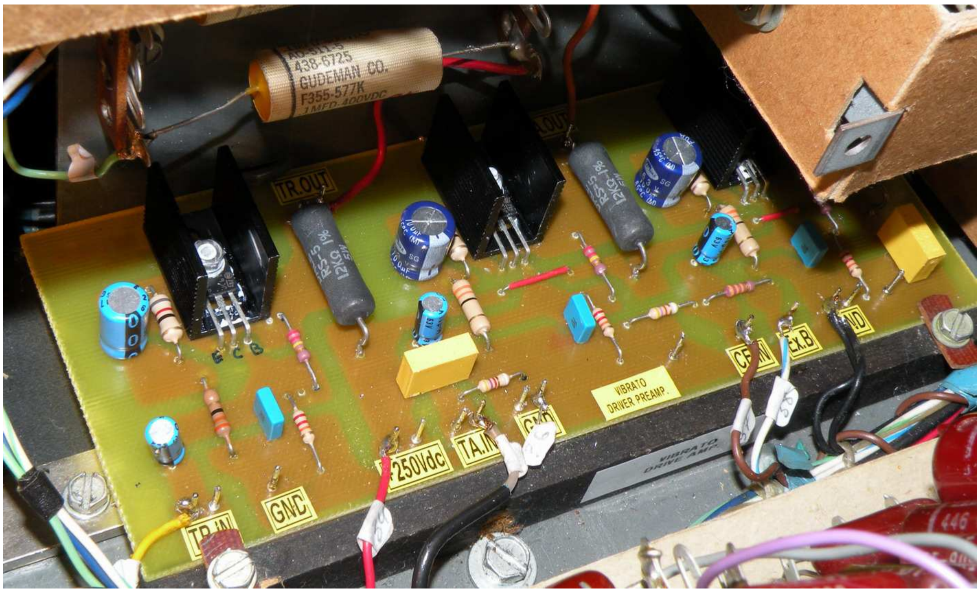
Hammond® **X-66**

Renovating the Vibrato Driver Preamp

by Dan.Vigin



Binche / Belgium **Dec.2010**

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Renovating the Vibrato Driver Preamp on Hammond X-66.

Forewords – Purpose of this Project

Several weeks ago, when playing an abnormal level of background noise and hiss was detected and this excessive noise made me nervous enough to start investigations in order to reduce this annoying noise.

This background noise was mostly audible in Drawbars use while being less significant with either Tabs or Percussions.

Even with no key depressed, by checking the outputs of the Vibrato Driver Preamp board, with the help of an oscilloscope, I found at once that one channel exhibited much more noise than the two others. This faulty channel was the Drawbar channel.

So, I decided to pursue my investigations. Measured voltages were normal, capacitors were previously replaced by new ones.

The conclusion is rather simple, the driver transistor creates this inherent noise in the Drawbar channel.

The first reaction is to find and replace this faulty component by a new one.

Unfortunately, this driver transistor labelled 21221 in the Hammond parts list is the equivalent of RCA 39699. This transistor was produced in the early 60's and is in the line with the first generation of Si NPN transistors launched at that time by RCA, about 50 years ago !.

Needless to say that this component is now unobtainable, at least in Europe.

In view of this situation, I decided to redesign this board and re-install much updated transistors providing better performances than the former RCA 396999.

This is exactly the purpose of this chapter.

General Description.

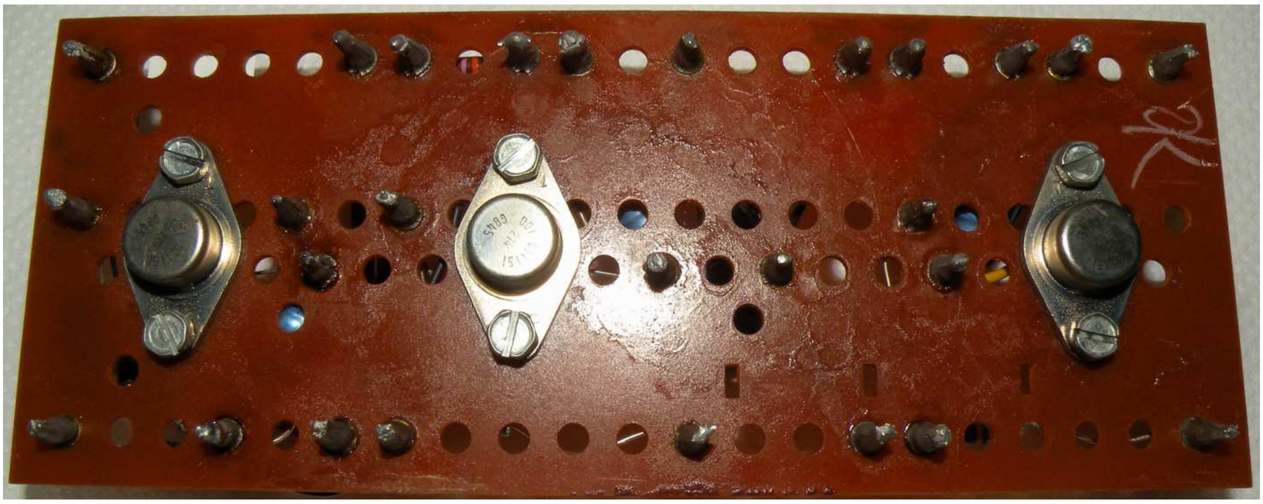
Original Vibrato Driver Preamp circuit.

The board AO-32297-1 is located at the back side of the scanner block, under the Upper keyboard.

