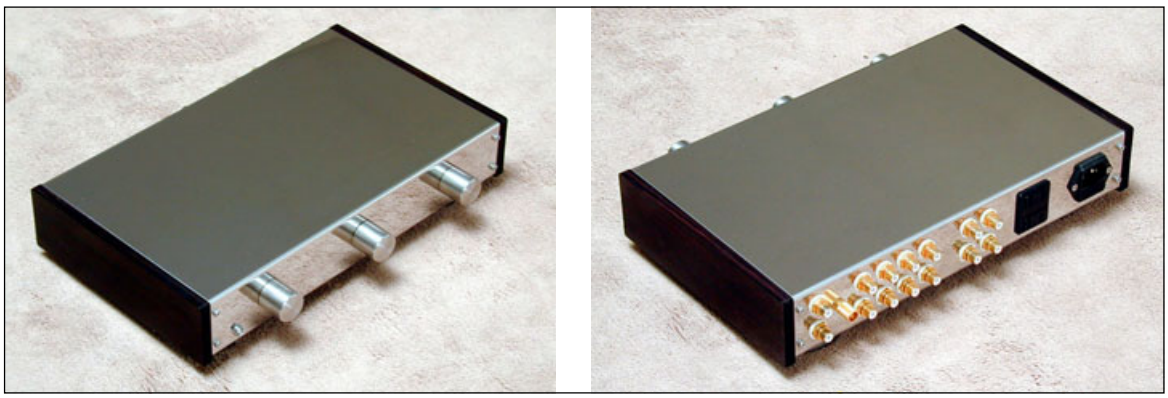
Building a complete 2-channel DACT preamp By Satoru Kobayashi

Building a solid state preamplifier using DACT components



Mr. Kobayashi's final DACT preamplifier, front and rear view

Front cover of AudioXpress Magazine issue July 2001

On the following pages you may read an article written by Mr. Satoru Kobayashi. The article is a reprint from AudioXpress Magazine, July 2001.

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CAUTION

This project involves working with connections to mains voltages (100-240 VAC). Please be aware that mains voltages may be lethal if touched by humans. Unless you are experienced working with mains voltages, we recommend that a trained technician carries out all connections of the mains voltages.
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An Easy Solid State Preamplifier

This amplifier provides for easy assembly with Danish-made module amplifiers and peripheral components. This article was originally published in Japan's premier high-end tube magazine, *MJ Audio Technology,* May 2000.

By Satoru Kobayashi

This preamplifier circuit was simple to make since I chose DACT components, for which ads appear in *AudioXpress*. DACT (Danish Audio ConnecT) is based in Denmark, although the sales office is somehow located in Bangkok, Thailand. It offers several unique high-end audio components such as the EQ Phono amplifier module, buffer amplifier modules, rotary switches, volume controls, stainless-steel milled knobs, and so on. Thus, DACT, which also handles Scan-Speak speakers, is the total-solution component manufacturer for high-end audio.

While accessing DACT's web pages (http://www.dact.com/), I decided I could easily build a superior preamplifier using its components and offer it to beginners who wish to construct their own amplifiers. I believed this would be as good as manufactured amps, since the particular products are nearly equal to them in quality.

Collecting the parts was very easy because DACT offers the major components I needed for this project through the Internet. I got the other parts from San-Ei Musen (now closed) in Akihabara, Tokyo. I custom-designed the case myself, and had it made by San-Ei Musen, which used stainless steel, thus giving it the appearance of a manufactured amplifier.

CIRCUIT

Because of company policy, I assume, DACT keeps the circuit of the modules themselves as a secret. The key component on the module was paint-shielded, so I could not see any top marking to identify its part number or manufacturer. All I can tell is that both modules use an operational amplifier. Thus I hesitate to explain the details of the circuit. But I will briefly describe the components to avoid errors in assembling them.

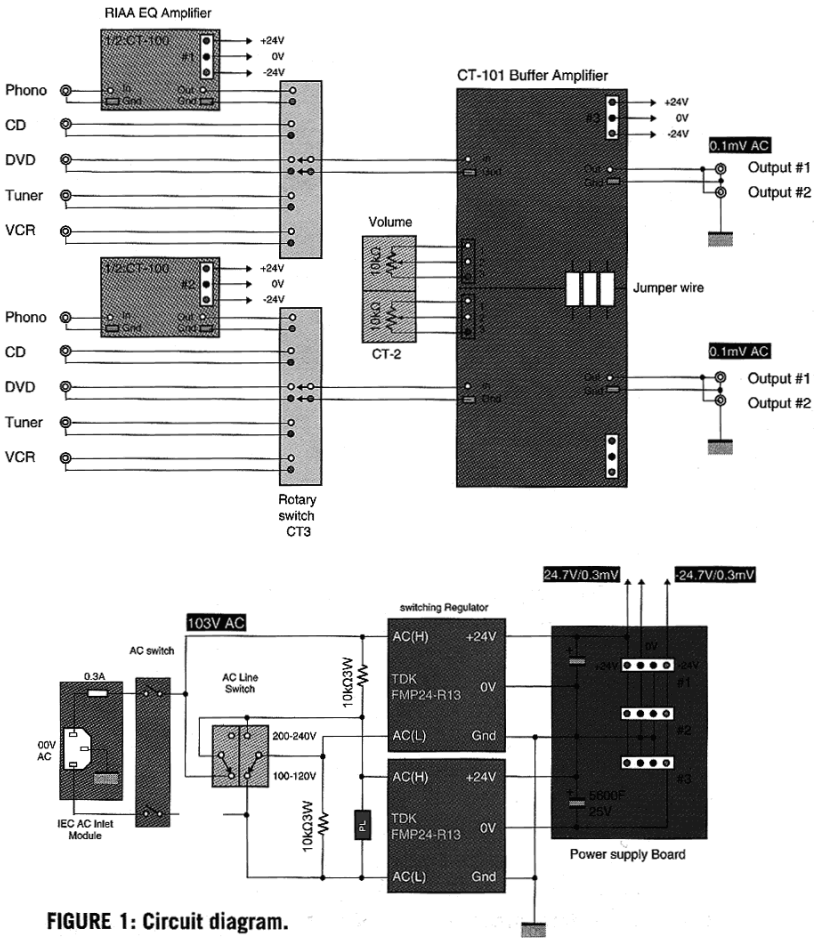

FIGURE 1: Circuit diagram.

