California State University, Northridge

College of Engineering & Computer Science

Electrical and Computer Engineering Department

ECE 443L Digital Electronics Laboratory

Report 10

CMOS based Comparator Circuit Design, Simulation and Experimental Test as well as Analysis

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Abstract:

Lab 4 exposes students of Comparators and their functionalities in everyday electronics. A comparator is simply a device which compares 2 input voltages or currents and outputs indicating which signal was larger. Comparators are largely utilized in Analog-to-digital converters, which are found in almost every advanced electronic.

Key Terms:

Comparator, ADC, converter

Simulation and Experimental Result:

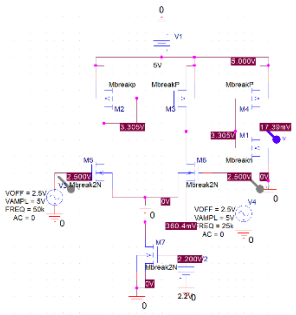
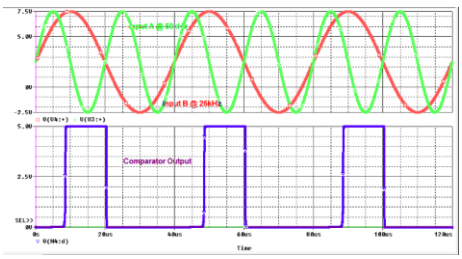


Figure 4.1: Case 1 EVAN Comparator Schematic @ 25kHz and 50kHz



Trace Color	Trace Name	Y1	Y2	Y1 - Y2		Y1(Cursor1) - Y2(Cursor2)	0.000			
	X Values	0.000	0.000	0.000		Y1 - Y1(Cursor1)	Y2 - Y2(Cursor2)	Max Y	Min Y	Avg Y
CURSOR 1,2	V(M4:d)	17.385m	17.385m	0.000		0.000	0.000	17.385m	17.385m	17.385m
	V(V4:+)	2.5000	2.5000	0.000		2.4826	2.4826	2.5000	2.5000	2.5000
	V(V3:+)	2.5000	2.5000	0.000		2.4826	2.4826	2.5000	2.5000	2.5000

