blown off with the temperature rise in the coil to protect the system.

(b) Noise filter

This block is composed of varistor V2, capacitor C61, and resistor R50. External surge is absorbed by the varistor and the capacitor to protect the internal system. R50 prevent against induction noise when a battery is not installed.

(c) Reverse connection protection circuit
This block is composed of the switch transistor FET, the oscillation comparator, the booster diode, the capacitor and the control diode.
If the battery is reversely connected, Q27 is forwardly biased to conduct Q27. The voltage between Q3 source (S) and the gate (G) becomes 0V, and Q3 is reversely biased and turned off. As a result, no voltage is supplied to the drain (D) side, protecting the system from breakage.
When the battery is properly connected, Q27 is reversely biased and turned off. At that time, power is supplied to the system by Q3's ???? diode. Then U8B starts operation to generate rectangular waveform. The output is passed to the clock shift boost circuit (D14, D15, D16, D80, D85, C69, C70, C76) to generate 10V which is applied to Q3 gate in turn on Q3. In this manner, voltage drop in Q is minimized.
When there is an AC adapter input, "H" signal is supplied through D20 to stop oscillation and reversely bias Q3, preventing a current from flowing to the battery.

(d) Input filter
This block is composed of C75, C10, C11, and C12, and absorbs noise generated in switching and reduces the impedance of the power source.

(e) Switching control block
This block is composed of oscillation IC Q2, gate IC U23, resistor R46, FET Q1, comparator U8A, voltage detection resistors PR5A and PR5B, rectifier diode D1, overvoltage preventing zenor diode D17, and control diode D21.
The divided value of the output voltage is compared with the reference voltage by the comparator U8A. When the output voltage falls below the specified value (5V), the output of Q2 in the rectangular waveform generating IC is applied to Q1 through U23 gate to switch Q1.
When Q1 is switched, energy is accumulated in L19 to overlap energy in the battery to boost the voltage level.
C91 is used to correct the comparator phase.
D17 conducts to blow F2 to protect the system when the output voltage rises abnormally.

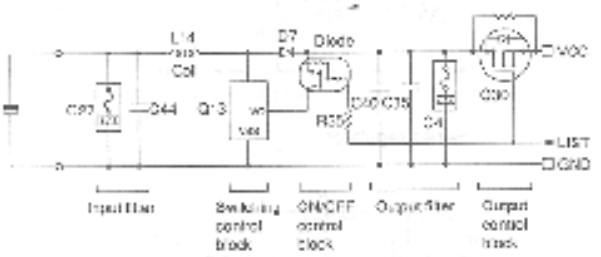
(f) Output filter
This block is composed of C76, C13, and C12.
It smoothes the waveform switched by the switching block.

[2] DC-DC for lithium battery (PSU2)

(1) Composition

As shown in Fig. 6-3, this block is composed of the input filter, the switching control block, the on/off control block, the output filter block, and the output control block.

Lithium battery boost DC-DC (PSU2)



(2) Outline of the operations

The power supplied from the lithium battery is supplied to the coil through the input filter. The number of on/off operations is controlled by the coil current switching control block to adjust the energy accumulated in the coil, adjusting the output voltage. This block operates only when the control signals (LIST and) of the on/off control block and the output control block are active.

(3) Details of the blocks

(a) Input filter block
This block is composed of C27 and C44, absorbs noises generated by switching, and reduces impedance in the battery side.

(b) Switching block
This block is composed of the switching control IC Q13, coil L14, and diode D7. Q13 performs switching at LX pin when the voltage at VO pin falls below 5V. Energy is charged or discharged to boost, and the current is rectified in diode D7 to transmit energy to the output filter.

(c) Output filter
This block is composed of C40, C35, and C4. Energy from the switching block is accumulated and smoothed in this block.

(d) ON/OFF control block
This block is composed of digital transistor Q14 and resistor R35.
When Q14 is turned on through R35, power is supplied to the switching block to start switching. When Q14 is turned off, switching is stopped.

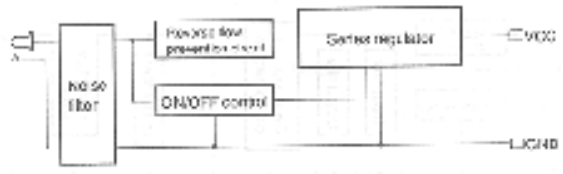
(e) Output control section
This block is composed Q30 of Pch FET.
When Q30 gate is reversely biased (+5V), Q30 is turned off and connected to VCC through the parasitic diode between the source and the drain.
When Q30 gate is forwardly biased (0V), Q13 is turned on to allow power to be supplied to VCC in small impedance.

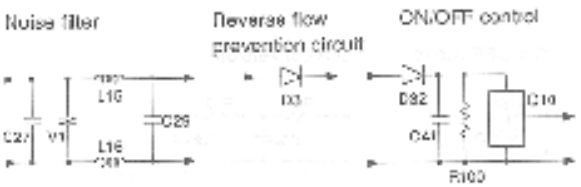
[3] AC adapter series regulator (PSU3)

(1) Composition

This block is composed of the noise filter, the reverse flow prevention circuit, the ON/OFF control circuit, and the series regulator.

