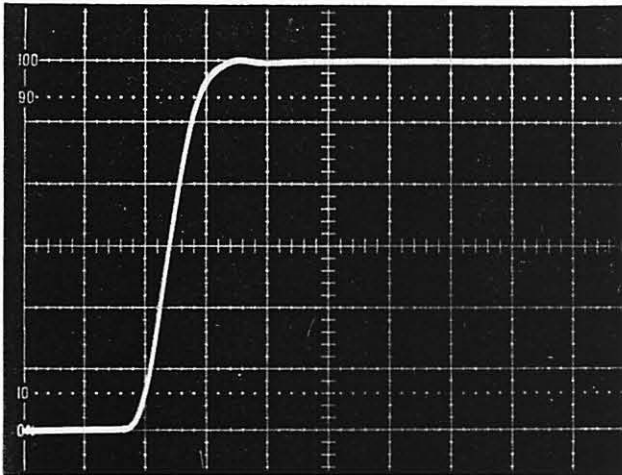# Data Sheet

jensen transformers
INCORPORATED

JE-DB-E
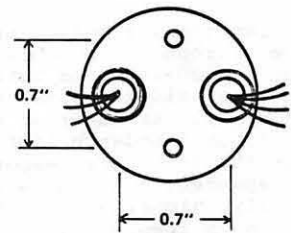# DIRECT BOX
TRANSFORMER

5 μS/division

REGARDING THE OSCILLOSCOPE PHOTO
This actual oscilloscope photo was made from a Tektronix Model 453A (certified calibration). The transformer was fed with a source impedance of 20 K ohms (representing a typical pickup) and had a load impedance of 1K ohm (representing a typical mic preamplifier input).
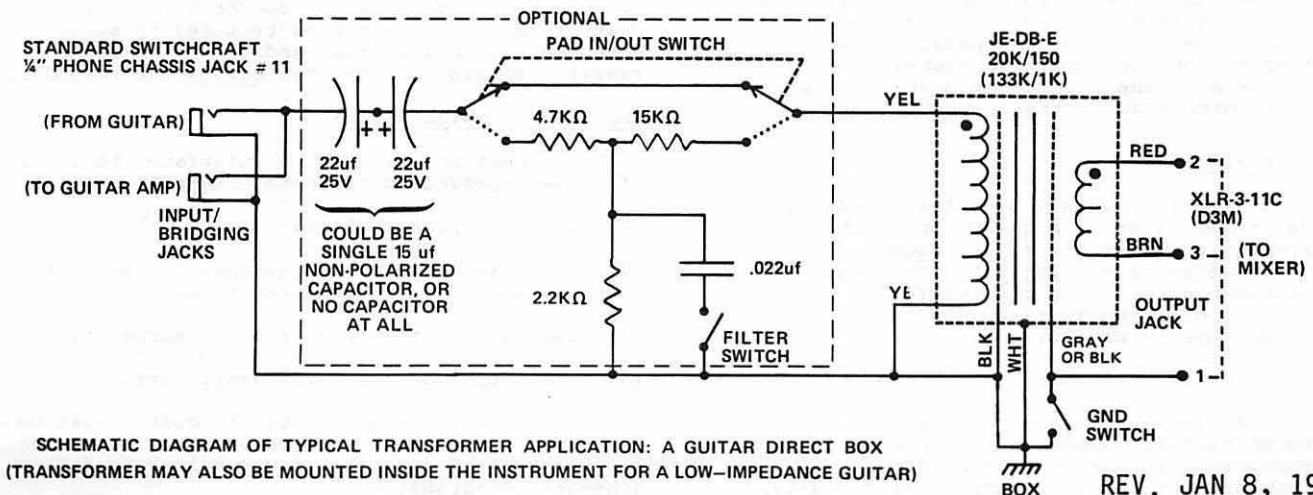

1-1/8"
7/8"

