BISYN™ SYNCHRONOUS RECTIFIER

UBS430

For Low-Voltage (<5.0V) Loads

FEATURES

- Very Low On Resistance — Typically 7 milliohms
- High Reverse Blocking Voltage — V_{ECS} = 40V
- Can be PWM Controlled to Provide Regulated Voltage to Load
- Low Temperature Coefficient of On Resistance
- Fast Switching Times Make Operation at High Frequency Easy
- High Gain Reduces Base Losses

DESCRIPTION

The BISYN is a bipolar junction transistor that is specifically designed to perform the rectifying function in the secondary of a switching power supply. Unlike a conventional bipolar, the BISYN has a much higher emitter-base breakdown voltage (typically 50V) *which is needed for full-wave rectifier circuits. Base drive losses are kept at a minimum* by the relatively high current gain of the BISYN.

The BISYN's most significant specification feature is its very low V_F, 0.3V at 30A, compared with 0.6V for a Schottky and only 0.1V at 10A. Its most significant functional feature is its programmability.

The very low V_F of this product reduces the rectifier power loss in a power supply secondary, improving its efficiency. This becomes particularly significant as load voltages drop below 5V. For example, with a 3V load the power loss associated with the Schottky contributes to a 20% reduction in efficiency, while with a synchronous rectifier this loss is reduced to 10% or less.

The programmability feature gives the designer a new way to provide regulation to a load. Its main advantage is the reduced power component count as compared with a buck regulator and the resulting improvement in efficiency.

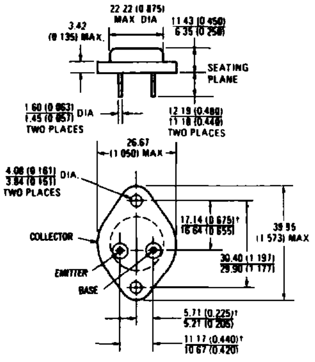
ABSOLUTE MAXIMUM RATINGS

Continuous Forward Current	I_F	40A
Peak Forward Emitter Current*	I_{ERM}	150A
Inductive Forward Current Clamped	I_{FLM}	80A**
Continuous Base Current*	I_B	8A
Peak Base Current*	I_{BRM}	50A
Forward Blocking Voltage	V_{CES}	50V
Reverse Blocking Voltage	V_{ECS}	40V
Thermal Resistance	R_θ	1.0°C/W
Power Dissipation		150W @ 25°C
Derating Factor		1.0W/°C
Operating Temperature Range		−65°C to +175°C

Notes: *1msec pulse.
**See Figure 1.

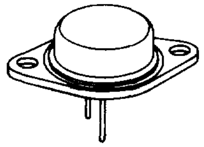
MECHANICAL SPECIFICATIONS

UBS430



Dimensions in Millimeters and (Inches)

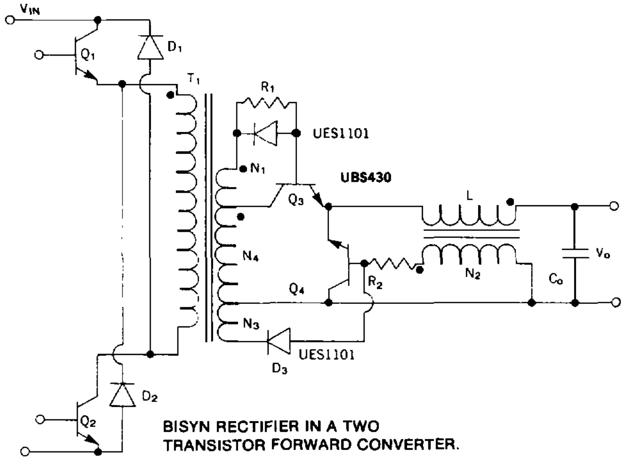
TO-204AE (TO-3 modified, 60 mil. pin)



ELECTRICAL CHARACTERISTICS (at 25°C unless noted)

TEST	SYMBOL	MIN.	TYP.	MAX.	UNIT	CONDITIONS
On Resistance	$R_{CE(ON)}$		7	10	mΩ	$I_C = 30A$, $I_B = 1.2A$
			10	13	mΩ	$I_C = 30A$, $I_B = 1.2A$, $T = 125°C$
Current Gain	h_{FE}	50	100			$I_C = 20A$, $V_{CE} = 0.5V$
Base Saturation Voltage	$V_{BE(sat)}$		1.2	1.5	V	$I_C = 30A$, $I_B = 1.2A$
Rise Time	t_r		85	120	nS	$I_C = 20A$, $I_B = 2A$, $V_{CC} = 10V$
Storage Time	t_s		300	500	nS	$I_C = 20A$, $I_B = 2A$, $V_{CC} = 10V$
Fall Time	t_f		75	120	nS	$I_C = 20A$, $I_B = 2A$, $V_{CC} = 10V$
Forward Leakage Current	I_{CES}			100	μA	$V_{CE} = 50V$
				1	mA	$V_{CE} = 50V$, $T = 125°C$
Reverse Leakage Current	I_{ECS}			200	μA	$V_{EC} = 40V$
				1	mA	$V_{CE} = 40V$, $T = 125°C$
Collector Capacitance	C_{OBO}		1000	1500	pf	$V_{EC} = 10V$, f = 1MHz

