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[54] **MICROCONTROLLER CHIP WITH INTEGRATED LCD CONTROL MODULE AND SWITCHED CAPACITOR DRIVER CIRCUIT**

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[58] **Field of Search** 345/38, 50, 52, 345/87, 211, 212, 94, 95, 98, 99, 100, 204, 205, 206, 213

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[57] **ABSTRACT**

Apparatus for providing multiple of discrete voltage levels to drive a liquid crystal display (LCD) from an LCD module on board a microcontroller chip includes a charge pump with a switched-capacitor that develops the discrete voltages as multiples of the value of a base voltage that remains substantially without change irrespective of change in the supply voltage. A switched-capacitor charging circuit selectively charges a capacitor to produce successive additive charges individually retrievable from the capacitor. An LCD drive selectively transmits the discrete voltage levels to activate the LCD according to status of an external system under the control of the microcontroller. Voltage losses that may occur during the switched-capacitor charging are compensated to maintain the levels of the discrete voltages free of decay. Compensation is achieved by overcharging the capacitor by an amount substantially equivalent to the amount of voltage loss on the capacitor, using active feedback obtained from monitoring the charge on the capacitor.

17 Claims, 10 Drawing Sheets

