April 14, 2009

Electric Guitar MULTI-FX

and Sequencing

In Tune Innovations

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Itinerary

- Background
- The Effects
- Digital Logic
- User Interface
- Timeline & Business Plan
- Future Work
- Lessons Learned
- Questions?

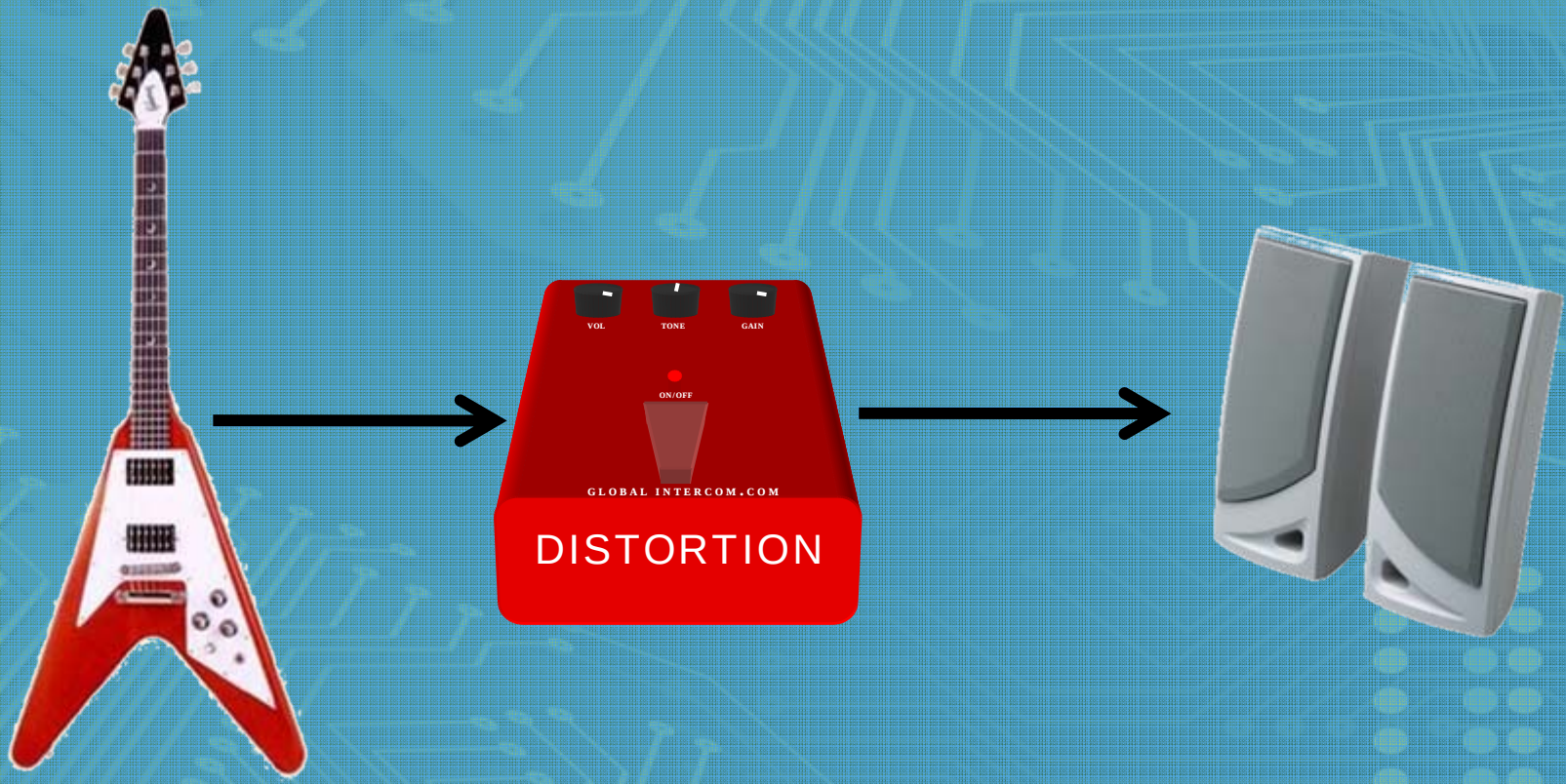
Background

Source: Javart, wikipedia

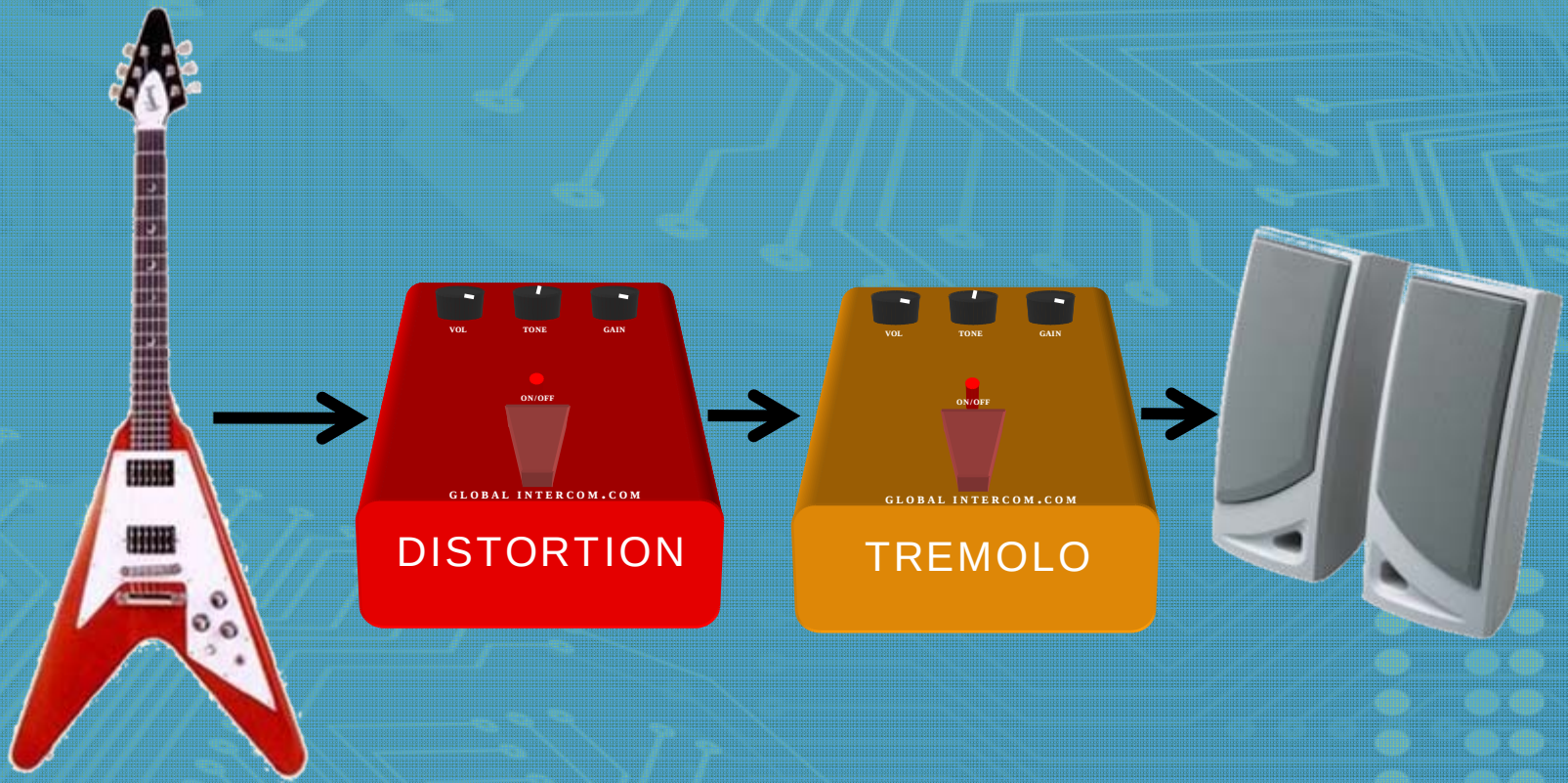
- Electric Guitar Effects
- Single & multi effects
- What is lost in commercial multi-FX?
  - What is gained?

