Multi-Voltage Output Incorporating Diode Charge Pump Circuitry

■ General Description
Diode charge pumps comprised of diodes and capacitors are useful for constructing a multi-voltage power supply at low cost or producing a negative voltage or high voltage with ease. The diode charge pump makes it possible to generate positive or negative integral multiples of the source voltage without using an IC or coil, efficiently producing up to approximately 10 mA. The basic circuitry of the diode charge pump is explained below.

■ Functional Description
The basic circuit is shown in Fig. 1. \( V_{\text{OUT1}}, V_{\text{OUT2}}, \) and \( V_{\text{OUT3}} \) denote one-fold, two-fold, and three-fold voltage outputs, respectively. Multiple stages of the circuit produce an \( N \) (\( \geq 2 \))-fold step-up output by using clock pulses and a separate power supply and, by only using clock pulses, an inverted \( -N \) (\( \geq 2 \))-fold output. Power loss occurs in each stage due to Schottky diodes. Hence, an \( N \)-fold output voltage will be calculated by:

\[
V_{\text{OUT(N)}} = V_{\text{IN}} \times N \times V_F \times 2(N - 1) - (a)
\]

where \( V_F \) is the forward voltage of a Schottky diode.

(a) denotes other power losses.

Figure 2 shows a variation of the circuit. The circuit shown in Fig. 2 exhibits a shorter rise time than the basic circuit, with a compromise in stability. Figure 3 shows a method of producing step-up voltages using clock pulses only. This circuit eliminates the need for a separate power supply, although it necessitates the addition of a diode and capacitor.

Figure 4 shows an application example of a multi-voltage power supply circuit incorporating the circuit shown in Fig. 3. The design is best suited to PDA and LCD applications, as multi-voltage positive and negative outputs are available using simply a 1-ch DC/DC converter, such as the XC9103 series. The circuit is realized not only by a DC/DC converter, but also by clock pulses (a square wave), ensuring its use in a wide range of applications.

■ Features
- Comprised simply of Schottky diodes (small and inexpensive 2-unit packages are best) and ceramic capacitors
- Produces positive and negative voltages
- High efficiency achieved by charge pump operation
- Best suited as an auxiliary voltage output to a DC/DC converter

■ Circuits
Fig. 1 Basic Circuit (1)

Fig. 2 Basic Circuit (2)

Fig. 3 Step-Up Voltages Gained by Using Clock Pulses Only

Fig. 4 Application Example of Multi-Voltage