Side View

0.7"
0.7"
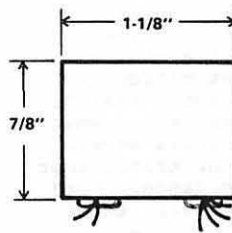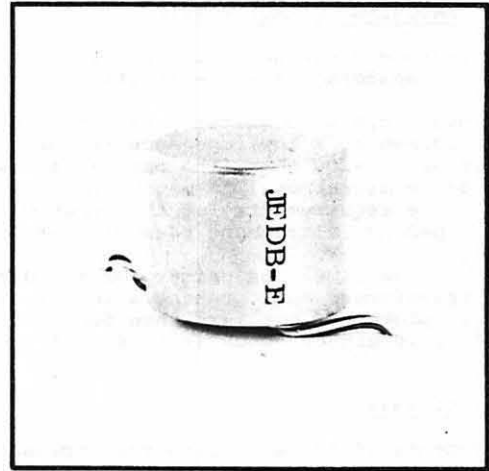
Bottom View

Mounting Holes
Clearance for #4 screw
Lead Holes
Use 0.35" hole to clear grommet

✳ PLEASE SEE LAST PAGE FOR CURRENT Schematic

STANDARD SWITCHCRAFT ¼" PHONE CHASSIS JACK # 11

(FROM GUITAR)

(TO GUITAR AMP)

INPUT/ BRIDGING JACKS

22uf 25V   22uf 25V

COULD BE A SINGLE 15 uf NON-POLARIZED CAPACITOR, OR NO CAPACITOR AT ALL

OPTIONAL PAD IN/OUT SWITCH

4.7KΩ   15KΩ

2.2KΩ

.022uf

FILTER SWITCH

JE-DB-E 20K/150 (133K/1K)

YEL

YE

BLK   WHT

RED   2

XLR-3-11C (D3M)

BRN   3   (TO MIXER)

OUTPUT JACK

GRAY OR BLK

1

GND SWITCH

BOX

SCHEMATIC DIAGRAM OF TYPICAL TRANSFORMER APPLICATION: A GUITAR DIRECT BOX
(TRANSFORMER MAY ALSO BE MOUNTED INSIDE THE INSTRUMENT FOR A LOW-IMPEDANCE GUITAR)

REV. JAN 8, 1985

JE-DB-E

IMPEDANCE MATCHING CHARACTERISTICS

The impedance matching requirements of the direct-box transformer are bi-directional.

(a) The high impedance guitar pickup must be transformed to a low impedance in the range of 150-200 ohms (the same as a low impedance microphone) to match the source impedance requirements for the input of a low impedance microphone preamplifier.

(b) At the same time, the primary of the direct-box transformer must present a load to the guitar pickup of not less than 50K ohms, and preferably higher, such as 100K ohms.

Synthesis of (a):

Measurements of the actual source impedances of many guitar pickups indicate some variation centering around 20K ohms. The impedance ratio of 20K/150 was chosen to match the average guitar pickup to a low impedance in the range of 150-200 ohms to satisfy requirement (a).

It is important to match the input of a low impedance microphone preamplifier with a source impedance of 150-200 ohms because most microphone preamplifiers utilize an essentially unterminated, high-ratio input transformer exhibiting a somewhat reactive input impedance (not a pure resistance). Therefore the frequency response of the transformer will be dependent upon the source impedance. More specifically, higher source impedances will cause a loss of high frequencies, and lower source impedances will cause a high frequency peak or resonance. This resonance creates transient distortion, which can be heard as a rough or raspy high-frequency distortion, sometimes referred to as an "edgy" sound. It is often described as a "lack of transparency". This resonance can be evaluated in the laboratory by observing the overshoot and ringing of a square wave on an oscilloscope. To avoid this potential source of transient distortion, or frequency response error, created by operating the microphone preamplifier's input transformer from a source impedance outside it's optimum range, the source impedance must be on the order of 150-200 ohms. Of course, the transformer used in the direct-box must also be free from resonances as is the JE-DB-E.

Synthesis of (b):

The actual input impedance of a low impedance microphone preamplifier is not 150 ohms. The 150 ohm specification refers to the <u>required</u> source impedance to be <u>connected to the input</u>. The load impedance which the preamplifier presents to the microphone is usually on the order of 1000 ohms or higher.