Basic Concept

If you can have one pedal…



…then you can have two pedals…



...Or more than two...

source: dolphinstreet.com

…Or more than you can count…

source: redbubble.com

…Or Chaos…

Source: lizzydaymont.com

Clean up time

Multi-FX


BOSS ME-70 GUITAR MULTIPLE EFFECTS
PREAMP
REVERB
OUTPUT LEVEL
EZ TONE
PEDAL FX
COMP/FX
OD/DS
MODULATION
DELAY
COMP
OD/DS
MOD
DELAY
BANK SELECT
TUNER/ BYPASS
MEMORY MODE
COSM

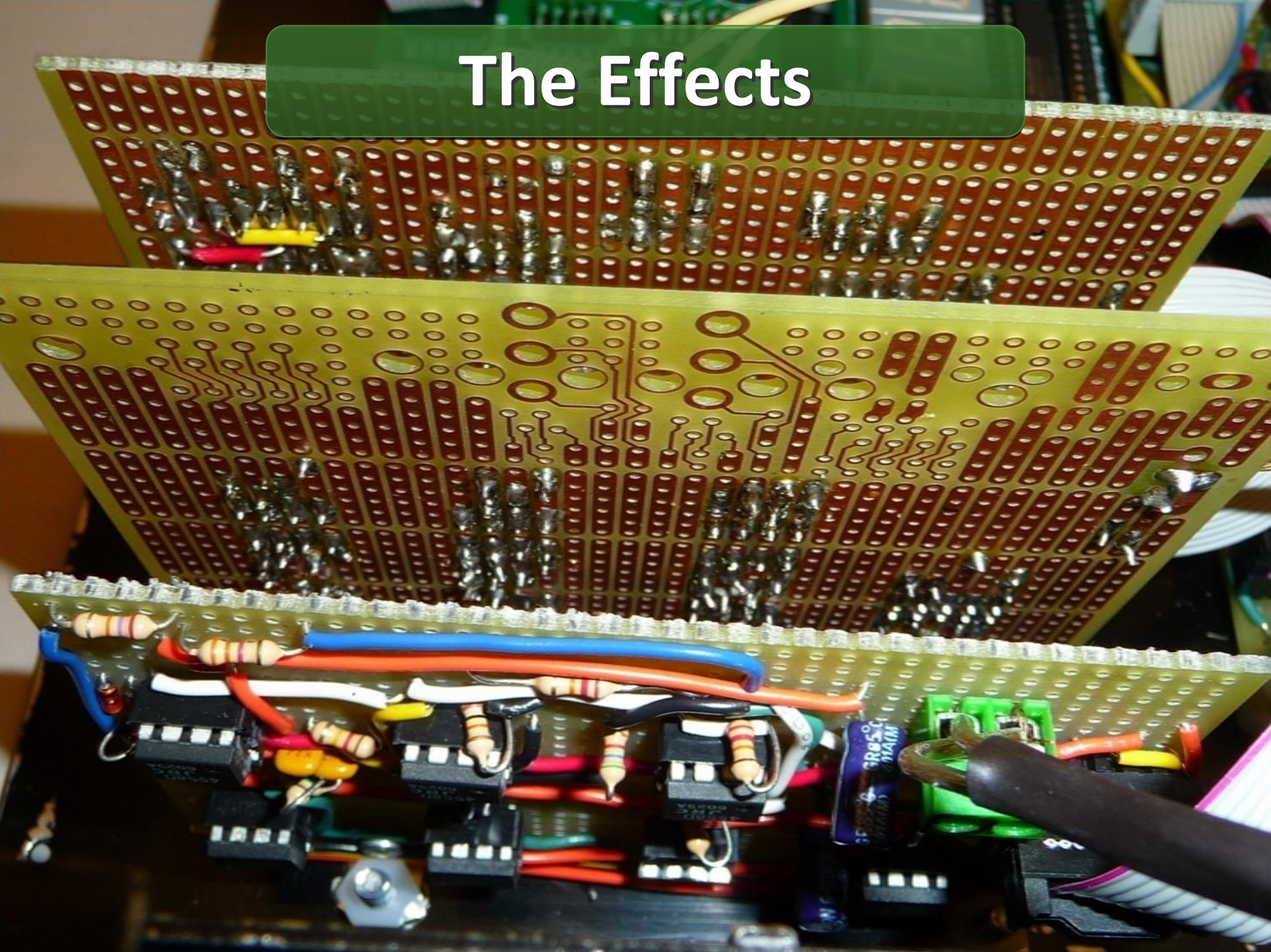
MULTI-FX

Guitar FX

- **In Tune Innovations product:**
  - 3 in 1 Electric Guitar Multi-FX
    - Settings can be saved and recalled

