

## SWITCHING REGULATOR POWER OUTPUT STAGES

### DESCRIPTION

The SM645/646/647 series of Power Output Stages are especially designed to be driven with standard PWM integrated circuits to form an efficient switching power supply. The SM645, SM646 and SM647 are optimized for non-isolated Buck and Buck-Boost application. The hybrid circuit construction utilizes thick film resistors on a beryllia substrate for maximum thermal conductivity and resultant low thermal impedance. All of the active elements in the hybrid are fully passivated.

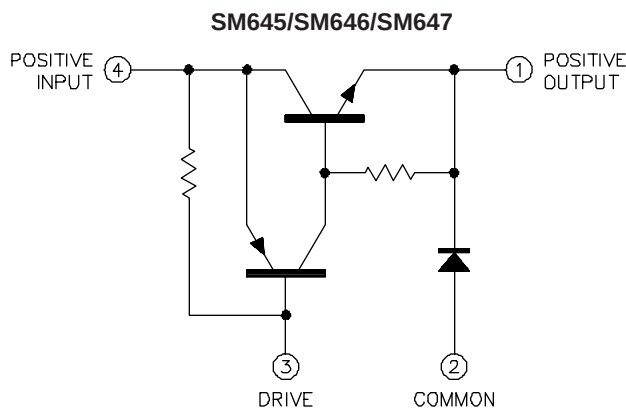
### FEATURES

- Equivalent to the Unitrode PIC 645, 646, 647
- 15A current capability
- Cost saving design reduces size, improves efficiency, reduces noise and RFI
- High operating frequency (to > 100KHz) results in smaller inductor-capacitor filter and improved power supply response time
- High operating efficiency at 7A typical performance -  
Rise and fall time < 300ns  
Efficiency > 85%

### HIGH RELIABILITY FEATURES

- ◆ Available with high reliability processing

### FUNCTIONAL DIAGRAM



## ABSOLUTE MAXIMUM RATINGS (Note 1)

|                                              | SM645 | SM646 | SM647 |
|----------------------------------------------|-------|-------|-------|
| Input Voltage, $V_{4-2}$ .....               | 60V   | 80V   | 100V  |
| Output Voltage, $V_{1-2}$ .....              | 60v   | 80v   | 100V  |
| Drive Input Reverse Voltage, $V_{3-4}$ ..... | 5V    | 5V    | 5V    |
| Continuous Output Current, $I_1$ .....       | 15A   | 15A   | 15A   |
| Peak Output Current .....                    | 20A   | 20A   | 20A   |
| Drive Current, $I_3$ .....                   | -0.4A | -0.4A | -0.4A |

### Thermal Resistance

|                                       |          |
|---------------------------------------|----------|
| Power Switch, $\theta_{j-c}$ .....    | 2.0°C/W  |
| Commutating Diode .....               | 2.0°C/W  |
| Case to Ambient, $\theta_{c-a}$ ..... | 30.0°C/W |

### Operating Junction Temperature

|                                                |                |
|------------------------------------------------|----------------|
| Hermetic (K Package) .....                     | 150°C          |
| Storage Temperature Range .....                | -65°C to 150°C |
| Lead Temperature (Soldering, 10 Seconds) ..... | 300°C          |

Note 1. Exceeding these ratings could cause damage to the device.

## THERMAL DATA

### K Package:

|                                                              |         |
|--------------------------------------------------------------|---------|
| Thermal Resistance-Junction to Case, $\theta_{j-c}$ .....    | 2.0°C/W |
| Thermal Resistance-Junction to Ambient, $\theta_{j-a}$ ..... | 35°C/W  |

Note A. Junction Temperature Calculation:  $T_j = T_a + (P_d \times \theta_{j-a})$ .

Note B. The above numbers for  $\theta_{j-c}$  are maximums for the limiting thermal resistance of the package in a standard mounting configuration. The  $\theta_{j-a}$  numbers are meant to be guidelines for the thermal performance of the device/pc-board system. All of the above assume no ambient airflow.