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The major components of this amplifier (*Fig. 1*) are an RIAA equalizing amplifier (CT100), input selector, volume control, buffer amplifier (CT101), and the power supply. For satisfactory completion, the preamp might need some features such as tape in/out and tone control, but I removed them all to simplify assembly, since high-end audio might not need them. Please note that DACT's web page provides an Adobe pdf formatted specification and installation manual. I strongly suggest that you download the file and read it before building this project.

The RIAA equalizing amp (CT100) provides a feature that can make one of a number of selections, such as 10 Ohm, 30 Ohm, or 47 kOhm for input resistance, input capacitance, and time constant through DIP switches on the board (*Fig. 2*). The CT100 even handles a 0.1 to 0.3mV signal from a moving-coil cartridge with very low impedance such as 10 Ohm, which obviates a step-up transformer and thus saves money. The amplifier generates up to 7V RMS at the maximum input level of 100mV with a high signal-to-noise (S/N) ratio of 98dB.

INPUT SELECTOR

CT3, a 4-pole, 5-position rotary switch *(Fig. 3)*, is capable of switching even a ground terminal of RCA pin/jacks. So you can switch the ground terminal of inputs as well as the signal line to improve S/N ratio.

The 20 pins evenly aligned on the back makes it easy to install the connecting wires between the pins and RCA jacks on the rear panel. I guess the only drawback is that all pins are placed on the same plate, so crosstalk between channels might be worse in the high-frequency range (above 100kHz) than with a splitplate rotary switch for each channel.

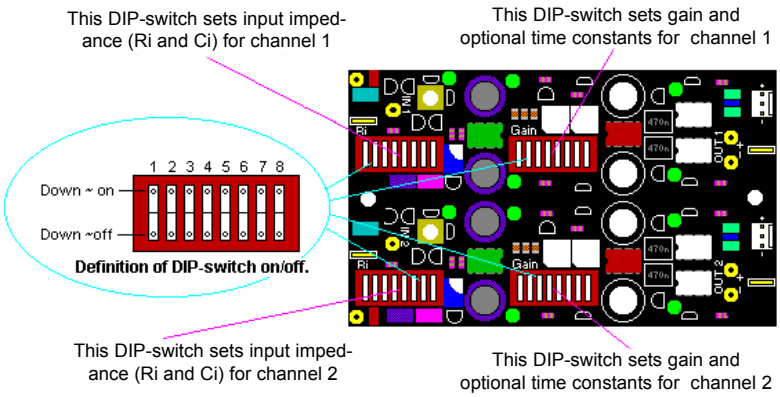

FIGURE 2: CT100 DIP-switch settings

INPUT IMPEDANCE SETTING

Resistance, Ri	"Input impedance"-DIP switch settings on/off							
Ohms	1	2	3	4	5	6	7	8
10	on	on	on	on	on	on	-	-
15	on	off	on	on	off	on	-	-
18	on	off	off	on	off	off	-	-
20	on	off	off	off	off	off	-	-
25	off	on	on	on	on	on	-	-
30	off	on	on	off	on	on	-	-
40	off	on	off	on	off	on	-	-
50	off	on	off	off	off	off	-	-
60	off	off	on	on	on	on	-	-
70	off	off	on	on	off	off	-	-
80	off	off	on	off	on	on	-	-
90	off	off	on	off	off	on	-	-
100	off	off	on	off	off	off	-	-
150	off	off	off	on	on	on	-	-
180	off	off	off	on	on	off	-	-
200	off	off	off	on	off	on	-	-
250	off	off	off	on	off	off	-	-
400	off	off	off	off	on	on	-	-
600	off	off	off	off	on	off	-	-
1k	off	off	off	off	off	on	-	-
47k	off	off	off	off	off	off	-	-

Capacitance, Ci	"Input impedance"-DIP switch settings on/off.							
pF	1	2	3	4	5	6	7	8
100	-	-	-	-	-	-	off	off
200	-	-	-	-	-	-	on	off
300	-	-	-	-	-	-	off	on
400	-	-	-	-	-	-	on	on

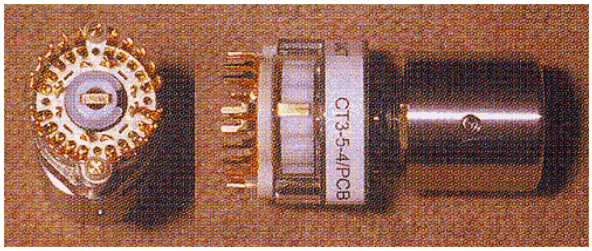

FIGURE 3: CT3 Stainless Milled Knob

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If you are concerned about this crosstalk, you might use a two-stage, 2-pole, 5-position rotary switch to reduce it, such as a unit made by Fujitsu, for example. But this CT3 is very compact and well constructed, with a thick gold-plated electrode providing higher reliability than the regular product.

The CT3 is furnished with a very attractive milled knob, made of stainless steel, which fits perfectly in my custom-designed case. Since I have never seen such a stainless steel milled knob, such as you can find in a golf putter, this is really a nice feeling, because of its weight and surface finish.

VOLUME CONTROL

The volume control (*Fig. 4*) also comes from DACT. It is the integrated product of the aforementioned rotary switch and a rounded copper-clad PCB with a number of surface mount resistor chips. The surface-mount resistor is used in a lot of handy and mobile equipment where small size is needed; for example, in mobile gear like Palm PC or Walkman, cellular telephones, and so on.

The resistor itself is tiny to handle, but its size reflects the frequency response to be higher than ever - 50MHz. The feeling when rotating the knob is also as good as the rotary switch. This is really better than the conventional switches that come with telecommunications equipment. I chose the value of 10kOhm to meet the output impedance of the EQ and buffer amplifier.

The volume itself provides a convenient feature that simplifies wiring between the volume and other components using a printed circuit connector as well as the buffer amplifier that mates up with this control.