This is done for two reasons:

(1) The higher load impedance results in improved high-frequency performance of many microphones. In the case of condenser microphones with built-in amplifier circuits, the headroom may be improved, resulting in lower distortion.

(2) The higher load impedance also results in 4 to 5 dB higher output level from the microphone, which yields improved signal-to-noise ratio.

The impedance ratio of the direct-box transformer has been determined by the synthesis of (a), which concerned the impedance transformation of the source impedance of the guitar pickup to a new source impedance at the secondary. Of course, the transformer also transforms impedance in the other direction by the same ratio, or more properly, by the reciprocal of that ratio. The 20K/150 ratio determined in (a) reduced (divided) the source impedance by a factor of 133. Likewise the input impedance of the microphone preamplifier will be increased (multiplied) by 133 to a new input or load impedance at the primary. The resulting load impedance which the primary presents to the guitar pickup is 133K ohms, satisfying requirement (b).

SPECIAL CONSIDERATIONS

Note that the direct-box transformer must operate as a 20K/150 ohm transformer in one direction, and as a 1K/133K transformer in the other direction. This requires some special design attention to response characteristics and losses. For example, the primary must exhibit high inductance and low capacitance in order to avoid loading the guitar pickup at the extremes of the frequency range. If these reactive loading effects were not considered, both high and low frequency response losses would result due to the high actual source impedance of the guitar pickup. The JE-DB-E direct box transformer exhibits reactive loading, equivalent to about 600K ohms across the primary, which does reduce the 133K figure to about 110K ohm load across the guitar pickup...still within acceptable limits to satisfy requirement (b).

Operation of a transformer from a high actual source impedance also results in low frequency distortion if the primary inductance is too low or if the magnetic material used exhibits excesive hysteresis losses. For these reasons, special attention has been given to both the magnetic material characteristics and the winding configuration.

To evaluate any of the performance parameters of a transformer in the laboratory, always simulate the actual source and load impedances which will be encountered during operation. In this case, a 20K ohm resistor is required <u>in series</u> with the test oscillator, and a 1K ohm load resistor should be connected <u>across</u> the secondary.

GROUNDING CONSIDERATIONS

The direct-box is used to interface the input of a low impedance microphone preamplifier to:

(1) a guitar pickup alone.

(2) a guitar pickup which is also connected to the input of a guitar amplifier.

(3) the output of an electronic instrument.

(4) the output of the guitar amplifier.

In case (1), the ground of the guitar must be connected through to the ground of the recording equipment by closing the ground switch (refer to schematic diagram).

In all the other cases, which involve electronic equipment, the ground of the signal source may need to be isolated from the ground of the recording equipment for lowest hum and buzz. The decision to operate with the ground switch open or closed is always made "on the spot".

Referring to the schematic diagram, note that the box itself is connected to the input ground, rather than the ground pin #1 of the 3 pin output connector. This decision results in lower buzz in the guitar amplifier in case (2). If the box were connected to the output ground, the capacitance between the box and the internal wiring to the guitar amplifier input could cause hum or buzz into the guitar amplifier with the ground switch open. However, with the box connected to the input ground, as shown, caution must be taken to avoid any connection between the outer shell of the output connector and pin #1, which would short across the ground switch. This would occur if the cable connector used at the output had an internal strap between the shell and pin #1. The safest solution is to use a mounting for the 3 pin output connector which insulates it from the box.

The schematic diagram shows the input connectors as insulated bushing types to avoid ground currents from flowing in the metal of the box itself. Actually a non-insulated type connector would not cause any ground currents if the only connection to the box is at the connector.

With the ground switch open, a voltage potential could exist between the direct-box and the microphones or stands. If the direct box is allowed to make contact to a mic stand, the resulting ground current could cause hum or buzz. Caution should be exercised to avoid personal contact with any two of these metal objects simultaneously to avoid shock hazard.