## RECOMMENDED OPERATING CONDITIONS (Note 2)

|                                              | SM645 | SM646 | SM647 |
|----------------------------------------------|-------|-------|-------|
| Input Voltage, $V_{4-2}$ .....               | 50V   | 70V   | 90V   |
| Output Voltage, $V_{1-2}$ .....              | 50v   | 70v   | 90V   |
| Drive Input Reverse Voltage, $V_{3-4}$ ..... | 4V    | 4V    | 4V    |
| Output Current, $I_1$ .....                  | 13A   | 13A   | 13A   |
| Drive Current, $I_3$ .....                   | -0.3A | -0.3A | -0.3A |

### Operating Ambient Temperature Range

|                |                |
|----------------|----------------|
| SM6XXK .....   | 0°C to 70°C    |
| SM6XXHRK ..... | -55°C to 125°C |

Note 2. Range over which the device is functional.

## ELECTRICAL CHARACTERISTICS

(Unless otherwise specified, these specifications apply for the operating ambient temperature of  $T_a = 25^\circ\text{C}$ . Low duty cycle pulse testing techniques are used which maintains junction and case temperatures equal to the ambient temperature.)

| Parameter                      | Test Conditions                                                  | SG645/646/647 |      |      | Units         |
|--------------------------------|------------------------------------------------------------------|---------------|------|------|---------------|
|                                |                                                                  | Min.          | Typ. | Max. |               |
| On-State Voltage (Note 3)      | $I_4 = 7\text{A}(-7\text{A}), I_3 = -30\text{mA}(30\text{mA})$   |               | 1.0  | 1.5  | V             |
|                                | $I_4 = 15\text{A}(-15\text{A}), I_3 = -30\text{mA}(30\text{mA})$ |               | 2.5  | 3.5  | V             |
| Diode Forward Voltage (Note 3) | $I_4 = 7\text{A}(-7\text{A})$                                    |               | 0.85 | 1.25 | V             |
|                                | $I_4 = 15\text{A}(-15\text{A})$                                  |               | 0.95 | 1.75 | V             |
| Off-State Current              | $V_4 = \text{Rated input voltage}$                               |               | 0.1  | 10   | $\mu\text{A}$ |
|                                | $V_4 = \text{Rated input voltage}, T_a = 125^\circ\text{C}$      |               | 10   |      | $\mu\text{A}$ |
| Diode Reverse Current          | $V_1 = \text{Rated output voltage}$                              |               | 1.0  | 10   | $\mu\text{A}$ |
|                                | $V_1 = \text{Rated output voltage}, T_a = 125^\circ\text{C}$     |               | 500  |      | $\mu\text{A}$ |

Note 3. Pulse test: Duration = 300 $\mu\text{s}$ , Duty Cycle  $\leq 2\%$ .

## ELECTRICAL CHARACTERISTICS (continued)

| Parameter                                                 | Test Conditions | SG645/646/647 |      |      | Units |
|-----------------------------------------------------------|-----------------|---------------|------|------|-------|
|                                                           |                 | Min.          | Typ. | Max. |       |
| Dynamic Characteristics (See Figures 1 & 2) (Notes 4 & 5) |                 |               |      |      |       |
| Current Delay Time                                        |                 |               | 35   | 60   | ns    |
| Current Rise Time                                         |                 |               | 65   | 150  | ns    |
| Voltage Rise Time                                         |                 |               | 40   | 60   | ns    |
| Voltage Storage Time                                      |                 |               | 700  |      | ns    |
| Voltage Fall Time                                         |                 |               | 70   | 175  | ns    |
| Current Fall Time                                         |                 |               | 175  | 300  | ns    |
| Efficiency (Note 5)                                       |                 |               | 85   |      | %     |

