RIFA

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M/TI1 Bert Thuresson	M/TC	PBL 3717/2	
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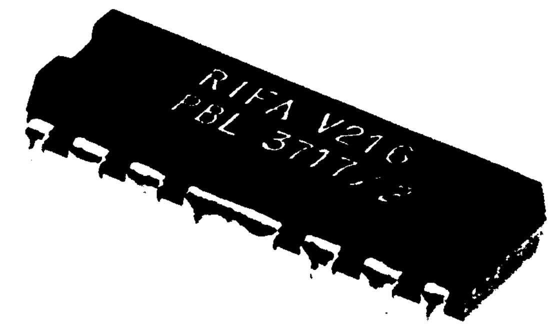
Preliminary Datasheet
PBL 3717/2

Stepper Motor Drive Circuit

PBL 3717/2 is a bipolar monolitic circuit intended to control and drive the current in one winding of a stepper motor.

The circuit consists of a LS-TTL compatible logic input, a current sensor, a monostable multivibrator and a high power H-bridge output stage with built-in protection diodes.

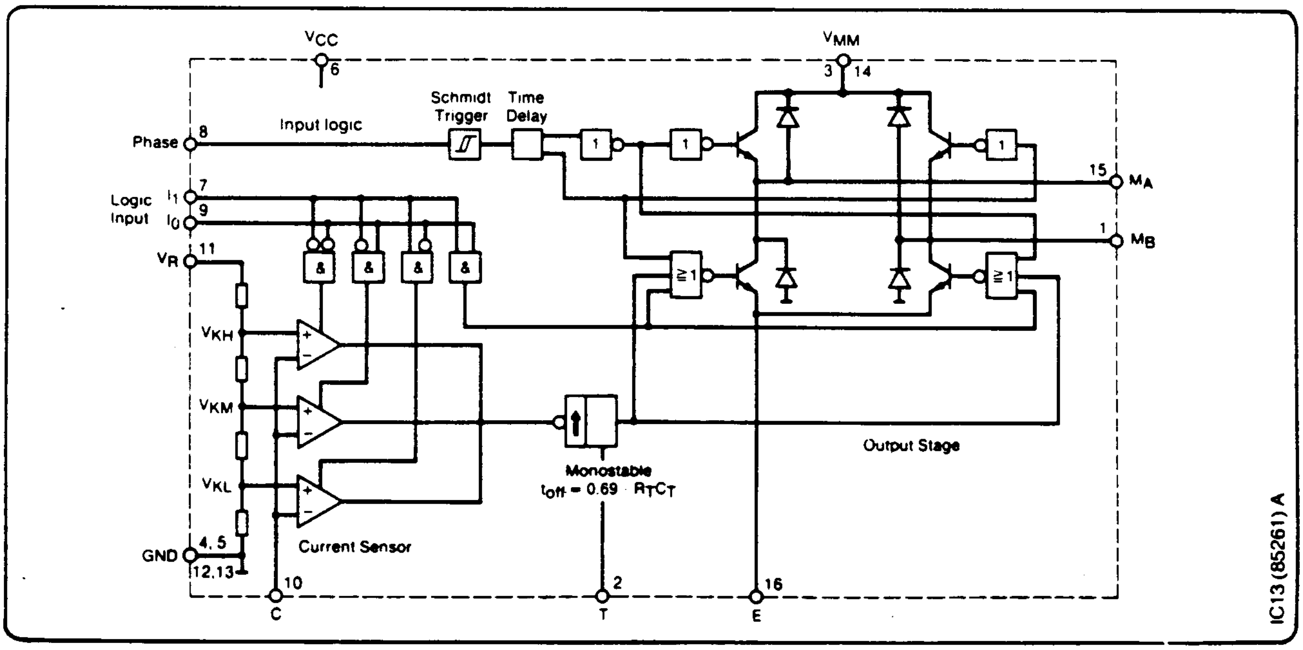
2*PBL 3717/2 and a small number of external components form a complete control and drive unit for LS-TTL or microprocessor controlled stepper motor systems.



Features

- Half-step and full-step modes
- Switched mode bipolar constant current drive
- Wide range of current control 5-1200 mA
- Wide voltage range 10-50 V
- Designed for unstabilized motor supply voltage
- Current levels can be selected in steps or varied continuously
- Thermal overload protection
- Built-in protection diodes

Block Diagram



8

RIFA B 1970 86-09

Absolute Maximum Ratings (note 1)

Voltage		Input Current	
Logic Supply,Vcc	7V	Logic Inputs(pins 7,8,9)	-10mA
Output Supply,Vmm	50V	Analogue Inputs(pins 10,11)	-10mA
Input Voltage		Output Current(pins 1,15)	1.2A
Logic Inputs(pins7,8,9)	6V	Junction Temperature,Tj	+150'C
Analogue Input(pin 10)	Vcc	Operating Amb Temp Range	0-+70'C
Reference Input(pin11)	15V	Storage Temp Range	-55-+150'C

Note 1.All voltages measured with respect to ground.Currents are positive into and negative out of the specified terminal.

Recommended Operating Conditions

Symbol	Parameter	Min	Typ	Max	Unit
Vcc	Supply Voltage	4.75	5.0	5.25	V
Vmm	Supply Voltages	10		45	V
Im	Output Current	20		1000	mA
Ta	Ambient Temperature	0		70	'C
tr	Rise Time Logic Inputs			2	us
tf	Fall Time Logic Inputs			2	us

Electrical Characteristics

Electrical characteristics over recommended operating conditions.

