Verification of competency for ELTR courses

The purpose of these performance assessment activities is to verify the competence of a prospective transfer student with prior work experience and/or formal education in electronics, but where the depth and rigor of the prior learning is unknown. New students with no prior work experience or formal education in electronics must take all ELTR courses and are not allowed to challenge any by completing these activities.

All activities are performance-based. That is, the individual must perform all necessary predictions (calculations) based on conditions and component values specified by the instructor, then must actually *build* the circuit and use properly test equipment to verify those predictions. Each assessment is pass/fail. Either the individual is able to successfully predict, build, and test the circuit, or the individual is not able to predict, build, and/or test the circuit.

Prospective transfer students are allowed to review the verification activities prior to performing them, but will receive no help from the instructor. They are to study and prepare on their own. Electronic components and test equipment for the activities will be provided by the instructor. No books are allowed during the verification activity, but one page of notes may be used (per activity).

"Given conditions" for each activity will be randomly provided by the instructor at the time of verification, not prior. This way, prospective transfer students must prove mastery of the analysis techniques by successfully working through a set of given conditions they have not seen before.

Competence verification activities

ELTR100 – DC 1
Performance assessment: *Series-parallel resistor circuit (Question 1)*

ELTR105 – DC 2
Performance assessment: *RC time constant circuit (Question 2)*

ELTR110 – AC 1
Performance assessment: *Passive RC filter circuit with specified cutoff (Question 3)*

ELTR115 – AC 2
Performance assessment: *Auto-transformer (Question 4)*

ELTR120 – Semiconductors 1
Performance assessment: *AC-DC power supply (Question 5)*

ELTR125 – Semiconductors 2
Performance assessment: *BJT amplifier with specified gain (Question 6)*

ELTR130 – Opamps 1
Performance assessment: *Op-amp amplifier with specified gain (Question 7)*

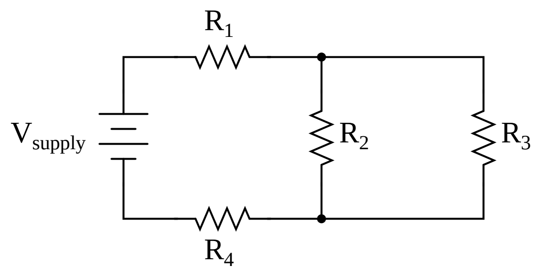
ELTR135 – Opamps 2
Performance assessment: *Active RC filter circuit with specified cutoff (Question 8)*

ELTR140 – Digital 1
Performance assessment: *Logic circuit from truth table (Question 9)*

ELTR145 – Digital 2
Performance assessment: *Flip-flop counter circuit (Question 10)*

Competency: **Series-parallel DC resistor circuit** Version:

Schematic



Given conditions

V_{supply} = R_1 = R_2 = R_3 = R_4 =

Parameters

	Predicted	Measured		Predicted	Measured
I_{supply}			I_{R1}		
V_{R1}			I_{R2}		
V_{R2}			I_{R3}		
V_{R3}			I_{R4}		
V_{R4}					

Fault analysis

Suppose component [ ] fails [ ] open [ ] shorted [ ] other ____________

What will happen in the circuit?

file 01606

Answer 1

Use circuit simulation software to verify your predicted and measured parameter values.

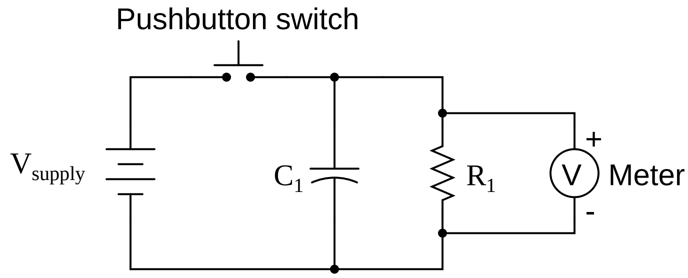
Notes 1

Use a variable-voltage, regulated power supply to supply any amount of DC voltage below 30 volts. Specify standard resistor values, all between 1 kΩ and 100 kΩ (1k5, 2k2, 2k7, 3k3, 4k7, 5k1, 6k8, 8k2, 10k, 22k, 33k, 39k 47k, 68k, 82k, etc.).

An extension of this exercise is to incorporate troubleshooting questions. Whether using this exercise as a performance assessment or simply as a concept-building lab, you might want to follow up your students' results by asking them to predict the consequences of certain circuit faults.

Competency: **RC discharge circuit** Version:

Schematic



Given conditions

V_{supply} = C_1 = R_1 =

t_1 = t_2 = t_3 =

Parameters

	Predicted	Measured
V_{t1}		
V_{t2}		
V_{t3}		

Calculations

file 01648

Answer 2

Use circuit simulation software to verify your predicted and measured parameter values.