## AC TEST CIRCUIT AND SWITCHING TIME WAVEFORMS (Note 6)

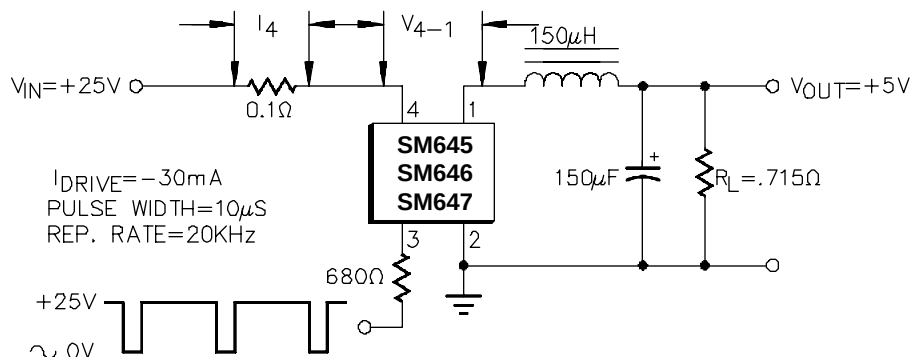


FIGURE 1 - SM645/646/647 SWITCHING SPEED CIRCUIT

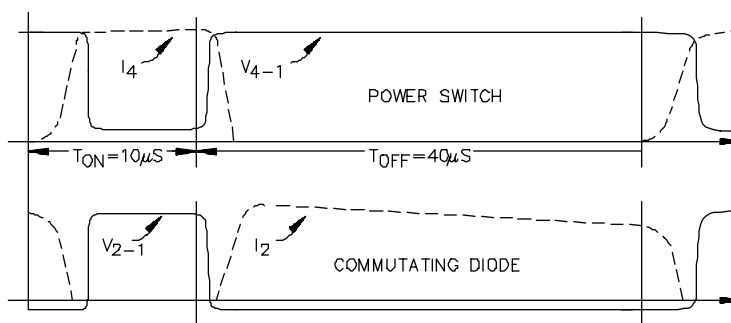


FIGURE 2 - SM645/646/647 SWITCHING WAVEFORMS

Note 4. In switching an inductive load, the current will lead the voltage on turn-on and lag the voltage on turn-off (see Figure 2). Therefore, Voltage Delay Time ( $t_{dv} \cong t_{di} + t_{ri}$ ) and Current Storage Time ( $t_{sv} \cong t_{sv} + t_{rv}$ ).

Note 5. The efficiency is a measure of internal power losses and is equal to Output Power divided by Input Power. The switching speed circuit of Figure 1, in which the efficiency measured, is representative of typical operating conditions for the SM600 series switching regulators.

## APPLICATION CIRCUITS

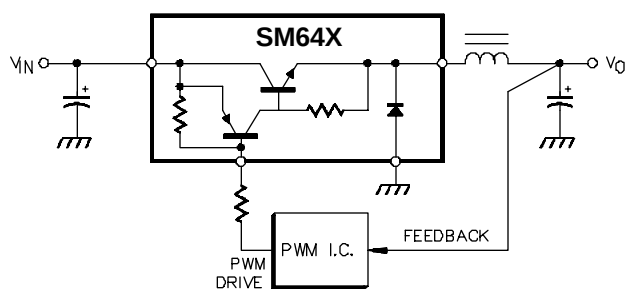


FIGURE 3 - STEP DOWN (BUCK) CONVERTER

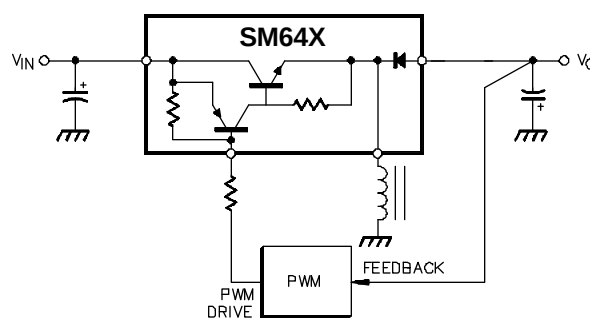
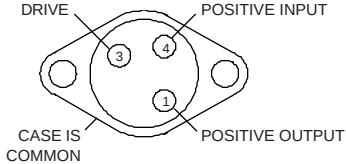


FIGURE 4 - NEGATIVE OUTPUT DOWN/UP (BUCK-BOOST) CONVERTER

CONNECTION DIAGRAMS & ORDERING INFORMATION (See Note Below)

| Package                                     | Part No. | Ambient Temperature Range | Connection Diagram                                                                  |
|---------------------------------------------|----------|---------------------------|-------------------------------------------------------------------------------------|
| 4-TERMINAL TO-3<br>METAL CAN<br>K - PACKAGE | SM645K   | 0°C to 70°C               |  |
|                                             | SM645HRK | -55°C to 125°C            |                                                                                     |
|                                             | SM646K   | 0°C to 70°C               |                                                                                     |
|                                             | SM646HRK | -55°C to 125°C            |                                                                                     |
|                                             | SM647K   | 0°C to 70°C               |                                                                                     |
|                                             | SM647HRK | -55°C to 125°C            |                                                                                     |

Note 1. All packages are viewed from the top.  
2. Consult factory for additional screening available.