Personnaly, I don't like at all the way this board has been engineered. This is the kind of board commonly used to create prototypes in lab's but not for production units. This is a personal opinion.

Top view

Bottom view



The three Vibrato Driver Preamp's (VDP's for short) are located on the same board. The concept of each VDP is the same however they all have some slight differences that have to be taken into consideration.

In fact, the role of each VDP is to procure enought amplitude to 'drive' its corresponding vibrato phase shift line that is linked directly to the scanner.

The VDP board is then composed of three sections:

- on the left, the TREBLE VIBRATO DRIVE PPREAMP
- in the center, the TAB VOICE VIBRATO DRIVE PREAMP
- on the right, the CELESTE VIBRATO DRIVE PREAMP

There is no so much to tell about the circuitry. Basic 'Common Emitter' configuration is used with a partial decoupling in the emitter resistors.

Refer to original schematic diagram hereunder.

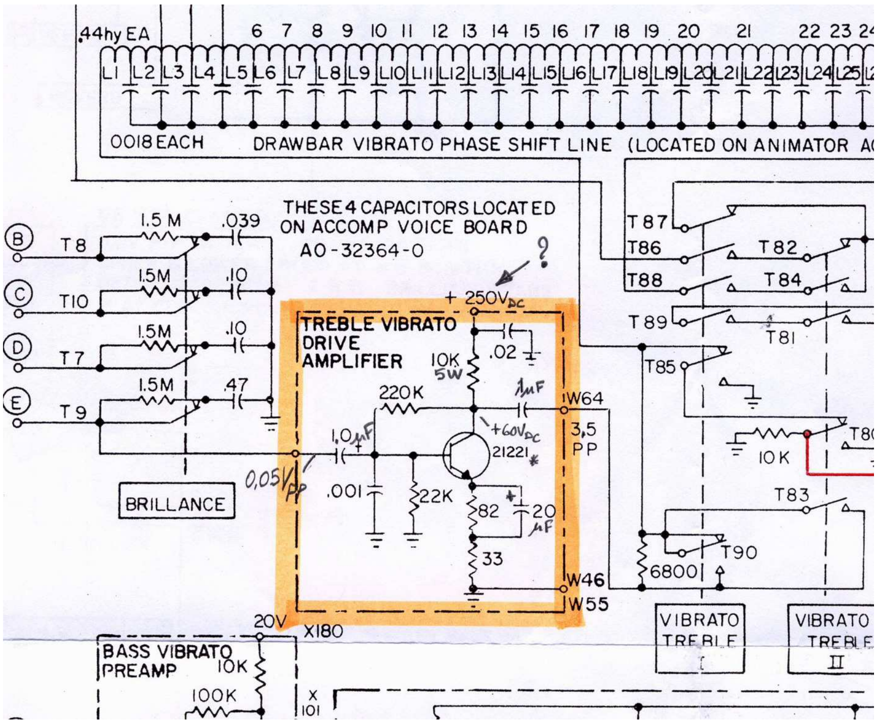


Fig 5-7 (partial) of X-66 Service Manual.

X-66 Headroom concept

We can notice on the diagram that those preamp's are fed by a voltage of +250 Vdc which is totally unusual for a conventional audio preamp. In the X-66 console, this voltage is even more, +265 Vdc were measured !

When looking on the original schematic diagram Fig 5-7, we can see that the incoming voltage at the Treble Vibrato Drive Preamp (Drawbars) is only 0.05 Vpp (Pt. E from Flute Filter) and the output voltage is 3.5 Vpp. So the amplification factor is 70.

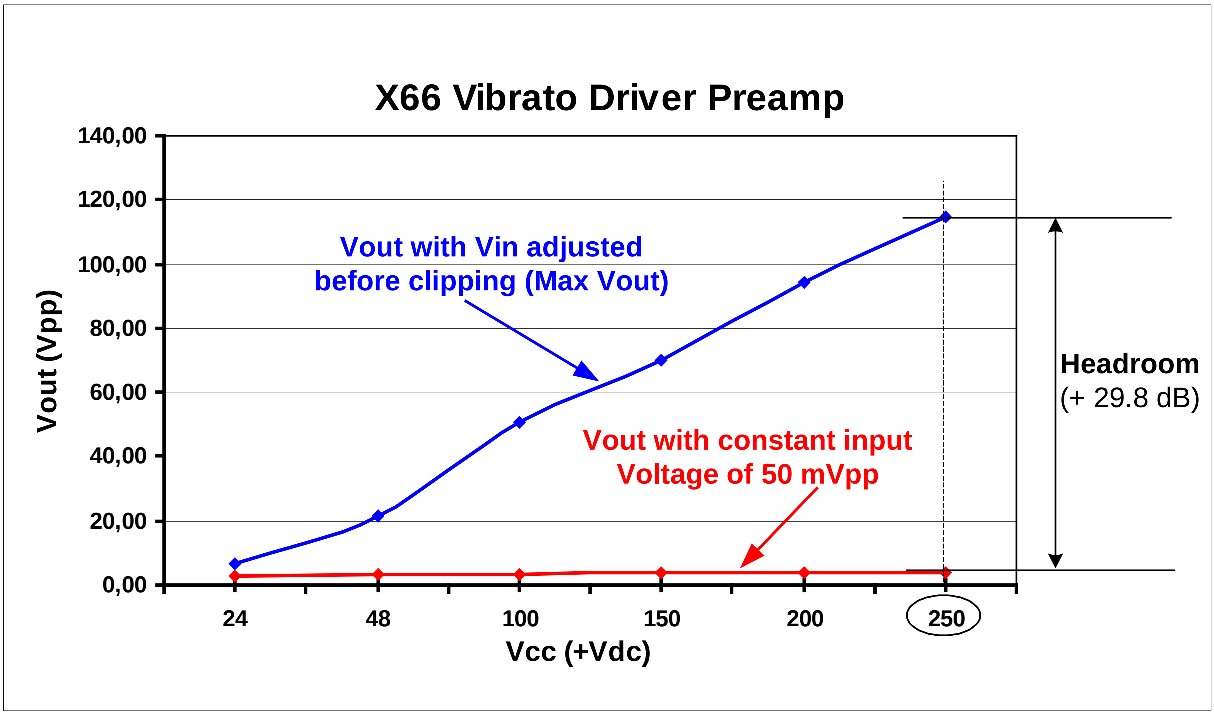
Then the question is: " Why to feed this circuit with such a high voltage of +250Vdc ? "

