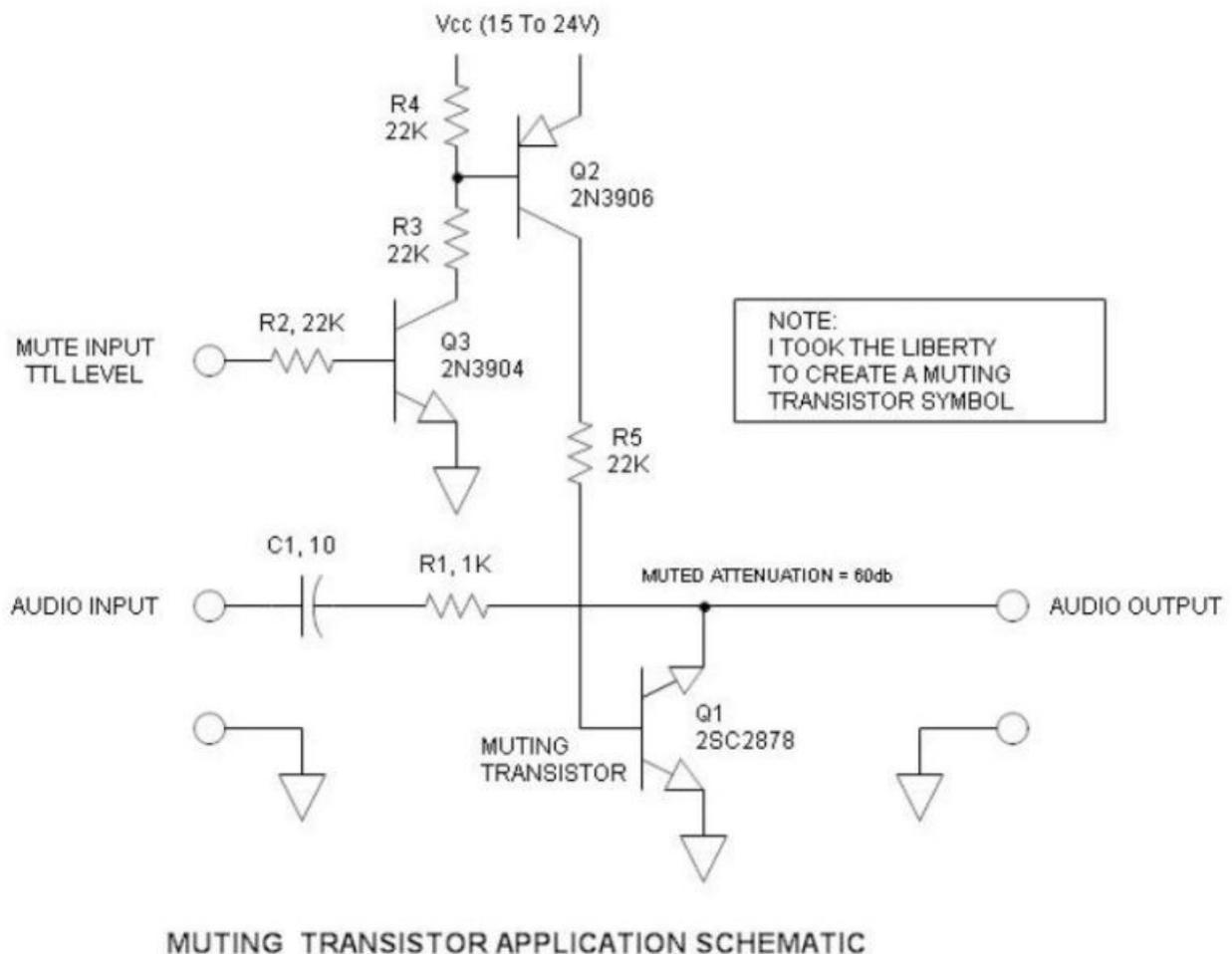
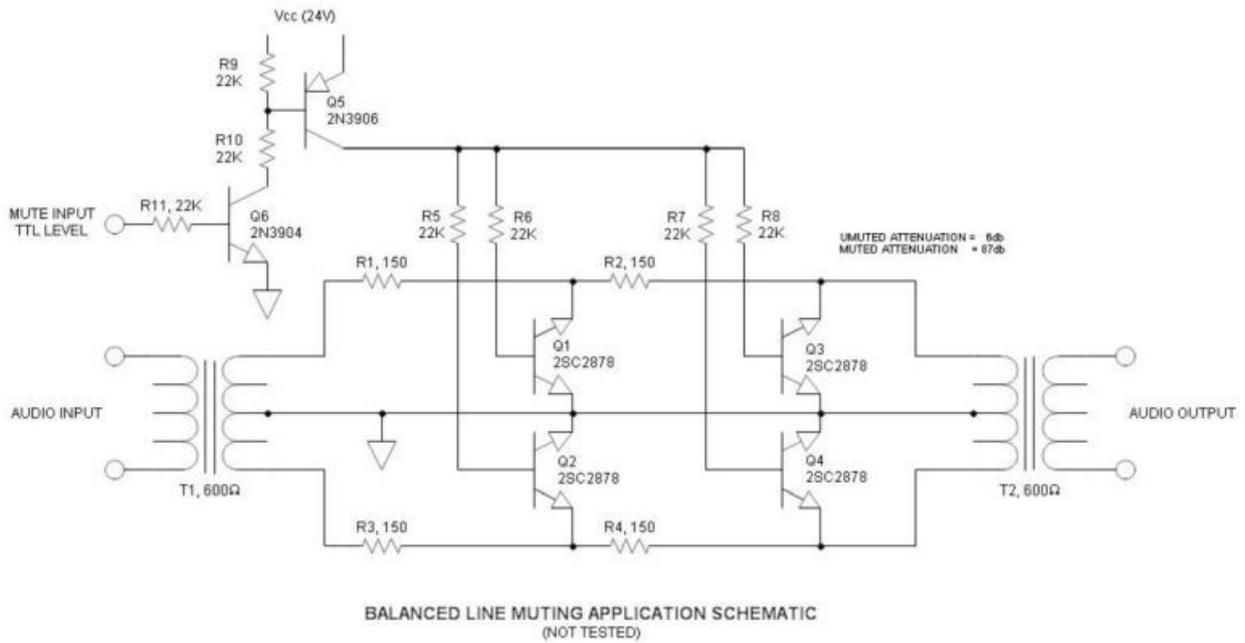


