Bay Area Rapid Transit District

Study Guide for the Electronics Technician Pre-Employment Examination

INTRODUCTION

The Bay Area Rapid Transit (BART) District makes extensive use of electronics technology to operate the many systems within the District. The revenue vehicles, train control systems, fare collection machines, and many other systems are electronic or electronically controlled. Due to the large number of electronic systems, a person seeking District employment as an electronics technician should have a broad background in basic electronics.

The Pre-employment Test screens applicants basic electronics knowledge. The basic skills and knowledge are prerequisites for BART's job training courses for hired Electronics Technicians. BART does not currently provide basic skills training to newly hired Electronics Technicians.

The examination examines the breadth of an applicant's knowledge, covering many facets of electrical and electronic technology. The Extended Skills Assessment determines whether the applicant possesses specific knowledge or skills that the hiring department deems essential.

Basic Skills

The Basic Skills Assessment covers three areas of Electronics Technology. These areas are:

General Electronics Knowledge and Computational Skills

This section determines the applicant's knowledge of electronic components, and the applicant's ability to perform mathematical computations involving these components, without using a calculator.

Identifying and Using Semiconductors and Operational Amplifiers

This section determines the applicant's knowledge of semi-conductor components and operational amplifier configurations, and the applicant's ability to analyze the behavior of simple circuits, given certain conditions.

Basic Digital Electronics

This section determines the applicant's knowledge of digital electronic components, digital logic, Boolean Algebra, the terminology of microprocessor-based systems, and the applicant's ability to analyze the behavior of simple circuits, given certain conditions.

Extended Skills

The Extended Skills Assessment consists of modules that have a narrow technical focus. The hiring departments select these modules to examine skills directly applicable to a specific Electronics Technician position. The modules are:

Mechanical Concepts and Tools

This section determines the applicant's knowledge of common hand tools and mechanical terminology.

Fundamentals of Communications Electronics

This section determines the applicant's knowledge of components, terminology, and principles required to operate, maintain, and repair radios, telephones, and digital transmission equipment.

Fundamentals of Computer Electronics

This section determines the applicant's knowledge of components, terminology, and principles required to operate, maintain, and repair computer systems, including microprocessors, personal computers, peripherals, and industrial mainframes.

Fundamentals of Industrial Electronics and Control Circuits

This section determines the applicant's knowledge of components, terminology, and principles required to maintain and repair motor control circuits and systems common to an industrial environment.

The Skills Assessments that are required for each Technician position are shown in Table 1. Applicants for these positions must take the Basic Skills Assessment and, if required the Extended Skills Assessment. The Basic Skills Assessment consists of the same number of multiple choice test items. The number of test items in the Extended Skills Assessment varies, according to the requirements established by the hiring department for a particular position.

Table 1 Skills Assessments for each Electronics Technician Position

Electronics Technician Position	Basic Electronic Skills Assessment	Extended Skills Assessment
Automatic Fare Collection	All areas	Mechanical Concepts and Tools
Communications	All areas	Fundamentals of Communications Electronics
Computer Specialist	All areas	Fundamentals of Computer Electronics
Revenue Vehicle	All areas	Industrial Electronics and Control Circuits
Train Control	All areas	**Not required**

BASIC SKILLS ASSESSMENT LIST

This list of topics is not all-inclusive, but is a good measure of the skills and knowledge that an applicant must have to do well on the test.

1) **Mathematics**
   a) Perform simple radix conversions
   b) Read and interpret graphs
   c) Express the values of electronic parameters using scientific notation and exponents
   d) Use the principles of Boolean Algebra to describe and simplify logic functions

2) **Passive Components**
   A. Identify the schematic symbol for each of the following components
      a) Resistor
      b) Capacitor
      c) Inductor
      d) Transformer

3) **DC Circuit Theory**
   a) Calculate the solution to simple circuit problems using the properties of passive components, Ohms Law, Kirchhoff's Voltage Law, and Kirchhoff's Current Law
   b) Determine the time constant of a RC network

4) **AC Circuit Theory**
   a) Calculate reactance, impedance, and resonant frequency
   b) Relate the characteristics of tuned circuits and state how these characteristics affect the operation of filters and oscillators
   c) Relate the characteristics of and applications for transformers

5) **Active Components**
   a) Identify the schematic symbol for each of the following components
      i) Diodes (Zener, Tunnel, Signal)
      ii) Transistors (NPN, PNP and Unijunction)
      iii) Field Effect Transistors (JFET, MOSFET, IGBT)
      iv) Silicon Controlled Rectifier (SCR), Diac, Triac
      v) Operational Amplifier

6) **Active Components: Operating Characteristics**
   a) Determine the expected output of a simple circuit that uses active components, given a particular input.
   b) Determine the expected output of a simple defective circuit, given a particular input and device failure mode.