After invesitigations, I came to the conclusion that one reason of feeding this circuit with +250 Vdc is to procure very high "headroom" to the outgoing signal.

Headroom can be defined as *' the difference between the normal operating level and the clipping level (or undistorted value) of an audio device'.*

During tests, I found that the announced 3.5 Vpp level as indicated on Fig 5-7 can be easily obtained with a supply voltage of +25 Vdc. However, if we increase the level of the incoming signal, distortion appears rapidly (mostly clipping).

If the same circuit is powered with +250 Vdc (i.e. 10 times more), then clipping (distortion) only appears when the outgoing signal reaches 115 Vpp i.s.o. 3.5 Vpp !
This way of doing provides an 'headroom' of 115 Vpp – 3.5 Vpp = 111.5 Vpp.
Generally, headroom value is expressed in dB.
In this case, the headroom is + 29,8 dB, unusually high.
Extensive measurements were conducted on workbench and as an issue the next graphic was outlined.



The purpose of having sufficient headroom above normal operating signal is to avoid clipping and hence audible distortion.

It is evident that when Percussion signals carrying very sharp transients are in use, sufficient headroom is needed in order to avoid clipping.

For Tabs Voice signals, it is less needed since levels are quite constant while 'spikes' with Kinura tab depressed f.i. may justify some adequate headroom.

For Drawbars signals issued from the flute filters, then such amount of headroom is not at all required because signals driving this VDP are almost pure sine waves or harmonics components of them.

The X-66 designers of this VDP do have certainly other good technical reasons which remain unclear to me up to now.

New VDP circuit.

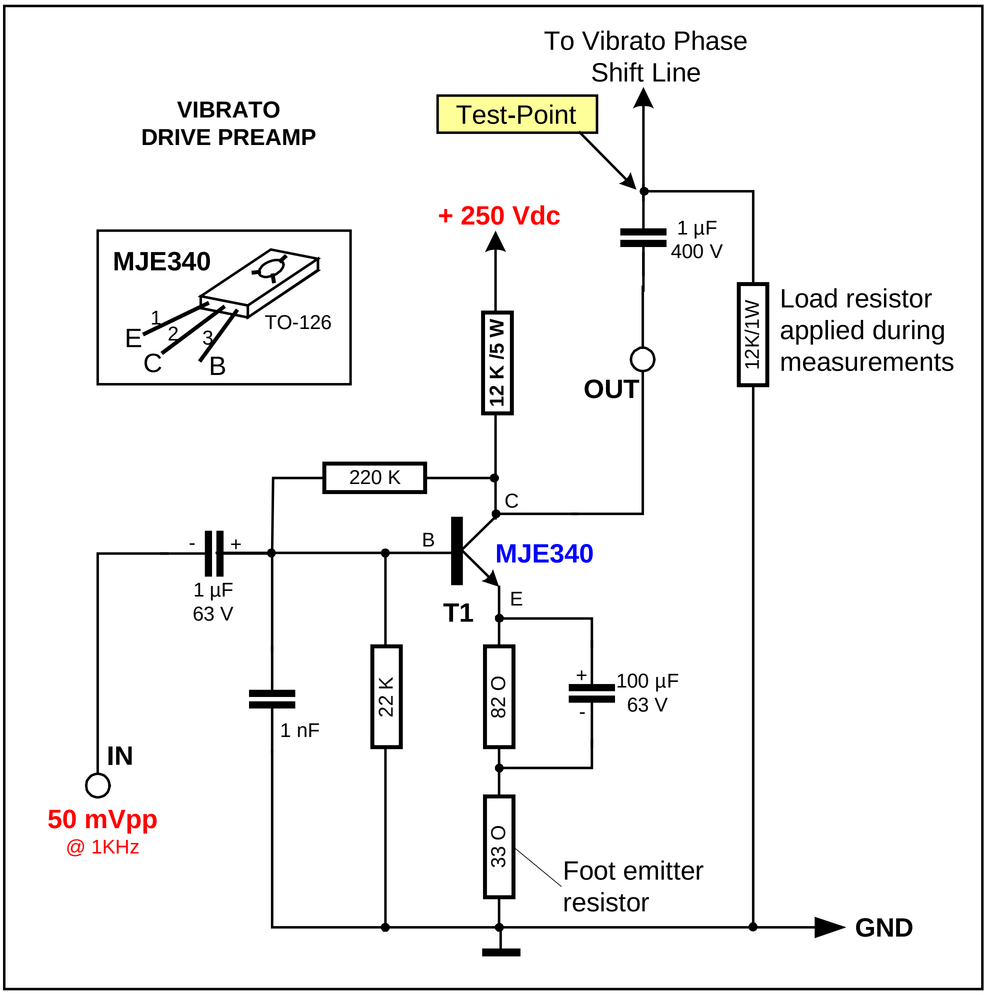
Since very few information as far as the specifications of this VDP board are available in the X-66 Service Manual, the original board AO-32297-1 board was dismounted and put on the workbench for test.

