

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)*

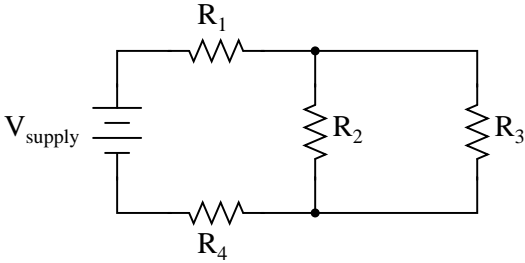
ELTR140 – Digital 1

Performance assessment: *Logic circuit from truth table (Question 9)*

ELTR145 – Digital 2

Performance assessment: *Flip-flop counter circuit (Question 10)*

Question 1

Competency: Series-parallel DC resistor circuit		Version:	
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px;">Schematic</div>			
			
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px;">Given conditions</div>			
$V_{\text{supply}} =$	$R_1 =$	$R_2 =$	$R_3 =$
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px;">Parameters</div>			
	Predicted	Measured	
I_{supply}			I_{R1}
V_{R1}			I_{R2}
V_{R2}			I_{R3}
V_{R3}			I_{R4}
V_{R4}			
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px;">Fault analysis</div>			
Suppose component fails <div style="display: inline-block; vertical-align: middle; margin-left: 10px;"> <input type="checkbox"/> open <input type="checkbox"/> other _____ <input type="checkbox"/> shorted </div>			
<i>What will happen in the circuit?</i>			

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 k Ω and 100 k Ω (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.

Question 2

Competency: RC discharge circuit		Version:
Schematic		
Given conditions		
$V_{\text{supply}} =$	$C_1 =$	$R_1 =$
$t_1 =$	$t_2 =$	$t_3 =$
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.

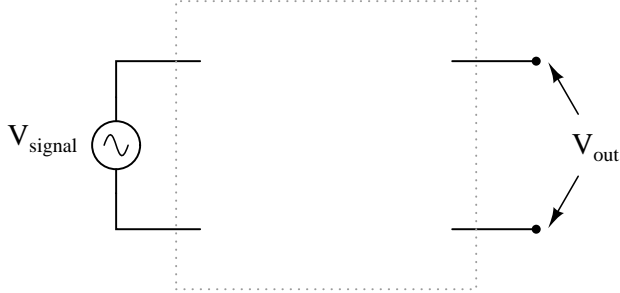
Notes 2

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.

Question 3

Competency: Passive RC filter circuit design	Version:									
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px;">Description</div>										
Design and build an RC filter circuit, either high pass or low pass, with the specified cutoff frequency.										
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px;">Given conditions</div>										
<div style="text-align: right; margin-right: 50px;"><i>(instructor checks one)</i></div> <div style="display: flex; justify-content: space-around; align-items: center;"> <div> $f_{-3dB} =$ </div> <div> High-pass <input style="width: 30px; height: 20px;" type="checkbox"/> </div> <div> Low-pass <input style="width: 30px; height: 20px;" type="checkbox"/> </div> </div>										
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px;">Parameters</div>										
<table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;"></th> <th style="width: 20%; text-align: center;">Predicted</th> <th style="width: 20%; text-align: center;">Measured</th> </tr> </thead> <tbody> <tr> <td>f_{-3dB}</td> <td style="border: 1px solid black; height: 25px;"></td> <td style="border: 1px solid black; height: 25px;"></td> </tr> <tr> <td>θ_{-3dB}</td> <td style="border: 1px solid black; height: 25px;"></td> <td style="border: 1px solid black; height: 25px;"></td> </tr> </tbody> </table>			Predicted	Measured	f_{-3dB}			θ_{-3dB}		
	Predicted	Measured								
f_{-3dB}										
θ_{-3dB}										
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px;">Schematic</div>										
										

file 02095

Answer 3

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

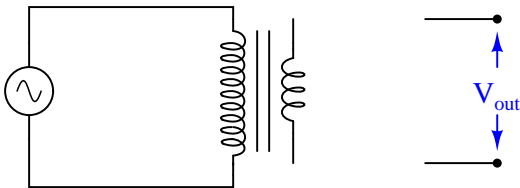
Notes 3

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.

