AN964

Trigger Design Ideas
for Diac Replacements

INTRODUCTION

The family of devices designed for controlling SCRs and triacs are called triggers. The more common triggers are unijunction transistors, programmable unijunction transistors, silicon bilateral switches, diacs and sidacs.

The diac has been a popular trigger for driving triacs because of its good symmetrical characteristics and has even found its way into SCR designs. Unfortunately, with the obsolescence and reduced availability of diacs, it has become necessary to explore alternative trigger configurations.

There are some discrete devices and combination of devices which have advantages over diacs with respect to specific drive considerations, i.e., improved symmetry, higher or lower trigger voltage, higher trigger currents. This application note addresses some alternative trigger circuits where in most cases, the part cost is the same or less than the diac they replace.

Table 1 and Figures 1 through 8 contrast the properties of alternative trigger devices. The closest equivalent to the diac is the SBS.

DIAC REPLACEMENT WITH SBS

Figures 11 through 14 contrast trigger performance in a simple phase control circuit. The 28 volt diac (1N5760) provides peak gate currents exceeding triac gate ratings when no series gate damping resistance is used. The short high amplitude pulse (Figure 12) of the SBS used without series gate resistance (R2 = 0) is preferred when short turn-on delay and high di/dt rates must be switched.

Inductive loads require stretching the gate pulse until the load and snubber provide current above the latching and holding value. To convert to a MBS4991 SBS (Figure 2):

$$R2 = \frac{V_S - V_F}{I_G} = \frac{9 - 1.7}{0.25} \cong 27 \text{ Ohm}$$

$$C_1 = \frac{tw_{10}}{2.3\ R2} = \frac{17\ \mu s}{(2.3)(27)} = 0.27\ \mu F$$

where
tw_{10} = 10% level of diac current pulse
I_G = peak current with diac

The timing resistor (R1) must be increased for the same conduction angle because of the lower SBS voltage.

ALTERNATE METHODS OF TRIGGERING

Trigger performance is determined by device physics and the application circuit. Although the devices shown in Table 1 differ greatly in structure and physics of operation, they all require sufficient peak point current at the peak voltage to initiate switching. In relaxation oscillator applications the timing resistor must supply less than the holding or valley current or 1-shot operation and latch-up in the on-state will occur. In ac and pulsating dc applications this is not important because turn-on of the triac or SCR removes the bias from the trigger circuit or alternatively line zero crossing resets the trigger.

Sensitive unilateral triggers can be constructed for many voltages using a SCR or PUT, nitride passivated zener, and bias resistor. Figure 9 illustrates the concept.