As stated earlier, only one channel was defective (noisy), so the two others were workable for measurements.

The original board AO-32297-1 was powered by +250 Vdc with an incoming signal of 50 mVpp @ 1Khz . The collector of transistor 21221 (RCA 39699) was loaded by a 12K/1W resistor to ground via one 1µF/400Vdc capacitor. See simplified schematic herafter.

The three sections of the AO-32297-1 board were configurated so and results of measurements were recorded in order to redesign a new VDP board.

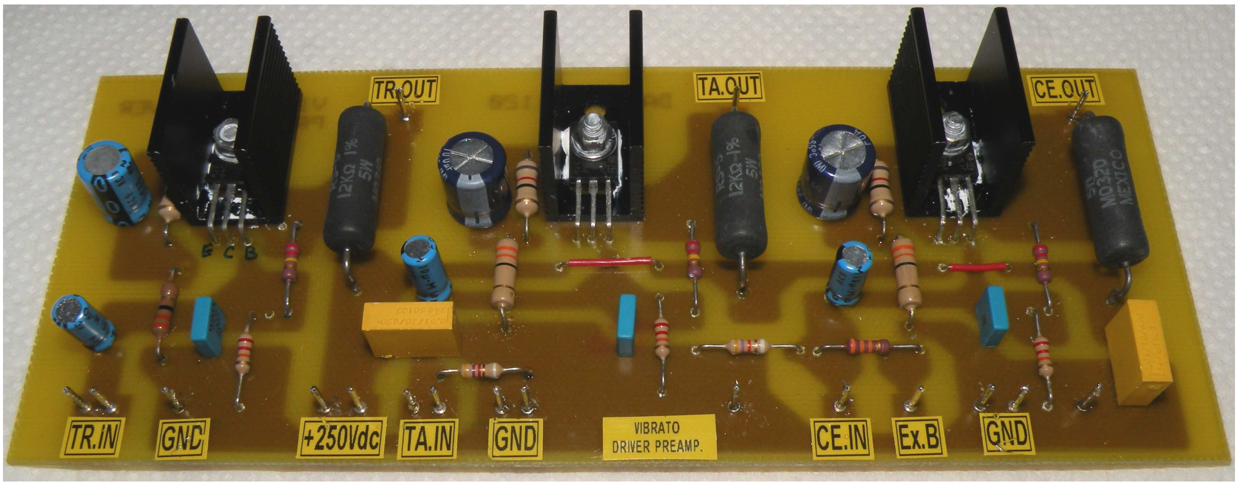
With the help of a workbench simulator software, a new VDP circuit was redesigned based on MJE340 transistor having much superior performances than RCA 36699.



The overall new schematic diagram can be found on the next page.

This new schematic diagram is almost identical to the original one. Beside the replacement of the old RCA transistor by MJE340, only the collector resistor has been changed from 10K/5W into 12K/5W to slightly decrease the collector current and reduce to a certain extend the power dissipation that is not negligeable due to high B+ voltage involved. Dale 12K / 5W – 1% resistors were installed.

Here is the new VDP board.



Transistors MJE340.

While not necessary by calculation, for reliability purpose, the transistors MJE340 were mounted on heatsink. Silicon compound was used for better heat transfert.

It is strongly recommended to select h_{FE} values (DC current gain) of those transistors. h_{FE} may vary from 30 up to 240 according to datasheet of the transistor supplier which is indeed a very wide range.
The correct h_{FE} value for each MJE340 transistor should remain in the range of min. 70 to max. 85. In my case, the three transistors had an h_{FE} value of 83.

Datasheet of MJE340 are also provided in the next pages.