GAIN AND TIME CONSTANT SETTING

MC/MM nom. output level	"Gain"-DIP switch settings on/off.							
mV	1	2	3	4	5	6	7	8
0.10	off	off	off	off	on	on	-	-
0.12	off	off	off	off	off	on	-	-
0.15	on	off	off	off	on	on	-	-
0.18	on	off	off	off	off	on	-	-
0.20	off	on	off	off	on	on	-	-
0.25	off	on	off	off	off	on	-	-
0.30	on	on	off	off	off	on	-	-
0.40	off	off	on	off	on	on	-	-
0.45	on	off	on	off	on	on	-	-
0.50	off	off	on	off	off	on	-	-
0.55	on	on	on	off	on	on	-	-
0.60	off	on	on	off	off	on	-	-
0.70	on	on	on	off	off	on	-	-
0.80	off	off	off	on	on	on	-	-
0.90	off	on	off	on	on	on	-	-
1.0	off	off	off	on	off	on	-	-
1.1	off	off	on	on	on	on	-	-
1.2	off	on	on	on	on	on	-	-
1.3	off	off	on	on	off	on	-	-
1.4	on	off	on	on	off	on	-	-
1.5	off	on	on	on	off	on	-	-
1.6	off	on	on	off	on	off	-	-
1.8	on	on	on	off	on	off	-	-
2.0	off	on	off	off	off	off	-	-
2.5	off	off	off	on	on	off	-	-
3.0	on	on	off	on	on	off	-	-
3.5	off	off	on	on	on	off	-	-
4.0	on	on	on	on	on	off	-	-
4.5	off	on	on	off	off	off	-	-
5.0	on	on	on	off	off	off	-	-
7.0	off	off	off	on	off	off	-	-
8.0	on	on	off	on	off	off	-	-
9.0	off	off	on	on	off	off	-	-
10.0	on	on	on	on	off	off	-	-

Time constant	"Gain"-DIP switch settings on/off.							
uS	1	2	3	4	5	6	7	8
3.18off / 7950off	-	-	-	-	-	-	on	on
3.18off / 7950on	-	-	-	-	-	-	on	off
3.18on / 7950off	-	-	-	-	-	-	off	on
3.18on / 7950on	-	-	-	-	-	-	off	off

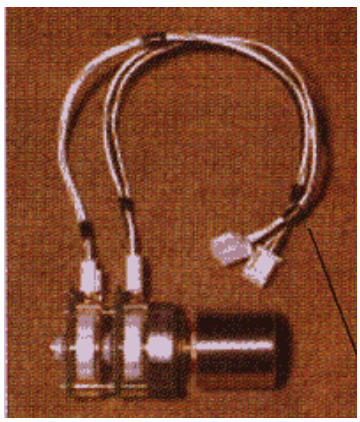

FIGURE 4: CT2 volume control

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The buffer amplifier CT101 (*Fig. 5*) is very small, like a cellular telephone, with a frequency response up to 25MHz and flat in this frequency range. Also, three jumper pins on the board are available to select the gain (0dB, 6dB, or 12dB). This is a very convenient feature that I like.

Common features exist in both CT100 and CT101, since both modules use an operational amplifier:

1) They both need a complementary power supply, such as ±17-35V. Note that both modules provide a zener-diode-regulated ripple filter on the board, so that the internal voltage is stabilized at ±15V.

2) There is no need to solder hooking wires to the board, since printed circuit connectors are used, and they come included with cables.

3) They feature low crosstalk through a power-supply line because of dual mono-amplifier structure.

4) Both feature ultra-low output impedance of 0.1 Ohm, bringing the high hum immunity through an output line cable, and eliminating a shielded wire for the internal wiring. I did not use any shielded line cable inside.

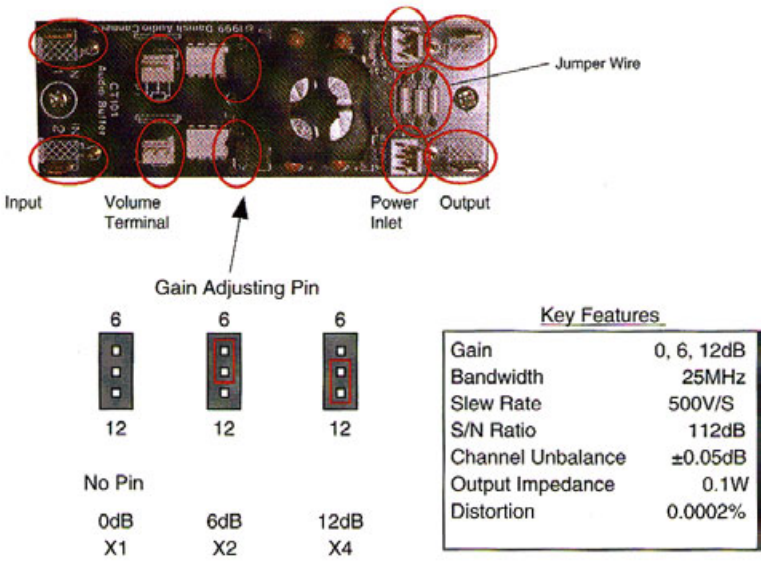

FIGURE 5: CT101 buffer amplifier

POWER-SUPPLY MODULE

The power-supply module (*Fig. 6*) is my first occasion to use a switching regulator as the ±24V DC power source. This is rarely seen in D1Y types of amplifiers, whereas most digital circuits like PCs use this frequently because of its compactness and lightweight. I happened to find this in Akihabara, suggesting that I could make this amplifier as small as a cookie case. The module - from TDK - is small enough to integrate into a small case.

The module produces no magnetic field; is small, compact, and light; and possesses a very wide range of AC line voltage between 90V and 120V, which allows this amplifier world-wide use compared to a conventional power supply with an E-I cored transformer.

The power consumption of the modules is 45mA and 5mA, respectively, so this power supply can drive both adequately because of its maximum supply current of 130mA. On the other hand, you might prefer a battery-powered supply if you do not like this switching power supply.

Two power modules are needed to drive these DACT modules because they require a complementary power supply. In addition, the AC line-voltage selection circuit offers 200 to 240V AC operation even in Europe. To do this, both power modules are connected in series with a couple of bleeder resistors to achieve the AC voltage even out of 200V AC inlet since the AC power consumption is less than 0.lA AC.

Such a voltage delivery will probably work without any failure.

To make sure, I performed a 24-hour test under 200V AC operation as burn-in (regularly done at the semiconductor production stage), and I confirmed that no failure occurred under this configuration. This test result certifies that you can use this module anywhere in the world. If you use it only in Japan or in the US, where l00—120V AC is available, then you might dispense with the line-voltage selection circuit.

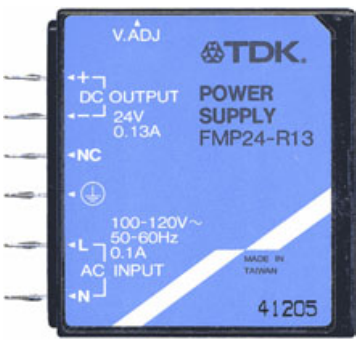

FIGURE 6: Switching power module

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ENCLOSURE DESIGN

For the case, I chose a size of 320 x 200 x 55mm (Figs. *7A-7C).* The enclosure itself is shell-structured, with the top cover and the internal case using a 1.5mm thick stainless-steel plate. The major reason to use a top cover is to hide the screws that fix the parts over the inner case. The top cover of a stainless-steel plate conveys the impression of a manufactured amplifier and matches the stainless-steel knobs on the front panel. The drawback is making the case very heavy (2kg or so).