7) **Test Equipment**
   a) Demonstrate knowledge of these oscilloscope fundamentals
      i) Vertical sensitivity
      ii) Horizontal sweep rate
      iii) Triggering
   b) Demonstrate knowledge of the use of an oscilloscope to measure these waveform characteristics
      i) Frequency
      ii) Period
      iii) Amplitude
      iv) Duty cycle
      v) Average voltage of a sine or rectangular waveform
      vi) RMS voltage of a sine wave

8) **Electromechanical Devices**
   a) Analyze the operation of relays, solenoids, and contactors in electrical circuits
   b) Evaluate the use of relays as logic elements in control applications
   c) Evaluate faults in electrical circuits using basic theory of motors and generators

9) **Digital Electronics**
   a) Develop the Truth Tables for simple and complex logic circuits
   b) Analyze the function of a logic diagram having sequential logic elements (clocked logic)

10) **Troubleshooting**
   a) Trace a signal using a schematic diagram
   b) Determine the output of a complex network, given a schematic diagram and input signal characteristics

EXTENDED SKILLS ASSESSMENT LIST

Mechanical Concepts and Tools

1) Determine the proper tool to accomplish a given task
2) Determine whether calipers, micrometers, or feeler gauges are best suited for a measurement, given an example of a situation requiring a measurement device.
3) Determine the direction and rate of rotation of a shaft, given a particular arrangement of pulleys or gears

Fundamentals of Communications Electronics

1) Identify transmission characteristics of copper cables
2) Recognize common terms associated with the operation and maintenance of digital transmission systems
3) Recognize common terms and practices associated with the operation and maintenance of FM transceivers
4) Identify the characteristics of these modes of communications
   a) Simplex
   b) Half duplex
   c) Full duplex
5) Relate the functions of each layer of the OSI Model.

Fundamentals of Computer Electronics

1) Identify components such as UART, Static RAM, and Dynamic RAM, from their functional descriptions.
2) Relate the functional definitions of computer terminology, such as Memory-mapped I/O, Interrupt, and Analog-to-Digital Conversion.
3) Describe the operational instruction to a Personal Computer, given the DOS command.
4) State the functions of the input and output expected at a PC Port, given its name, such as COM 1.

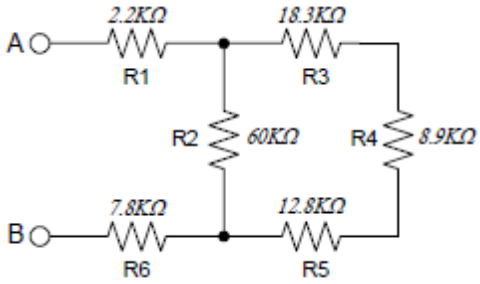
Industrial Electronics and Control Circuits

1) Recognize common terms associated with controls and electronics in an industrial environment, including motor control circuits and power electronics.
2) Identify the schematic symbols of components common to Industrial Electronics.

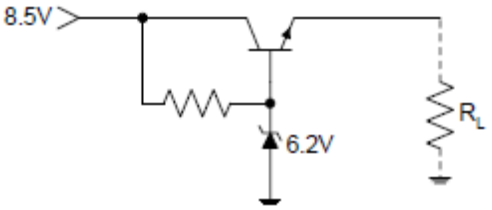
SAMPLE QUESTIONS

This section contains several sample questions similar to those on the Basic Skills Assessment. The answers to these sample questions are on the last page of this Study Guide.

1) Refer to Figure 1. What is the total resistance between Terminals A and B?
   A) 15.2 Kohms
   B) 24 Kohms
   C) 34 Kohms
   D) 44 Kohms



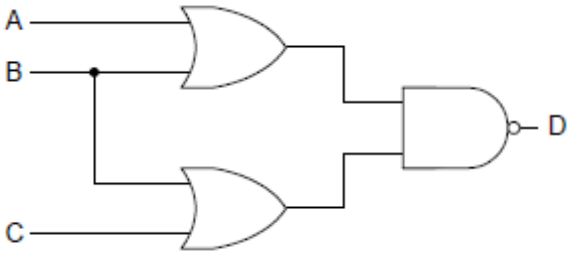
2) What is the regulator's expected output voltage (VR_L)?
   A) 4.5 Volts
   B) 5.0 Volts
   C) 5.5 Volts
   D) 8.5 Volts



3) A circuit that converts DC voltages to data that a microprocessor can use is a/an:
   A) Universal Asynchronous Receiver / Transmitter.
   B) RS-422C interface.
   C) Analog-to-Digital Converter.
   D) Digital-to-Analog Converter.