- Combining multi-FX, preset capability and effect sequencing

The Effects



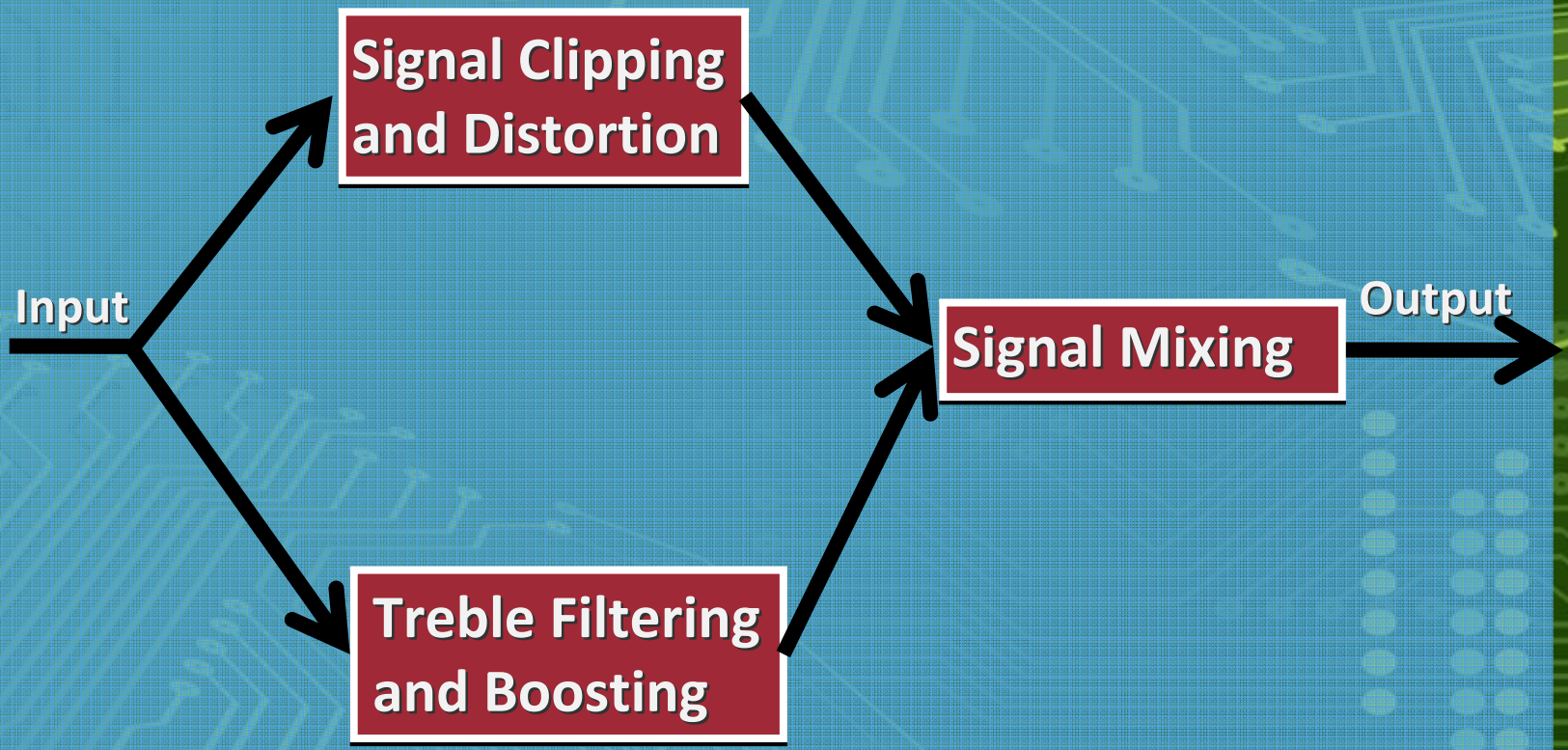
The Effects

- Distortion with Treble Boost
- Tremolo
- Auto-Wah

Distortion

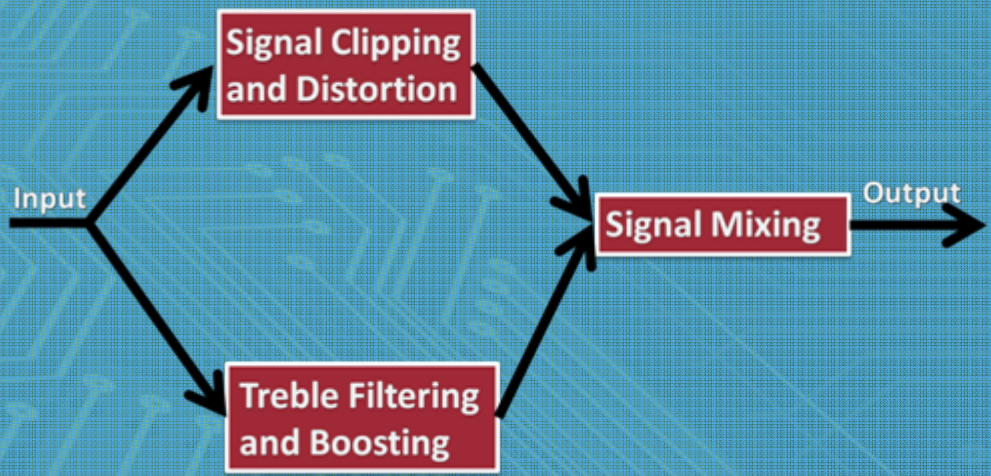
Yes, there is such a thing as good distortion

Distortion

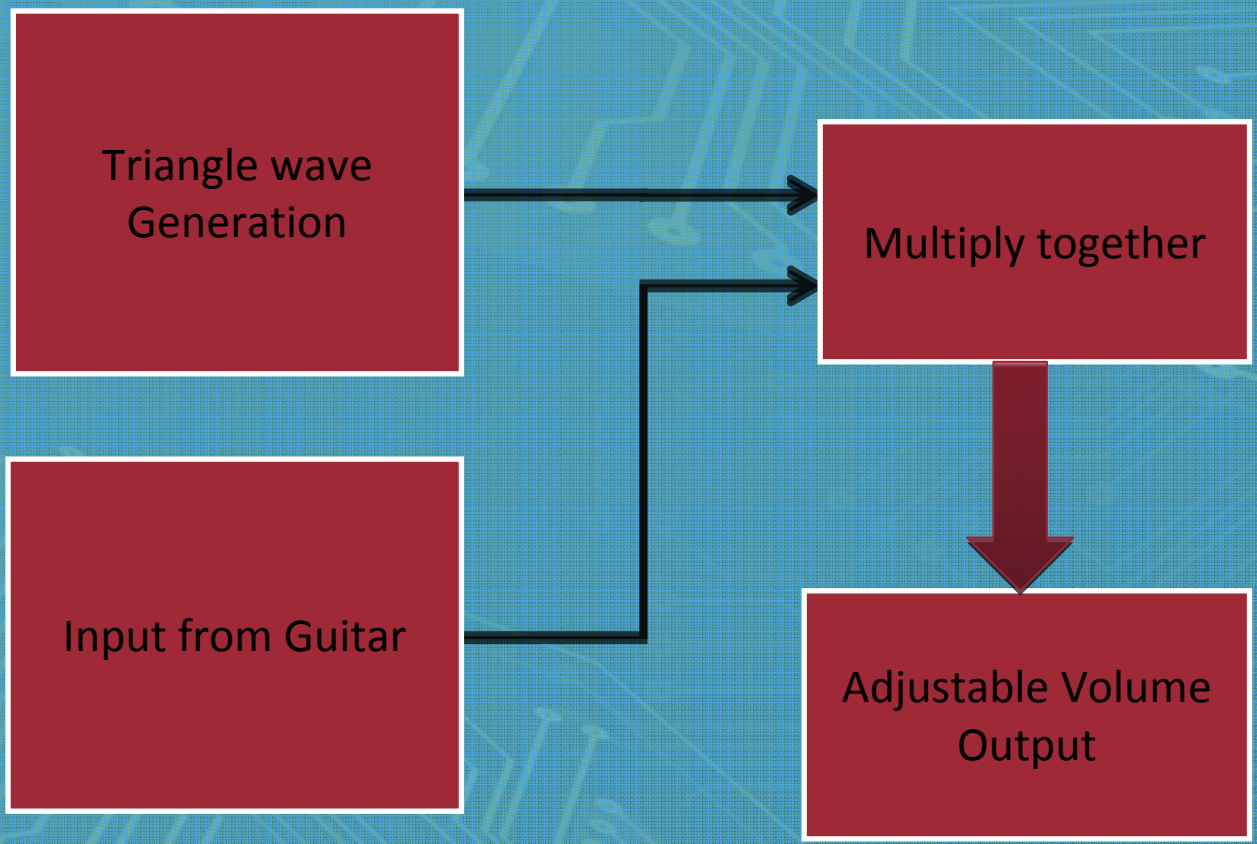

Input
Signal Clipping and Distortion
Treble Filtering and Boosting
Signal Mixing
Output

Distortion

- Controllable Aspects
  - Clarity Adjust
  - Treble Boost Mix
  - Output Volume

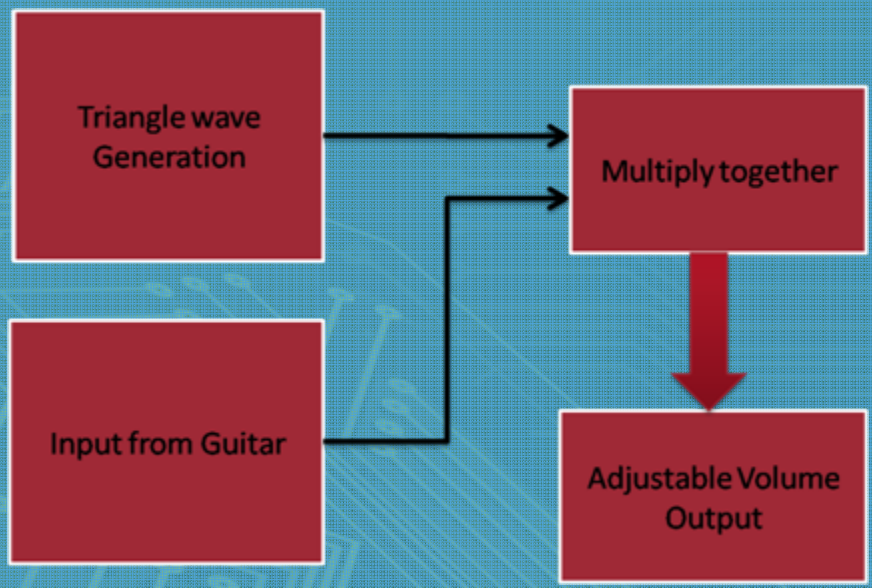


Tremolo


Triangle wave Generation
Input from Guitar
Multiply together
Adjustable Volume Output