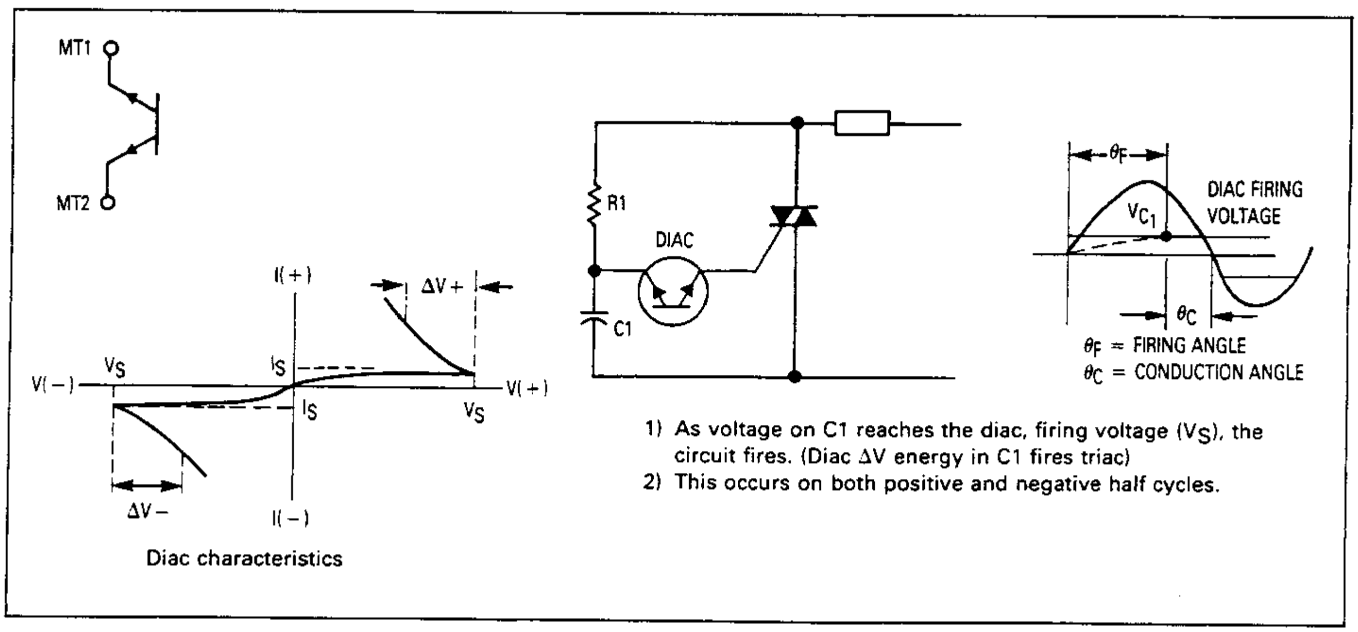
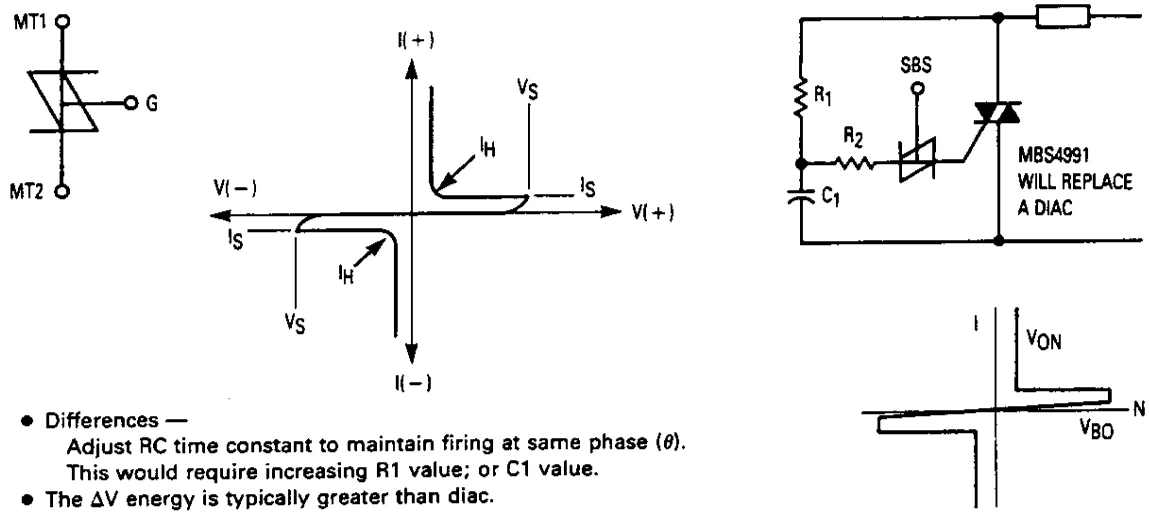


Figure 1. Typical Diac Operation



- Differences —
  Adjust RC time constant to maintain firing at same phase (θ).
  This would require increasing R1 value; or C1 value.
- The ΔV energy is typically greater than diac.
- Symmetry is improved.