A wooden panel (200 x 58 x 9mm) of teakwood or similar quality is attached to the sidewall (*Fig. 8*). The panel was polished with #400-#600 sandpaper, drilled to fix to the metal side panel by three screws, and polished again with walnut oil. As a result, the surface of the wood became as fine and smooth as if it had been crafted by a professional.

I installed a rotary switch, a volume control (*Fig. 9*) and an AC power switch over the L-shaped sub panel separately built toward the back panel so the internal wiring would be shorter than usual. This structure requires an extension shaft, a shaft coupler, and so on, bringing the shaft of each component to the front panel.

THE ASSEMBLY

First of all, disassemble the case, with its inner plate and side panels to be split. Second, affix power modules, the inner plate, and so on over the inner top plate. Third, attach a teakwood side panel over the side metal panel with three screws. Fourth, fix RCA pin jacks over the rear panel. Fifth, attach the volume control and switch onto the inner panel.

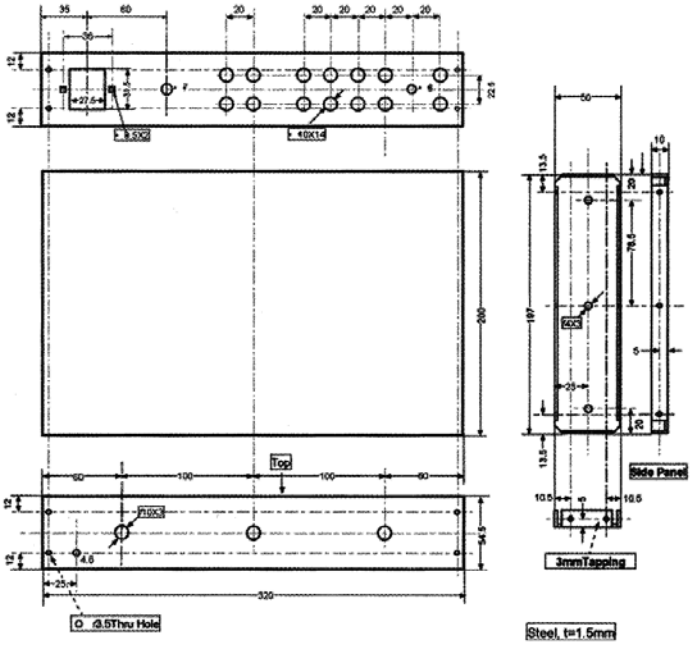


FIGURE 7A: Case drawing.

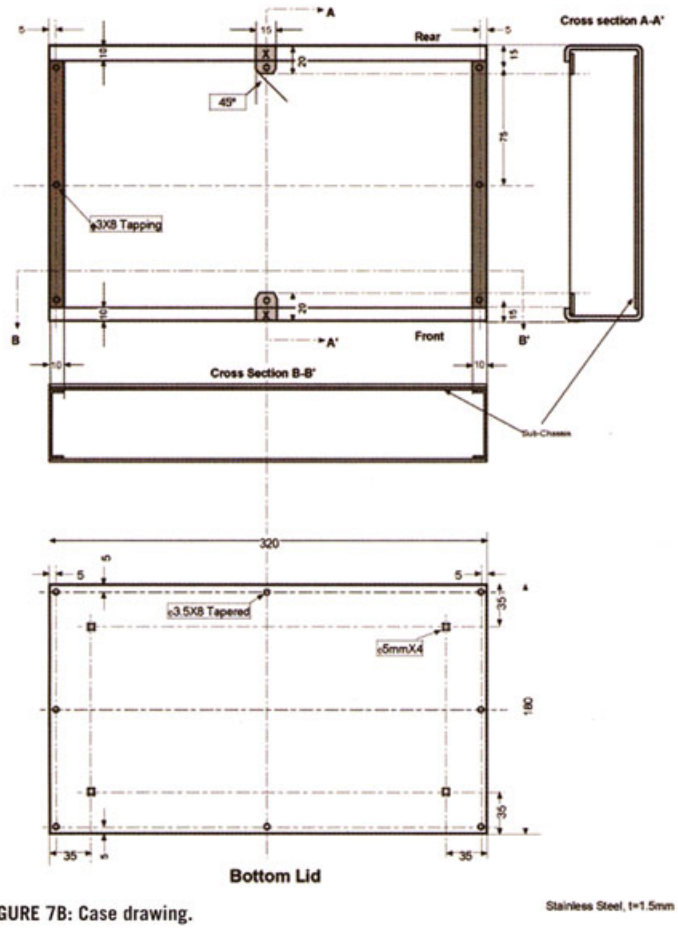


FIGURE 7B: Case drawing.