DUAL FARADAY SHIELD

A Faraday shield is a copper foil shield inserted between the primary and secondary windings. Sometimes called an electrostatic shield, it's purpose is to significantly reduce the capacitive coupling from the primary to the secondary. This type of shielding gives the transformer it's common-mode rejection characteristics usually referred to as isolation.

Referring to the schematic diagram, note that the JE-DB-E has two Faraday shields, as indicated by the two vertical dashed lines between the windings. One surrounds the primary winding, the other surrounds the secondary. The use of two Faraday shields yields excellent isolation in both directions. The secondary shield significantly reduces hum and buzz in the microphone preamplifier (recording equipment). The primary shield prevents hum and buzz in the guitar amplifier in case (2). Without the primary shield, capacitive coupling from the secondary shield to the high side of the primary would cause hum or buzz in the guitar amplifier. The leads for each winding and its respective shield are brought out through seperate holes in the case to maintain even lower capacitance between primary and secondary circuits (improved isolation). Note that, in the direct box shown, each Faraday shield is connected to its respective ground circuit. The ground switch connects the two ground circuits together when it is closed.

The mu-metal case of the transformer provides 30 dB of magnetic shielding to prevent hum pickup in the transformer itself. The case has a separate white lead and is connected to the box.

PAD CIRCUIT

For cases (1) & (2), the pad is switched out of the circuit when the signal source is a guitar pickup. For cases (3) & (4), the 10 dB pad is switched in to prevent overload of the transformer from higher output levels, i.e., from electronic instruments or guitar amplifier speaker outputs.

The pad presents a load to the output of the electronic instrument of about 6800 ohms and a source impedance to the direct-box transformer of about 16K ohms (approximating the guitar pickup). The latter is required to prevent transient distortion in the microphone preamplifier as described in requirement (a) under "impedance matching characteristics".

Electronic instruments may have some DC voltage present at the output which would cause low frequency losses and distortion in the direct-box transformer. The two electrolytic capacitors in series with the input signal block this DC voltage to maintain optimum low frequency performance.

FILTER CIRCUIT

The output signal of a guitar amplifier may exhibit severe clipping from amplifier overload. However, the high frequency roll-off characteristic of the typical guitar speaker attenuates the resulting distortion products which are upper harmonics of the fundamental notes.

Since the direct-box transformer does not roll off these upper harmonics, the clipping or distortion will be heard in the recording. The filter circuit can be switched in to simulate the high frequency roll-off characteristic of the guitar speaker, more closely approximating the speaker's sound. The filter response is 6 dB per octave starting at about 4 kHz to 5 kHz. The value of the filter capacitor can be changed for more or less high frequency attenuation.

GUITAR CABLE LOSSES

The capacitance of a coiled guitar cable can be in the range of 1000 pF or greater. If the source impedance of the guitar pickup is in the range of 20K ohms, the resulting high frequency roll-off starts at about 8 kHz. There will be even more high frequency losses if the cord is longer or if the pickup impedance is higher.

This loss of the upper end of the frequency spectrum will affect the "brilliance" of the instrument. All of this suggests that the shorter the cable length between the high impedance pickup and the direct-box, the better the sound.

LOW IMPEDANCE GUITAR CONVERSION

Given enough space, the direct-box transformer can be installed in the guitar to significantly reduce the capacitive load on the high impedance pickup. A connector on the secondary would then be a low impedance output which could drive a very long cable without high frequency losses (the same as a low impedance microphone). Since the low impedance conversion of the guitar also creates a step-down 20 dB voltage loss, a reciprocal conversion would be required at the guitar amplifier input. A microphone input transformer (step-up) installed in the guitar amplifier input circuit will complete the conversion. Then the cable would be connected from the secondary of the direct-box transfoemer to the now low impedance input of the guitar amplifier. The result will be a considerable improvement in high frequency response or brilliance, even with long cables.

The graphs shown are actual measurements using the Hewlett-Packard 8903A audio analyzer, interfaced to a 9872A plotter, controlled by a 9845T desktop computer.