4) Complete the truth table for the logic circuit shown in Figure 4.

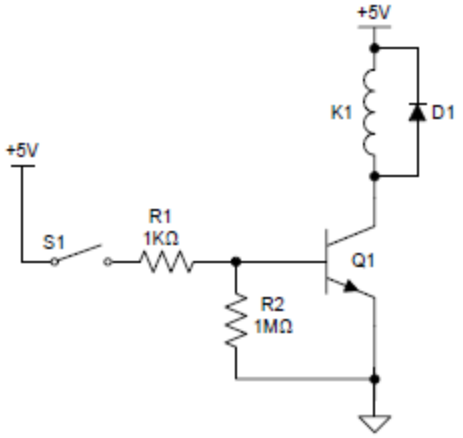
A	B	C	D
L	L	L	
H	L	L	
L	H	L	
H	H	L	
L	L	H	
H	L	H	
L	H	H	
H	H	H	

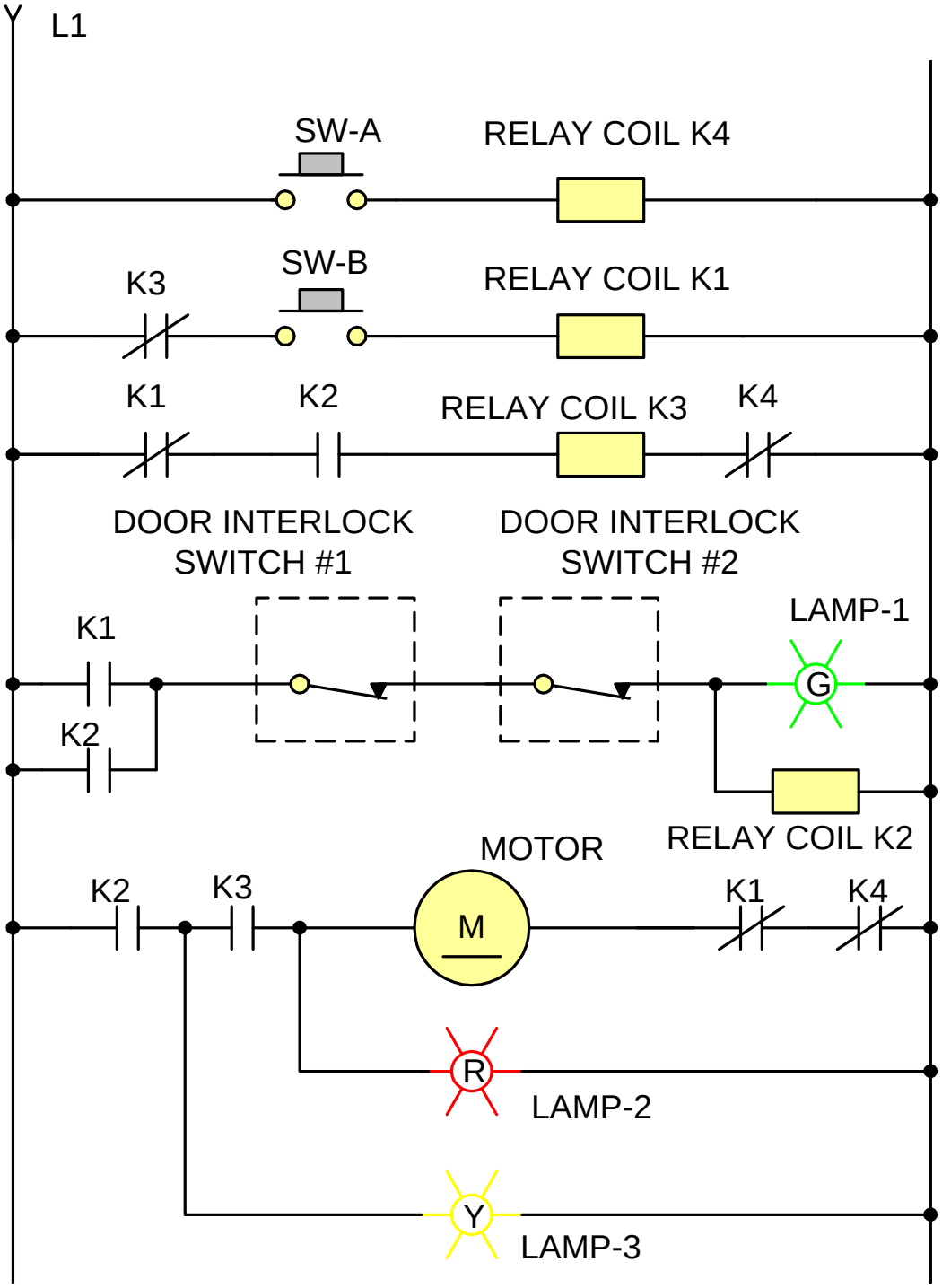


5) Inductance is defined as the property of an electrical circuit that opposes any change in _____.

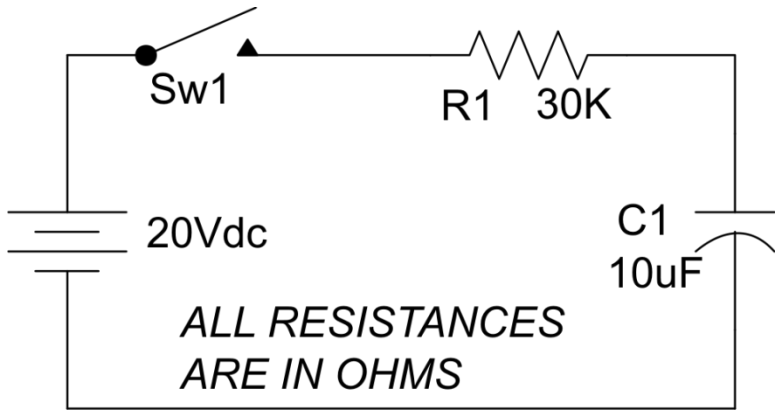
6) In the circuit shown in Figure 6, what is the purpose of D1?

A) AC rectification
B) Level shifting
C) Negative feedback