AC adaptor series regulator (PSU3)





(2) Outline of the operations

In this power block, an input from the DC jack is passed through the noise filter to the reverse flow prevention circuit and the ON/OFF control circuit.

In the ON/OFF circuit, the series regulator can be operative only when the input voltage is more than the specified level. The power voltage from the reverse flow prevention circuit is inputted to the series regulator, where it is stabilized and passed supplied to VCC.

(3) Details of blocks

(a) Noise filter block

This block is composed of varistor V1, capacitors C27 and C29, coils L15 and L16. External surge and noise are absorbed by the varistor, the capacitors, and the coils to protect the interna system and prevent noises in the internal system from dissipating outward.

(b) Reverse flow prevent on block

This block is composed of the silicon diode D3. When a reverse voltage is applied, it is prevented by the diode to protect the system.

(c) ON/OFF control block

This block is composed of diode D32, capacitor C41, resistor R100, and voltage detection IC Q10. R32 prevent the circuit when a reverse polarity input voltage is applied. C41 prevent against malfunction and destruction caused noises. R100 protect the circuit when the input is open. Q10 (voltage detection IC) supplies HIGH level output when the input voltage rises above about 4.7V. With this signal, the series regulator block starts operation.

(c) Series regulator block

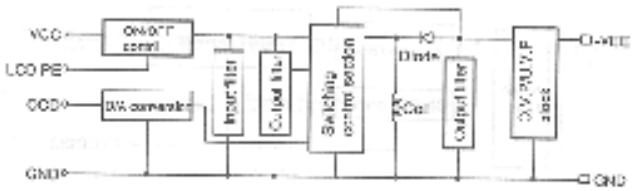
This block is composed of diode D5, D11, capacitors C45, C107, C108, transistor Q28, resistor R99, and series regulator IC U7. C107, C108, and 47 are filter capacitors to stabilize the operation of U7. D5 is a protection diode for U7. D11 is a bias setting diode. Q28 is U7 operation control transistor, which operates when Q28 is on. R99 performs to limit the Q28 base current.

[4] -VEE DC-DC (PSU4)

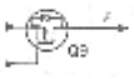
(1) Composition

This block is composed of the ON/OFF control block, the D/A converter block, the input filter block, the reference voltage block, the switching control block, the output filter, and O.V.P/U.V.P. block.

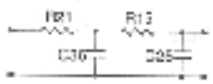
-VEE DC-DC (PSU4)



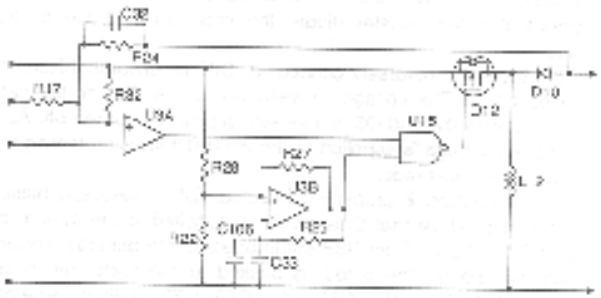
ON/OFF control



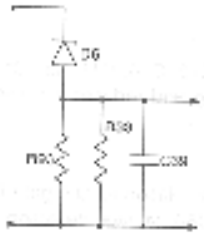
D/A conversion



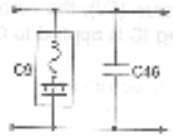
Switching control block



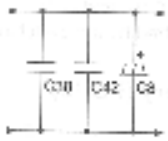
Reference voltage



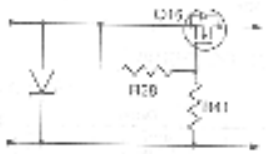
Input filter



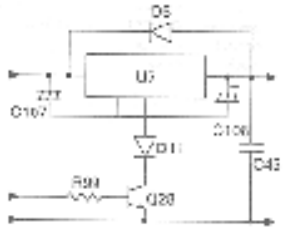
Output filter



O.V.P/U.V.P block



Series regulator



(2) Outline of operations

The ON/OFF control block controls ON/OFF of the PSU4 power. The power voltage from the control section is lowered by the power impedance in the input filter and applied to the reference voltage block and the switching control block. In the D/A conversion block, rectangular waveform duty supplied from external CDC signal is converted into a voltage. In the switching circuit block, the voltage determined with the reference voltage block output and the D/A output is compared with the output voltage (-VEE) to determine the pulse row of switching, controlling the number of switching of the coil.
Energy accumulated in the coil is varied by switching, taken out through the diode, and smoothed by the output filter to generate stabilized negative voltage. In the O.V.P/U.V.P block, the overvoltage and overcurrent protection circuit supplies -VEE only when the output filter voltage is within the specified range.

(3) details of blocks

(a) ON/OFF control block

This block is composed of PchFET Q9. When 0V is applied to Q9 gate, it is turned on and power voltage is supplied to PSU4 through the drain. In this manner, operation is started.