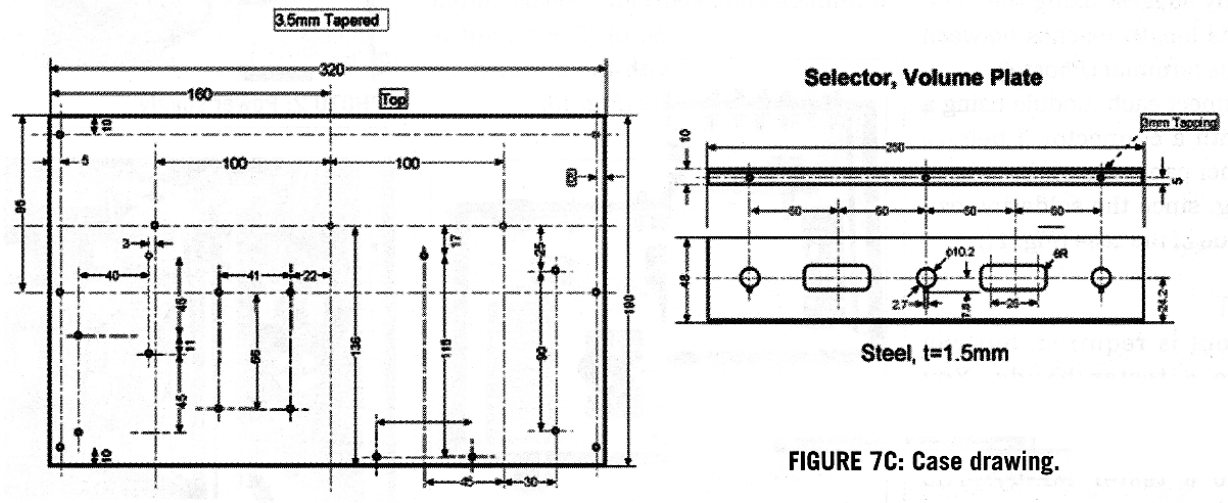


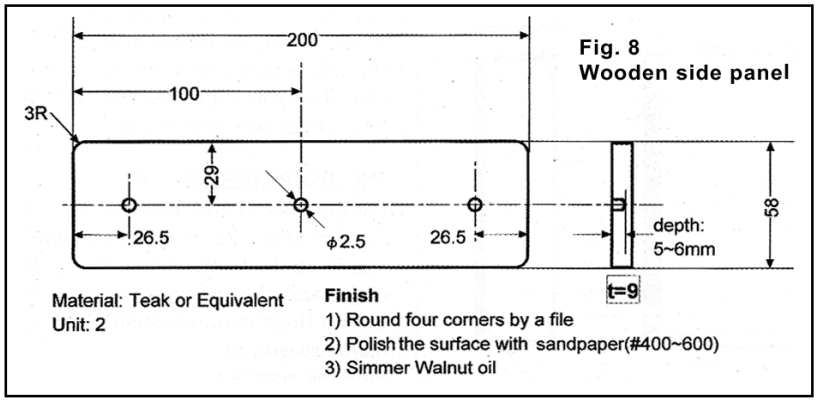
FIGURE 7C: Case drawing.

Sixth, attach an extension sleeve, rod, and axes onto the front panel. Finally, fix the AC line inlet, pilot lamp and so on *(Photo 1)*.

Soldering is needed only for the portion of the power supply and the input selector. To make assembly and maintenance as simple as possible, I devised a method of connectors and mating cables. The amplifier modules are linked with the volume control and power supply via such a cable *(Photo 2, Fig. 4)*.

The input-selector section needs soldering at 48 points: the RCA input jacks and each terminal point of the rotary switch, using 3 to 4" hook wires. This is the toughest job. To make this soldering easy, I strongly suggest fixing the hook wires to the terminal pins of the rotary switch before installing the switch in the internal case. The wire should be trimmed so its length reaches between the jack and its terminal *(Photo 4)*.

Finally, connect each module using a hook wire with a connector. I believe even a beginner can manage this wiring and soldering, since the soldering can be done outside of the case (*Fig. 11)*.



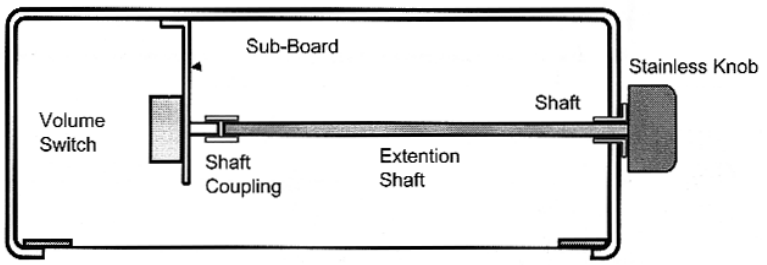


FIGURE 9: Volume-control and switch installation.

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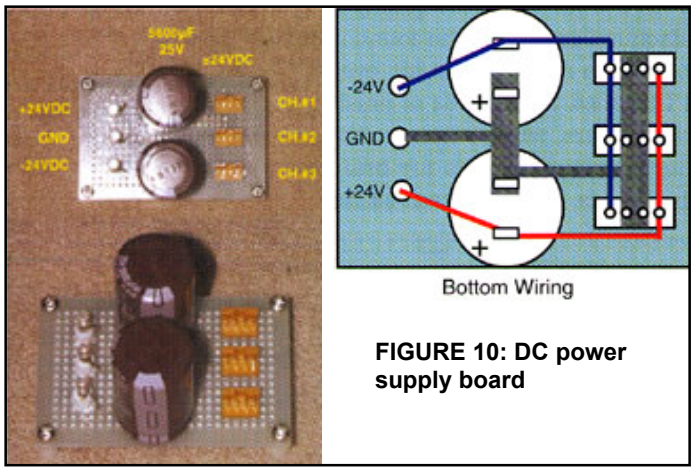

FIGURE 10: DC power supply board

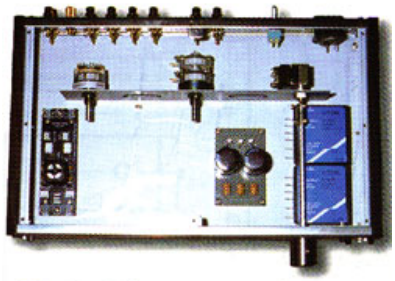

PHOTO 1: Major components installed.

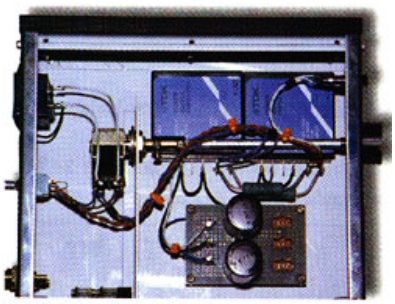

PHOTO 2: Power supply.

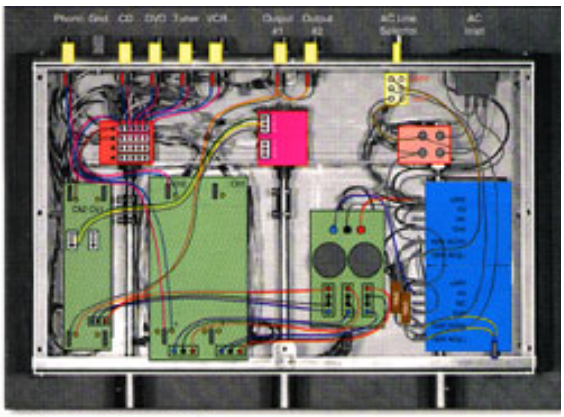

FIGURE 11: Internal wiring.