Parameter	Conditions	Min	Typ	Max	Unit
Supply Current,Icc				25	mA
High-level logic input voltages pins 7, 8,9.		2.0			V
Low-level input voltage				0.8	V
High-level logic input currents pins 7 8,9	Vi=2.4V			20	uA
Low-level input currents	Vi=0.4V	-0.4			mA
Reference input current	Vr=5.0V			1	mA
Comparator threshold					
Comparator threshold voltage	I0=logic 0 I1=logic 0 Vr=5.0V	400	415	430	mV
	I0=logic 1 I1=logic 0 Vr=5.0V	240	251	265	mV
	I0=logic 0 I1=logic 1 Vr=5.0V	70	80	90	mV
Comparator input current		-20		20	uA
Output leakage current	Io=logic 1 I1=logic 1 Ta=25'C			100	uA

Parameter	Conditions	Min	Typ	Max	Unit
Saturation voltage drop					
Sink driver	Im=0.5A		0.9	1.2	V
	Im=0.8A		1.1	1.4	V
Source driver	Im=-0.5A		1	1.25	V
	Im=-0.8A		1.2	1.5	V
Lower diode forward	Im=-0.5A	-1.5	-1.2		V
voltage drop	Im=-0.8A	-1.7	-1.3		V
Upper diode forward	Im=0.5A		1	1.25	V
voltage drop	Im=0.8A		1.2	1.45	V
Total power dissipation	fs=23kHz Im=0.5A Vmm=36V, Note 2		1.3	*)	W
	fs=23kHz Im=0.8A Vmm=36V, Note 3		*)		W
Cut offtime, toff	See fig 3 and 5 Vmm=10V ton>5us	27	31	35	us
Turn off delay, td	See fig 3 and 5 Ta=+25'C dVc/dt≥50mV/us		0.9	1.5	us
Thermal shutdown junction temp			+170		'C

Note 2. Soldered on a 35 um thick 20 cm2 PC board copper area.

Note 3. External heatsink (Staver V7) and minimal PC board copper area. Typical Θja = 27.5'C/W.

*) To be specified.

Typical Application

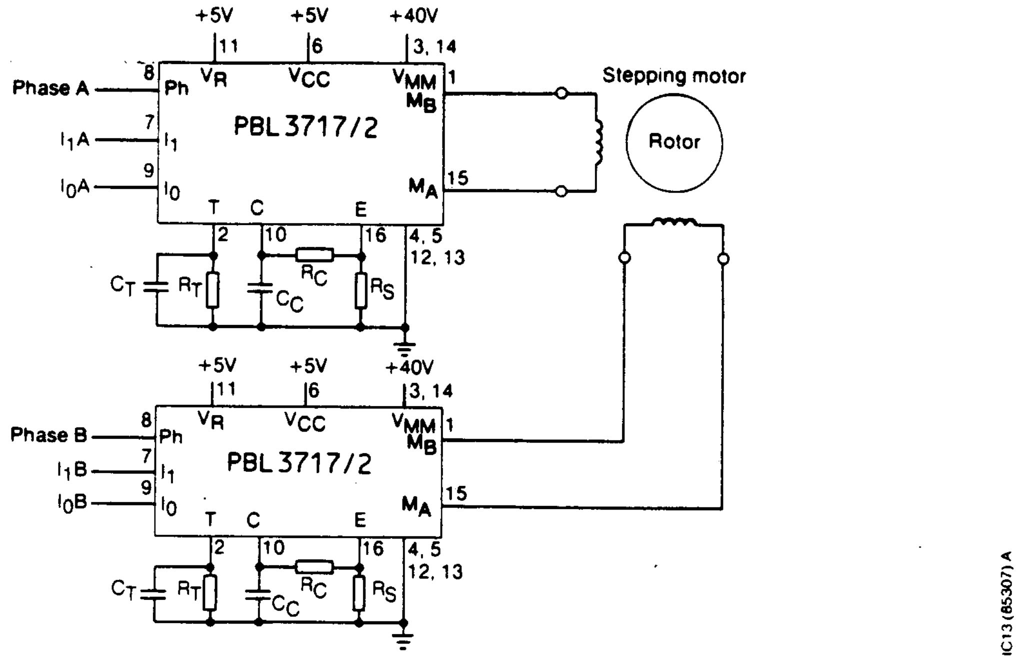


Fig. 1 Typical stepper motor driver with PBL 3717/2

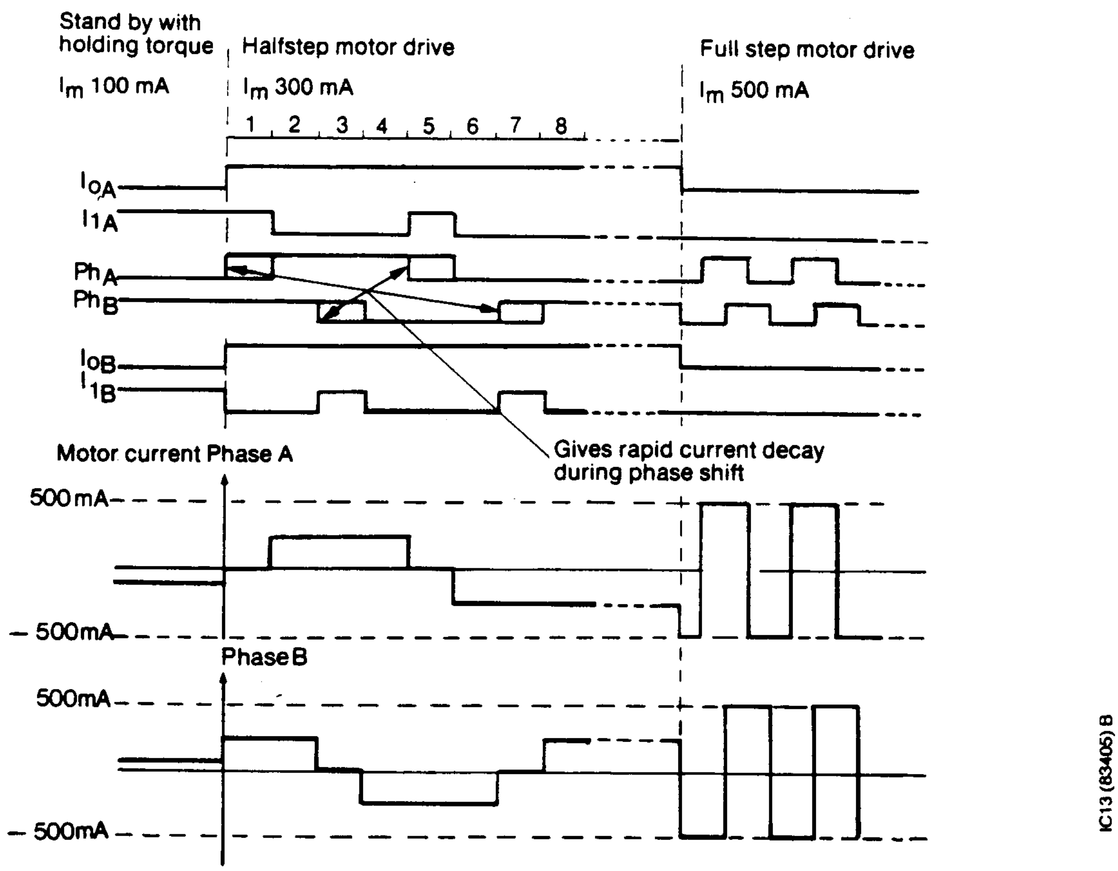
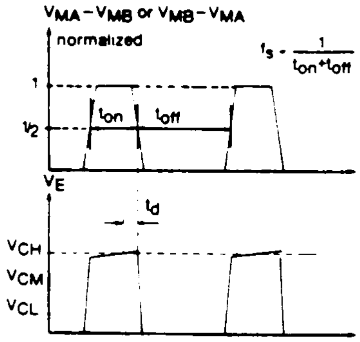