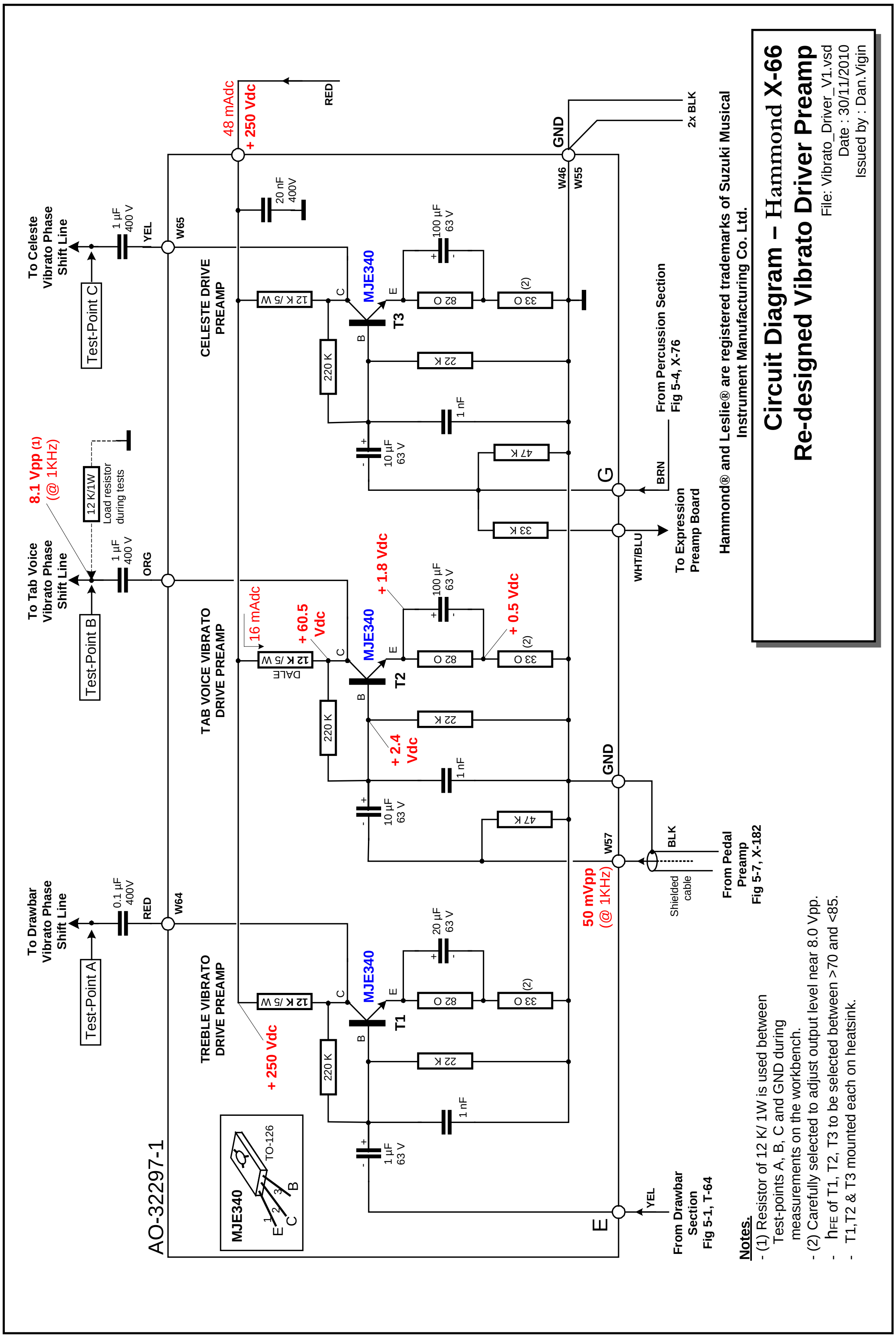
<u>Simplified characteristics</u>

	RCA 39699	**MJE340**
NPN Technology	Early generation Si Transistor	Planar Epitaxial Silicon transistor
VCB0	400 V	300 V
VCE0	300 V	300 V
VEB0	6 V	5 V
Collector Dissip.	8 W	20 W
h_{FE}	40 ~ 80	30 ~ 240

33 Ω Emitter resistors.

In addition to that, if one wants to keep an equivalent output level at each section of the VDP board, it is also important to carefully select the foot emitter resistor of 33 Ω. Higher value of this 33Ω resistor will decrease the overall gain while lower value will increase the overall gain.

Note: during life-tests, for reliability purpose, the voltage supply was increased from +250 Vdc up to +270 Vdc. No breakdown was recorded.


Circuit Diagram – Hammond X-66
Re-designed Vibrato Driver Preamp
File: Vibrato_Driver_V1.vsd
Date : 30/11/2010
Issued by : Dan.Vigin
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AO-32297-1
TREBLE VIBRATO DRIVE PREAMP
TAB VOICE VIBRATO DRIVE PREAMP
CELESTE DRIVE PREAMP
To Drawbar Vibrato Phase Shift Line
To Tab Voice Vibrato Phase Shift Line
To Celeste Vibrato Phase Shift Line
Test-Point A
Test-Point B
Test-Point C
12 K/1W
Load resistor during tests
8.1 Vpp (1) (@ 1KHz)
48 mAdc
+ 250 Vdc
16 mAdc
+ 60.5 Vdc
+ 1.8 Vdc
+ 0.5 Vdc
+ 2.4 Vdc
50 mVpp (@ 1KHz)
MJE340
T1
T2
T3
TO-126
From Drawbar Section Fig 5-1, T-64
From Pedal Preamp Fig 5-7, X-182
From Percussion Section Fig 5-4, X-76
To Expression Preamp Board
Shielded cable
2x BLK
Notes.
- (1) Resistor of 12 K/ 1W is used between Test-points A, B, C and GND during measurements on the workbench.
- (2) Carefully selected to adjust output level near 8.0 Vpp.
- hFE of T1, T2, T3 to be selected between >70 and <85.
- T1,T2 & T3 mounted each on heatsink.

Output levels.

During measurements of the original board AO-32297-1, output levels of 7.2 Vpp were recorded with an input sine wave signal of 50 mVpp @ 1KHz.
As already stated, those values are measured with a load resistor of 12K / 1W on each section.

With the new VDP board, I have intentionally selected the transistors MJE340 and the foot resistors of 33 Ω <u>to obtain a value of 8.0 Vpp</u> (i.s.o. 7.2 Vpp as on original one).
Limits for new VDP should remain around +/- 0.2 Vpp i.e. 7.8 Vpp ~ 8.2 Vpp.

This difference gives some 'voltage boost' that was positively evaluated during final listening tests. By altering the value of this emitter resistor of 33 Ω, it is possible to refind exactly the value of 7.2 Vpp as on the original board. It's a matter of choice.