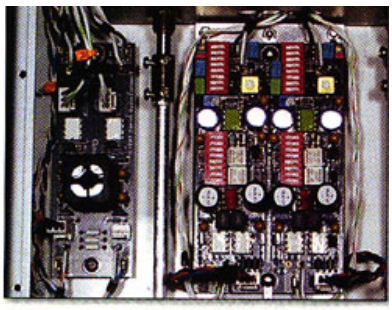

Photo 3: The amplifier modules

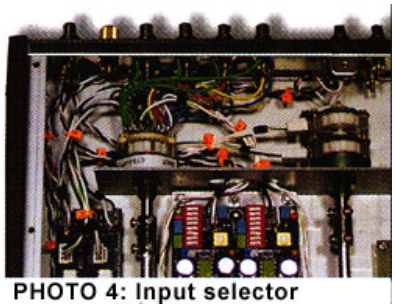

PHOTO 4: Input selector

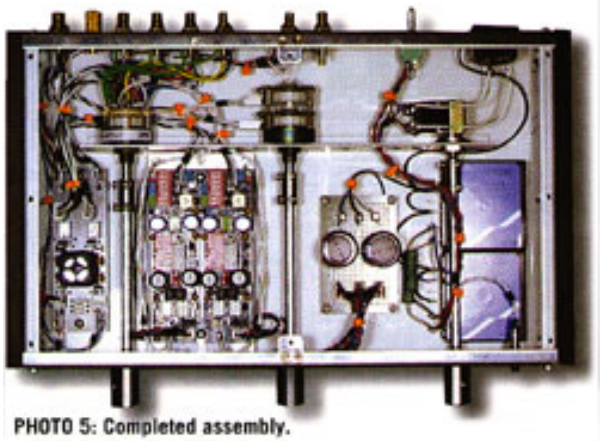

PHOTO 5: Completed assembly.

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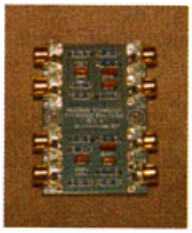
FIGURE 12A: KF-1 reverse RIAA filter.



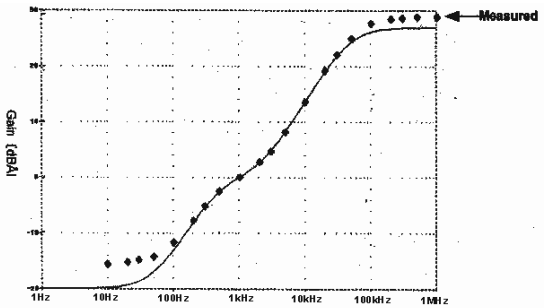


FIGURE 12B: KF-1 frequency response.

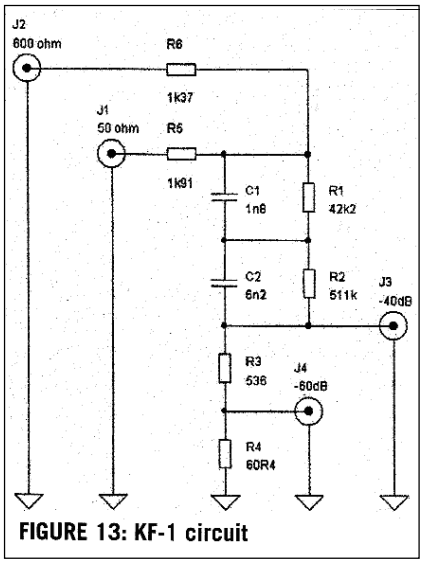


FIGURE 13: KF-1 circuit

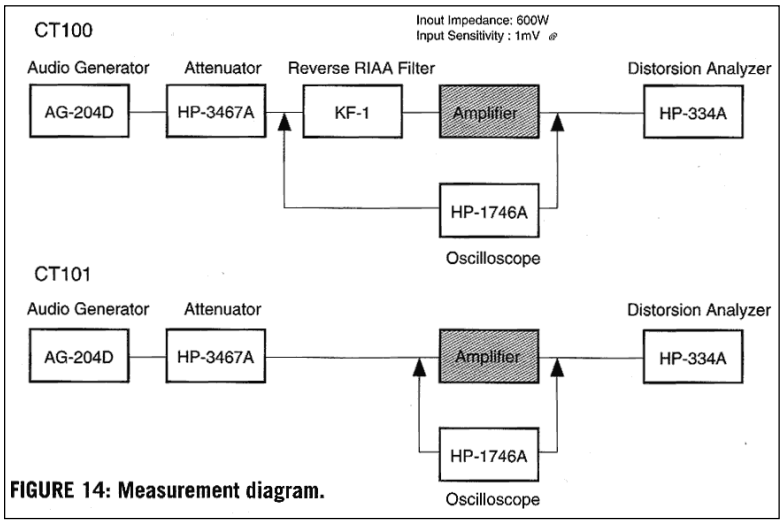


FIGURE 14: Measurement diagram.

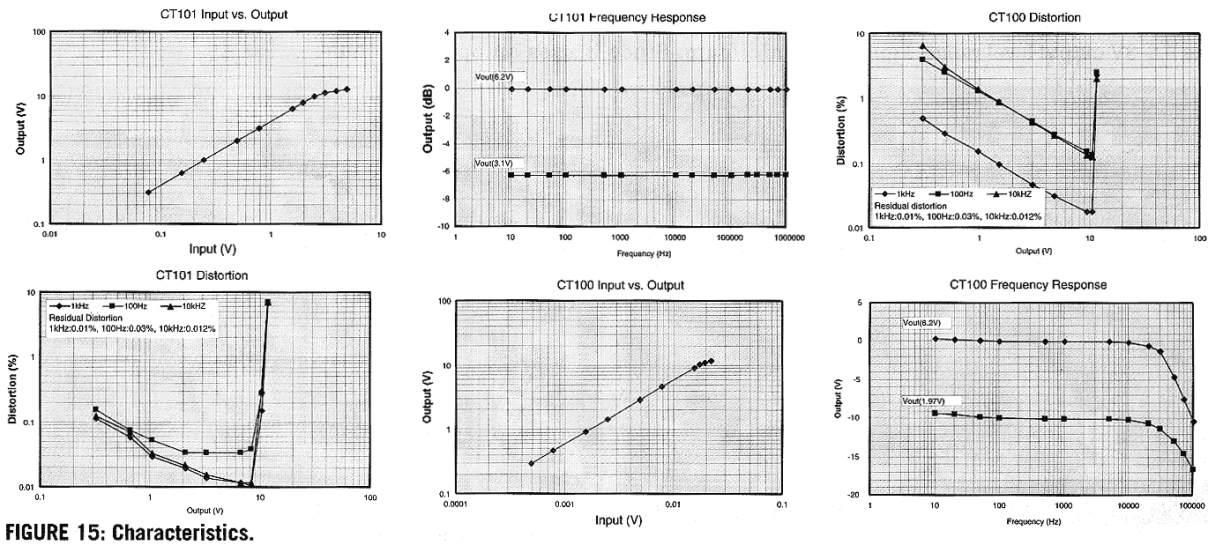


FIGURE 15: Characteristics.