Figure 2. Principal Operating Sequence



IC13 (85262) A

Figure 3. Connections and component values as in Figure 5

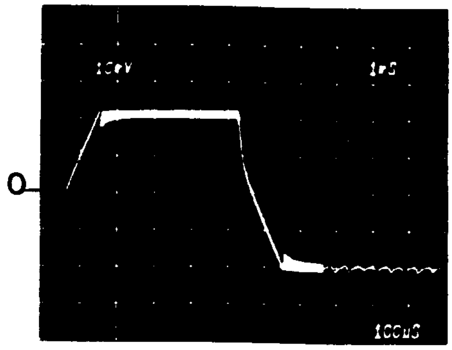


Figure 4. Motor current (I_m)
Vertical: 200 mA/div
Horizontal: 1 ms/div expanded part 100 µs/div

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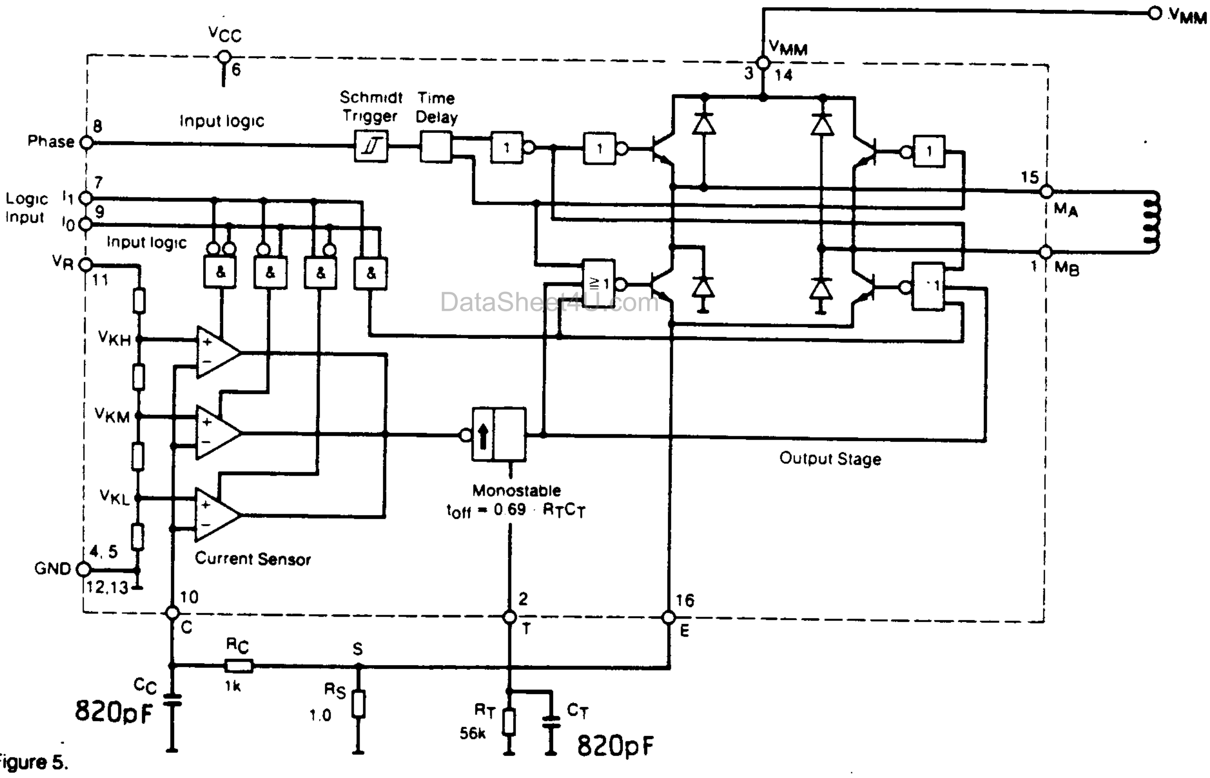

Figure 5.

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Functional Description

The PBL3717/2 is intended to drive a bipolar constant current through one motor winding of a 2-phase stepper motor.

Current control is achieved by switched mode regulation, see fig 4.

Three different current levels and zero current can be preset by the input logic.

The circuit contains the following functional blocks:

- Input logic
- Current sensor
- Single pulse generator
- Output stage

Input logic

Phase input

The phase input determines the direction of the current in the motor winding. High input forces the current from terminal M_A to M_B and low input from terminal M_B to M_A. A Schmidt trigger provides noise immunity and a delay circuit eliminates the risk of cross conduction in the output stage during a phase shift.

Half and full step operation is possible.

Current level selection

The status of I_0/I_1 inputs determines the current level in the motor winding. Three fixed current levels and zero current can be selected according to the table below.

8

RIFA B 1970 86-09

Motor current		I_0	I_1
High level	100%	L	L
Medium level	60%	H	L
Low level	20%	L	H
Zero current	0%	H	H

The specific values of the different current levels are determined by the reference voltage V_R together with the value of the sensing resistor R_S.

The motor current can also be continuously varied by modulating the voltage reference input.

Current sensor

The current sensor contains a reference voltage divider and three comparators for measuring each of the selectable current levels. The motor current is sensed as a voltage drop across the current sensing resistor R_S and compared with one of the voltage references from the divider. When equal the comparator triggers the single pulse generator. Only one comparator at a time is activated by the input logic.