There is no indication whatsoever in the X-66 Service Manual as far as the effective load composed by the vibrato phase line circuits. When analysing the structure of those circuits, it seemed to me that this load should fall in the range of 12 K.
It's a my pure guess. Measurements at no-load condition makes no sense and since the same load value of 12 K / 1W was used for both original board and new one, the conditions of measurements remain identical and trustworthy.

Realization.

A shown on the picture, a new board was redesigned <u>keeping the same external dimension</u> of the original one. The position of the terminals was also kept for easiness of rewiring.
The three output capacitors (0.1 µF/400 Vdc and 2x 1 µF/400 Vdc) were found perfect and hence were left in their initial position on the scanner chassis.

Negative and components sides of this PCB are provided in the next pages for those who envisage to realize this VDP board.
There is no so much to tell about the board itself, quite basic for any qualified technician.

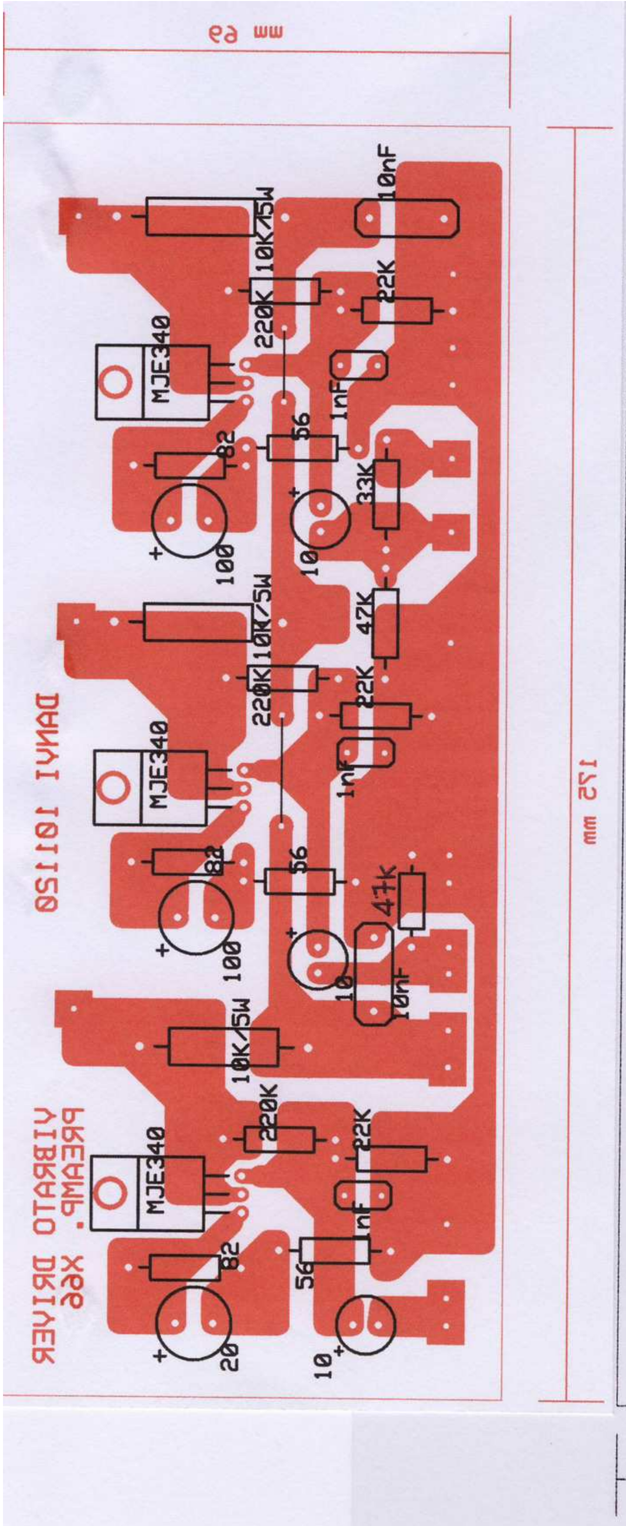
Conclusion.

Initially, I had no intention to redesign this board AO-32297-1. This was caused by the excessive 'inherent noise and hiss' that suddenly appeared in the Drawbar channel.
In fact, since I was forced to resolve that failure, from there came the idea of redesigning this board. At the end, it was a good decision because the replacement of old RCA transistors by MJE340's provides to the X-66 console a real 'boost' while reducing to some extend the overall inherent background noise (rather subjective).
This is only my personal feeling.

