The Class-A Amplifier Site
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Transistor Substitutes

The semiconductors used in the original 1969 circuit are, naturally, no longer available and even some of those shown in the 1996 update article can be difficult to source in some localities. The following list of substitutes has been prepared to assist those who are having difficulties in finding the specified devices. I have also included details of the working voltage, current and power dissipation for each transistor, when used in the 1996 circuit, so that other alternative devices may be considered.

Device	Original Device 1969	Original Device 1996	Substitutes
Tr1 / Tr2	MJ480 / MJ481	2N3055	2N3055 / 2 x TIP3055
Tr3	2N697 / 2N1613	2N1711	2N3019 / BD139
Tr4	2N3906	BC212	BC559 / BC560
Tr5	None	MJE371	BD140

Table 1. Commonly available or preferred transistor substitutes.

Notes to Table 1:
The 2N3055 should be epitaxial-base type with high f_T (preferably 4 MHz)
The 2 x TIP3055 are a parallel pair with 0R1 emitter resistors
The BD139 should preferably be selected for high gain to minimise distortion. If possible, use the BD139-16 (the manufacturer's higher gain device)

The use of more modern 'audio' power transistors with a high current gain-bandwidth product (f_T), such as the 2SC5200, 2SC3281 and MJL3281A, is not recommended at present. The >30MHz f_T of these devices causes the open-loop gain to remain above unity when the phase shift through the amp reaches 180°. This results in instability and oscillation, which requires additional compensation such as a dominant pole capacitor. In a simple circuit such as this, the provision of a compensation capacitor can significantly increase distortion levels unless other circuit changes are made (which perhaps defeats the object of this simple design). However, I will be investigating various possible options for solving the instability problems since I would really like to try the highly linear MJL3281A device.

I have received feedback from one constructor, Tim Andrew, who has been trying alternative output transistors in his JLH 1996 version. The MJL3281A gave clearly audible oscillation. The MJ21194 gave a noticeable improvement in sound quality, but introduced a low frequency hum, the cause of which has yet to be determined. The MJ15003 gave a significant improvement in sound quality, similar to the MJ21194 but without the side effects. Tim's opinion is that, when compared to the 2N3055, the bass is tauter and faster and the top end less 'splashy'. In a subsequent email about the MJ15003, Tim went on to say:

> "It's no good, I just had to email you again to say how good these transistors are. Recordings that were previously hard and bright are now sumptuous with crystal clarity, while recordings that were dull are now alive with a new sense of vibrancy. They seem to go particularly well with the tantalum film resistors that I have just fitted. I know you plan at some point to change to full range speakers, but I would seriously recommend that instead, you try these transistors with paper-in-oil caps, preferably copper foil on the input. Audio Note are introducing large value 50 volt P-in-Os for speaker crossovers. If you try these too, I would say you would be very happy indeed. It seems people just don't realise what they are missing with these P-in-Os. They have a total lack of hardness that has to be heard to be believed. My tweeters are metal domes, people say they don't like them because they sound metallic, but here they have a smoothness and clarity that is difficult to describe. Anyway, thanks again for the suggestion of these transistors, they are a big step up from the 2N3055s and I wouldn't go back now."

Following Tim's successful trial of the MJ15003, another constructor, Jason Wou, tried the substitution and sent me the following feedback:

> "I just replaced 2N3055 with MJ15003. It was direct swap. I didn't really have to adjust anything, it was
> basically a one-to-one swap. I had lots of MJ15003 to build a Leach Amp.
>
> My impression is the MJ15003 is DEFINITLY better!! I was getting goosebumps. ;) Sounded so real. Smoother highs and midrange (I won't comment on bass since I use a subwoofer). It improved the already superb sounding amplifier even more! I guess I won't be using those transistors for the Leach Amp any more!
>
> The MJ15003 is more expensive than the 2N3055, but not by much. Maybe a dollar or two more. From now on if there's any amp project with 2N3055 in it, I will be using the MJ15003!
>
> How exciting. My amp is singing at this very moment, it sounds just so much better."

The MJ802 has also been proven to work in place of the venerable 2N3055, see 'A JLH Class-A for the Quad ESL57'

If alternative power transistors are required, they should be selected to meet the requirements of Table 2 and should have an f_T of around 4MHz. Devices with a low junction-case thermal resistance are preferred.

I have not yet found a commonly available alternative for the 2N1711 (Tr3), other than the (selected) BD139. The 2N1711 and 2N3019 are preferred (if one or the other can be found) over the BD139, due to their higher gain.

Other substitutes for Tr4 include, amongst others, the BC212L, BC556, BC557 and 2SA872. Low noise devices such as the BC559, BC560 and 2SA872 are preferred.

Note, the substitutes given above do not necessarily have the same case style or lead-out arrangement as the original devices. Manufacturer's data sheets should be consulted to determine the relevant differences.

The following table can be used to assist in the selection other suitable transistors. The table shows the peak values (derived from simulation) of voltage, current and power in each transistor for a 1996 design with +/- 22V supply rails and a quiescent current of 2A. The simulations were run using 4, 8 and 16 ohm resistive loads and full-load figures were checked with source voltages set to give the maximum (non-clipping) output and with source

frequencies of both 50Hz and 1kHz. The maximum figures obtained in the simulations are included in Table 2. Note, the maximum figures for a 1969 design will be lower as the power output is less if the original article is adhered to. When selecting alternative devices, an allowance must be made to provide a factor of safety. I suggest as a minimum that the voltage and current be multiplied by a factor of 1.5 and the power by a factor of 2.

Device	Voltage (Vce)	Current (Ic)	Average Power	Maximum Power
Tr1	40V	3.1A	45W	49W
Tr2	40V	2.7A	43W	56W
Tr3	40V	47mA	475mW	575mW
Tr4	23V	0.41mA	6mW	8mW
Tr5	39V	50mA	985mW	2W

Table 2. Maximum voltage, current and power for transistors in a 1996 design.

Before I get any queries, please note that the maximum power, under load, does not coincide with the maximum voltage or the maximum current, therefore the power figures cannot be derived from the multiplication of columns 2 and 3.

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22/05/2001 2N3019 added
27/05/2001 Reference to BD139-16 added
09/09/2001 Caution regarding high ft output transistors added
07/11/2001 Notes re MJ15003 and MJ802 added