(b) D/A converter block

This block is composed of resistors R21, R16, capacitors C25 and C26. In PSU5, A/D output voltage is varied by external CDC signal duty, and -VEE is also varied with that.
The given rectangular waveform (CDC) is smoothed by the integral circuit (filter) to generate a voltage according to the duty.

(c) Reference voltage block

This block is composed of zener diode D5, resistors R33, R39, and capacitor C39.
D5 is a constant voltage diode. R39 and R33 are the bias resistors to determine the current flowing through D5. C39 functions as the filter capacitor which absorbs noises. Since D4 zener voltage varies with temperatures, the change in temperature appears in the reference voltage, to change the output voltage (-VEE). In this manner, temperature compensation of liquid crystal density is performed.

(f) Switching control block

This block is composed of the hysteresis self-run multi-vibrator block (composed of resistors R26, R22, R27, capacitors C130, C33, and comparator IC U3B), the error amplifier block (composed of gate IC U1C), switching FET Q12, rectifier diode D10, and coil L12.
U3A compares the D/A output, the reference voltage, and the output voltage (-VEE). When -VEE is higher than the specified voltage, U3A opens gate U1C and send the rectangular waveform generated in U3B to Q12, controlling switching operation.
Q12 is the switching FET to switch the current flowing through L12. L12 stores energy with the switched current and send the energy to the output side.

(g) Input filter block

This block is composed of capacitors C9 and C46.
It absorbs switching noises and foils the impedance of the power source.

(i) O.V.P/U.V.P block

This block is composed of resistors R38, R41, NchFET Q16 and zener diode D13.

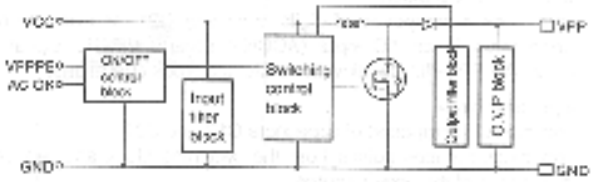
O.V.P: Over voltage protector
U.V.P: Under voltage protector

O.V.P. is composed of zener diode D13. When the output exceeds the zener voltage, D13 conducts to limit the generation of an overvoltage to protect the system.
U.V.P is composed of R41, R38, and Q16. The output voltage is divided by R38 and R41 to applied to Q12 gate. When this voltage is lower than the Q12 gate threshold voltage, Q16 is off to quicken the voltage drop on power off to protect the liquid crystal unit.

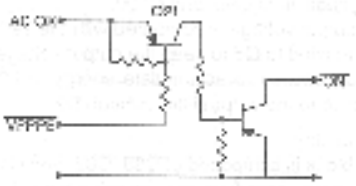
[5] VPP boost DC-DC (PSU5)

(1) Composition

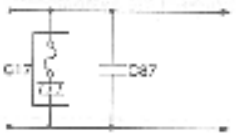
This block is composed of the ON/OFF control block, the input filter block, the switching control block, the output filter block, and the O.V.P block.



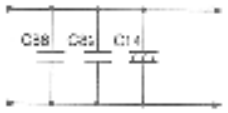
ON/OFF control block



Input filter block

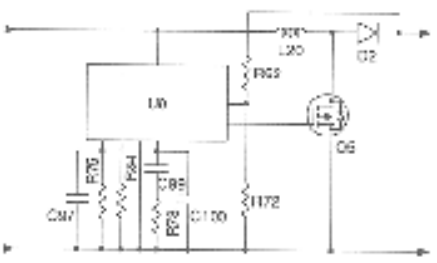


Output filter block



O.V.P block

Switching control block



(2) Outline of operations

The power voltage applied to the VCC is controlled by the switching block. Energy is stored in the coil, taken out by the diode, sent through the output filter and O.V.P to be outputted. This output (Vop) is controlled by the ON/OFF control circuit to output +5V or +12V.

(3) Details of blocks

(a) ON/OFF control block

This block is composed of digital transistor Q21, and active only when there is an AC input (ACOK="H") and VPPFE signal is active (VPPFE="L") to allow the switching block operations.

(b) Input filter block

This block is composed of capacitors C17 and C87.

This block reduces noises from the switching block and reduces impedance of the power source.

(c) Switching block

This block is composed of oscillating frequency setting resistor R76, capacitor C97, the output voltage setting resistor R62, R72, main switching FET Q5, PWM control IC U9, U0 drive current setting resistor R84, U19 frequency characteristics setting resistor R78, capacitors C99, and C100.

The output voltage is compared with the set value to change pulse duty applied to Q5 to keep the output voltage at a constant level.

Q5 is switched to accumulate energy in L20, then the energy is supplied to the output filter through D2.

(d) Output filter

This block is compresar of C88, C82, and C14.

The energy sent from the switching block is stored and smoothed to provide stabilized output.

(e) O.V.P

This block is composed of zenor diode D16, and absorbs an overcurrent to protect the system.