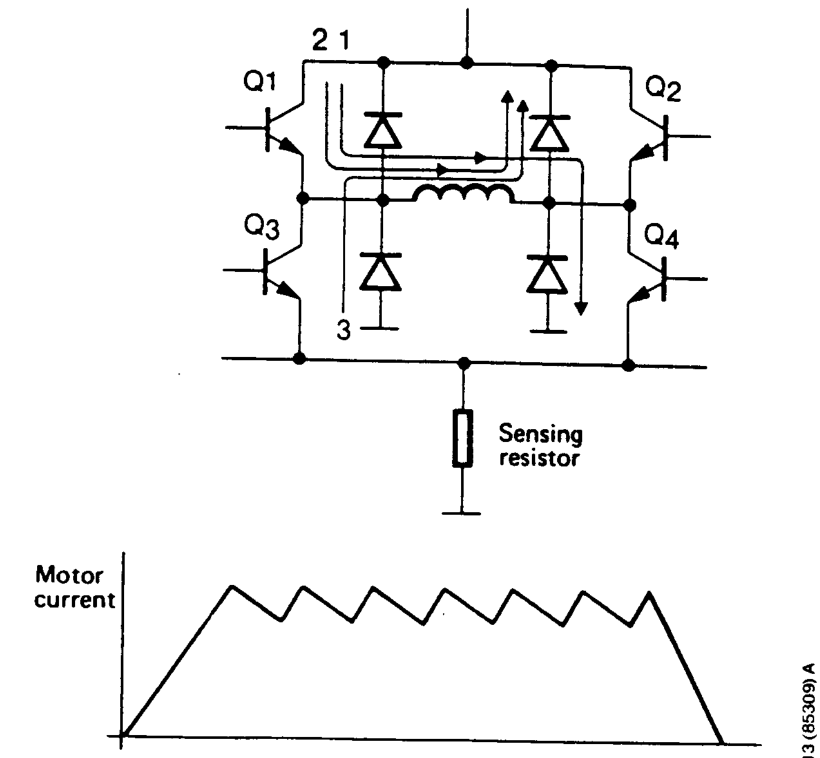


Fig 6. Schematic of an output stage.

Single-Pulse Generator

The pulse generator is a monostable multivibrator triggered on the positive flank of the comparator output. The multivibrator output is high during the pulse time, t_{off}, which is determined by the timing components R_T and C_T.

$t_{off} = 0.69 \times R_T C_T$

The single pulse switches off the power feed to the motor winding, causing the winding current to decrease during t_{off}.

If a new trigger signal should occur during t_{off}, it is ignored.

Output Stage

The output stage contains four darlington transistors and four diodes, connected in an H-bridge. The two sinking transistors are used to switch the power supplied to the motor winding, thus driving a constant current through the winding. See fig. 4.

Overload Protection

The circuit is equipped with a thermal shut down function, which will limit the junction temperature. The output current will be reduced if the maximum permissible junction temperature is exceeded. It should be noted however, that it is not permitted to short circuit the outputs.

Operation

When a voltage V_{MM} is applied across the motor winding, the current rise follows the equation:

$$i_m = \frac{V_{MM}}{R}\left(1 - e^{-\frac{R \cdot t}{L}}\right)$$

R= Winding resistance
L= Winding inductance
t= Time

(See fig 6 arrow 1)

The motor current appears across the external sense resistor R_S as an analog voltage. This voltage is fed through a lowpass filter R_C C_C to the voltage comparator input (pin 10). At the moment the sensed voltage rises above the comparator threshold voltage the monostable is triggered and its output turns off the conducting sink transistor.

The polarity across the motor winding reverses and the current is forced to circulate through the appropriate upper protection diode back through the source transistor. (See fig 6 arrow 2).

After the monostable has timed out, the current has decayed and the analog voltage across the sensing resistor is below the comparator threshold level.

The sinking transistor then closes and the motor current starts to increase again. The procedure is repeated until a current reverse command is given or an inhibiting signal is forced.

By reversing the logic level of the phase input (pin 8), both active transistors are turned off and the opposite pair turned on after a slight delay. When this happens the current must first decay to zero before it can reverse. This current decay is steeper because the motor current is now forced to circulate back through the power supply and the appropriate sinking transistor protection diode. This causes a higher reverse voltage build-up across the winding which results in a faster current decay. (See fig 6 arrow 3).

For best speed performance of the stepper motor at half step mode operation, the phase logic level should be changed at the same time the current inhibiting signal is applied (See fig 2).

Thermal data

	Typ	Unit
Thermal resistance, Junction to Case θ_{jC}	11	°C/W
Thermal resistance, Junction to Ambient θ_{jA} *	45	°C/W

* (Soldered on a 35 µm thick 20 cm² PC board copper area)

Heatsinking

The junction temperature of the chip highly affects the lifetime of the driver circuit. Thus in high current applications the heatsinking must be carefully conisdered.

The θ_{jA} of the PBL 3717 can be reduced by soldering the GND-pins to a suitable copper area on the printed circuit board (see fig 11) or by applying an external heatsink type V7 or V8 (see fig. 12). The diagram in figure 7 shows the maximum permissible power dissipation versus the ambient temperature in °C, for heatsinkers of the type V7, V8 or a 20 cm² copper area respectively. Any external heatsink or printed circuit board copper area must be connected to electrical ground.
For motor currents higher than 500 mA heatsinking is recommended to assure optimal reliability.
The diagrams in fig. 7 and fig. 10 can be used to determine the required heatsinking of the circuit. In some systems forced air cooling may be available to reduce the temperature rise of the circuit.