D) Reverse voltage clamp

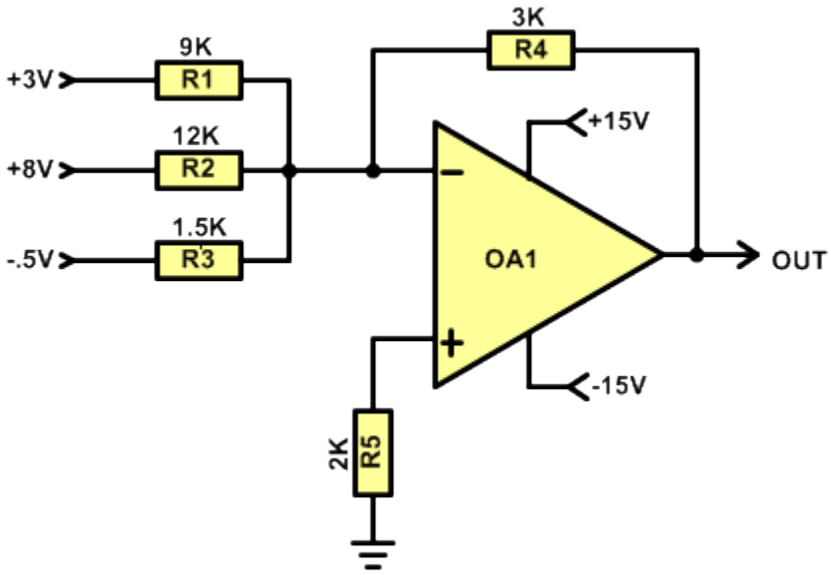




7) Motor, M, is energized and running. When SW-A is activated, the motor stops. What effect does activating SW-A have on the indicator circuits?
   A) All the indicators go out.
   B) The green lamp (G) remains on, and the red (R) and yellow (Y) lamps go out.
   C) The green lamp (G) goes out, and the red (R) and yellow (Y) lamps remain on.
   D) The red lamp (R) goes out, and the green (G) and yellow (Y) lamps remain on.

