General Certificate of Education
Advanced Level Examination
June 2011

# Electronics ELEC4

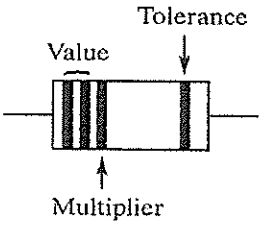
## Data Sheet
## Unit 4 ELEC 4 Programmable Control Systems

**Resistors**
Preferred values for resistors (E24) series:
1.0, 1.1, 1.2, 1.3, 1.5, 1.6, 1.8, 2.0, 2.2, 2.4, 2.7, 3.0, 3.3, 3.6, 3.9, 4.3, 4.7, 5.1, 5.6, 6.2, 6.8, 7.5, 8.2, 9.1 ohms etc.

**Resistor Printed Code (BS 1852)**
This code consists of letters and numbers:
R means × 1
K means × 1000 (i.e. $10^3$)
M means × 1 000 000 (i.e. $10^6$)
Position of the letter gives the decimal point
Tolerances are given by the letter at the end of the code,
F = ± 1%, G = ± 2%, J = ± 5%, K = ± 10%, M = ± 20%.

**Resistor Colour Code**

| Number | Colour |
|---|---|
| 0 | Black |
| 1 | Brown |
| 2 | Red |
| 3 | Orange |
| 4 | Yellow |
| 5 | Green |
| 6 | Blue |
| 7 | Violet |
| 8 | Grey |
| 9 | White |




Tolerance, gold = ±5%, silver = ±10%, no band = ±20%

**Silicon diode** $V_F = 0.7$ V

**Silicon transistor** $V_{be} \approx 0.7$ V in the on state, $V_{ce} \approx 0.2$ V when saturated

**Resistance**

$$R_T = R_1 + R_2 + R_3 + \ldots \quad \text{series}$$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots \quad \text{parallel}$$

**Capacitance**

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots \quad \text{series}$$

$$C_T = C_1 + C_2 + C_3 + \ldots \quad \text{parallel}$$

**Time constant** $T = CR$, $T_{1/2} = 0.69\,CR$

**ac theory**

$$I_{rms} = \frac{I_0}{\sqrt{2}}$$

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

$$X_C = \frac{1}{2\pi fC} \quad \text{reactance}$$

$$X_L = 2\pi fL \quad \text{reactance}$$

$$f = \frac{1}{T} \quad \text{frequency, period}$$

$$f_0 = \frac{1}{2\pi\sqrt{LC}} \quad \text{resonant frequency}$$

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| | | |
|---|---|---|
| **Operational amplifier** | $G_V = \frac{V_{out}}{V_{in}}$ | voltage gain |
| | $G_V = -\frac{R_f}{R_1}$ | inverting |
| | $G_V = 1 + \frac{R_f}{R_1}$ | non-inverting |
| | $V_{out} = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right)$ | summing |
| | $V_{out} = (V_+ - V_-)\frac{R_f}{R_1}$ | difference |
| **555 Astable and Monstable** | $T = 1.1RC$ | monostable |
| | $t_H = 0.7\,(R_A + R_B)C$<br>$t_L = 0.7\,R_BC$ | astable |
| | $f = \frac{1.44}{(R_A + 2R_B)C}$ | astable frequency |
| **Electromagnetic waves** | $c = 3 \times 10^8\ \text{m s}^{-1}$ | speed in vacuo |

**Assembler language microcontroller instructions**

| Mnemonic | Operands | Description | Operation | Flags | Clock cycles |
|---|---|---|---|---|---|
| NOP | none | No operation | none | none | 1 |
| CALL | K | Call subroutine | stack <=PC<br>PC <=K | none | 2 |
| RET | none | Return from subroutine | PC <= stack | none | 2 |
| | | | | | |
| INC | R | Increments the contents of R | (R) <= (R) + 1 | Z | 1 |
| DEC | R | Decrements the contents of R | (R) <= (R) – 1 | Z | 1 |
| | | | | | |
| ADDW | K | Add K to W | W <= W + K | Z, C | 1 |
| ANDW | K | AND K with W | W <= W • K | Z, C | 1 |
| SUBW | K | Subtract K from W | W <= W – K | Z, C | 1 |
| ORW | K | OR K and W | W <= W + K | Z, C | 1 |
| XORW | K | XOR K and W | W <= W ⊕ K | Z, C | 1 |
| | | | | | |
| JMP | K | Jump to K (GOTO) | PC <= K | none | 2 |
| JPZ | K | Jump to K on zero | PC <= K if Z=1 | Z=1 | 2 |
| JPC | K | Jump to K on carry | PC <= K if C=1 | C=1 | 2 |
| | | | | | |
| MOVWR | R | Move W to the contents of R | (R) <= W | Z | 1 |
| MOVW | K | Move K to W | W <= K | Z | 1 |
| MOVRW | R | Move the contents of R to W | W <= (R) | Z | 1 |