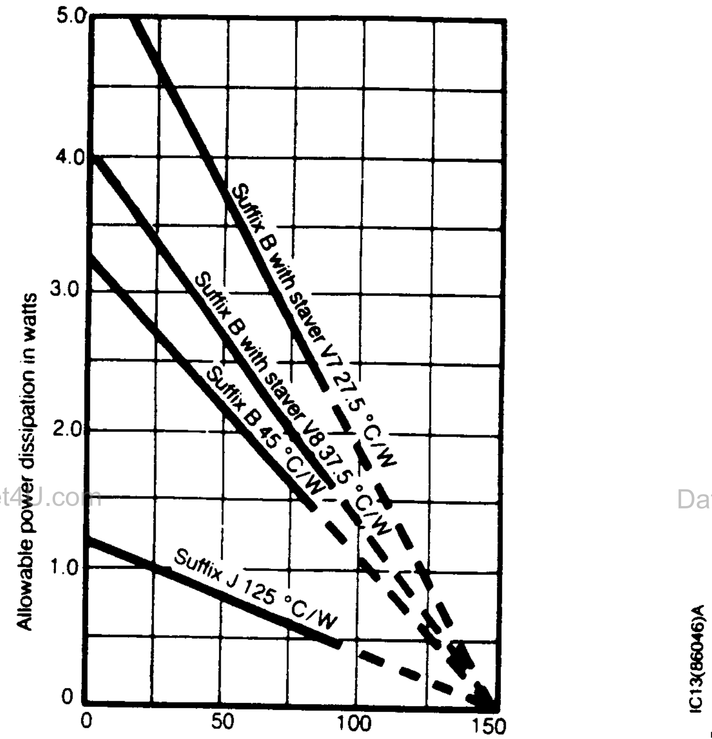
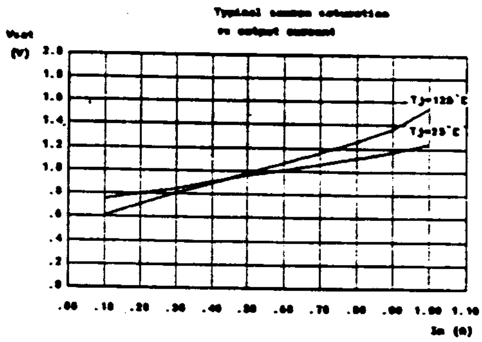
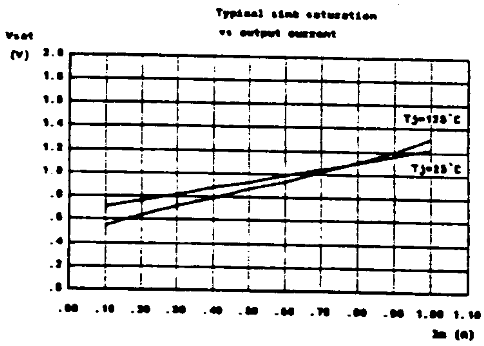
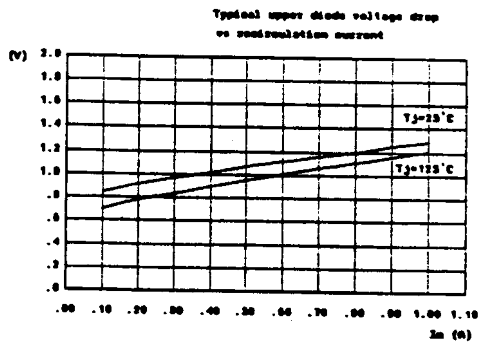
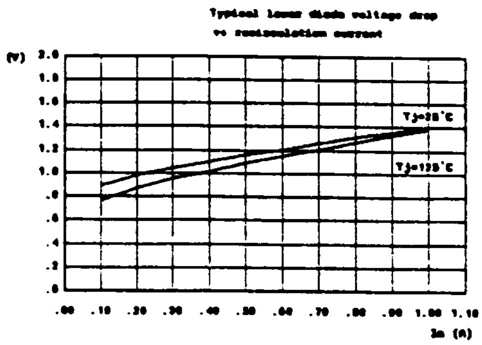


Fig 7. Ambient temperature in °C.









Mounting Instructions

Soldering temperature must not exceed 260 °C and the maximum soldering temperature must not be applied for more than 10 seconds.

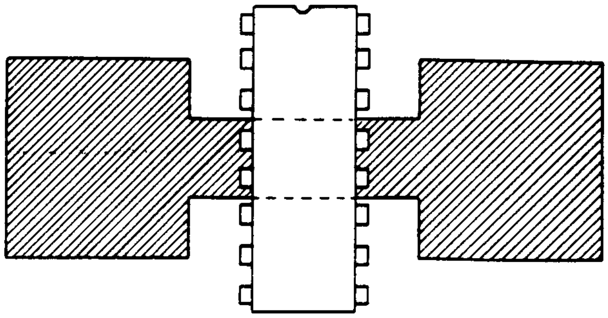


Figure 11. PC-board copper area used as heatsinker

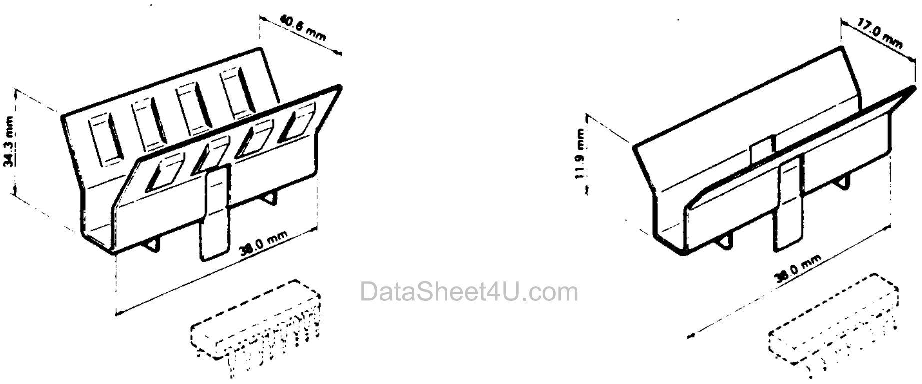


Figure 12. Heatsinkers typ C V7, V8

Application Notes

Motor Selection

Some stepper motors are not designed for continuous operation at maximum current. As the circuit drives a constant current through the motor, its temperature can increase exceedingly both at low and high speed operation.

Also, some stepper motors have such high core losses that they are not suited for switched mode current regulation.

Interference

As the circuit operates with switched mode current regulation, interference generation problems can arise in some applications. A good measure is then to decouple the circuit with a 15 nF ceramic capacitor, located near the package across the power line V_{MM} and ground.

The ground lead between R_S, C_C and circuit GND should be kept as short as possible. This applies also to the leads connecting R_S and R_C to pin 16 and pin 10 respectively.

In order to minimize electromagnetic interference it is recommended to route the M_A and M_B leads in parallel on the printed circuit board directly to the terminal or connector. The motor wires should also be twisted in pairs each phase seperately, when installing the motor in the system.

Unused Inputs

Unused inputs should be connected to proper voltage levels in order to obtain the highest possible noise immunity.

