



About Resistor Types

There are many types of resistors available and used in amplifier circuits, and each type has characteristics that can be favorable or unfavorable when used in different parts of the circuit. There is not really any one type that is best for all applications. This information is provided to aid in the optimum selection of resistors for your amp. I am not an expert on this but I am presenting a consensus of information I have researched. This is information not generally provided in manufacturer's datasheets.

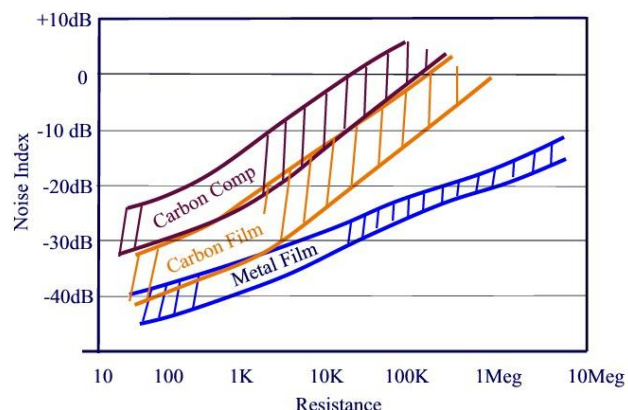
The general types of resistors offered on my site are Metal Film, Carbon Film, Carbon Composition, Ceramic, and Wirewound. The Metal Film resistors are of two types. I offer the common 300 volt rated import metal film resistors which are fine for many applications and are 1% or 5% tolerance. They're similar to what you would find at say a Radio Shack store, and probably what are used in most places in many current production amps. But voltages in nearly all tube amplifiers are in some parts of the circuit above 300 volts, so I also offer a selected range of 500v rated premium Vishay 1% metal film resistors. These are ½ watt sized, but rated by the manufacturer for ¾ watt up to 1 watt. The Carbon Film resistors are current production 350v. rated 1% or 5% imports. The Carbon Comp and Wirewound types are mostly New Old Stock, USA made if I can find them, but I also carry a selection of the currently produced IRC, Xicon, KOA, or TE (Tyco) versions that are still available. Many of these are going end of life and are getting harder to find. Most of the carbon comp resistors are rated 350v or sometimes 500v. I don't stock all values in all types. The wirewound and ceramic block resistors are used for power resistors, I carry only a few selected sizes.

Vintage amplifiers used mostly carbon composition and wirewound resistors, because that was all that was available for practical applications at the time they were designed. Now those types are getting scarcer, as the manufacturers discontinue production. Many carbon comps ended production in the late 1990's. Carbon composition resistors were made by mixing powdered carbon and binder into a vulcanized rubber, phenolic, or ceramic rod, to which the leads were attached. The amount of carbon determined the resistance. Closer tolerances were achieved by testing and selecting. Carbon film resistors are made by printing an insulating ceramic substrate with ink containing carbon particles or by depositing amorphous carbon on a ceramic substrate which is then cut into a helix by using laser or diamond cutter techniques. Metal film resistors are similarly made but with vacuum deposition of thin metal films on the substrate. Wirewound resistors are usually made by wrapping a fine nichrome wire around a ceramic rod. All types are then insulated with a coating and usually color coded.

There is much controversy in the various forums over the type of resistors needed for the best vintage tube amp tones. Some will say to use all carbon comp types, and others will say use metal film only, or a mix of types. A few choose carbon film as a compromise between the two types. Carbon comp resistors are somewhat noisy, and have a voltage coefficient of resistance. All resistors have a temperature coefficient of resistance, but carbon comp particularly, and to some extent carbon film and metal film have a significant change in resistance when different voltages are applied. This does introduce some distortion, which may be considered good in some ways. Some say this voltage coefficient distortion is pleasant and warmer sounding, and thus is the key to the magic vintage tone of carbon comp resistors while others say it is not significant. Voltage coefficient is measured in percent or in parts per million per volt, and is generally negative in sign, the resistance decreases with increasing voltage. Noisiness is measured in terms of Noise Index. Here is a sketch of the general range of voltage coefficient and noise index for various types. Wirewound resistors have no significant noise index.



	Range of Voltage Coefficient	
	Percent / Volt Min	Max
Carbon Comp (recent)	0.005	0.035
Carbon Comp NOS	0.02	0.05
Carbon Film	0.005	0.01
Metal Film	0.0001	0.003
Wirewound	0.0001	0.0005



Carbon Comp resistors are generally not flameproof and thus should not be used in power supply applications or where there is significant risk of overheating and fire. For safety reasons don't replace a ceramic block resistor with a carbon comp type. The major reasons that wirewound resistors are not commonly used are their high cost, lack of availability in larger resistance values, and inductance, but they do have the least noise of all types. The noise index is also affected by the wattage rating. Larger wattage resistors have lower noise. However, larger wattage carbon comp resistors have significantly higher voltage coefficients. The amplifier stage is another factor to consider. Noise induced by carbon comp resistors in early amplifier stages will only be amplified hiss in later stages. Pleasing or not, noise is still noise. Some of the major components of noise are directly related to current flow, so using carbon comp resistors in applications such as for plate resistors is going to be noisier than if the same resistor is used as a grid resistor where the current is less.

Pros and Cons by Type

Carbon composition - vintage accurate, but availability is spotty, little current production. High voltage coefficient is both a pro and a con. High noise index. Also have higher thermal coefficient of resistance than other types. Able to withstand voltage surges better than other types except wirewound. Subject to moisture absorption, and have poor long term stability, low tolerance to soldering heat.

Carbon Film – commonly available and inexpensive. Lower noise than carbon comp, and lower voltage coefficient, but higher than metal film types. Long term stability better than carbon comp but not as good as metal film.

Metal Film – high precision, widely available and low cost. Excellent long term stability and resistance to soldering heat. Low thermal and voltage coefficients. Low to very low noise index.

Wirewound – typically bulky, and often very costly. Available in very low ohm values, often with extremely tight tolerances, but seldom available in higher ohm ranges. Lowest noise index. Best surge capability. Very low thermal coefficient. Tend to be inductive. Excellent power dissipation. Excellent long term stability. Not commonly specified mainly due to cost and availability.

Ceramic Block - basically a wirewound resistor housed in a ceramic block. Also called cement resistor or sandblock resistor. Flameproof construction used in power supplies for safety reasons. Special winding techniques can be used to minimize induction.



Resistor Color Code (4 Band Resistors)		
First and Second Color Band	Third Color Band	Fourth Color Band: Tolerance
Black 0	Black x1	
Brown 1	Brown x 10	Brown 1%
Red 2	Red x 100	Red 2%
Orange 3	Orange x 1K	Gold 5%
Yellow 4	Yellow x 10K	Silver 10%
Green 5	Green x 100K	None 20%
Blue 6	Blue x 1 Meg	
Violet 7	Silver ÷ 100	
Gray 8	Gold ÷ 10	
White 9		

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