JE-DB-E GENERAL CHARACTERISTICS

Turns Ratio
11.55:1
Impedance Ratio
20K/150
Primary Source Impedance
20K ohms (typical guitar pickup)
Secondary Load Impedance
1K ohms (typical mic pre input)
Faraday Shield
Two shields, separate leads
Magnetic Shield
30 dB, separate lead
**Maximum Input Level at 20 Hz**
+19 dBv (Re: 0.775v)

PHYSICAL CHARACTERISTICS

Package
Mu-metal can
Termination
Wire leads
Dimensions
1-1/8'' diameter, 7/8'' high
Mounting
2 holes, 0.7'' center-to-center,
self-tapping screws supplied

TYPICAL PERFORMANCE

Voltage Loss
20.7 dB
Input Impedance
135K ohms @ 1 kHz
107K ohms @ 10 kHz
Secondary Source Impedance
265 ohms @ 1 kHz
278 ohms @ 10 kHz
Total Harmonic Distortion (Below Saturation)
0.096% maximum @ 20 Hz
0.054% maximum @ 30 Hz
0.026% maximum @ 50 Hz
0.0048% maximum @ 1 kHz
Input Level @ 1% Saturation (dBv Re: 0.775v)
+19 dBv @ 20 Hz
+24 dBv @ 30 Hz
+30 dBv @ 50 Hz
Frequency Response (Re: 1 kHz)
−0.2 dB @ 20 Hz
−0.2 dB @ 20 kHz
(No resonance peak)
−3dB @ 80 kHz
Phase Response
−18° @ 20 kHz
Rise Time
4.5 μS (10%-90%)
Overshoot
<1%
Common-Mode Voltage (maximum)
>1000v peak
Common-Mode Rejection Ratio
>85 dB @ 1 kHz
>65 dB @ 10 kHz

FREQUENCY RESPONSE
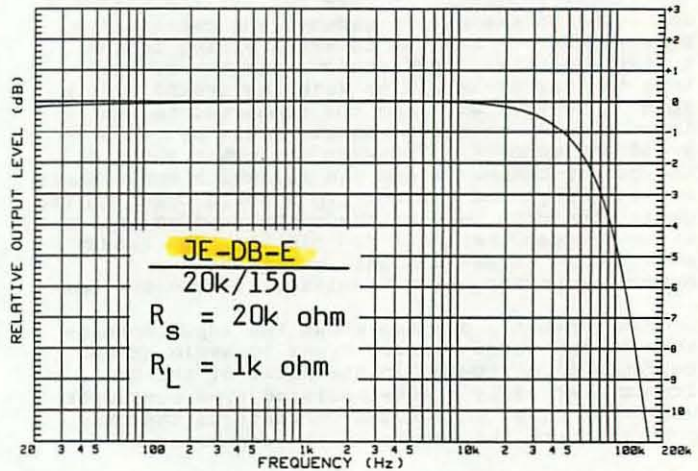
DISTORTION
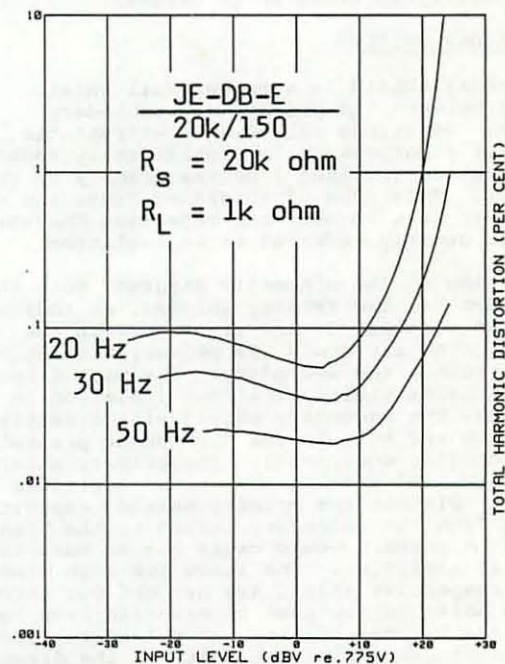
MECHANICAL DESIGNERS: Dimensions are approximate. Please have a transformer in hand when laying out panel cutouts.