Notes 2

I recommend choosing resistor and capacitor values that yield time constants in the range that may be accurately tracked with a stopwatch. I also recommend using resistor values significantly less than the voltmeter's input impedance, so that voltmeter loading does not significantly contribute to the decay rate.

Good time values to use (t_1, t_2, t_3) would be in the range of 5, 10, and 15 seconds, respectively.

An extension of this exercise is to incorporate troubleshooting questions. Whether using this exercise as a performance assessment or simply as a concept-building lab, you might want to follow up your students' results by asking them to predict the consequences of certain circuit faults.

Competency: **Passive RC filter circuit design** Version:

Description

Design and build an RC filter circuit, either high pass or low pass, with the specified cutoff frequency.

Given conditions

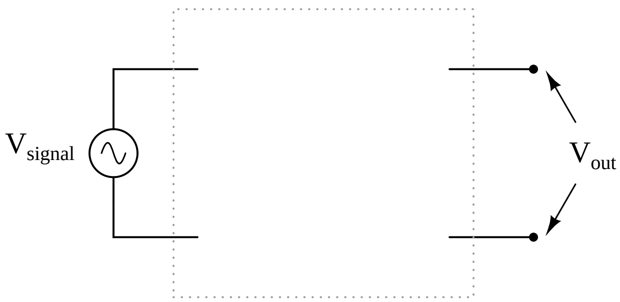
(instructor checks one)

f_{-3dB} = High-pass ☐ Low-pass ☐

Parameters

	Predicted	Measured
f_{-3dB}		
θ_{-3dB}		

Schematic



file 02095

Answer 3

Use circuit simulation software to verify your predicted and measured parameter values.

Notes 3

Use a sine-wave function generator for the AC voltage source. Specify a cutoff frequency within the audio range.

I recommend setting the function generator output for 1 volt, to make it easier for students to measure the point of "cutoff". You may set it at some other value, though, if you so choose (or let students set the value themselves when they test the circuit!).

I also recommend having students use an oscilloscope to measure AC voltage in a circuit such as this, because some digital multimeters have difficulty accurately measuring AC voltage much beyond line frequency range. I find it particularly helpful to set the oscilloscope to the "X-Y" mode so that it draws a thin line on the screen rather than sweeps across the screen to show an actual waveform. This makes it easier to measure peak-to-peak voltage.

Competency: **Auto-transformers** Version:

Description

Connect a step-down transformer as an auto-transformer, to either boost or buck the input voltage.

There must be no exposed line power conductors!

Given conditions

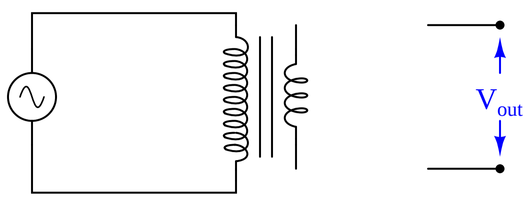
V_{supply} =

Transformer step-down ratio =

Boost ☐

Buck ☐

Schematic



(Be sure to note the transformer's polarity using dot convention)

Parameters

	Predicted	Measured
V_{output}		

file 02131

Answer 4

Use circuit simulation software to verify your predicted and measured parameter values.

Notes 4

The *real* challenge in this assessment is for students to determine their transformers' "polarities" before connecting them to the AC voltage source! For this, they should have access to a small battery and a DC voltmeter (at their desks).

You may use a Variac at the test bench to provide variable-voltage AC power for the students' transformer circuits. I recommend specifying load resistance values low enough that the load current completely "swamps" the transformer's magnetization current. This may mean using wire-wound power resistors instead of $\frac{1}{4}$ watt carbon composition resistors.

Note that there may very well be a shock hazard associated with this circuit! Be sure to take this into consideration when specifying load resistor values. You may also want to use low supply voltage levels (turn the Variac *way* down).

An extension of this exercise is to incorporate troubleshooting questions. Whether using this exercise as a performance assessment or simply as a concept-building lab, you might want to follow up your students' results by asking them to predict the consequences of certain circuit faults.

Competency: **AC-DC power supply circuit** Version:

Description

Build a "brute force" AC-DC power supply circuit, consisting of a step-down transformer, full-wave bridge rectifier, capacitive filter, and load resistor.

Given conditions

V_{supply} = C_{filter} = R_{load} =

Schematic

Parameters

	Predicted	Measured
$V_{out(DC)}$		
$V_{out(ripple)}$		

file 01622

Answer 5

Use circuit simulation software to verify your predicted and measured parameter values.