Muting Transistor Attenuator Circuits and the 2SC2878

Among semiconductors, the muting transistor and its audio application is perhaps the most obscure and poorly understood of all. There is extremely little information on this subject available on the internet and what is available is sketchy.

Schematics



Applications for muting circuits.

Types of muting circuits.

Obviously, the function of muting circuits is to mute (kill) the audio signal. This can be done in a number of ways including switches, relay contacts, junction FETs, analog switches and bipolar muting transistors. Switch and relay contacts can be noisy and intermittent due to contact bounce. Furthermore, properly applied contacts must be dry circuit rated due to both the low current and potential across the contacts –this forces the use of bifurcated dry circuit contacts that are special and expensive. While a junction FET is sometimes applied as a variable attenuator, its use as a muting device is a misapplication due to the lack of symmetry because it cannot support more than about 600mV due to its intrinsic body diode. Analog switches can do the job if applied correctly, but lack the audio range required in professional line and level applications, may be subject to crosstalk between sections and are also very sensitive to ESD. On the other hand, the bipolar muting transistor does everything well and inexpensively.

What is unique about the bipolar muting transistor?

The standard NPN transistors is symmetrical in that it consists of 3 layers, 2 layers of “N” material (collector & emitter) separated by a layer of “P” material (base). However, that is as far as the symmetry goes as the layer thicknesses and doping varies greatly. The standard transistor still functions with the collector and emitter terminals reversed, but the hFE (current gain) in this mode is reduced by perhaps two orders of magnitude and the reversed voltage rating (V_{beo}) generally limited to about 5V.

In comparison, the muting transistor is a good deal more symmetrical –it has high reverse hFE and some types offer a 15 to 40V base to emitter reverse voltage rating (V_{beo}). In effect, it is rated for AC operation and this suits it well for audio voltage signals that are AC in nature. Whichever terminal (emitter or collector) is the most negative becomes the effective emitter terminal. If sufficient base drive is applied, it will saturate either polarity, and this is exactly what is required to implement the mute function.

Two categories of muting transistors.

The two categories are graded by the base to emitter reverse voltage rating (V_{beo}).