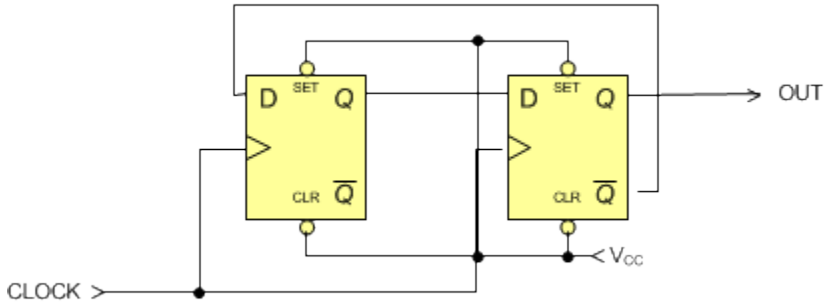


8) What is the voltage across C1 300 milliseconds after the closure of SW1 in volts? (Assume C1 initially discharged.) Your answer must be accurate within 5%.



9) What is the expected voltage in volts at the output terminal with the given input conditions?
   A) 15V (Positive Rail)
   B) -3.0V
   C) 11V
   D) 25.6V
   E) 2.0V
   F) -2.0V

G) 3.0V
H) -25.6V
I) -11V
J) -15V (Negative Rail)



10) Given a clock input frequency of 16Khz, what it the resulting output frequency?
A) 32Khz
B) 8Khz
C) 16Khz
D) 4Khz

Answers to SAMPLE QUESTIONS

1) Series resistance adds, parallel resistance is the inverse sum. For this example, the formula is $R_{A-B} = R1 + ((R2^{-1}+(R3+R4+R5)^{-1})^{-1} + R6 = 2.2K + (60K^{-1}+(18.3K+8.9K+12.8K)^{-1})^{-1} + 7.8K = 2.2K + (60K^{-1}+40K^{-1})^{-1} + 7.8K = 2.2K + (1.7^{-5}+2.5^{-5})^{-1} + 7.8K = 2.2K + (4.2^{-5})^{-1} + 7.8K = 2.2K + 24K + 7.8K = 34K$. The answer is C.

2) The base of the transistor is tied to a 6.2V Zener diode. Typical emitter - base voltage is .5 to .7 volts. This makes the voltage across RL = 6.2V - .7V = 5.5V. The answer is C.

3) This is a definition for an Analog to Digital Converter. The answer is C.

4) D is always high unless there are two high inputs on D's NAND gate. The two inputs to the NAND gate are fed by two OR gates. Either input on the or gate going high makes the output go high. This means that any time that both A and C are high or B is high will cause D to go low. All other times D is High. That makes the truth table H/H/L/L/H/L/L/L. The answer is D.

5) An inductor creates a magnetic field around itself proportional to the current flowing through it. That magnetic field will fluctuate to oppose any changes in current. The answer is Current.

6) D1 is reversed bias around relay coil K1. When K1 is energized there is a magnetic field around the coil. The coil acts as an inductor. When Q1 turns off, K1 de-energizes. The magnetic field then collapses inducing a reverse voltage. This voltage can be high enough to burn out Q1. D1 would be forward biased and absorb this spike protecting Q1. The answer is D, Reverse voltage clamp.

7) Since the initial condition is that the motor is running, you know that K2 and K3 are energized. By examining the circuit, you can see that K2 locks in once K1 is energized. To energize K1, SW-B must be momentarily pressed. What happens when SW-A is pressed? K4 is energized which drops out K3 and also stops the motor. When K3 drops out, Lamp 2 de-energizes. Nothing dropped K2 so Lamp-01 and Lamp-3 is still on. That makes the answer D, The red lamp (R) goes out, and the green (G) and yellow (Y) lamps remain on.

8) This is a simple RC charge network. $V_{cap} = (1-e^{-T/(RC)}) * V_{source}$ where e is the natural log and T is the time since voltage was applied. In this case, $V_{Cap} = (1 - e^{-.3/(30K*10u)}) * 20V = (1 - e^{-.3/(300m)}) * 20V = (1-e^{-1}) * 20V = .64 * 20V = 12.647V$. The answer is between 12.01 and 13.28.

9) The output of the summer operational amplifier is $V_{out} = -(V_{in} * R_{fb}/R_{in})$. In the case of this multiple input operational amplifier, you need to add them all together. For this example, $V_{out} = -(3V*3K/9K + 8V*3K/12K - .5V*3K/1.5K) = -(1V + 2V – 1V) = -2V$

10) Each D type flip flop is a divide by two circuit. There are two stages creating a divide by 4 circuit. The formula is $Clock/2^n$ where n is the number of stages. $16Khz/2^2 = 16Khz/4 = 4Khz$. The answer is D.