Ramping

A stepper motor is a synchronous motor and does not change its speed due to load variations. This means that the torque of the motor must be large enough to match the combined inertia of the motor and load for all operation modes. At speed changes, the required torque increases by the square, and the required power by the cube of the speed change. Ramping i.e. controlled acceleration or deceleration must then be considered to avoid motor pull out.

Pin Configuration

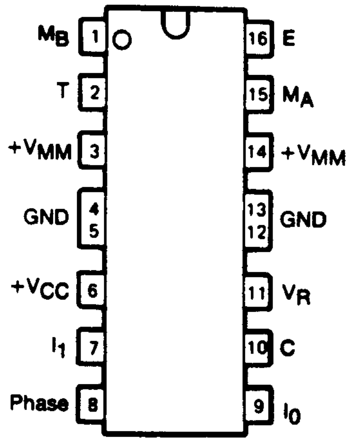


Figure 13. DIP-16 "Bat Wing" Top View

IC13 (85264) A

V_{CC}, V_{MM}

The supply voltages V_{CC} and V_{MM} can be turned on or off in any order. Normal dv/dt values are assumed.

However, before a driver circuit board is removed from its system all supply voltages must be turned off to avoid destructive transients beeing generated by the motor.

Switching Frequency

The motor inductance together with the pulse time t_{off} determines the switching frequency of the current regulator. The choise of motor may then require other values on the R_T C_T-components than those recommended in figure 5 to reach a switching frequency above the audible range. Switching frequencies above 40 KHz is not recommended because the current regulation can be affected.

Analog Control

As the current levels can be continuously controlled by modulating the V_R input, microstepping can be achieved. A sinus shaped motor current is required for this purpose.

Sensor Resistor

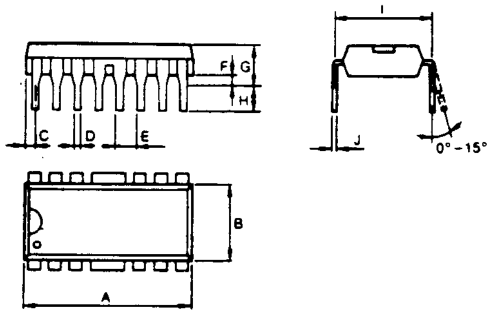
The R_S resistor should be of a non inductive type power resistor. A 1.0 ohm resistor, tolerance ≦ 1 %, is a good choice for 420 mA max motor current at V_R=5V.

The maximum motor current i_m can be calculated by using the formula:

$$i_m = \frac{V_R \cdot 84}{RS} \text{ mA}$$

Mechanical Data

16 pin Dual-In-Line package (DIP). Type "BAT WING" with tin dipped leads.



	Inches		Millimeters	
	Min	Max	Min	Max
A		0.870		22.1
B	0.220	0.280	5.59	7.11
C	0.015	0.060	0.38	1.52
D	0.015	0.020	0.38	0.51
E	0.100		2.54	
F	0.020		0.51	
G		0.200		5.08
H	0.100	0.160	2.54	4.06
I	0.290	0.327	7.37	8.3
J	0.008	0.017	0.20	0.42

Figure 14

IC13 (85308) A

Ordering Information

PBL 3717/2 B Encapsulation plastic

Additional Technical Information

Additional technical and reliability information about this product is available through our local representatives.