The 1st category V_{beo} is limited to 5V and is suited for consumer electronics that has an average program signal level of -7.8dbu (0.315V_{rms} or 0.445V_{peak}). A 5V rated device provides 21db headroom to handle program material transients.

The 2nd category V_{beo} starts at 15V and is suited for professional studio line and level devices that have an average program signal level of +4dbu (1.228V_{rms} or 1.736V_{peak}). A 15V rated device provides 18.7db headroom to handle program material transients.

Preferred devices for the experimenter

Toshiba 2SC2878, TO-92, V_{beo} = 15V, reverse hFE = 150 typ, obsolete but many remain in the surplus pipeline –this is the only thru-hole device available –get some from eBay while available, \$0.85 each.

Every experimenter should have some of these in his bag of tricks.

Rohm 2SD2407K, SO-23, V_{beo} = 25V, DigiKey 2SD2704KT146CT-ND, \$0.52 each.

Interesting Data Sheet Circuits.

●Ron measurement circuit

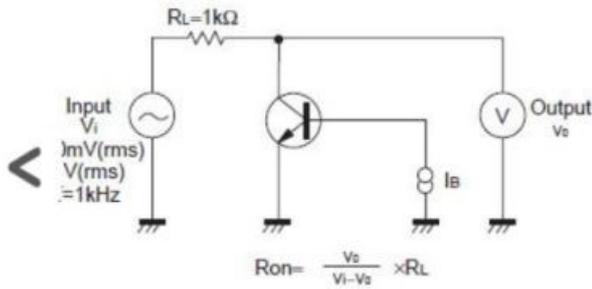


Fig.15 Ron measurement circuit (I)

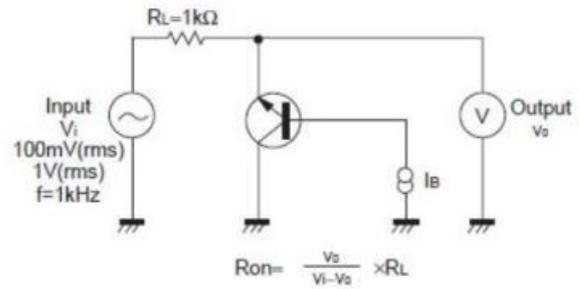


Fig.16 Ron measurement circuit (II)

Muting transistor failures –frequent repair item.

Muting transistors are susceptible to ESD and have a high failure rate. This is not because they are different than other semiconductors, but where they are used in the circuit –at the output connector. I believe that the main reason for failure is the widespread use of the ancient, sub-standard RCA phono jack connector –the long center pin establishes initial contact directly to the muting transistor before the ground sleeve makes contact forcing any charge directly into the transistor. This discharge destroys or degrades the transistor. ESD protection may be provided or added, but I believe that it is still a race as to which device fails first: the ESD protection device or the transistor. To avoid ESD damage, the best preventative measure is to touch the sleeve of the connector to the chassis before plugging in the connector –and remember that cables have two ends.

Note that only the relay method is not susceptible to ESD.

Driving the muting transistor –IMPORTANT DETAIL!

When OFF, the muting transistor base drive must be high impedance over the entire signal voltage swing – in other words, the base may not simply be grounded because it would act like a diode when the signal swings negative. Base drive is best provided via a PNP transistor connected to the positive 15 to 24V rail – a series resistor limits the base drive to approx. 1mA. Multiple muting transistors may be driven by the same PNP transistor because all base inputs tend to act as diodes when OFF and all ‘anodes’ may be effectively tied together thus preventing reverse base current flow or interaction.

Attenuation.

A muting transistor has very low ON resistance –in the order of 1Ω . With a 1K audio signal source resistance, it provides 60db attenuation –this is much better than the best analog switches in the ON mode. In audio mixer applications additional attenuation (perhaps 80db) is recommended to completely silence unused inputs. The additional attenuation may be provided simply by cascading two attenuators. Measured attenuation = 51db ($R_5 = 22\text{K}$, $I_b = 650\mu\text{A}$). This attenuation could likely be significantly improved by reducing the value of R_5 .

Note that this is not effective as a linear (adjustable) attenuator.

Other uses for the muting transistor.

Other uses include low voltage synchronous transistor experiments, and any application that needs a high V_{be} reverse voltage rating.

