tup-tun-dug-dus

Wherever possible in Elektor circuits, transistors and diodes are simply marked 'TUP', 'TUN', 'DUG' or 'DUS'. This indicates that a large group of similar devices can be used without detriment to the performance of the circuit.

In this article the minimum specifications for this group are listed, with tables of equivalent types. Also described are several simple measuring procedures that make it possible to find the connections and approximate performance of an unmarked device.

As far as possible, the circuits in Elektor are designed so that they can be built with standard components that most retailers will have in stock.

It is well-known that there are many general purpose diodes and low frequency transistors with different type numbers but very similar technical specifications. The difference between the various types is often little more than their shape. This family of semiconductors is referred to in the various articles by the following abbreviations:

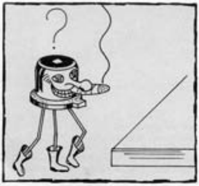
TUP = Transistor, Universal PNP,
TUN = Transistor, Universal NPN,
DUG = Diode, Universal Germanium,
DUS = Diode, Universal Silicon.

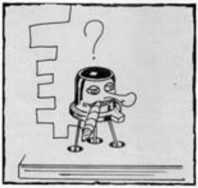
TUP, TUN, DUG and DUS have to meet certain minimum specifications – they are not just 'any old transistor' or 'any old germanium diode' . . . . The minimum specifications are listed in tables 1a and 1b. It is always possible, of course, to use a transistor with better specifications than those listed!

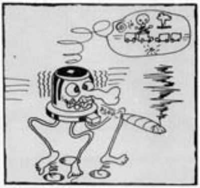
Simple measurements

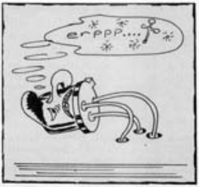
It is advisable only to use semiconductors with a clearly legible type number, and with known specifications. However, transistors without a type number are often cheaper, and some simple tests can give an indication of their value.

The first test serves to find out whether the transistor is a PNP or an NPN type,









and to locate the base connection. A multimeter is used, switched to the lowest resistance scale. The plus lead of the meter is connected to one of the pins of the transistor (figure 1a).

The minus lead is then touched to each of the other transistor pins in turn. If the meter shows a low resistance in both cases the transistor is probably a PNP type, and the plus lead from the meter is connected to its base. If the meter shows a low resistance at only one of the two remaining pins the transistor is probably an NPN type, and the minus lead from the meter is connected to its base.

If the meter doesn't show a low resistance in either case, the plus lead from the meter should be connected to one of the other two pins and the procedure repeated.

Having located the base connection and the probable type (PNP or NPN), a double check can be made according to figure 1b. For an NPN type, the minus lead from the meter is connected to the base and the plus lead is touched to each of the other connections in turn. The meter should show approximately the same (low) resistance value for both cases. After reversing the connections to the meter, the same test should show a very high resistance (little or no deflection) for both cases. For a PNP type, the first two measurements should show a high resistance and the second two should show a low resistance.

The next step is to locate the emitter and collector connections. The multimeter is now switched to the highest resistance scale and the test leads are connected to the two remaining transistor pins (the base is not connected). If the transistor is an NPN type and the meter shows a very high resistance (figure 1c), the minus lead is connected to the collector and the plus lead is connected to the emitter. On reversing the connections (figure 1d) a relatively low resistance value should be indicated. If the transistor is a PNP type, the measurement results are reversed.

If any of the tests show zero resistance between two pins of the transistor, there

Table 1a.

	type	U_{ce_0} max	I_c max	h_{fe} min.	P_{tot} max	f_T min.
TUN	NPN	20 V	100 mA	100	100 mW	100 MHz
TUP	PNP	20 V	100 mA	100	100 mW	100 MHz

Table 1b.

	type	U_R max	I_F max	I_R max	P_{tot} max	C_D max
DUS	Si	25 V	100 mA	1 µA	250 mW	5 pF
DUG	Ge	20 V	35 mA	100 µA	250 mW	10 pF

Table 2.

TUN		
BC 107	BC 208	BC 384
BC 108	BC 209	BC 407
BC 109	BC 237	BC 408
BC 147	BC 238	BC 409
BC 148	BC 239	BC 413
BC 149	BC 317	BC 414
BC 171	BC 318	BC 547
BC 172	BC 319	BC 548
BC 173	BC 347	BC 549
BC 182	BC 348	BC 582
BC 183	BC 349	BC 583
BC 184	BC 382	BC 584
BC 207	BC 383	

Table 3.

TUP		
BC 157	BC 253	BC 352
BC 158	BC 261	BC 415
BC 177	BC 262	BC 416
BC 178	BC 263	BC 417
BC 204	BC 307	BC 418
BC 205	BC 308	BC 419
BC 206	BC 309	BC 512
BC 212	BC 320	BC 513
BC 213	BC 321	BC 514
BC 214	BC 322	BC 557
BC 251	BC 350	BC 558
BC 252	BC 351	BC 559

Table 4.

DUS		DUG
BA 127	BA 318	OA 85
BA 217	BAX 13	OA 91
BA 218	BAY 61	OA 95
BA 221	1N914	AA 116
BA 222	1N4148	
BA 317		

tup tun dug dus

Table 5.