A RECOMMENDED DRIVE CIRCUIT



BISYN RECTIFIER IN A TWO TRANSISTOR FORWARD CONVERTER.

THE OPERATION OF THE CIRCUIT IS AS FOLLOWS:

During the on-time of transistors Q_1 and Q_2, BISYN Q_3 is biased on and delivers output load current through filter inductor L. The polarity of voltage developed across winding N_2 is such that BISYN Q_4 remains in a blocking state. Diode D_3 is also biased off. When transistors Q_1 and Q_2 turn-off; some of the energy stored in the magnetizing and leakage inductance enhances the recovery process of BISYN Q_3. The recovery time (300-400nS) of BISYN Q_3 extends the reset time of the core. However, in a typical design, half of the switching period is allocated for core reset time. Thus, the storage time has no significant effect on operation. The BISYN Q_4 starts conducting filter inductor current as soon as the voltage across the secondary collapses. BISYN Q_4 receives base drive energy from the filter inductor L, through winding N_2. The diode D_3 still remains reverse biased.

When transistors Q_1 and Q_2 turn-on again, the voltage across winding N_3 is clamped to approximately zero by diode D_3 and the forward biased collector to base junction of BISYN Q_4. This junction acts as a voltage source (≈0.7V) as long as BISYN Q_4 is conducting during the storage time. The turn-on of BISYN Q_3 is held off due to lack of base drive because winding N_3 is shorted, through diode D_3 and the collector-base junction of BISYN Q_4. Meanwhile, the current through the shorted turns (the rate of rise of which is limited by leakage inductance) is utilized to rapidly commutate BISYN Q_4 off. Diode D_3 is then reverse biased and BISYN Q_3 turns on through winding N_1.

The effect of the turn-off circuit, consisting of winding N_3 and D_3 is to eliminate high peak currents in the secondary. You will also find that with this circuit there are practically no switching losses.

Application Note U-103 contains additional design information and circuits for the BISYN.

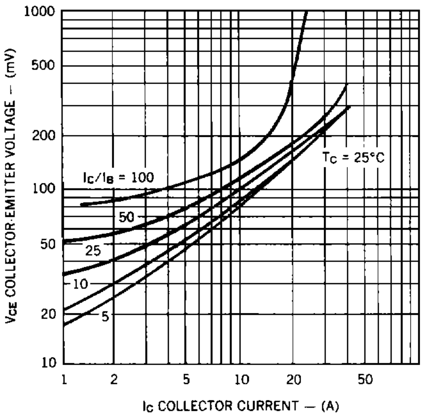
DESIGNING FOR MINIMUM POWER DISSIPATION

Although used as a rectifier the BISYN is a three terminal device. Therefore, the power dissipation due to the On Resistance and also the dissipation due to the base current must be taken into consideration. You will notice on curves 1 and 2 that the change in On Voltage (V_{CE}) at a particular collector current is small even with large changes in base current. As a result, achieving the lowest On Voltage for a particular load current does not result in the lowest overall power loss.

It has been determined that operating at a base current that achieves an On Voltage that is 110% of the On Voltage at a circuit gain of ten gives a result that is very close to optimum power dissipation. Curve 3 gives you the appropriate base current to achieve 110% of this On Voltage. This same curve shows that the appropriate base drive for optimum power dissipation at any particular load current is virtually the same throughout the operating temperature range.

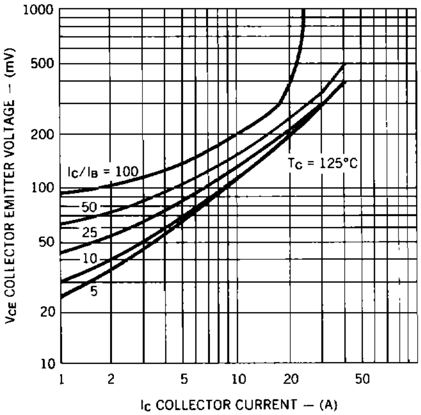
To calculate the power dissipation first estimate the operating temperature of the BISYN. Then using the appropriate temperature curve determine the On Voltage at a circuit gain of 10 for your load. Multiply this voltage by 1.1 and then by the load current to determine On Resistance power dissipation. Base current power dissipation is calculated by finding the base drive current on curve 3 and then going to the applicable temperature curve for Base Emitter Voltage vs Base Current (curves 4 and 5). Multiplying the Base Emitter Voltage by Base Current will give you the power dissipation due to base current.