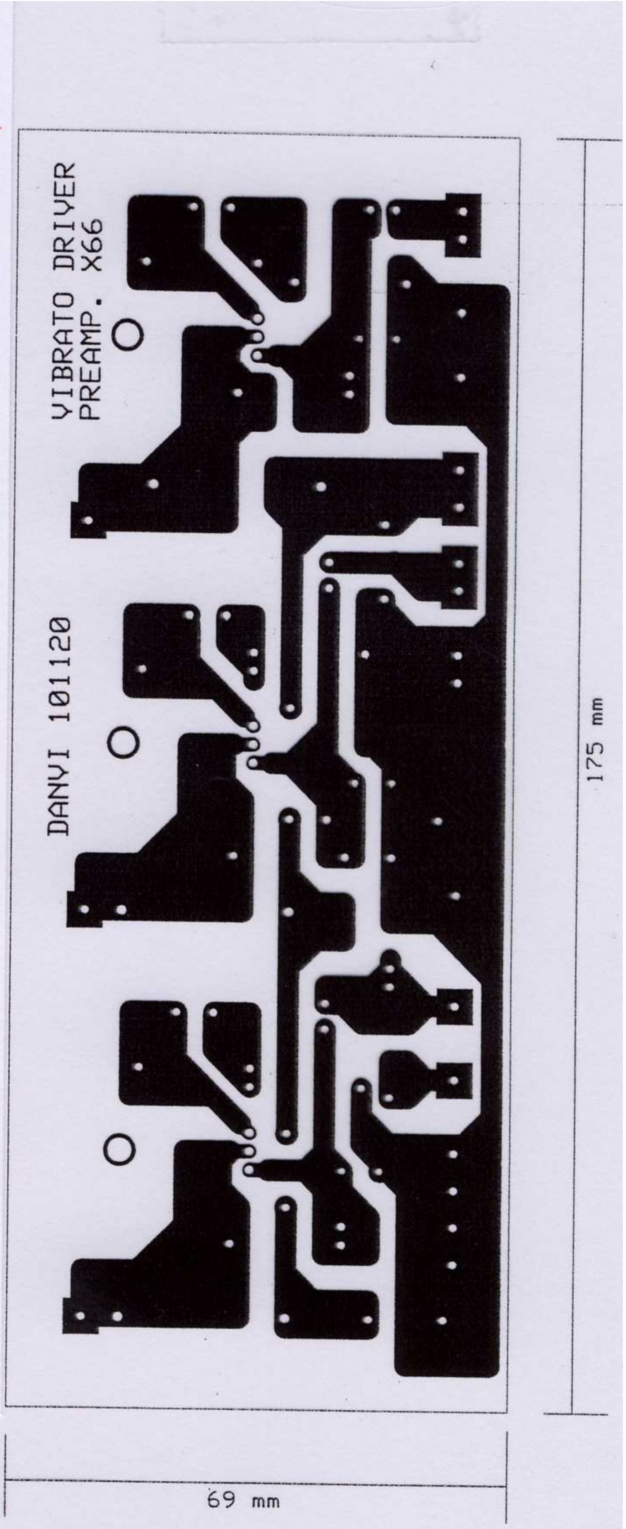
Dan. Vigin

PCB Layouts

Components side



Copper side



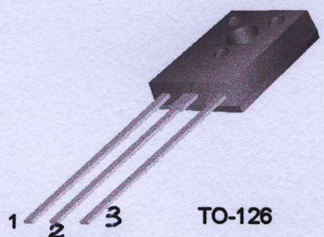
DATASHEET MJE340.

FAIRCHILD
SEMICONDUCTOR™

MJE340

High Voltage General Purpose Applications

- High Collector-Emitter Breakdown Voltage
- Suitable for Transformer
- Complement to MJE350



TO-126

1. Emitter 2.Collector 3.Base

NPN Epitaxial Silicon Transistor

Absolute Maximum Ratings T_C=25°C unless otherwise noted

Symbol	Parameter	Value	Units
V_{CBO}	Collector-Base Voltage	300	V
V_{CEO}	Collector-Emitter Voltage	300	V
V_{EBO}	Emitter-Base Voltage	5	V
I_C	Collector Current	500	mA
P_C	Collector Dissipation (T_C=25°C)	20	W
T_J	Junction Temperature	150	°C
T_{STG}	Storage Temperature	- 65 ~ 150	°C

Electrical Characteristics T_C=25°C unless otherwise noted

Symbol	Parameter	Test Condition	Min.	Max.	Units
BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 1mA, I_B = 0	300		V
I_{CBO}	Collector Cut-off Current	V_{CB} = 300V, I_E =0		100	µA
I_{EBO}	Emitter Cut-off Current	V_{BE} = 3V, I_C = 0		100	µA
h_{FE}	DC Current Gain	V_{CE} = 10V, I_C = 50mA	30	240	