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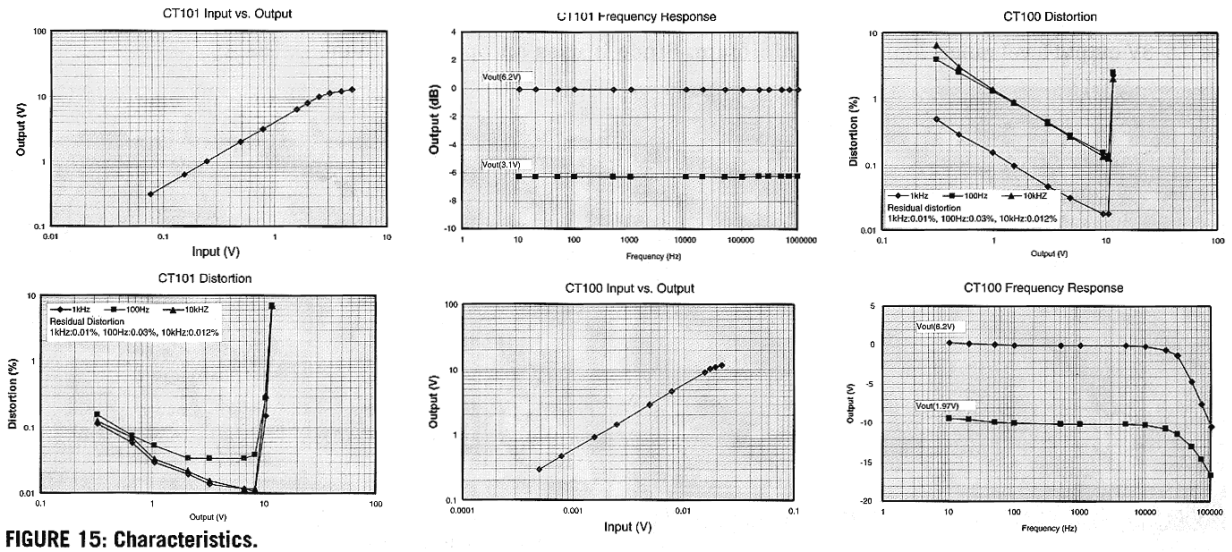

FIGURE 15: Characteristics.

ADJUSTMENT

No adjustment is required, but you should have a tester handy. You must check for wiring errors prior to turning on the power switch. Once you have checked and found no errors, disconnect the internal DC power connectors from the amplifier modules, then turn the AC power on.

Check the power-module output-pin level, which should be +24V or so. The module output voltage was adjusted at the factory, though you can change this by adjusting the trimmer, which is placed on the side panel.

After this, turn off the power, plug the connector cable back in, and turn the power on again for standby. *(Photo* 5).

MEASUREMENTS

First of all, I used an inverse RIAA network to see how the measured RIAA curve compared with the theoretical curve. The network features the fully complementary frequency-response curve against RIAA equalizing circuit, and provides both 600Ohm and 50Ohm input terminals and -40dB and -60dB output terminals *(Figs. 12a, b).* The circuit is easily assembled with the selected capacitors and resistors (*Fig. 13).*

The KF-1 circuit is easy to use since you can insert this network between an audio generator and the equalizer amplifier of CT100, which then generates a flat signal after equalization. If the output signal shows a flat frequency response, it would be assurance that the amplifier works well (*Fig. 14).*

- Input versus output characteristics (Fig. *15)*
  CTl00 showed very good linearity up to 10V output and also a stable gain factor of 6, for example, 600mV came out at the input level of 1mV. Also, CT100 generates a maximum output voltage of up to 10V. CT101 had as good linearity as CT100, also showing the flat gain of 12dB (4x of gain factor) up to 10V.
- Distortion (*Fig. 15)*
  CT100 showed a worse distortion at 100Hz and 10kHz than at 1kHz by one digit, though the lowest value showed as low as 0.1%. It might be desirable that the optimized input sensitivity would have the output level between 1 and 5V. CT101 showed a distortion below 0.1% in the 0.5—8V output-level range. I guess this is enough for regular usage, though at the output level over 10V, the distortion became dramatically worse.
- Frequency responses (*Fig. 15*)
  CT101 showed a very stable flat response over the frequency range from 10Hz through 1MHz and its deviation of gain is within 0.5dB. Even at a -6dB volume position against the maximum, the flat response curve showed performance to be stable.
- Waveform (*Fig. 16*)
  Since CT101 features a wide bandwidth of frequency-response curve of 25MHz, the square wave comes out without any distortion, overshoot, sags, and so on. On the other hand, the oscillator signal integrity might be a question. I do not see degradation of even 1MHz sine wave.

Building a complete 2-channel DACT preamp

By Satoru Kobayashi

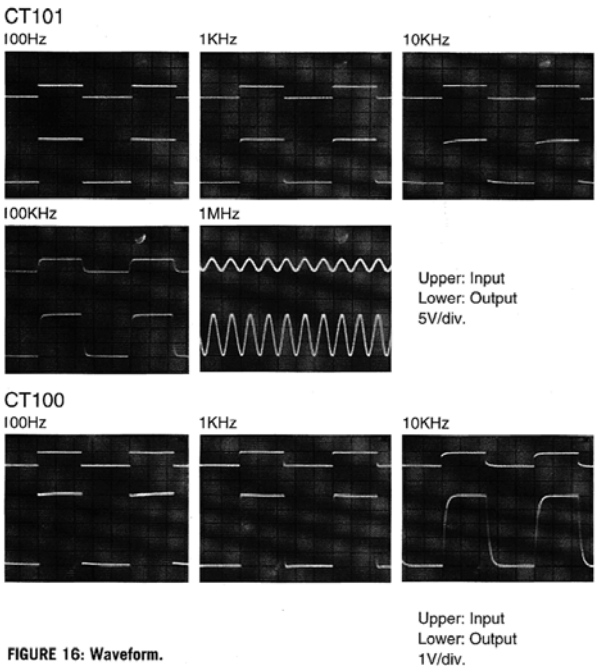

FIGURE 16: Waveform.