Collector-Emitter Voltage vs Collector Current at Various Forced Gains



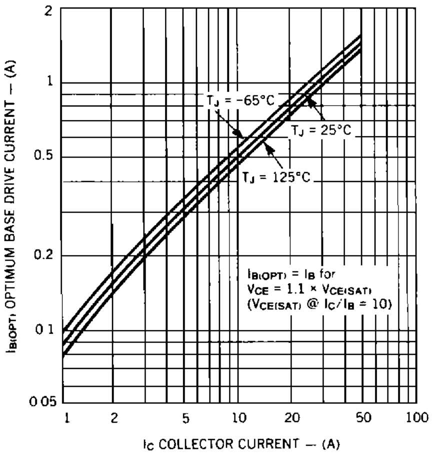
CURVE # 1

Collector-Emitter Voltage vs Collector Current at Various Forced Gains



CURVE # 2

Optimum Base Drive Current vs Collector Current



CURVE # 3

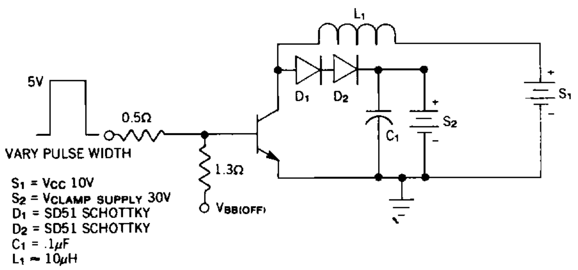
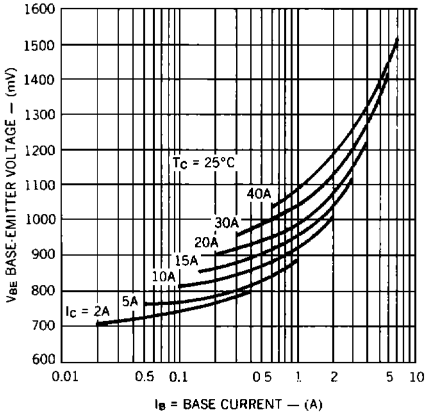


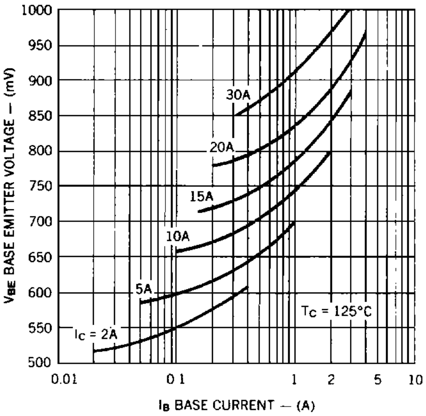
FIGURE 1. TEST CIRCUIT FOR I_{LPK}.