Typical Characteristics

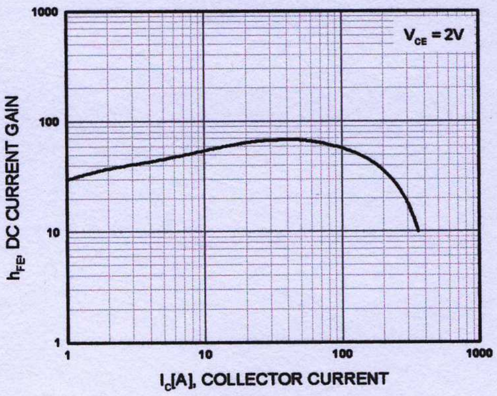


Figure 1. DC current Gain

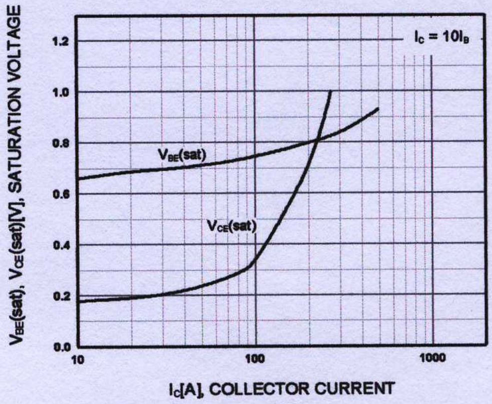


Figure 2. Base-Emitter Saturation Voltage Collector-Emitter Saturation Voltage

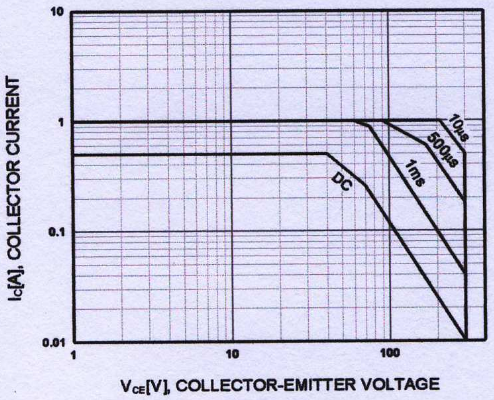


Figure 3. Safe Operating Area

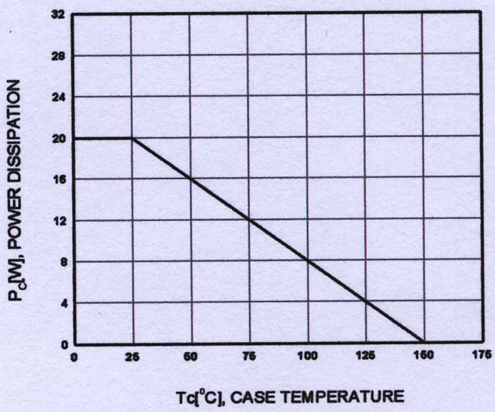
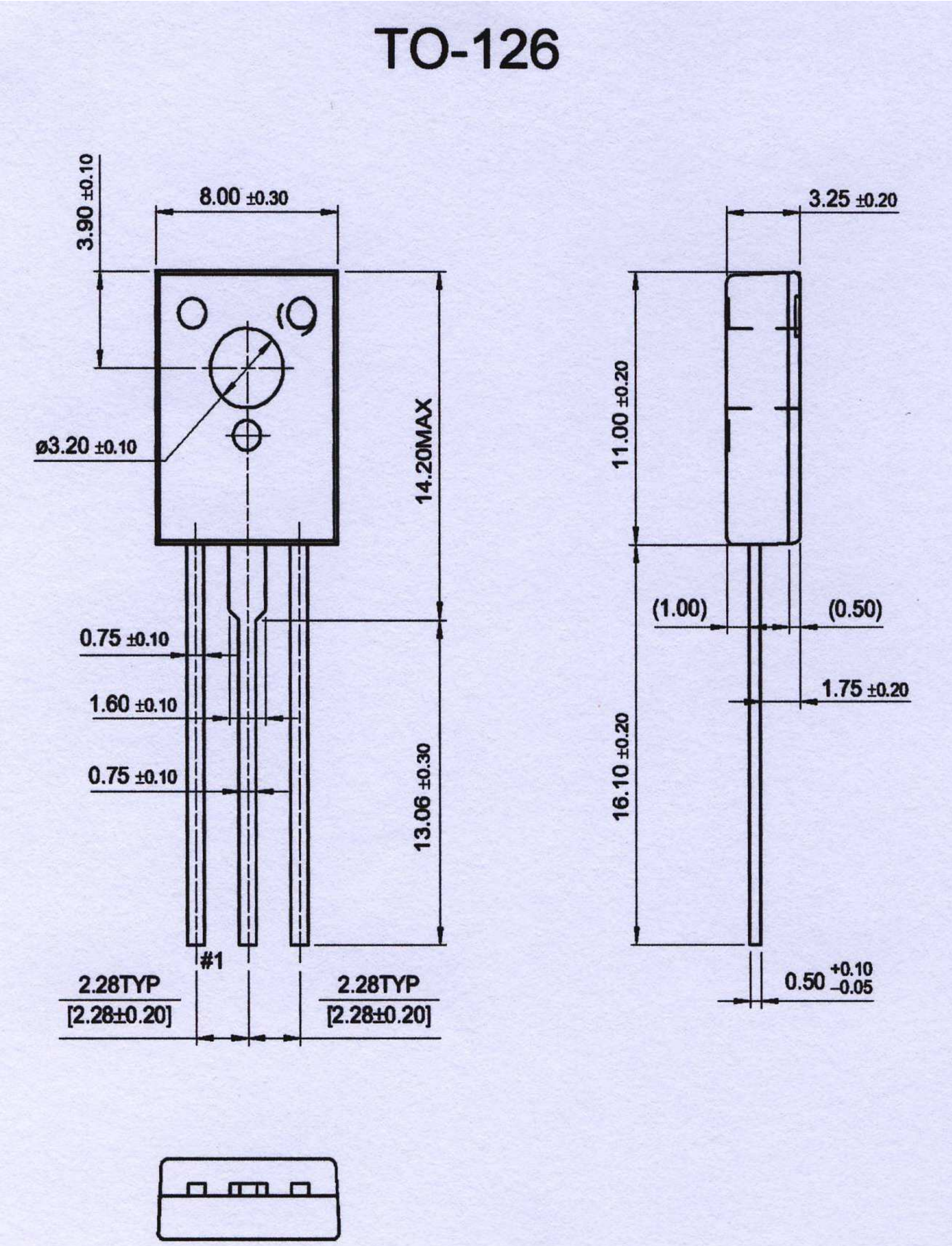


Figure 4. Power Derating



TO-126
3.90 ±0.10
8.00 ±0.30
3.25 ±0.20
ø3.20 ±0.10
14.20MAX
11.00 ±0.20
(1.00)
(0.50)
0.75 ±0.10
1.60 ±0.10
1.75 ±0.20
0.75 ±0.10
13.06 ±0.30
16.10 ±0.20
#1
2.28TYP
[2.28±0.20]
2.28TYP
[2.28±0.20]
0.50 +0.10 −0.05