RIFA

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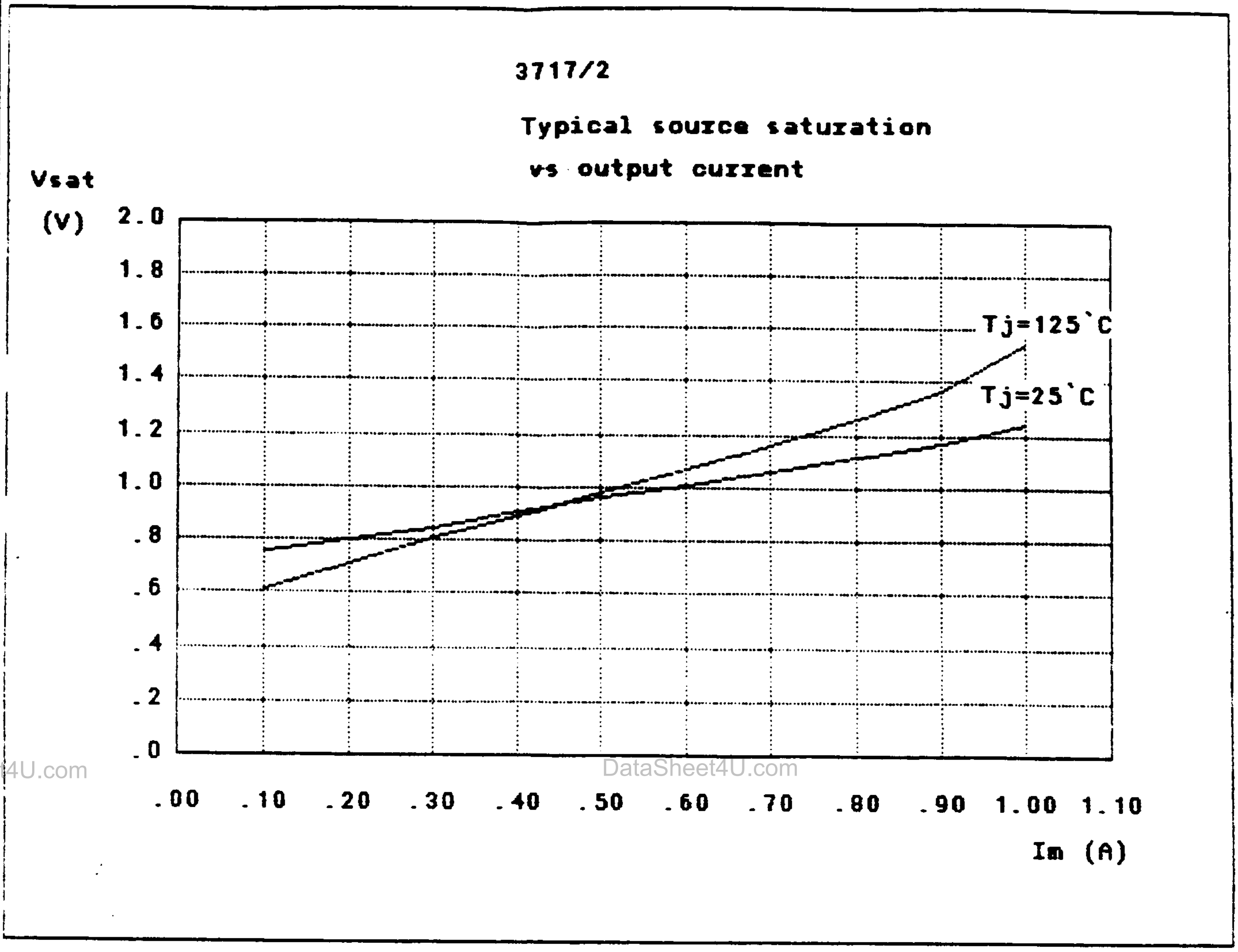
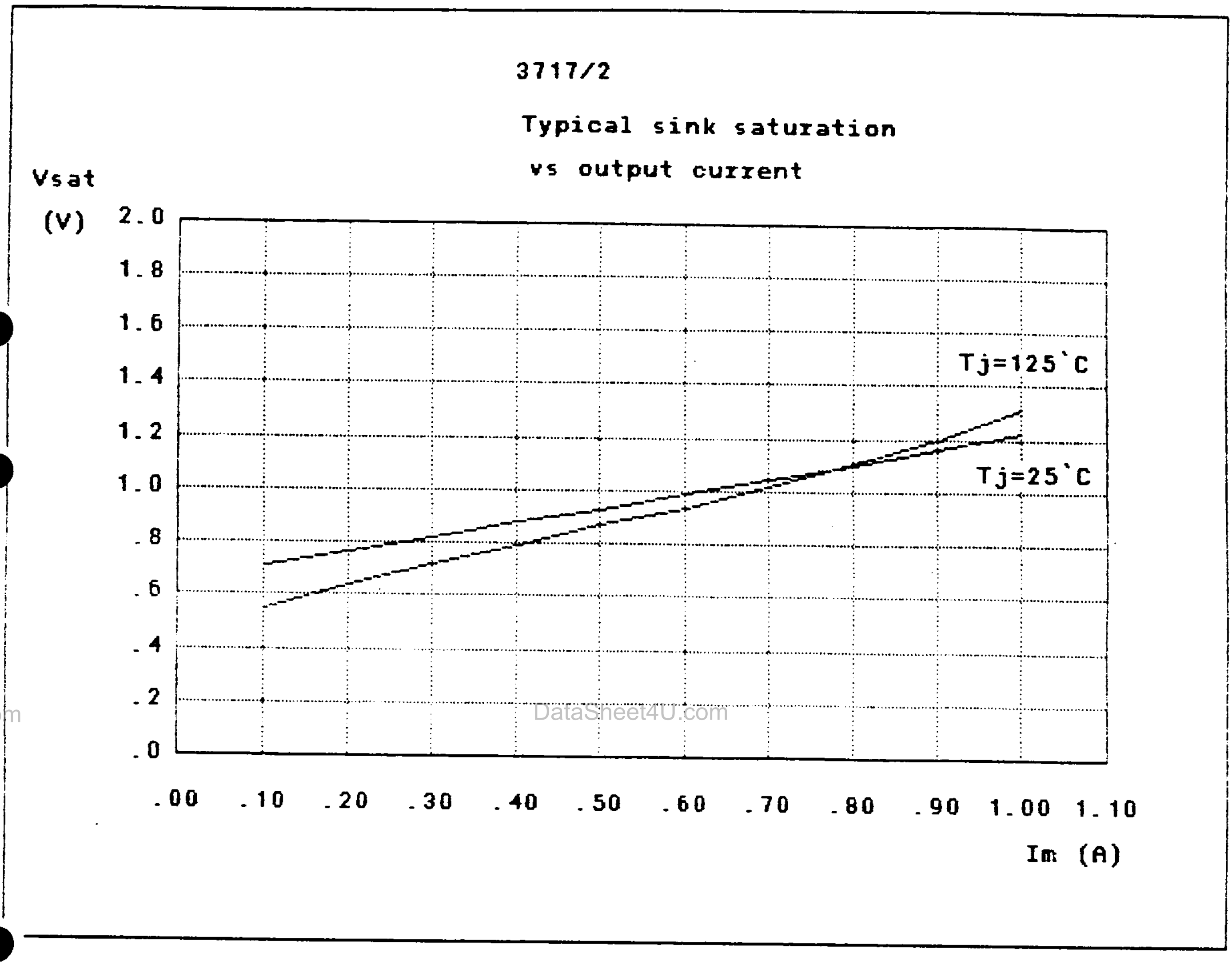
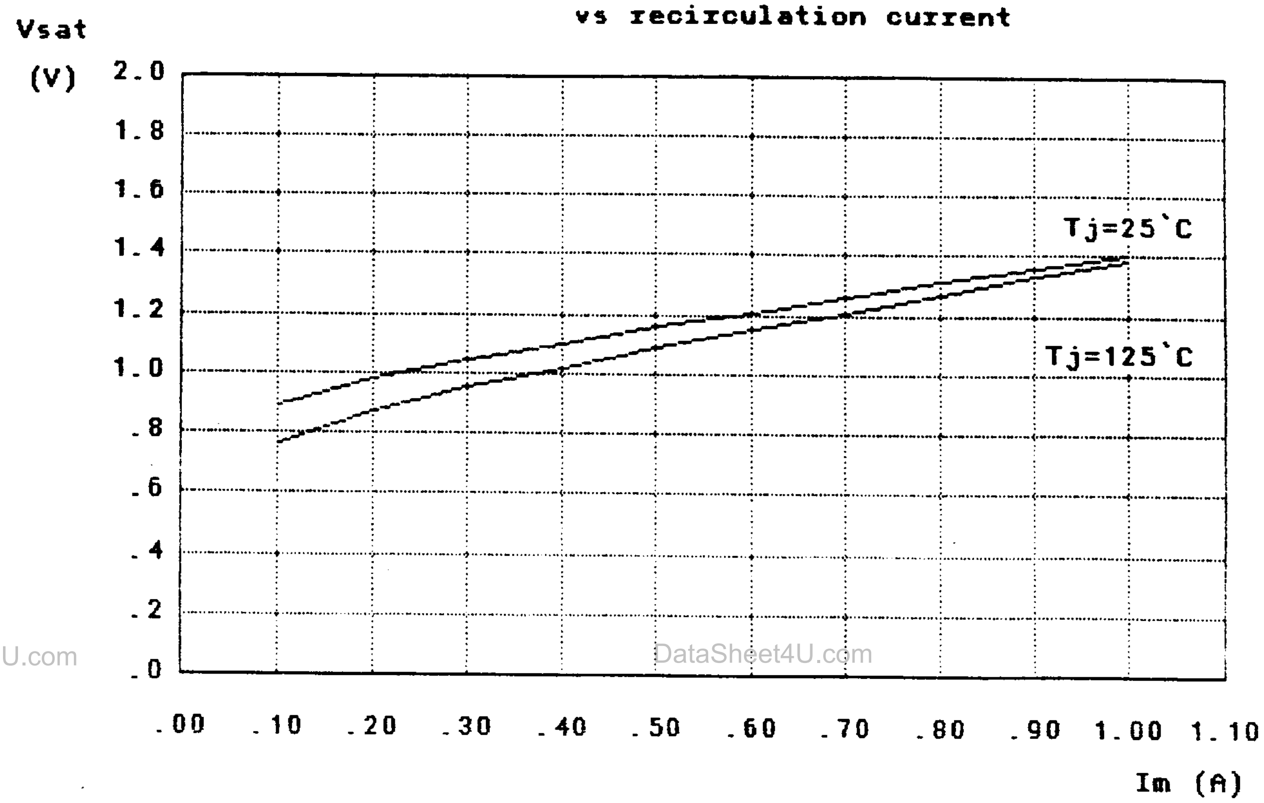