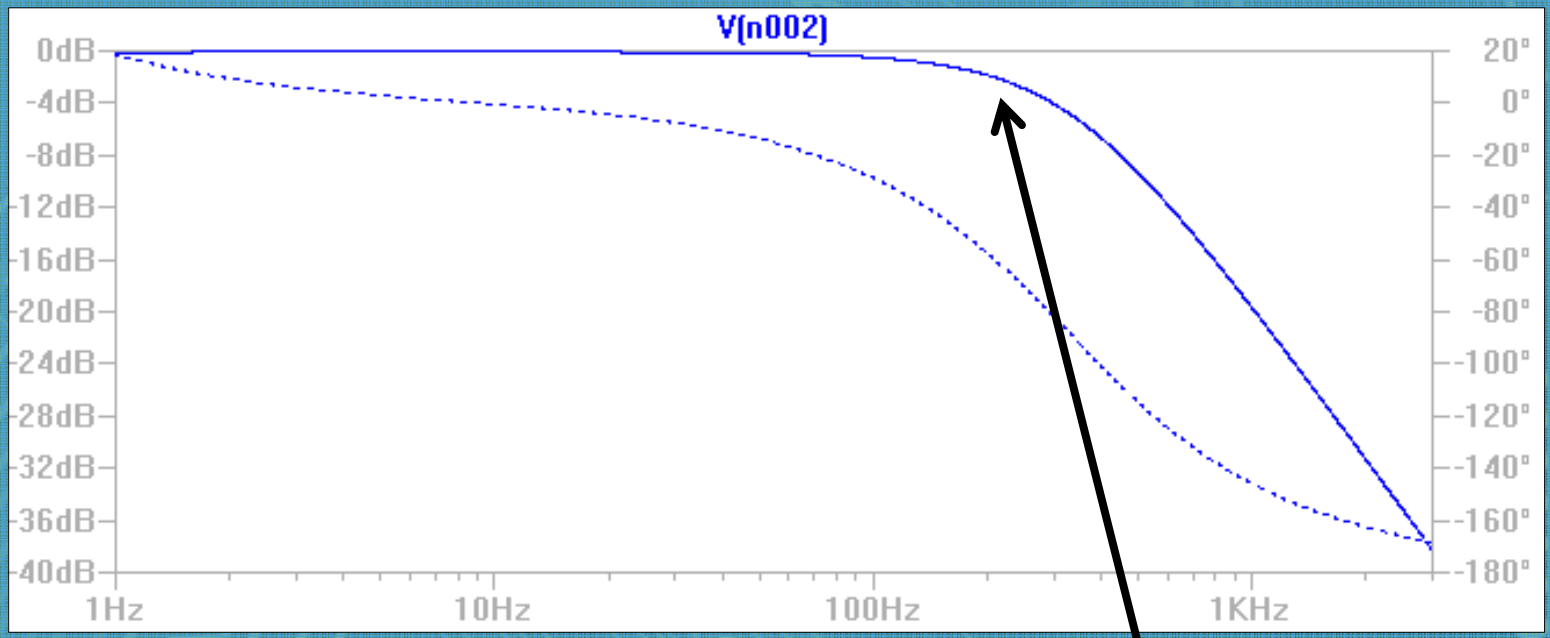
Tremolo

- Controllable Aspects
  - Period of Tremolo wave
  - Output Volume
  - Fine Tune