Figure 2. Typical SBS Operation (Same Circuit)

Table 1. Contrasting the Typical Characteristics of Trigger Devices

Description	Figure	Peak Point Voltage (Volts)	Peak Point Current (μA)	Valley or Holding Current (μA/mA)	Current Pulse Amplitude	Symmetry (Volts)	Suggested Application	Suggested Circuit Changes and Comments
Diac	3	16–34	<1–10	Not Applicable	Moderate to High	<4	Bilateral ac	To be discontinued.
SBS	3	6–10	50–500	100/1.5	Moderate	<0.5	Bilateral ac	Increase timing capacitor and or resistor. See AN526.
Series SBS, Zener	4	6–200	50–500	100/1.5	Low to Moderate	Asymmetric	Unilateral, Pulsating dc	Partial discharge of timing capacitor. Voltage widely adjustable.
Series SBS	5	12–20	50–500	100/1.5	High	<1	Bilateral, ac	High output.
Sidac	6	100–270	<1 to 100	10–100 mA	Very High	Good	Bilateral, ac	Series gate limiting resistor less than R_S required. See MKP9V120 Data Sheet and EB106.
Zener/SCR	7	6–200	0.5–50	Same as Peak Point Current	Moderate to Very High	Not Applicable	Unilateral, Pulsating dc	Can provide low peak point current and or widely adjustable voltage.
Zener/PUT	8	6–40	<1					
UJT	—	4–35	<5	>1 mA	Moderate	Not Applicable	dc	Wide frequency range. V_P depends on device and supply. See AN293, 294, AN413.
PUT	—	4–40	<0.1–5		Moderate to High			Wide, accurate, easy V_P adjustment with bias resistors. See AN527.

For more information refer to DL137, Thyristor Device Data.

R_G is used to provide a minimum zener bias current and provide a path for leakage. This prevents run-away at temperature and insures a well defined peak-point voltage. The peak-point current is the sum of the zener bias current, gate trigger current, and anode current. The anode current at the onset of regeneration is at least equal to the gate trigger current. Actual peak point current will be significantly lower than predicted because zener breakover noise aids triggering. These circuits provide holding currents almost identical to the peak point current. This is a consequence of the gate shunt resistor effecting the thyristor gain at the onset of conduction and at turn-off equally. SBS devices use internal emitter shorting which increases holding current because partial conduction takes place through the short following triggering and current spreading across the die.

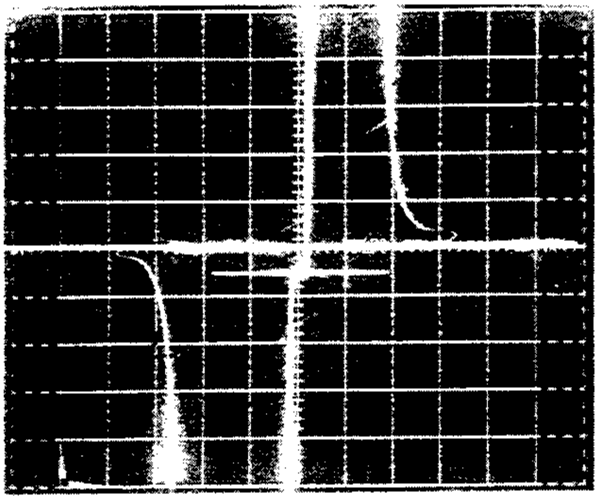


Figure 3. Diac and SBS Double Exposure. SBS Origin Offset 1/2 Division Below Center.
Vertical: 10 mA/Div.
Horizontal: 5 V/Div.

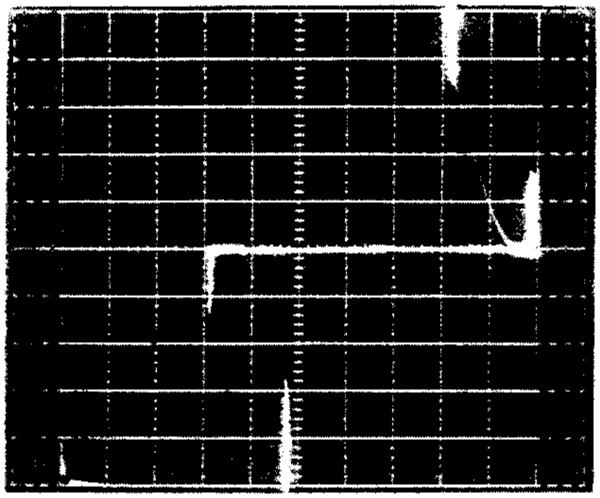


Figure 4. Series SBS and 1N4703 Zener. (0,0) at Center.
Vertical: 20 μA/Div.
Horizontal: 5 V/Div.