Notes 5

Use a Variac at the test bench to provide variable-voltage AC power for the students' power supply circuits.

An extension of this exercise is to incorporate troubleshooting questions. Whether using this exercise as a performance assessment or simply as a concept-building lab, you might want to follow up your students' results by asking them to predict the consequences of certain circuit faults.

Competency: **Class-A BJT amplifier w/specified gain** Version:

Description

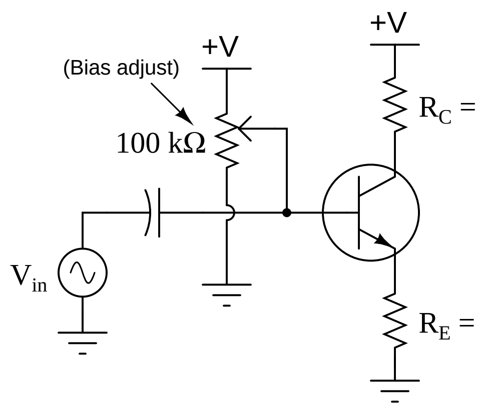
Design and build a class-A BJT amplifier circuit with a voltage gain (A_V) that is within tolerance of the gain specified.

You may use a potentiometer to adjust the biasing of the transistor, to make the design process easier.

Given conditions

V_{in} = +V = A_V = Tolerance_{A_V} =

Schematic



Parameters

Measured		Calculated	
V_{in}		A_V	
V_{out}		Error_{A_V}	

$$\frac{A_{V(actual)} - A_{V(ideal)}}{A_{V(ideal)}} \times 100\%$$

file 01935

Answer 6

Use circuit simulation software to verify your predicted and measured parameter values.

Notes 6

Students are allowed to adjust the bias potentiometer to achieve class-A operation after calculating and inserting the resistance values R_C and R_E. However, they are not allowed to change either R_C or R_E once the circuit is powered and tested, lest they achieve the specified gain through trial-and-error!

A good percentage tolerance for gain is +/- 10%. The lower you set the target gain, the more accuracy you may expect out of your students' circuits. I usually select random values of voltage gain between 2 and 10, and I strongly recommend that students choose resistor values between 1 kΩ and 100 kΩ. Resistor values much lower than 1 kΩ lead to excessive quiescent currents, which may cause accuracy problems (r'_e drifting due to temperature effects).

An extension of this exercise is to incorporate troubleshooting questions. Whether using this exercise as a performance assessment or simply as a concept-building lab, you might want to follow up your students' results by asking them to predict the consequences of certain circuit faults.

Competency: **Op-amp amplifier circuit w/specified gain** Version:

Description

Design and build an op-amp amplifier circuit with a voltage gain (A_V) that is within tolerance of the gain specified.

Given conditions

V_{in} =

A_V (ratio) =

Tolerance_{A_V} =

Inverting ☐

Non-inverting ☐

Schematic *Show all component values!*

Parameters

	Measured		Calculated
V_{in}		A_V (ratio)	
V_{out}		Error_{A_V}	

$$\frac{A_{V(actual)} - A_{V(ideal)}}{A_{V(ideal)}} \times 100\%$$

file 02132

Answer 7

Use circuit simulation software to verify your predicted and measured parameter values.

Notes 7

An extension of this exercise is to incorporate troubleshooting questions. Whether using this exercise as a performance assessment or simply as a concept-building lab, you might want to follow up your students' results by asking them to predict the consequences of certain circuit faults.

Competency: **Active RC filter circuit design** Version:

Description

Design and build an active RC filter circuit with a cutoff frequency specified by the instructor.

Given conditions

(instructor checks one)

f_{-3dB} = High-pass ☐ Low-pass ☐

Schematic *Show all component values!*

Parameters

	Predicted	Measured
f_{-3dB}		

file 02133

Answer 8

Use circuit simulation software to verify your predicted and measured parameter values.

Notes 8

Use a sine-wave function generator for the AC voltage source. Specify a cutoff frequency within the audio range.

I recommend setting the function generator output for 1 volt, to make it easier for students to measure the point of "cutoff". You may set it at some other value, though, if you so choose (or let students set the value themselves when they test the circuit!).

I also recommend having students use an oscilloscope to measure AC voltage in a circuit such as this, because some digital multimeters have difficulty accurately measuring AC voltage much beyond line frequency range. I find it particularly helpful to set the oscilloscope to the "X-Y" mode so that it draws a thin line on the screen rather than sweeps across the screen to show an actual waveform. This makes it easier to measure peak-to-peak voltage.