Question 4

Competency: Auto-transformers	Version:						
<div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;">Description</div> <p style="text-align: center;">Connect a step-down transformer as an auto-transformer, to either boost or buck the input voltage.</p> <p style="text-align: center;"><i>There must be no exposed line power conductors!</i></p>							
<div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;">Given conditions</div> <div style="display: flex; justify-content: space-between; align-items: flex-start;"> <div style="width: 45%;"> $V_{\text{supply}} =$ Transformer step-down ratio = </div> <div style="width: 50%;"> Boost <input style="width: 30px; height: 20px;" type="checkbox"/> Buck <input style="width: 30px; height: 20px;" type="checkbox"/> </div> </div>							
<div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;">Schematic</div> <div style="text-align: center; margin: 10px 0;">  </div> <p style="text-align: center;">(Be sure to note the transformer's polarity using dot convention)</p>							
<div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;">Parameters</div> <table style="width: 100%; margin-top: 10px;"> <thead> <tr> <th style="width: 15%;"></th> <th style="width: 35%; text-align: center;">Predicted</th> <th style="width: 35%; text-align: center;">Measured</th> </tr> </thead> <tbody> <tr> <td style="vertical-align: middle;">V_{output}</td> <td style="text-align: center;"><input style="width: 80px; height: 25px;" type="text"/></td> <td style="text-align: center;"><input style="width: 80px; height: 25px;" type="text"/></td> </tr> </tbody> </table>			Predicted	Measured	V_{output}	<input style="width: 80px; height: 25px;" type="text"/>	<input style="width: 80px; height: 25px;" type="text"/>
	Predicted	Measured					
V_{output}	<input style="width: 80px; height: 25px;" type="text"/>	<input style="width: 80px; height: 25px;" type="text"/>					

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.

Question 5

Competency: AC-DC power supply circuit	Version:									
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px; margin-bottom: 5px;">Description</div> <p style="text-align: center; margin-top: 20px;">Build a "brute force" AC-DC power supply circuit, consisting of a step-down transformer, full-wave bridge rectifier, capacitive filter, and load resistor.</p>										
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px; margin-bottom: 5px;">Given conditions</div> <div style="display: flex; justify-content: space-around; margin-top: 20px;"> $V_{\text{supply}} =$ $C_{\text{filter}} =$ $R_{\text{load}} =$ </div>										
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px; margin-bottom: 5px;">Schematic</div> <div style="height: 200px; border: 1px solid black; margin-top: 10px;"></div>										
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px; margin-bottom: 5px;">Parameters</div> <table style="width: 100%; margin-top: 20px;"> <thead> <tr> <th></th> <th style="text-align: center;">Predicted</th> <th style="text-align: center;">Measured</th> </tr> </thead> <tbody> <tr> <td>$V_{\text{out(DC)}}$</td> <td style="border: 1px solid black; width: 100px; height: 30px;"></td> <td style="border: 1px solid black; width: 100px; height: 30px;"></td> </tr> <tr> <td>$V_{\text{out(ripple)}}$</td> <td style="border: 1px solid black; width: 100px; height: 30px;"></td> <td style="border: 1px solid black; width: 100px; height: 30px;"></td> </tr> </tbody> </table>			Predicted	Measured	$V_{\text{out(DC)}}$			$V_{\text{out(ripple)}}$		
	Predicted	Measured								
$V_{\text{out(DC)}}$										
$V_{\text{out(ripple)}}$										

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.