3717/2
Typical source saturation
vs output current
Vsat
(V)
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
.0
Tj=125`C
Tj=25`C
.00
.10
.20
.30
.40
.50
.60
.70
.80
.90
1.00
1.10
Im (A)

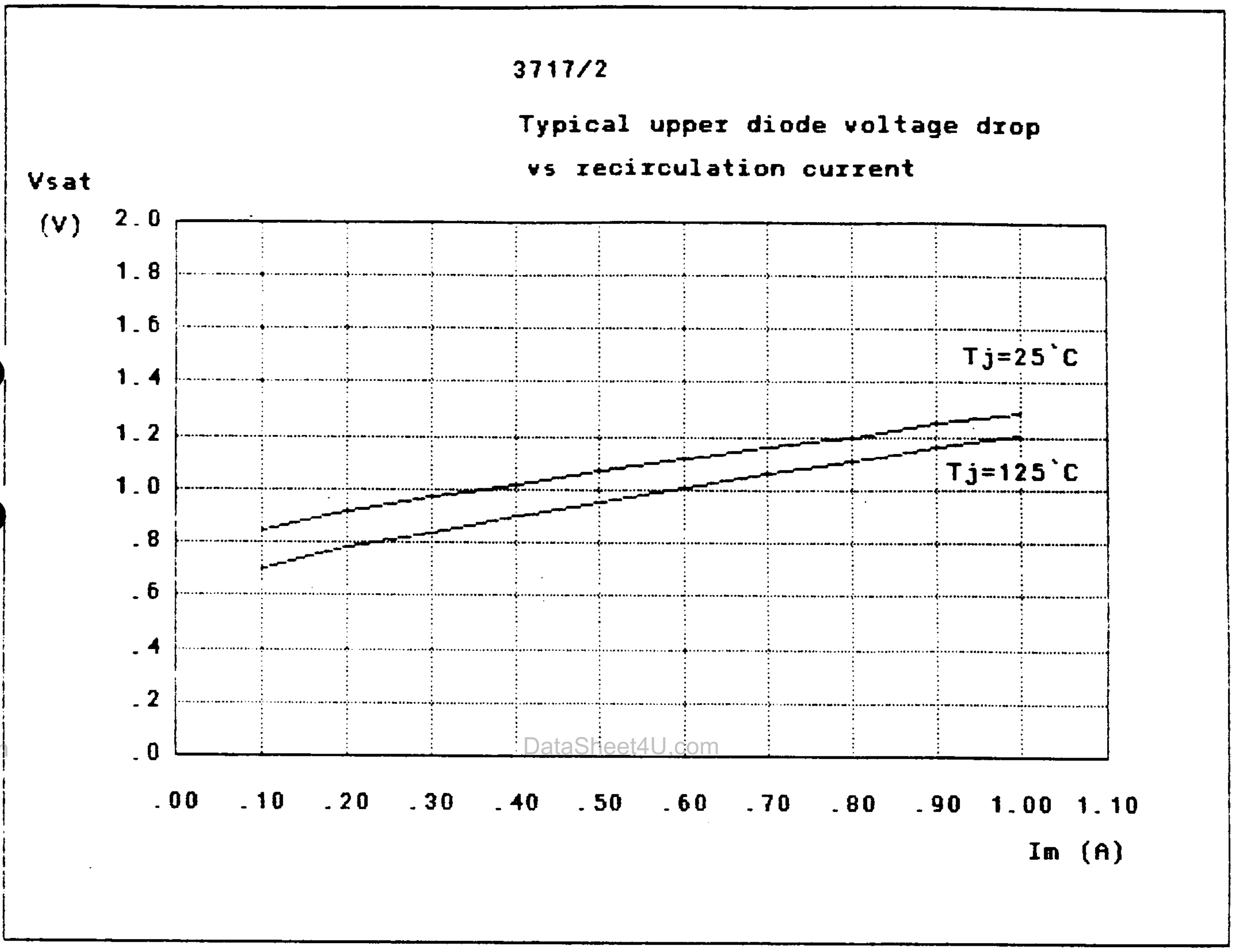


3717/2
Typical sink saturation
vs output current
Vsat
(V)
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
.0
Tj=125`C
Tj=25`C
.00
.10
.20
.30
.40
.50
.60
.70
.80
.90
1.00
1.10
Im (A)

3717/2

Typical lower diode voltage drop
vs recirculation current




3717/2
Typical upper diode voltage drop
vs recirculation current
Vsat
(V)
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
.0
Tj=25`C
Tj=125`C
.00
.10
.20
.30
.40
.50
.60
.70
.80
.90
1.00
1.10
Im (A)