Competency: **Gate circuit from truth table** Version:

Truth table

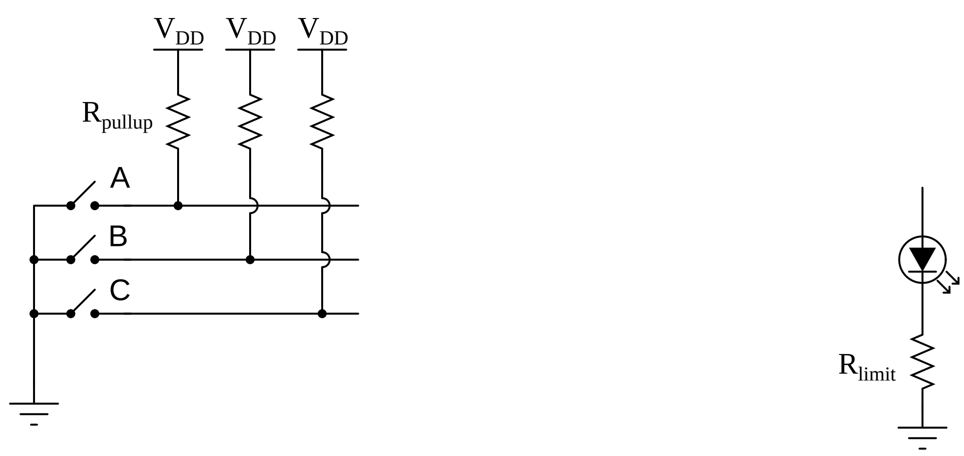
Given

A	B	C	Output
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

Actual

A	B	C	Output
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

Schematic



file 02134

Answer 9

Use circuit simulation software to verify your predicted and actual truth tables.

Notes 9

It should be noted that the input states in this circuit are defined by the voltage levels, not by the contact status. In other words, a closed contact equals a "low" (0) logic state.

Suggested truth tables include the following (encoded as Boolean SOP statements):

- $AB\overline{C} + ABC$
- $\overline{A}B\overline{C} + \overline{A}BC$
- $\overline{A}B\overline{C} + \overline{A}BC + \overline{A}\,\overline{B}\,\overline{C}$
- $A\overline{B}\,\overline{C} + A\,\overline{B}\,C$
- $AB\overline{C} + A\overline{B}\,\overline{C} + \overline{A}\,\overline{B}\,\overline{C}$
- $\overline{A}BC + \overline{A}\,\overline{B}C + \overline{A}\,\overline{B}\,\overline{C}$
- $ABC + \overline{A}BC + AB\overline{C}$
- $A\overline{B}C + \overline{A}\,\overline{B}C + \overline{A}\,\overline{B}\,\overline{C}$
- $ABC + A\overline{B}C + \overline{A}\,\overline{B}C$

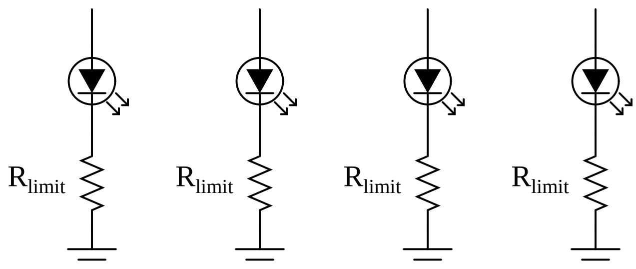
I strongly recommend having students build their logic circuits with CMOS chips rather than TTL, because of the less stringent power supply requirements of CMOS. I also recommend drawing a combinational circuit using four gates, because this is the common number of two-input gates found on 14-pin DIP logic chips.

Competency: **4-bit flip-flop counter circuit** Version:

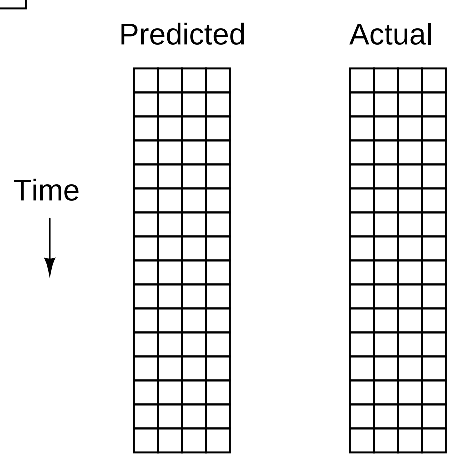
Description

Build a 4-bit counter circuit using individual J-K flip-flops

Schematic



Count sequence



file 02135

Answer 10

Use circuit simulation software to verify your predicted and actual truth tables.

Notes 10

I strongly recommend having students build their logic circuits with CMOS chips rather than TTL, because of the less stringent power supply requirements of CMOS.