A-LEVEL
ELECTRONICS

Programmable Control Systems ELEC4
Mark scheme

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COMPONENT NUMBER: ELEC4

COMPONENT NAME: Programmable Control Systems

Question	Part	Sub part	Marking Guidance	Mark	Comment
1	(a)		**Example** noisy input signal giving multiple crossing of threshold each period ✓ leading to more pulses being recorded by the counter ✓	2	
1	(b)		Schmitt trigger has two switching levels ✓ **Example** so signal must go above upper when going positive/below lower going negative **OR** relevant valid representation on diagram ✓ so preventing the multiple pulses occurring as the signal crosses the 0V point ✓	3	
1	(c)	(i)	input to op-amp inverting input ✓ feedback resistor to non-inverting input ✓ remainder of the circuit all functionally correct **AND** input and output labelled ✓	3	
1	(c)	(ii)	an appropriate calculation ✓ feedback resistor larger than other resistor ✓ all resistor values 1k – 1MΩ ✓ resistors in the ratio 2:1 ✓	4	
2	(a)	(i)	16μs ✓	1	
2	(a)	(ii)	**MOVW** 0x0F ✓ **MOVWR PRE** ✓	2	

2	(b)	(i)	4ms/16µs = 250 ✓ 0xFA ✓		2	
2	(b)	(ii)	**MOVRW SR** ✓ **ANDW** 0x02 ✓		2	
2	(c)	(i)	250 ±1 loops to give 1s ✓		1	
2	(c)	(ii)	**MOVW** 0xFA **MOVWR** 0xB0 ✓		1	

2	(c)	(iii)	**loop1:**
			CALL TIME1
			// initiate/call the 4ms subroutine ✓
			loop2:
			MOVRW SR
			ANDW 0x02
			JPZ loop2
			// check whether the 4ms delay has finished.
			DEC 0xB0
			MOVRW 0xB0
			JPZ end
			// decrement 0xB0 and check for zero ✓
			JMP loop1
			// return to loop1 and repeat ✓
			end:
				loop1:
				CALL TIME1
				// initiate/call the 4ms subroutine ✓
				DEC 0xB0
				MOVRW 0xB0
				JPZ end
				// decrement 0xB0 and check for zero ✓
				JMP loop 1
				// return to loop1 and repeat ✓
				end:
					3	First answer includes checking for the 4ms subroutine to end.
						
						Both are only **examples** – examiners will have to check answers carefully and award marks for the three basic steps – as shown by the comments.

3	(a)		closed ✓ there is (negative) feedback ✓		2	

3	(b)		calculation e.g. 50/256 = (0.195°C) ✓ ≈0.2°C ✓	2	
3	(c)		**Examples** a motor whose armature turns through discrete angles when powered ✓ two coils, not centre tapped ✓ coils need the current to be reversed ✓	3	
3	(d)		one n-channel and one p-channel in each arm ✓ n-channel on the bottom ✓ coil between two arms ✓ input to gates of MOSFETs ✓ correctly labelled power supply. ✓	5	
4	(a)	(i)	calculation 20/40 = ✓ 500mA ✓	2	
4	(a)	(ii)	sensible calculation ✓ sensible answer of around 2.5W ✓	2	
4	(b)		high power density, small physical size, etc ✓ cost, can explode if damaged, do not like cold temperatures etc ✓	2	
4	(c)		recognise that 12.6V is 63% of supply voltage ✓ calculation 40 x 4.7 = 188s ✓	2	
4	(d)	(i)	recognise that 4.7V is 37% of 12.6V ✓ calculation 1.5/4.7 = 0.319Ω ✓	1	

4	(d)	(ii)	**Example**. mean voltage (8.7V), justified voltage used ✓ sensible calculation ✓ 237W ✓ (More accurate answer is 214W)	3	**Example** if mean power calculated rather than voltage,then 282W.
5	(a)		voltage divider calculation 2.5 = (12.6 x 10)/(10 + R) ✓ 40.4kΩ ✓	2	
5	(b)		**Example** When capacitor voltage less than 4.7V, voltage divider of 13k and 15k give a voltage of less than 2.5V at D_1 ✓ microcontroller can detect this as logic 0 ✓	2	
5	(c)		appropriate flow chart with marks for the following key points correct symbols ✓ read D_0 until D_0 = 1 (loop) ✓ turn motor on ✓ read D_1 ✓ read D_1 until D_1 = 0 (loop) ✓ return loop with motor turned off ✓	6	
6	(a)		**Example** ADC-convert analogue signal from the PC to digital signal for transmission ✓ DAC convert received digital signal to analogue signal for the hi-fi ✓	2	
6	(b)		lower resolution ✓ fewer conversion levels ✓ less dynamic range ✓ etc	2 max	

6	(c)		calculation 1 / 44000 = ✓ 22.7μs ✓	2	
6	(d)	(i)	invert the output from op-amp A ✓ provide unity gain ✓	2	
6	(d)	(ii)	0x80 gives D_7 5V ✓ **Example** of calculation of summing amplifier leading to ✓ 10kΩ ✓	2 max	
6	(e)		Input value steadily increases, so output voltage steadily increases until count reaches 0xFF ✓ whereupon it starts again from 0 ✓	2	
7	(a)		calculation e.g. 3 LEDs each with 2 bits giving 6 bits ✓ $2^6 = 64$ ✓ **Accept** 63 – when all of the LEDs are off – not a colour	2	
7	(b)	(i)	only on for 33% of time ✓ so LED perceived as only being 1/3 as bright or similar ✓	2	
7	(b)	(ii)	human eye persistence of vision >50ms ✓ flash rate ≈ 3ms ✓	2	
7	(c)	(i)	input bits are 00 01 10 11 ✓ 0x1B ✓	2	
7	(c)	(ii)	red on continuously, green on for 2/3 duty cycle and blue on for 1/3 duty cycle red **plus** one other correct ✓ third colour correct ✓	2	