Base Emitter Voltage vs Base Current at Various Collector Currents



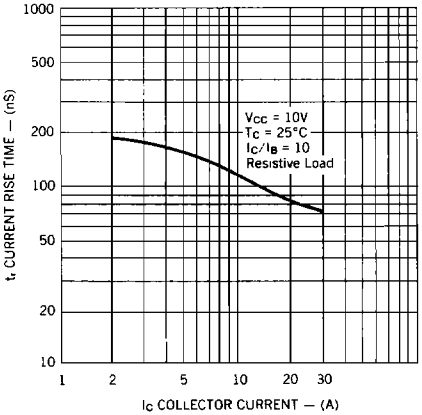
CURVE # 4

Base Emitter Voltage vs Base Current at Various Collector Currents



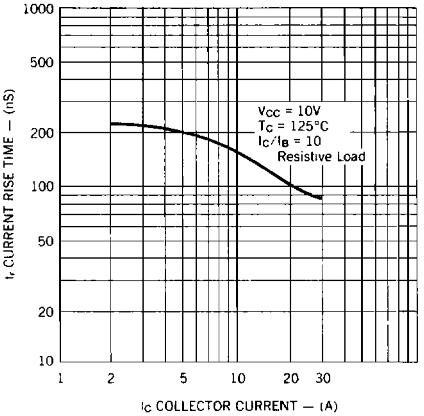
CURVE # 5

Current Rise Time vs Collector Current



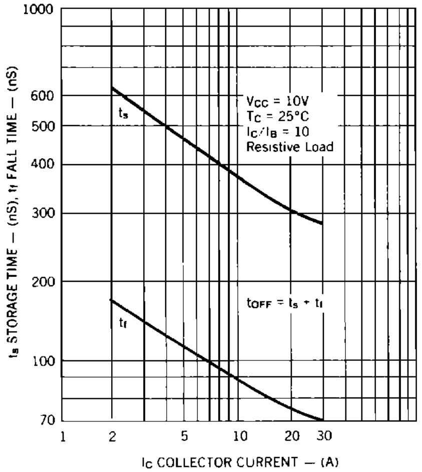
CURVE # 6

Current Rise Time vs Collector Current



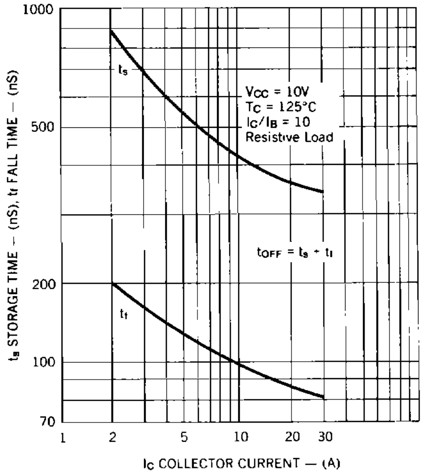
CURVE # 7

Turn Off Time vs Collector Current



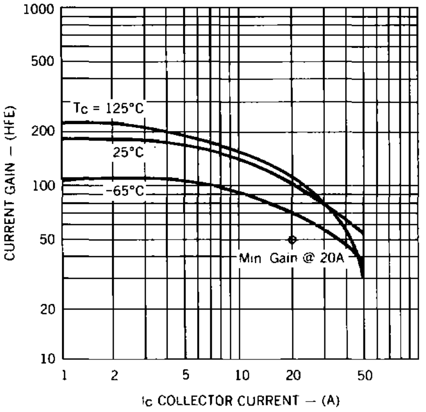
CURVE # 8

Turn Off Time vs Collector Current



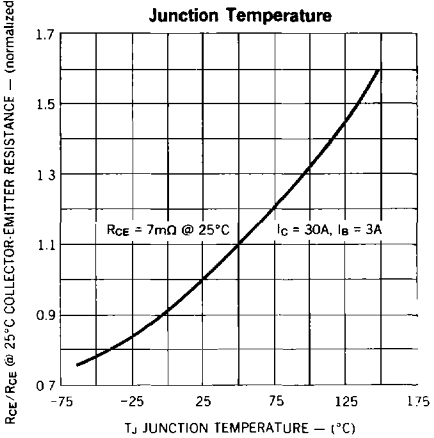
CURVE # 9

Gain vs Collector Current @ V_{CE} = 0.5V at Various Temperatures



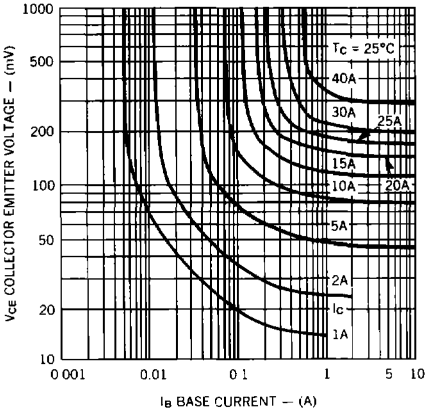
CURVE # 10

Collector-Emitter Resistance vs Junction Temperature