	NPN	PNP
	BC 107 BC 108 BC 109	BC 177 BC 178 BC 179
V_{ce_0} max	45 V 20 V 20 V	45 V 25 V 20 V
V_{eb_0} max	6 V 5 V 5 V	5 V 5 V 5 V
I_c max	100 mA 100 mA 100 mA	100 mA 100 mA 50 mA
$P_{tot.}$ max	300 mW 300 mW 300 mW	300 mW 300 mW 300 mW
f_T min.	150 MHz 150 MHz 150 MHz	130 MHz 130 MHz 130 MHz
F max	10 dB 10 dB 4 dB	10 dB 10 dB 4 dB

The letters after the type number denote the current gain:
A: α' (β, h_{fe}) = 125-260
B: α' = 240-500
C: α' = 450-900.

Table 6.

NPN	PNP	Case	Remarks
BC 107 BC 108 BC 109	BC 177 BC 178 BC 179		
BC 147 BC 148 BC 149	BC 157 BC 158 BC 159		P_{max} = 250 mW
BC 207 BC 208 BC 209	BC 204 BC 205 BC 206		
BC 237 BC 238 BC 239	BC 307 BC 308 BC 309		
BC 317 BC 318 BC 319	BC 320 BC 321 BC 322		I_{cmax} = 150 mA
BC 347 BC 348 BC 349	BC 350 BC 351 BC 352		
BC 407 BC 408 BC 409	BC 417 BC 418 BC 419		P_{max} = 250 mW
BC 547 BC 548 BC 549	BC 557 BC 558 BC 559		P_{max} = 500 mW
BC 167 BC 168 BC 169	BC 257 BC 258 BC 259	!	169/259 I_{cmax} = 50 mA
BC 171 BC 172 BC 173	BC 251 BC 252 BC 253		251 . . . 253 low noise
BC 182 BC 183 BC 184	BC 212 BC 213 BC 214		I_{cmax} = 200 mA
BC 582 BC 583 BC 584	BC 512 BC 513 BC 514		I_{cmax} = 200 mA
BC 414 BC 414 BC 414	BC 416 BC 416 BC 416		low noise
BC 413 BC 413	BC 415 BC 415		low noise
BC 382 BC 383 BC 384			
BC 437 BC 438 BC 439			P_{max} = 220 mW
BC 467 BC 468 BC 469		!	P_{max} = 220 mW
	BC 261 BC 262 BC 263		low noise

Table 1a. Minimum specifications for TUP and TUN.

Table 1b. Minimum specifications for DUS and DUG.

Table 2. Various transistor types that meet the TUN specifications.

Table 3. Various transistor types that meet the TUP specifications.

Table 4. Various diodes that meet the DUS or DUG specifications.

Table 5. Minimum specifications for the BC107, -108, -109 and BC177, -178, -179 families (according to the Pro-Electron standard). Note that the BC179 does not necessarily meet the TUP specification ($I_{c,max}$ = 50 mA).

Table 6. Various equivalents for the BC107, -108, . . . families. The data are those given by the Pro-Electron standard; individual manufacturers will sometimes give better specifications for their own products.

Figure 1. A simple method of finding the type (PNP or NPN) and the base, emitter and collector pins of an unknown transistor.

Figure 2. A simple method for estimating the current amplification factor of an unknown transistor.

is an internal short circuit in the transistor. It is then sometimes suitable as a diode, but usually can only be used as a very elegant kind of jumper wire . . . .

It should be noted that in all the above tests the positive lead from the meter is the one connected to the terminal marked '+'. In practice the voltage on this terminal is negative with respect to the terminal marked '–', when the multimeter is switched to resistance measurement. The measuring procedure is based on this polarity inversion.

An indication of the current gain of the unknown transistor can be found in a similar way (figure 2). The multimeter is switched to the highest resistance scale, the plus lead is connected to the emitter and the minus lead to the collector (if the transistor is an NPN type; otherwise the connections are reversed). If the previous tests were carried out correctly, the meter should show a fairly high resistance.

The collector and base connections are now bridged with one finger, so that current flows via the skin resistance to the base of the transistor under test. The meter should now register a fairly low resistance. The higher the current gain (and the lower the skin resistance!) the lower the indicated resistance value will be. A comparative measurement with a transistor of known quality will give an indication of whether or not the 'measured' current gain was sufficient.

Specifications and equivalents

A number of transistor types that meet the TUN specifications are listed in table 2. This list is, of course, incomplete – there are far more possible types. Table 3 lists a number of possibilities for use as TUP, while table 4 gives equivalents for DUG and DUS.

A further group of better quality transistors are the BC107 - BC108 - BC109 (NPN) and BC177 - BC178 - BC179 (PNP) families. The minimum specifications are listed in table 5, while table 6 gives a list of equivalents. As will be obvious from the specifications, the main differences between the types are that the BC107/BC177 are higher voltage types (V_{ceo} = 45 volts) and the BC109/BC179 are low-noise. If these differences are not important in a particular circuit, the various types are interchangeable.

The code letters A, B or C after the type number on these transistors denote various current amplification factors. For the A-types this is from 125 to 260, for the B-types it is 240 to 500 and for the C-types 450 to 900. A BC109C is therefore not a direct equivalent for a BC109B, for instance, although in many practical circuits it will make little or no difference.

When using the equivalent types BC167, -168, -169, BC257, -258, -259 or BC467, -468, -469 it should be noted that the base, emitter and collector leads are in a different order (see table 6).

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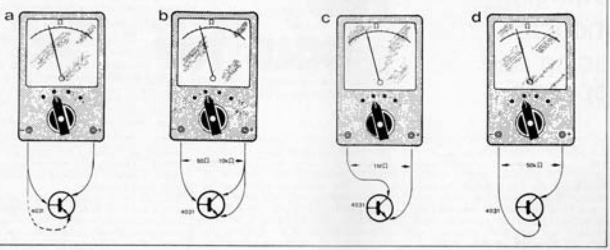

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