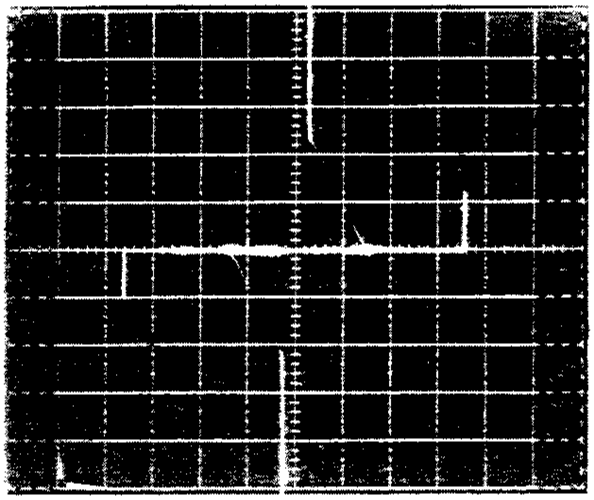


Figure 5. Series SBS
Vertical: 50 μA/Div.
Horizontal: 5 V/Div.

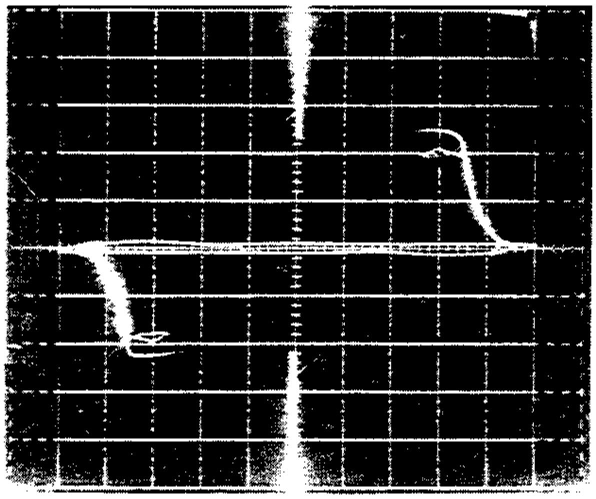


Figure 6. Sidac
Vertical: 10 mA/Div.
Horizontal: 20 V/Div.

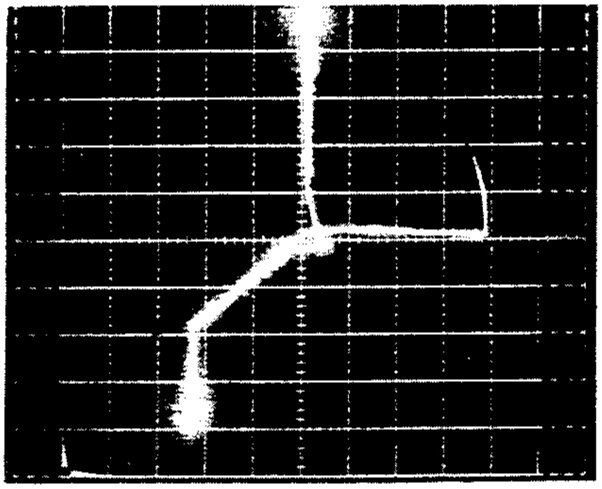


Figure 7. 2N5061 SCR, 1N4706 Zener, R_G = 1.2 Meg.
Vertical: 5 μA/Div.
Horizontal: 5 V/Div.
Reverse Slope is Due to R_G.