Question 6

Competency: Class-A BJT amplifier w/specified gain Version:															
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px; margin-bottom: 5px;">Description</div> <p style="margin-top: 10px;">Design and build a class-A BJT amplifier circuit with a voltage gain (A_V) that is within tolerance of the gain specified.</p> <p style="margin-top: 10px;">You may use a potentiometer to adjust the biasing of the transistor, to make the design process easier.</p>															
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px; margin-bottom: 5px;">Given conditions</div> <p style="margin-top: 10px;"> $V_{in} =$ $+V =$ $A_V =$ Tolerance$_{A_V} =$ </p>															
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px; margin-bottom: 5px;">Schematic</div> <div style="text-align: center; margin-top: 20px;"> </div>															
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px; margin-bottom: 5px;">Parameters</div> <table style="width: 100%; margin-top: 10px;"> <thead> <tr> <th style="width: 15%;"></th> <th style="width: 20%; text-align: center;">Measured</th> <th style="width: 15%;"></th> <th style="width: 20%; text-align: center;">Calculated</th> <th style="width: 30%;"></th> </tr> </thead> <tbody> <tr> <td>V_{in}</td> <td><input style="width: 100%;" type="text"/></td> <td>A_V</td> <td><input style="width: 100%;" type="text"/></td> <td rowspan="2" style="vertical-align: middle; text-align: center;"> $\frac{A_{V(\text{actual})} - A_{V(\text{ideal})}}{A_{V(\text{ideal})}} \times 100\%$ </td> </tr> <tr> <td>V_{out}</td> <td><input style="width: 100%;" type="text"/></td> <td>Error$_{A_V}$</td> <td><input style="width: 100%;" type="text"/></td> </tr> </tbody> </table>			Measured		Calculated		V_{in}	<input style="width: 100%;" type="text"/>	A_V	<input style="width: 100%;" type="text"/>	$\frac{A_{V(\text{actual})} - A_{V(\text{ideal})}}{A_{V(\text{ideal})}} \times 100\%$	V_{out}	<input style="width: 100%;" type="text"/>	Error $_{A_V}$	<input style="width: 100%;" type="text"/>
	Measured		Calculated												
V_{in}	<input style="width: 100%;" type="text"/>	A_V	<input style="width: 100%;" type="text"/>	$\frac{A_{V(\text{actual})} - A_{V(\text{ideal})}}{A_{V(\text{ideal})}} \times 100\%$											
V_{out}	<input style="width: 100%;" type="text"/>	Error $_{A_V}$	<input style="width: 100%;" type="text"/>												

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 $\pm 10\%$. 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 k Ω and 100 k Ω . Resistor values much lower than 1 k Ω 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.

Question 7

Competency: Op-amp amplifier circuit w/specified gain Version:	
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px;">Description</div>	
Design and build an op-amp amplifier circuit with a voltage gain (A_V) that is within tolerance of the gain specified.	
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px;">Given conditions</div>	
$V_{in} =$ A_V (ratio) = Tolerance $_{A_V} =$	Inverting <input style="width: 30px; height: 20px;" type="checkbox"/> Non-inverting <input style="width: 30px; height: 20px;" type="checkbox"/>
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px;">Schematic</div> <i>Show all component values!</i>	
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px;">Parameters</div>	
<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> Measured V_{in} <input style="width: 80px; height: 25px;" type="text"/> V_{out} <input style="width: 80px; height: 25px;" type="text"/> </div> <div style="text-align: center;"> Calculated A_V (ratio) <input style="width: 80px; height: 25px;" type="text"/> Error$_{A_V}$ <input style="width: 80px; height: 25px;" type="text"/> </div> </div>	$\frac{A_{V(actual)} - A_{V(ideal)}}{A_{V(ideal)}} \times 100\%$

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.

Question 8

Competency: Active RC filter circuit design		Version:						
Description	<p style="text-align: center;">Design and build an active RC filter circuit with a cutoff frequency specified by the instructor.</p>							
Given conditions	<p style="text-align: right;"><i>(instructor checks one)</i></p> <p> $f_{-3dB} =$ High-pass <input type="checkbox"/> Low-pass <input type="checkbox"/> </p>							
Schematic	<p><i>Show all component values!</i></p> <div style="height: 250px; border: 1px solid black;"></div>							
Parameters	<table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;"></th> <th style="width: 40%; text-align: center;">Predicted</th> <th style="width: 40%; text-align: center;">Measured</th> </tr> </thead> <tbody> <tr> <td style="vertical-align: middle;">f_{-3dB}</td> <td style="border: 1px solid black; height: 30px;"></td> <td style="border: 1px solid black; height: 30px;"></td> </tr> </tbody> </table>			Predicted	Measured	f_{-3dB}		
	Predicted	Measured						
f_{-3dB}								