Figure 4.2: Case 1 EVAN Comparator Waveform and Cursor @ 25kHz and 50kHz

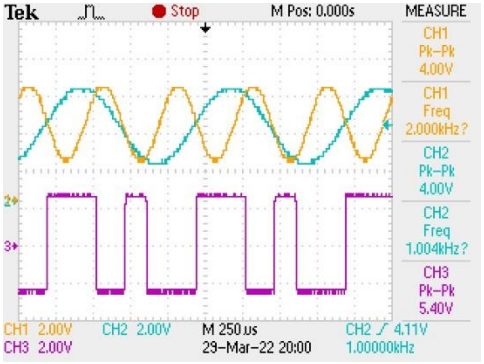


Figure 4.3: Case 1 EVAN Comparator Circuit Result @ 1kHz and 2kHz

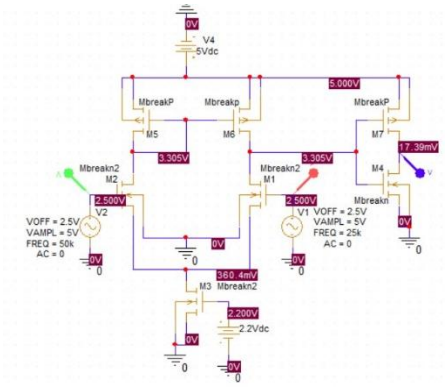


Figure 4.4: Case 1 CLAYTON Comparator Schematic @ 25kHz and 50kHz

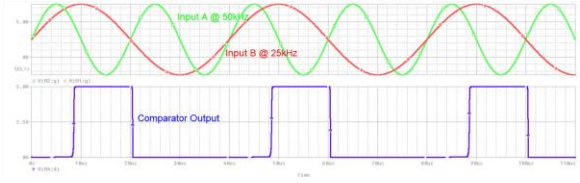


Figure 4.5: Case 1 CLAYTON Comparator Waveform @ 25kHz and 50kHz

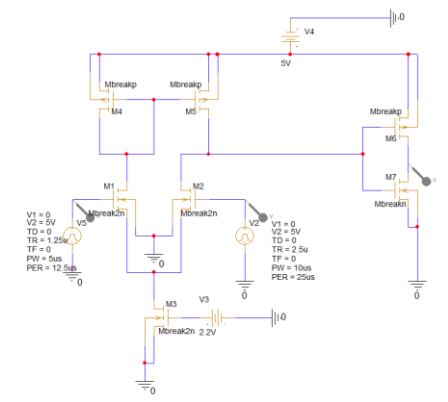
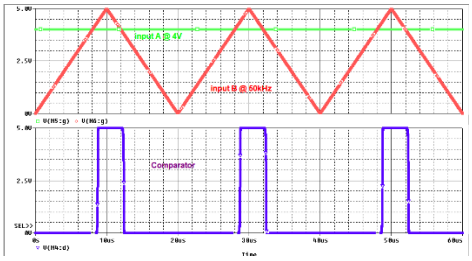
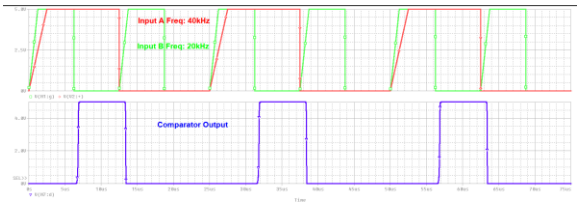


Figure 4.6: Case 2 HAROUTUN Comparator Schematic @ 20kHz and 40kHz



Trace Color	Trace Name	Y1	Y2	Y1 - Y2		Y1(Cursor1) - Y2(Cursor2)		0.000		
	X Values	0.000	0.000	0.000		Y1 - Y1(Cursor1)	Y2 - Y2(Cursor2)	Max Y	Min Y	Avg Y
CURSOR 1,2	V(M4:d)	21.662n	21.662n	0.000		0.000	0.000	21.662n	21.662n	21.662n
	V(M5:g)	4.0000	4.0000	0.000		4.0000	4.0000	4.0000	4.0000	4.0000
	V(M6:g)	5.0000u	5.0000u	0.000		4.9783u	4.9783u	5.0000u	5.0000u	5.0000u

Figure 4.9: Case 3 EVAN Comparator Waveform @ 50kHz and 4V



Trace Color	Trace Name	Y1	Y2	Y1 - Y2		Y1(Cursor1) - Y2(Cursor2)		5.0000		
	X Values	10.200u	14.800u	-4.6000u		Y1 - Y1(Cursor1)	Y2 - Y2(Cursor2)	Max Y	Min Y	Avg Y
CURSOR 1,2	V(M7:d)	5.0000	21.026n	5.0000		0.000	0.000	5.0000	21.026n	2.5000
	V(M1:g)	0.000	5.0000	-5.0000		-5.0000	5.0000	5.0000	0.000	2.5000
	V(V2:+)	5.0000	0.000	5.0000		19.592n	-21.026n	5.0000	0.000	2.5000