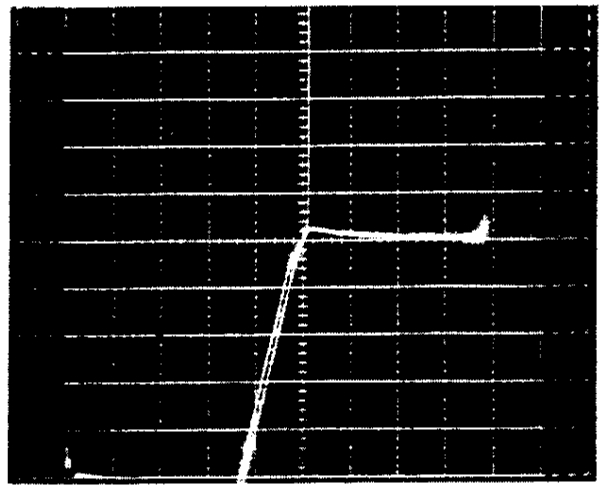
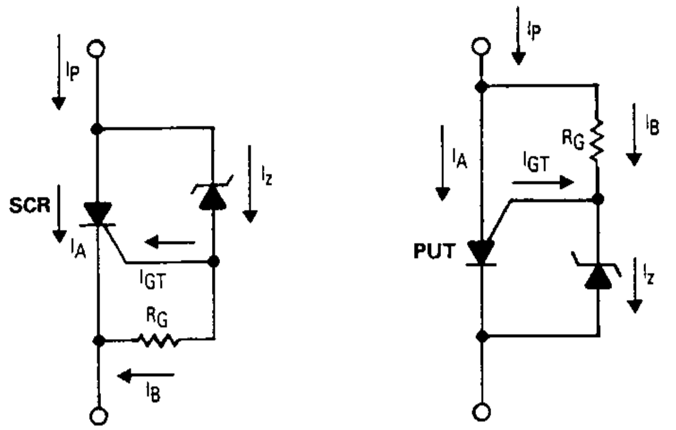


Figure 8. 2N6027 PUT, 1N4706 Zener, R_G = 1.2 Meg.
Vertical: 1 μA/Div.
Horizontal: 5 V/Div.



Minimum Zener Bias Current = $I_B = \frac{0.5\ V}{R_G}$

Peak Point Current = $I_P = I_B + I_{GT} + I_A$

$I_A \leq 10\ I_{GT}$ $\qquad$ I_A = Anode current required for regeneration.

Figure 9. Sensitive Unilateral Trigger
Using SCR or PUT

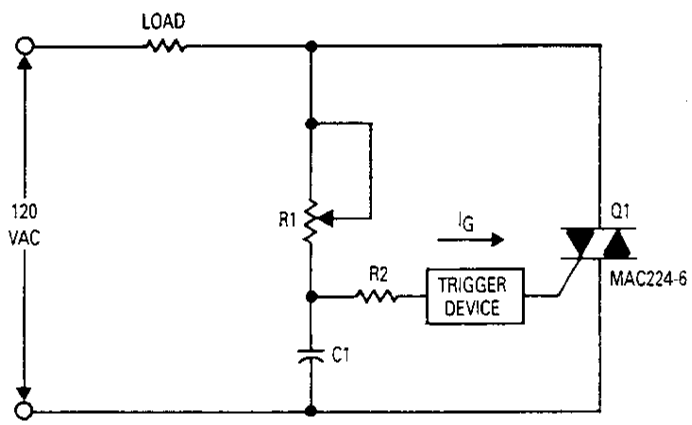


Figure 10. Test Circuit for Comparison
of Diac and SBS Devices

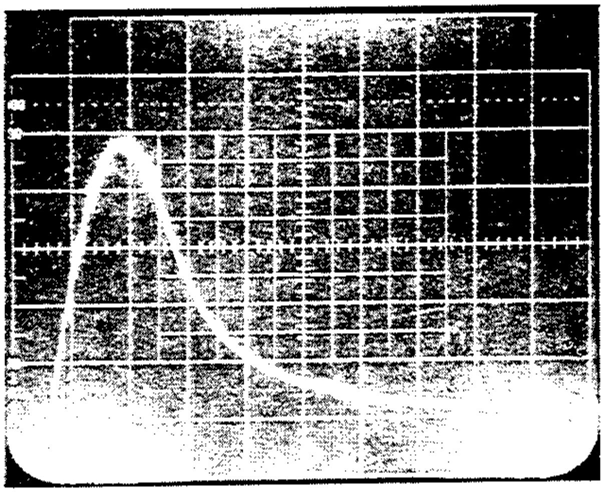


Figure 11. 28 V Diac (1N5760)
R2 = 0 C1 = 0.1
0.2 μs/Div. 1 A/Div.