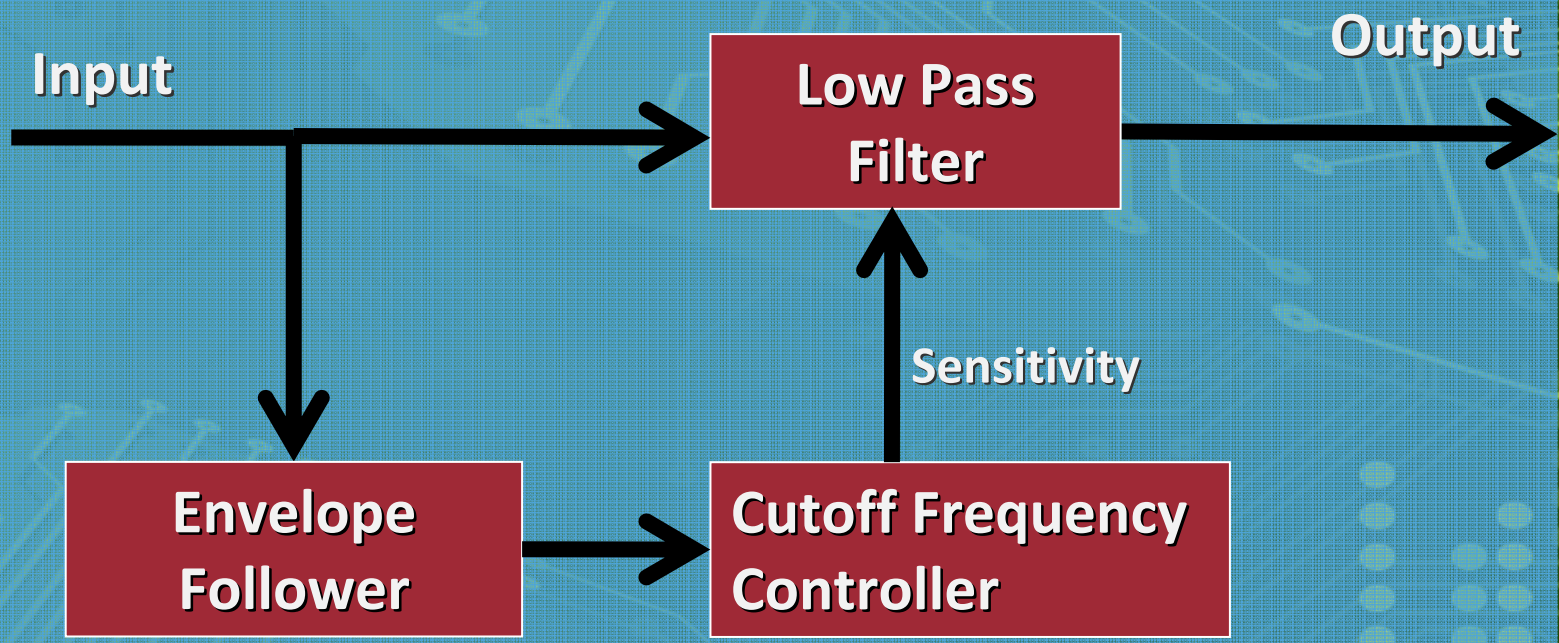


Auto-WAH

- Automatic filtering

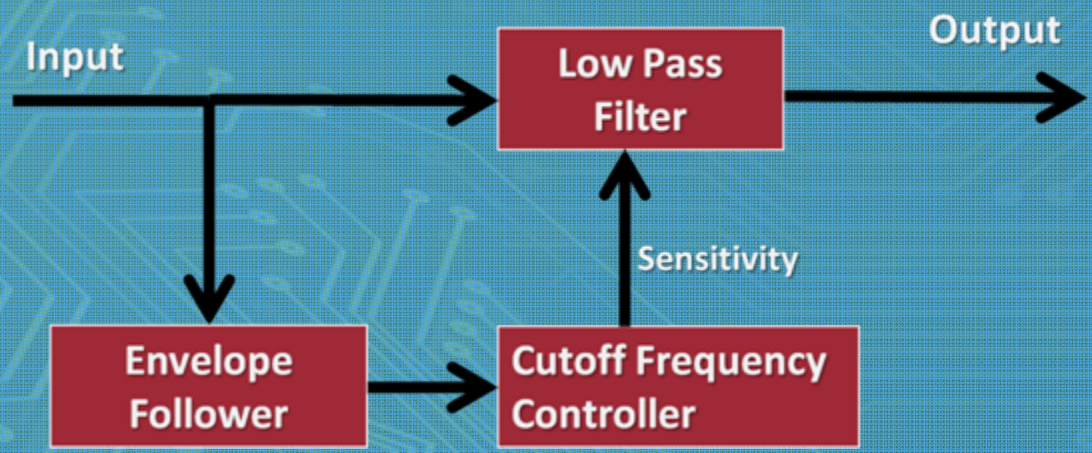


Auto-WAH

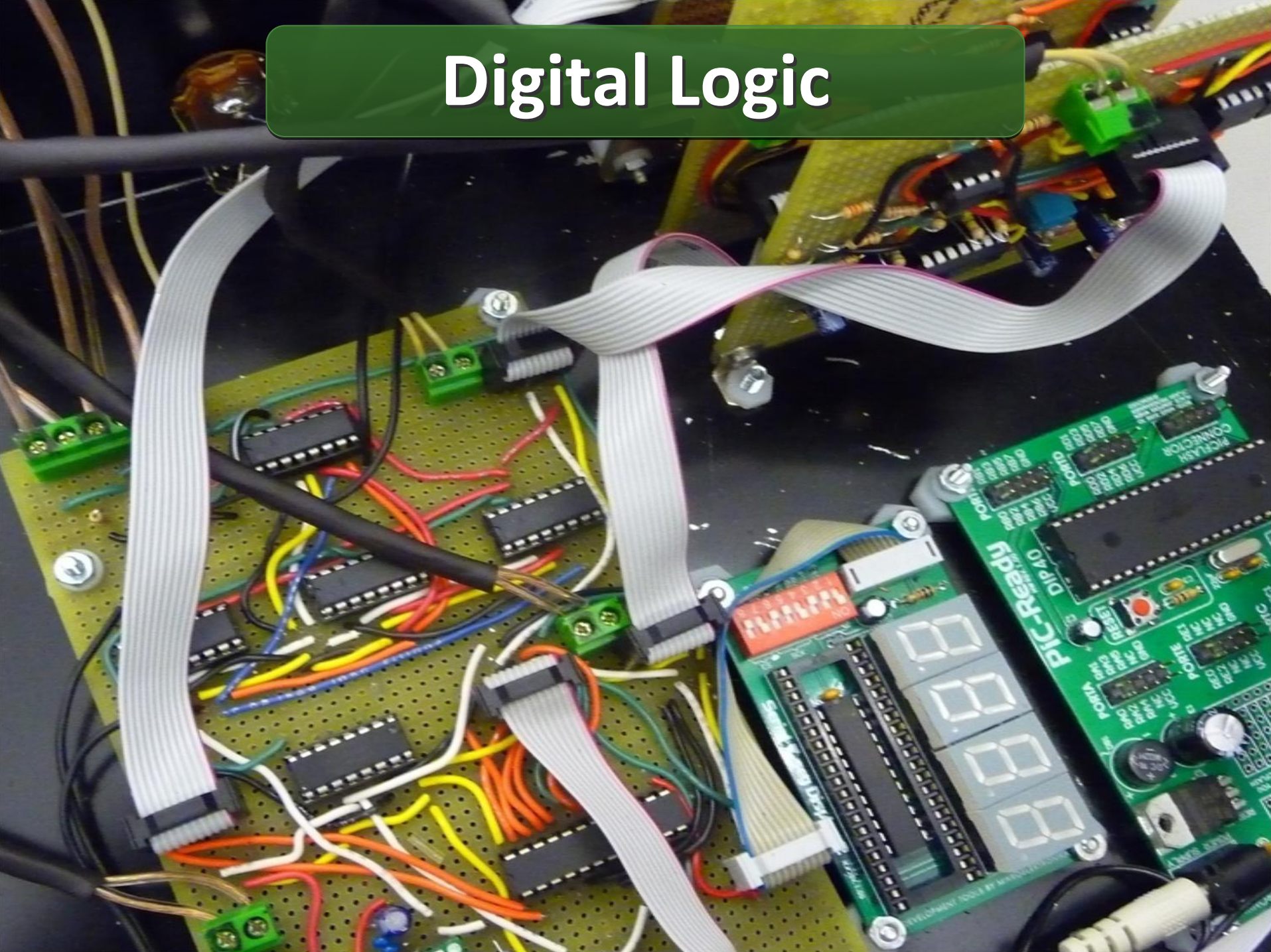

Input
Low Pass Filter
Output
Sensitivity
Envelope Follower
Cutoff Frequency Controller

Auto-WAH

- Controllable Aspects
  - Sensitivity of Filter (because based on loudness)
  - Moveable Range of Filter



Digital Logic

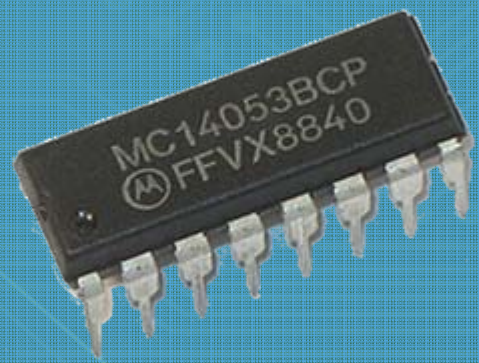


Effect Switching

- How do we route an analog signal using digital logic from our microcontroller?
  - Relays?
  - Transistor Logic?

Effect Switching

- Solution: Analog Multiplexers!
- Four chained together
  - Allows any combination of effects
- 16 permutations



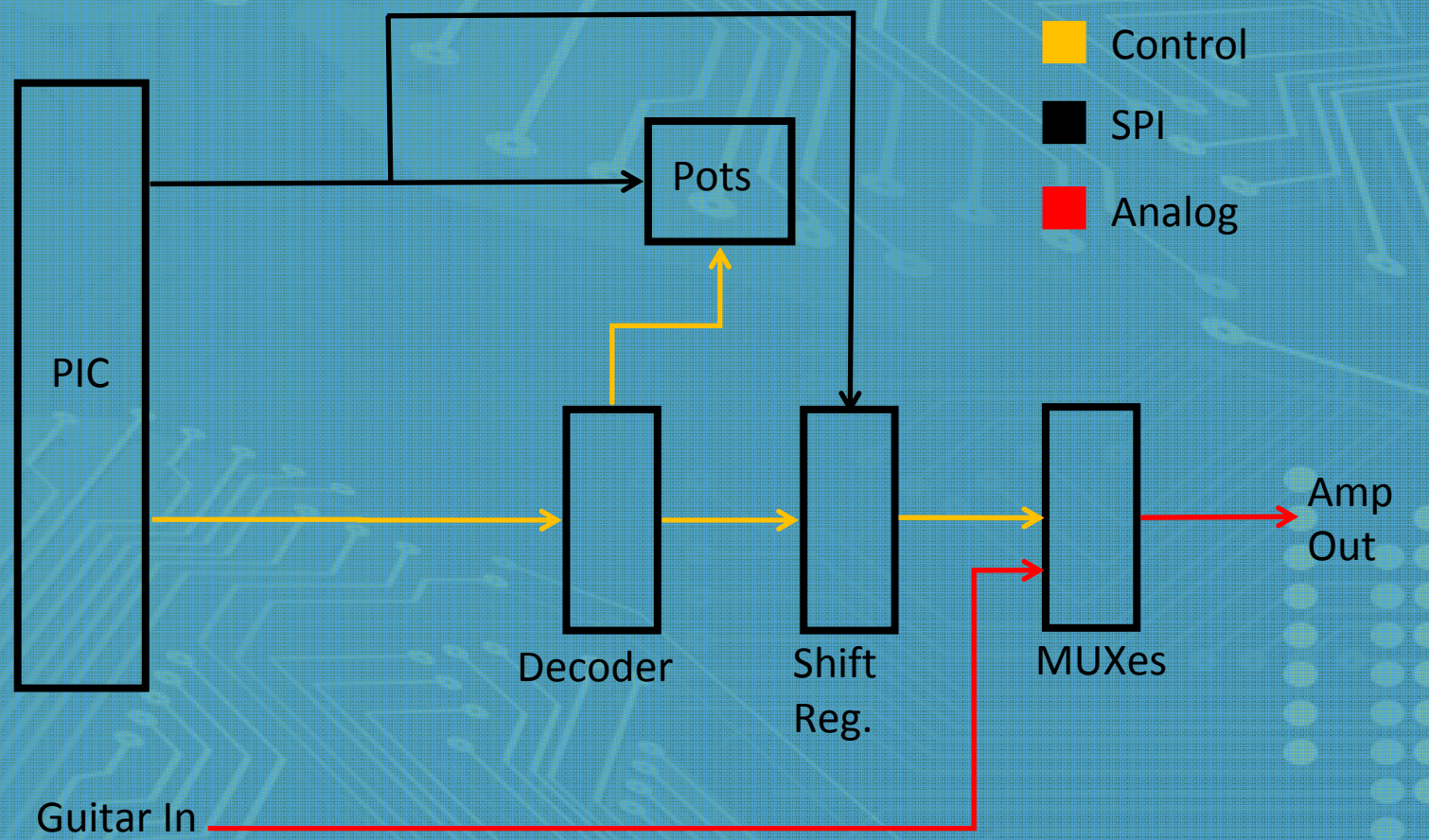
Effect Customization?