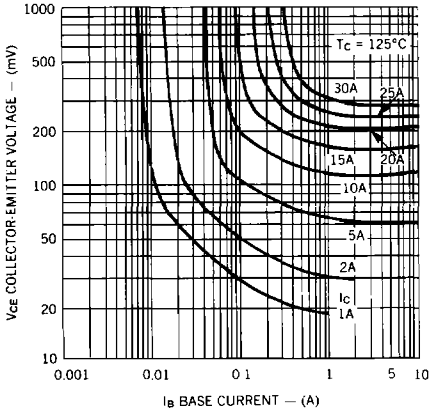
CURVE # 11

Collector-Emitter Voltage vs Base Current



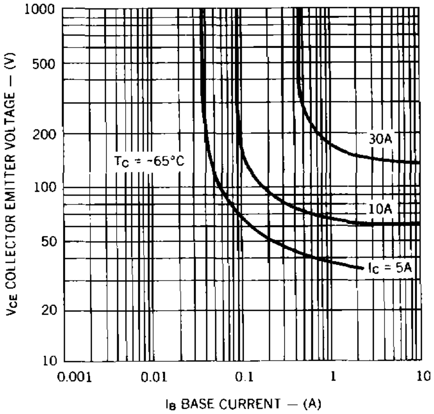
CURVE # 12

Collector-Emitter Voltage vs Base Current



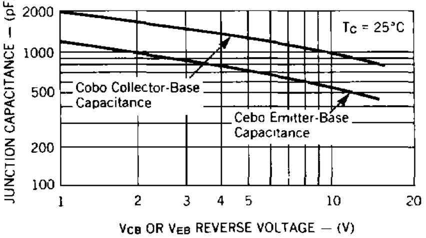
CURVE # 13

Collector-Emitter Voltage vs Base Current at Various Collector Currents



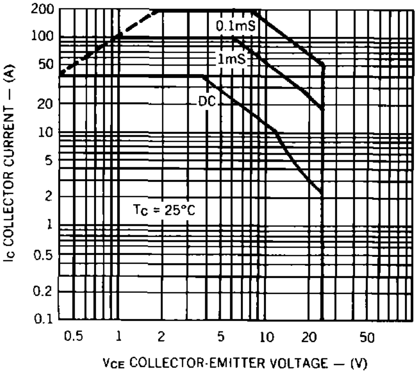
CURVE # 14

Junction Capacitance



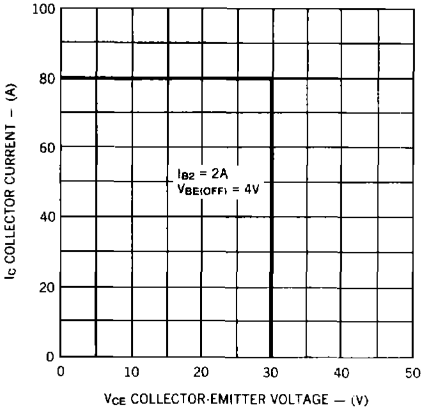
CURVE # 15

Forward Bias Safe Operating Area (SOA)



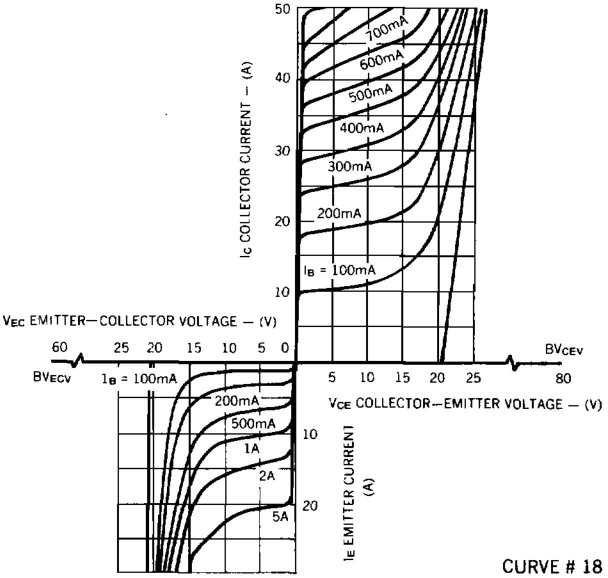
CURVE # 16

Reverse Bias Safe Operating Area



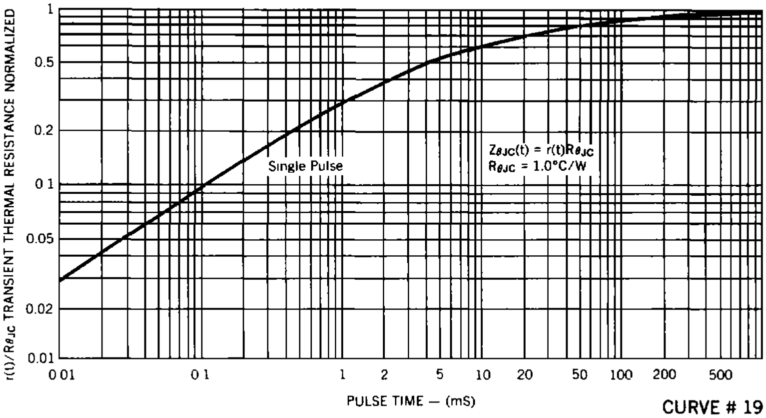
CURVE # 17

Common-Emitter Collector Characteristics



CURVE # 18

Transient Thermal Resistance vs Time



CURVE # 19

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