Figure 4.7: Case 2 HAROUTUN Comparator Waveform @ 20kHz and 40kHz

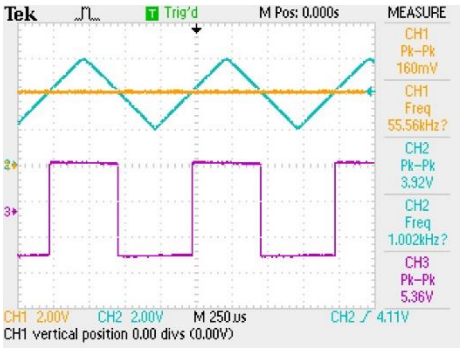


Figure 4.10: Case 3 EVAN Comparator Circuit Output @ 1kHz and 3.92V

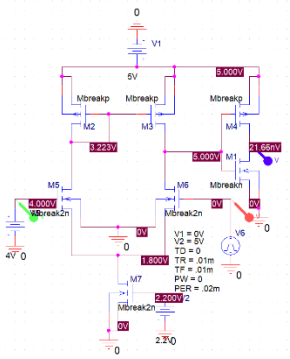


Figure 4.8: Case 3 EVAN Comparator Schematic @ 50kHz and 4V

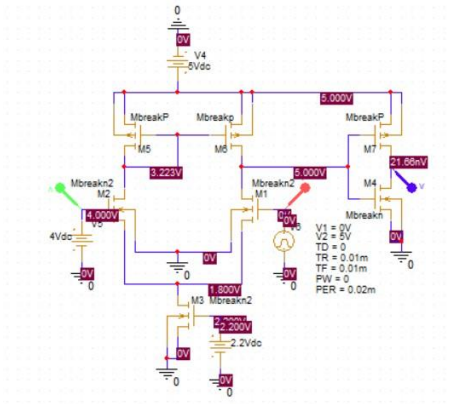


Figure 4.11: Case 3 CLAYTON Comparator Schematic @ 50kHz and 4V

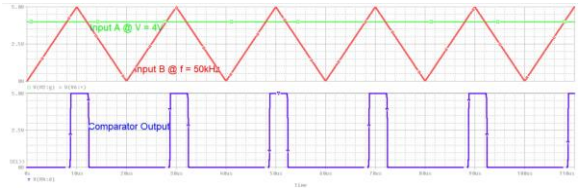


Figure 4.12: Case 3 CLAYTON Comparator Waveform @ 50kHz and 4V

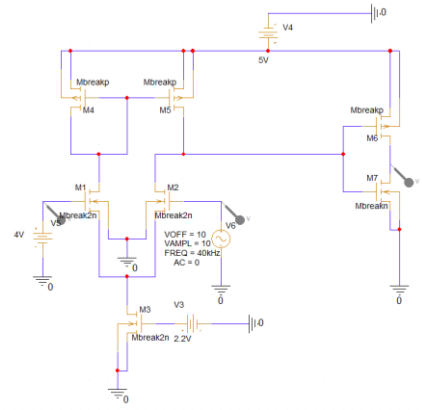
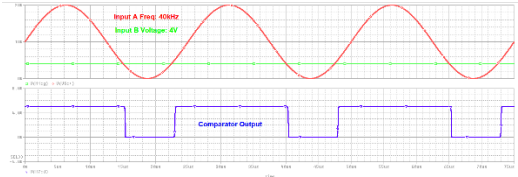


Figure 4.13: Case 4 HAROUTUN Comparator Schematic @ 40kHz and 4V



Trace Color	Trace Name	Y1	Y2	Y1 - Y2	Y1(Cursor1) - Y2(Cursor2)		15.997		
	X Values	31.351u	31.351u	0.000	Y1 - Y1(Cursor1)	Y2 - Y2(Cursor2)	Max Y	Min Y	Avg Y
	V(M7:d)	5.0000	5.0000	0.000	-14.997	1.0000	5.0000	5.0000	5.0000
CURSOR 2	V(M1:g)	4.0000	4.0000	0.000	-15.997	0.000	4.0000	4.0000	4.0000
CURSOR 1	V(V6:+)	19.997	19.997	0.000	0.000	15.997	19.997	19.997	19.997

Figure 4.14: Case 4 HAROUTUN Comparator Waveform @ 40kHz and 4V

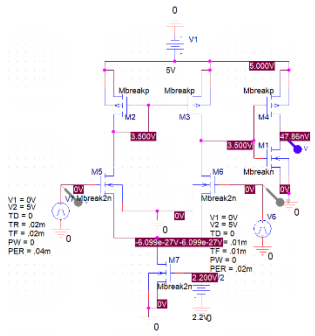
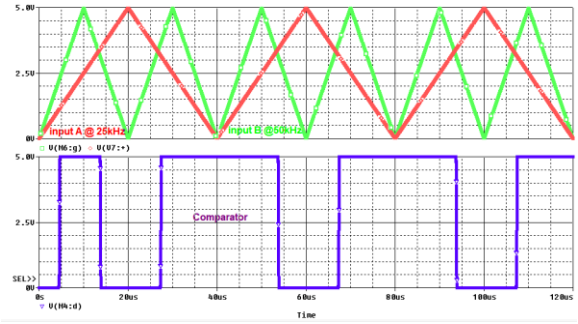


Figure 4.15: Case 5 EVAN Comparator Waveform @ 25kHz and 50kHz



Trace Color	Trace Name	X1	X2	Y1 - Y2	Y1(Cursor1) - Y2(Cursor2)		0.000		
	X Values	0.000	0.000	0.000	Y1 - Y1(Cursor1)	Y2 - Y2(Cursor2)	Max Y	Min Y	Avg Y
CURSOR 1,2	V(M4:d)	47.858n	47.858n	0.000	0.000	0.000	47.858n	47.858n	47.858n
	V(M6:g)	5.0000u	5.0000u	0.000	4.9521u	4.9521u	5.0000u	5.0000u	5.0000u
	V(V7:+)	2.5000u	2.5000u	0.000	2.4521u	2.4521u	2.5000u	2.5000u	2.5000u