Effect Customization

- Digital Potentiometers (pots)
- Two or three pots used per effect
- One hundred settings per pot

- High amount of customization
- Simplicity

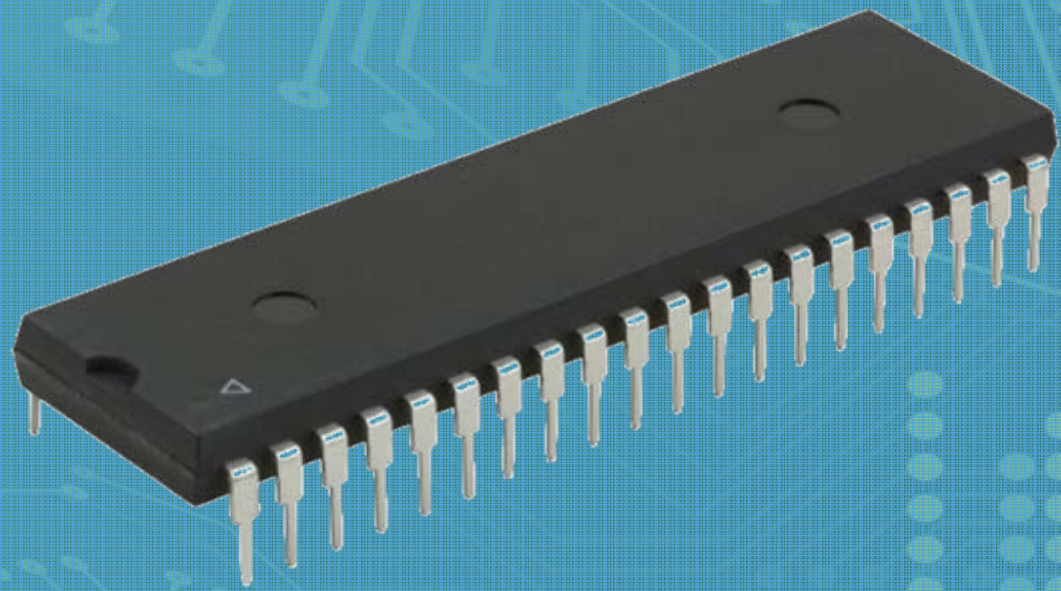
High Level Digital Circuitry



Microcontroller

Microcontroller

- Microchip's PIC
- PIC18F4520



- 40 Pin
- 10 MIPS
- 32KB Flash
- 1.5KB RAM
- 256B Eeprom

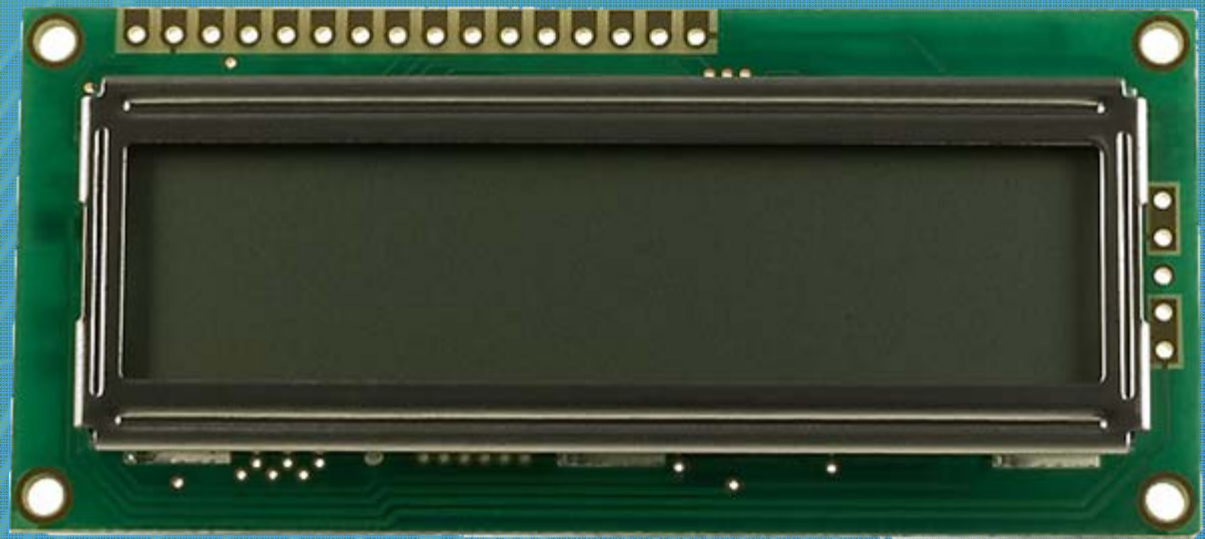
Eeprom

- Persistent storage
- Where saves are located

- Maximums
  - Eight effect chain saves
  - One effect chain autosave
  - One playlist save
- Can easily be expanded