- Residual noise voltage. The measured residual output-voltage level was 0.1mV at both channels when the volume position was the minimum. Since it uses an operational amplifier, CT101 generates a few mV DC offset voltage caused by a deviation in the fabrication of IC chips. I measured a 1.2mV DC offset level. So this might generate a pop noise through your speaker system when switching a selector. If this concerns you, I suggest inserting a capacitor into the output terminal to cut off this DC residual level.

Even when driving my homebrew SCX300A1pp amplifier with this preamp, the residual output voltage at this main amplifier was only 0.5mV to 0.6mV, so that I cannot recognize any hum at all through my JBL S3100 speaker system.

Also, I have checked the residual noise of the CT100 EQ amplifier by setting its input sensitivity to 0.25mV. The measurement of the output level of CT100 through CT101 was 0.2mV, 0.3mV at both channels when the volume position was the minimum. When tuning the volume level to the maximum, the output level at the main amplifier read several units of 10mV, though I could not hear any hum.

LISTENING IMPRESSIONS

I brought this amplifier to a friend's home and tested with his JVC direct-drive turntable system and Ortofon MC-20 cartridge. First of all, the sound coming from this preamplifier was very impressive, since its sound is as clear and dynamic as if it surpassed the quality of a manufactured amplifier. The sound itself brought me no fatigue at all, even though I listened to all kinds of music for several hours, while a low-quality amplifier sometimes kicks my brain through my ears. The tone itself seems very soft and mild, though; it was dynamic, bringing more realism than if I were at the concert hall.

Changing the source from an LP to a CD, I checked the buffer-amplifier characteristics. This is really nice sound making me forget about the presence of this buffer amplifier. Since this amplifier did not add any extra taste of sounds, it seems to me it is a monitor amplifier as well.

To close this listening test, when listening to the speaker system that I used, JBL 53100, I could no longer hear any microphonic noise. I think this is due to the extremely high S/N ratio of the buffer amplifier.
Furthermore, there was no hiss. Due to the ultra-low output impedance of 0.1Ohm, the residual noise-floor level of the main amplifier driven by this preamp is extremely low, below 1mV. This shows the cleanliness of this amplifier, due to the premium DACT components.

I am very satisfied with the performance and the quality of this amplifier, so I am confident that anybody, even beginners, can build this amp and achieve the same quality and performance as a manufactured preamplifier - with simple assembly and less labor than ever before.

TABLE 1
PARTS LIST

UNITS	PART	MODEL, SPECIFICATION, MANUFACTURER	PRICE
1	EQ amplifier module	CT100, DACT	US$ 4951
1	Buffer amp. module	CT101 DACT	US$ 1451
1	Rotary switch	CT3-5-4/wire, DACT, 4-pole, 5-position	US$ 62.10
1	Volume control	CT2-10K-2, DACT, 10kOhm	US$ 136.10
3	Knob	CT-knob1, DACT	US$ 43
3	Extension Shaft kit	CT-ext1/S, DACT	US$ 46.20
1	Custom made case	320 x 200 x 55mm, stainless steel, San El Musen	¥ 15,000
1	Side wall	Teak, 200 x 58 x 9mm	¥ 3,000
1	AC power inlet module	10A250V, NI000N	¥ 300
1	Power switch	ARNO1, 25A 1 25V, OTAX	¥ 850
1	AC line vol. sel. switch	125V 6A, 2-pole, 2-pos. ML206, ALCO	¥ 750
2	Switching power mod.	100VAC, 24V 0.13A, FMP24-R13, TDK	¥ 800
2	Electrolytic capacitor	5600 uF 25V, Nichicon	¥ 600
1	Epoxy PC board	SW-272, Sanhayato	¥ 100
1	PC board conn. set		¥ 600
2	Pilot lamp	Neon type	¥140
7	RCA pin jack	BS-01 5	¥ 4,900
1	Metal feet	IAG (USA)	US
	Screws & nuts	3mm dia. hex nuts, washer, etc.	¥ 500
1	Hook wires	five colors 5m-roll	¥ 1,500
		Grand total	¥ 133,000 (¥ 80,000[3])

w/o sales tax, US$=107 Yen

(Notes)
1) Price at DACT direct, including the shipping fee from Bangkok
2) Price at IAG direct
3) Option: w/o CT100, for the line amplifier

REFERENCES
CT100, CT101 Installation Instruction
DACT Technical Bulletin
Downloaded at http://www.DACT.com/

MEASUREMENT EQUIPMENT
Audio analyzer HP-334A
Audio generator, Kenwood AG-204D
Reverse RIAA fitter, Hageman Technology KF-1
AC voltmeter, HP-403B
Attenuator, HP-3467A
Digital multimeter, Fluke 8020A
Oscilloscope. HP-1746A

RESOURCES
EQ Amplifier, Volume control, Rotary Switch
Danish Audio ConnecT Thailand. Ltd.
15th FL, Unit 1501/3
Ban Chang Glas Haus Bldg.
1 Sukhumvit Rd., Soi 25
Bangkok. 10110 Thailand
(+662) 260-6070
Fax: (+662) 260-6071
E-mail: info@DACT.com
URL: http://www.dact.com/

Reverse RIAA Filter
Old Colony Sound Lab
305 Union Street, P0 Box 876
Peterborough, NH 03456-0876 USA
+1-603-924-6371
Fax: +1-603-924-9467
E-mail: custserv@audioXpress.com
URL: http://www.audioXpress.com/

Others (Tokyo, Japan)
Suzusho
Radio Store
Neji-No-Mizutani
Taiger Musen
Tokyu-Hands
Abo-Denki

Building a complete 2-channel DACT preamp

By Satoru Kobayashi

Comment received by DACT directly from the author of the article, Mr. Satoru Kobayashi:

I suggest to add a muting circuit disconnecting the output terminals. The muting circuit should be activated for 30 seconds or so when turning on the power switch. Because, at power on, the switching regulator driven by the mains voltage generates a buzz noise at the output terminals due to its transient phenomenon, causing high-level transient noises to be sent to the speaker systems.
Particularly when this amplifier would be hooked to a solid state amplifier, and turning it on simultaneously, then the buzz noise would go into the power amplifier driving the speaker system.

As another way to prevent this from occurring, I can suggest that the sequence of power on is to power on this amplifier first, then making a pause and turn on the power switch of the power amplifier. This would also be a safe way of operation.