Figure 4.16: Case 5 EVAN Comparator Waveform @ 25kHz and 50kHz

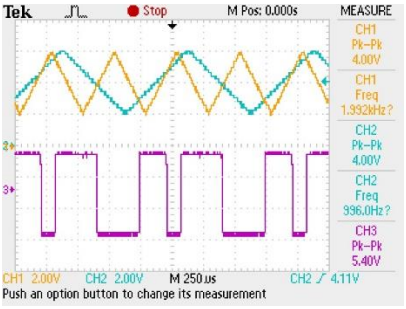


Figure 4.17: Case 5 EVAN Comparator Circuit Output @ 2kHz and 996Hz

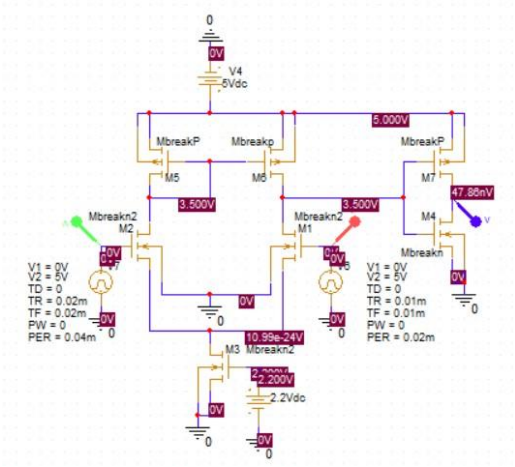


Figure 4.18: Case 5 CLAYTON Comparator Schematic @ 25kHz and 50kHz

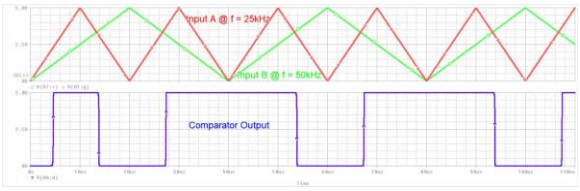


Figure 4.19: Case 5 CLAYTON Comparator Waveform @ 25kHz and 50kHz

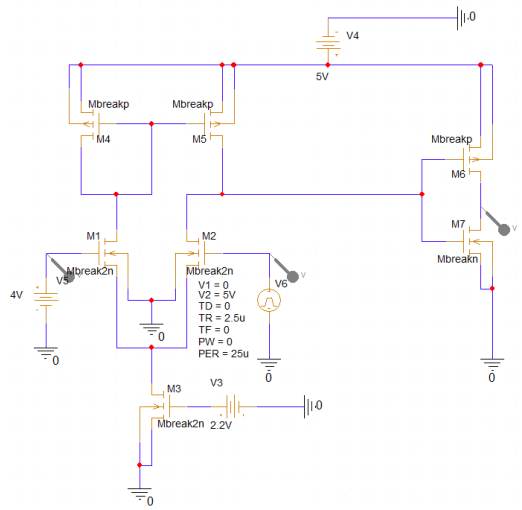
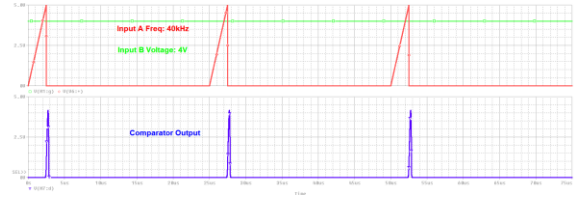


Figure 4.20: Case 6 HAROUTUN Comparator Schematic @ 40kHz and 4V



Trace Color	Trace Name	Y1	Y2	Y1 - Y2	Y1(Cursor1) - Y2(Cursor2)	1.0000		
	X Values	27.500u	23.751u	3.7495u	Y1 - Y1(Cursor1)	Y2 - Y2(Cursor2)	Max Y	Min Y	Avg Y
	V(M7:d)	817.545m	23.163n	817.545m	-4.1825	-4.0000	817.545m	23.163n	408.772m
CURSOR 2	V(M1:g)	4.0000	4.0000	0.000	-1.0000	0.000	4.0000	4.0000	4.0000
CURSOR 1	V(V6:+)	5.0000	0.000	5.0000	0.000	-4.0000	5.0000	0.000	2.5000

Figure 4.21: Case 6 HAROUTUN Comparator Waveform @ 40kHz and 4V

Conclusion:

Students not only constructed a comparator on the advanced software PSpice but recreated the circuit on a breadboard. As seen in figure 4.17, the comparator functions properly, indicating which input signal was higher. Comparators are found in almost every electronics which allows engineers to produce circuits based upon the comparative result of 2 signals.