User Interface

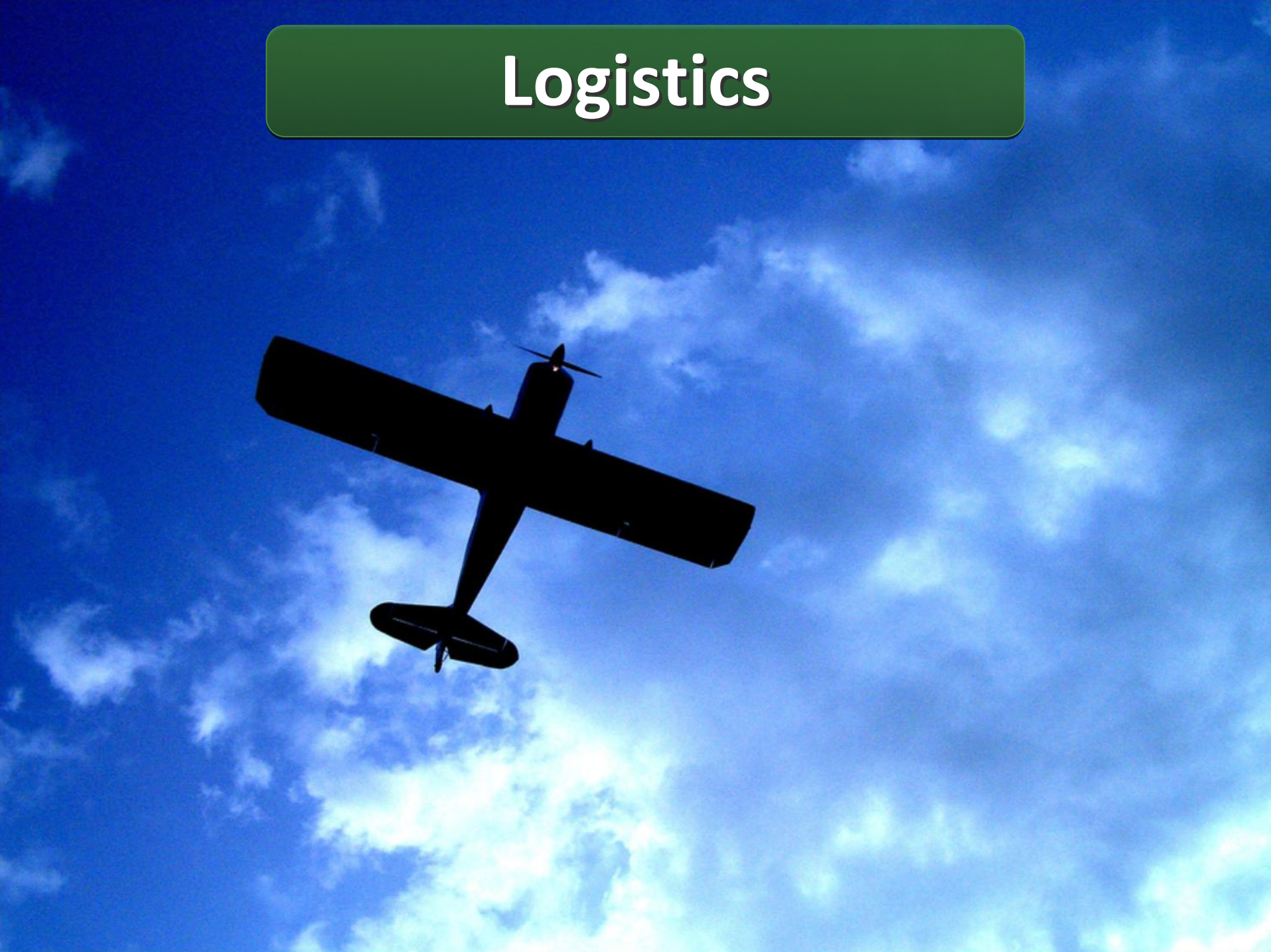
- Displays
  - 16x2 character LCD
  - Three 7-segment displays
  - Three LED bypass indicators



User Interface

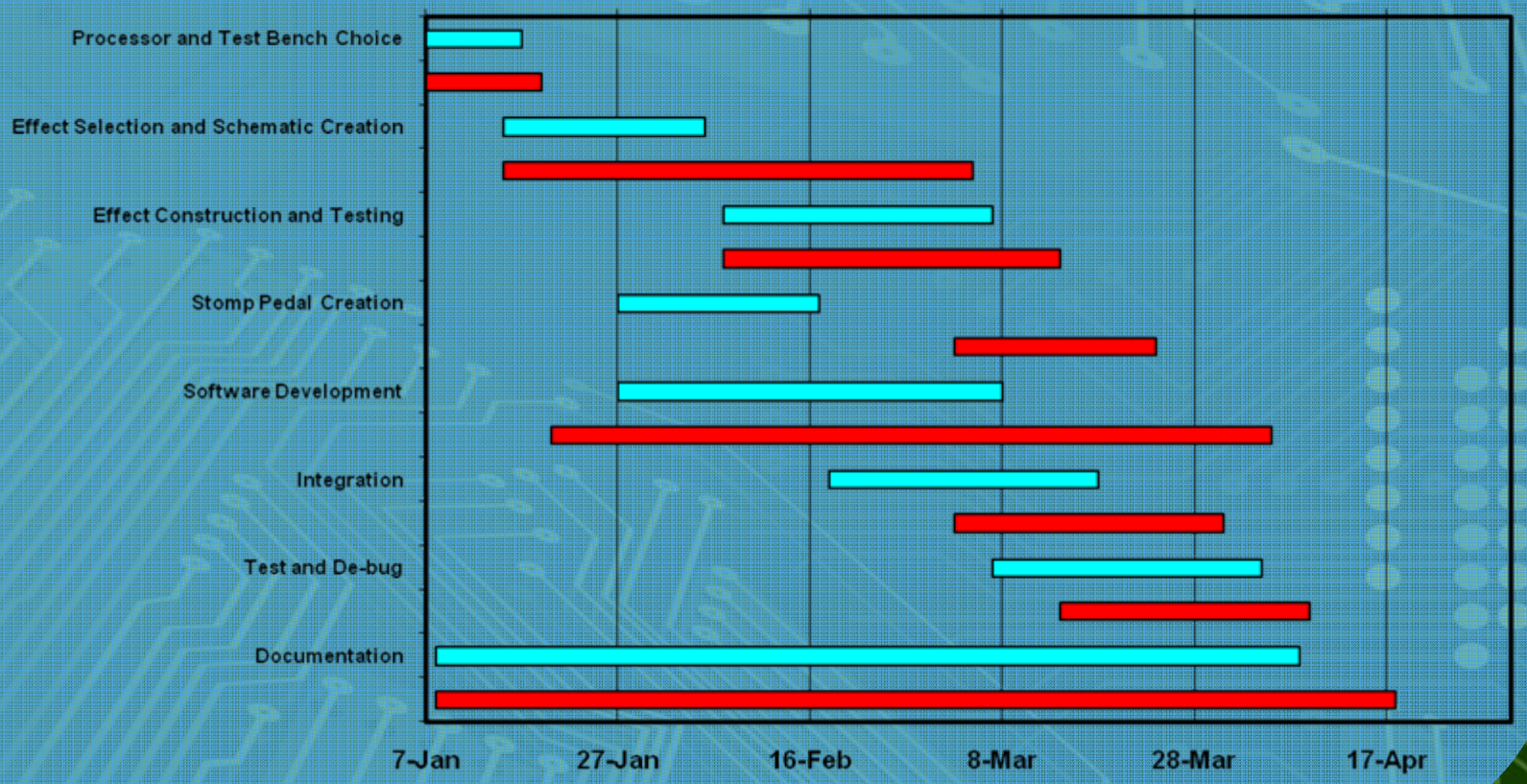
- Inputs
  - Four stomp switches
    - One momentary
  - Seven buttons
  - One rotary encoder

Logistics



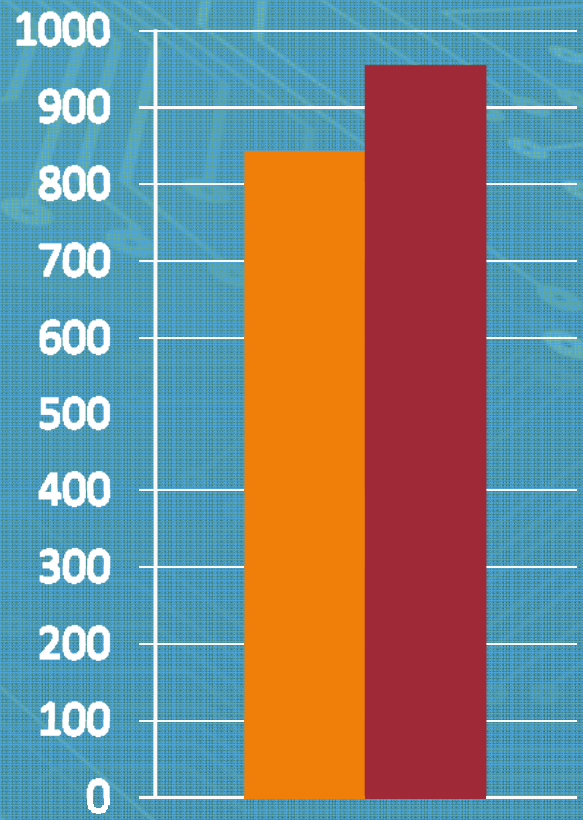
Timeline

Estimated in Blue, Realized in Red



Finances

- Estimated
  - Total Cost $840.91
- Realized
  - Total Cost $952.53



Cost Overruns?