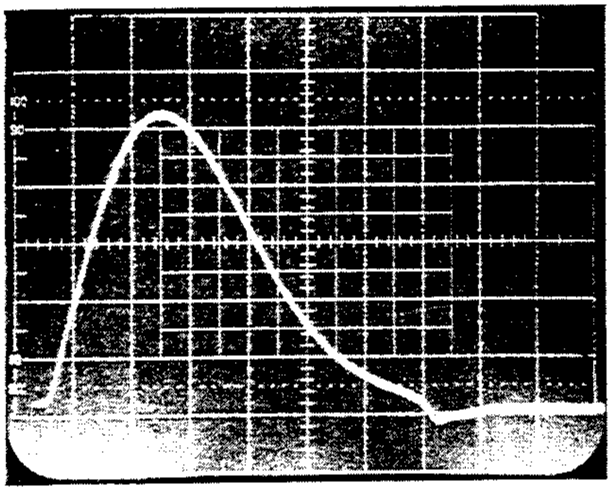


Figure 12. 9 V SBS (MBS4991)
R2 = 0 C1 = 0.1
0.2 μs/Div. 200 mA/Div.

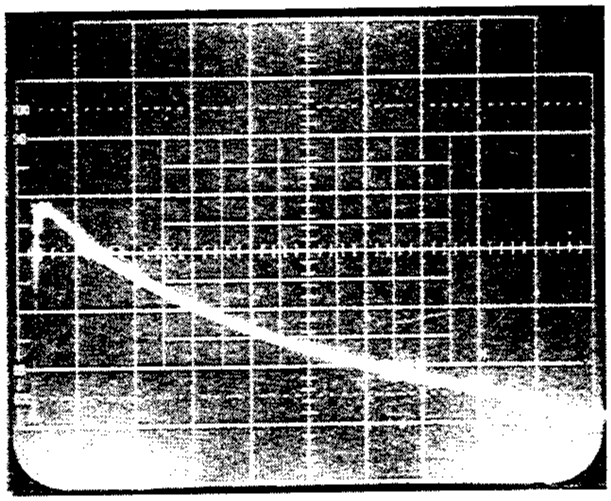


Figure 13. 28 V Diac (1N5760)
θ_C = 54 Degrees
R1 = 180 k C1 = 0.1 μF
R2 = 91 Ω
2 μs/Div. 50 mA/Div.

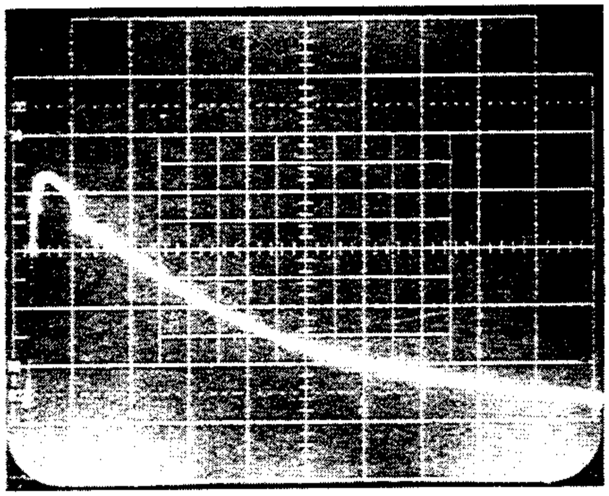


Figure 14. 9 V SBS (MBS4991)
θ_C = 54 Degrees
R1 = 310 k C1 = 0.22 μF
R2 = 27 Ω
2 μs/Div. 50 mA/Div.

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