file 02133

Answer 8

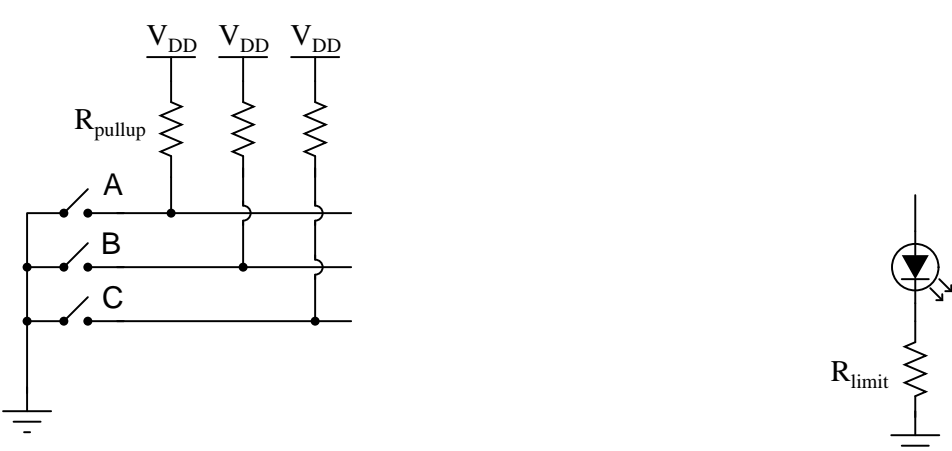
Use circuit simulation software to verify your predicted and measured parameter values.

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:																																																																								
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px; margin-bottom: 10px;">Truth table</div> <div style="display: flex; justify-content: space-around; align-items: flex-start;"> <div style="text-align: center;"> <p>Given</p> <table border="1" style="border-collapse: collapse; margin: auto;"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>Output</th> </tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>0</td><td></td></tr> <tr><td>0</td><td>0</td><td>1</td><td></td></tr> <tr><td>0</td><td>1</td><td>0</td><td></td></tr> <tr><td>0</td><td>1</td><td>1</td><td></td></tr> <tr><td>1</td><td>0</td><td>0</td><td></td></tr> <tr><td>1</td><td>0</td><td>1</td><td></td></tr> <tr><td>1</td><td>1</td><td>0</td><td></td></tr> <tr><td>1</td><td>1</td><td>1</td><td></td></tr> </tbody> </table> </div> <div style="text-align: center;"> <p>Actual</p> <table border="1" style="border-collapse: collapse; margin: auto;"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>Output</th> </tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>0</td><td></td></tr> <tr><td>0</td><td>0</td><td>1</td><td></td></tr> <tr><td>0</td><td>1</td><td>0</td><td></td></tr> <tr><td>0</td><td>1</td><td>1</td><td></td></tr> <tr><td>1</td><td>0</td><td>0</td><td></td></tr> <tr><td>1</td><td>0</td><td>1</td><td></td></tr> <tr><td>1</td><td>1</td><td>0</td><td></td></tr> <tr><td>1</td><td>1</td><td>1</td><td></td></tr> </tbody> </table> </div> </div>					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		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	
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<div style="border: 1px solid black; display: inline-block; padding: 2px 5px; margin-bottom: 10px;">Schematic</div> <div style="display: flex; justify-content: space-around; align-items: center;">  </div>																																																																												

file 02134

Answer 9

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

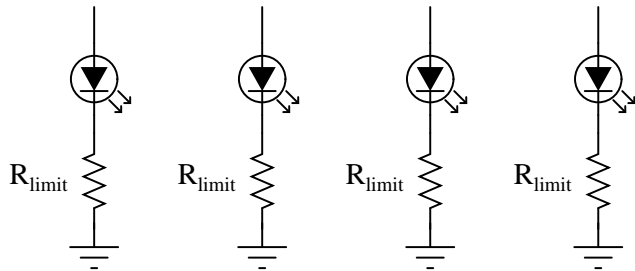
Notes 9

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):

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

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																																																																																																																											
																																																																																																																											
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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.