- Major Expenses
  - First order Doubled ≈ $100
  - Shipping on 1st Order ≈ $100
  - Replaced all stomp switches ≈ $50
  - Rebuilt Distortion Board ≈$20
  - Built new Button Board ≈$25

Cost per Unit

- Roughly $250 per unit
- Savings:
  - No Development boards
  - No PIC Programmer
  - Smaller 7-Seg
  - PCB instead of Vector Board
  - Only the parts we need!

Business Comparison

Holy Stain - $99US

Analog Distortion;
Other effects Digital
Only choice of Distortion + 1 Effect
No saves or memory

Boss ME-20 $200 US

17 Digital Effects
3 Effects Chained
Memory Feature

Business Comparison

Carl Martin Quattro - $623US

Pure Analog circuitry

Variable Effect Order

No saves or playlist ability

Future Work

Future Work

- Manufactured PCB's
- Sockets for effects
- More appropriate case
- Effect tweaking

Acknowledgements

- ESSEF
- Patrick Leung
- Steve Whitmore
- Jamie & Jason
- Fred Heep
- Peers

Lessons Learned

- Research and planning
- Standardization!

Lessons Learned

- Plan your exit early
- Take ownership

Lessons Learned

- Modularity
- Constant testing and repeatability

Lessons Learned

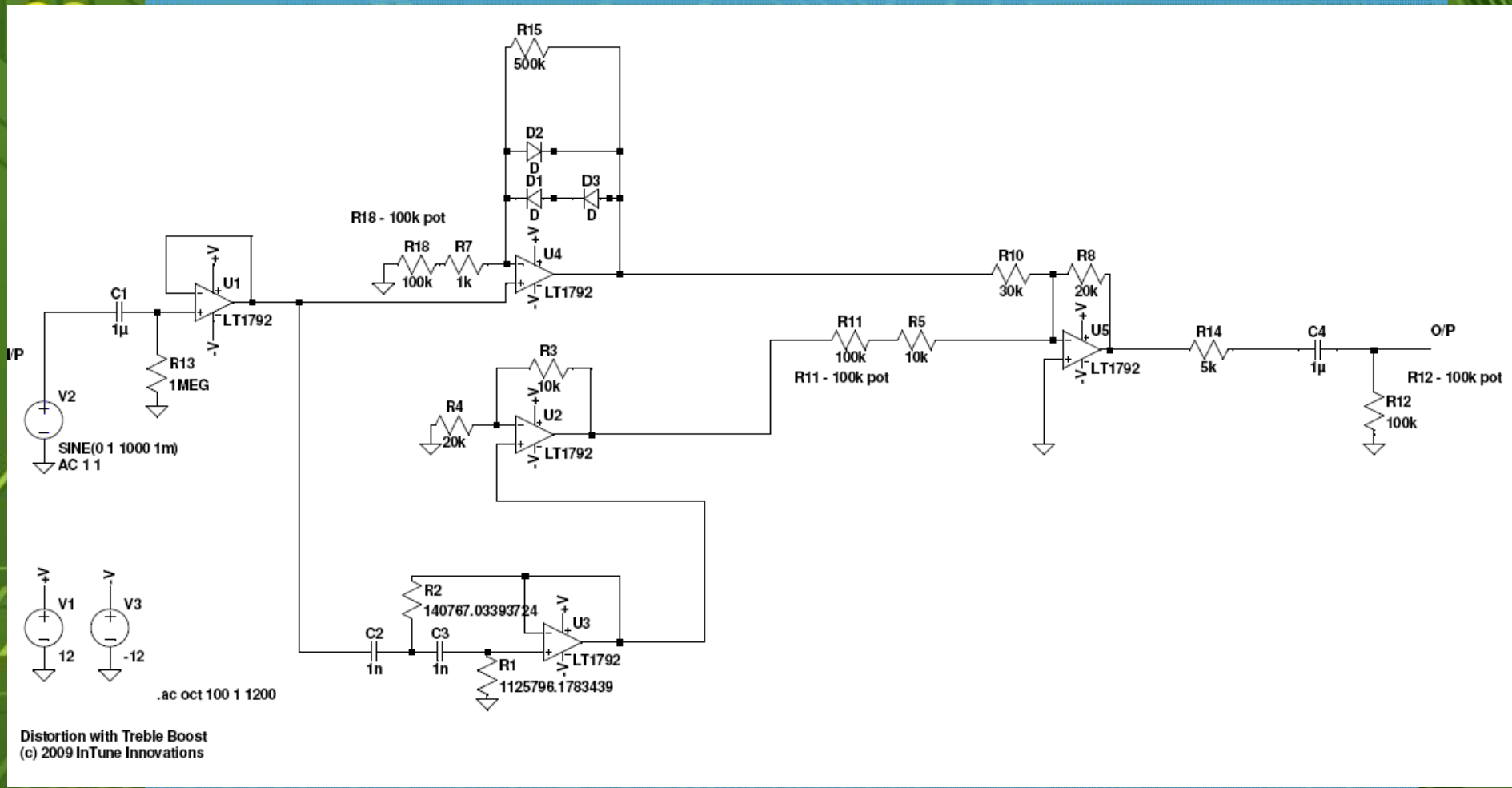
- Nothing is permanent
- Meet your deadlines

Questions, Comments?

Thank you for attending our presentation

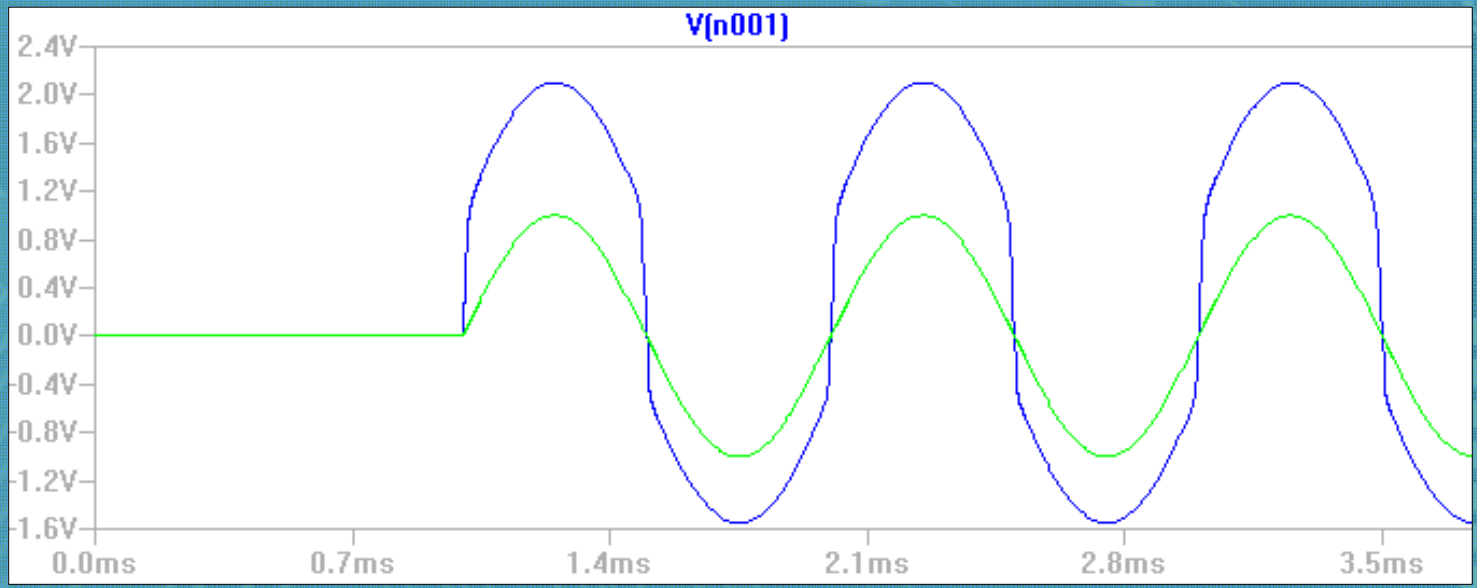
Technical Addendum

Distortion w/ Treble *BOOST*

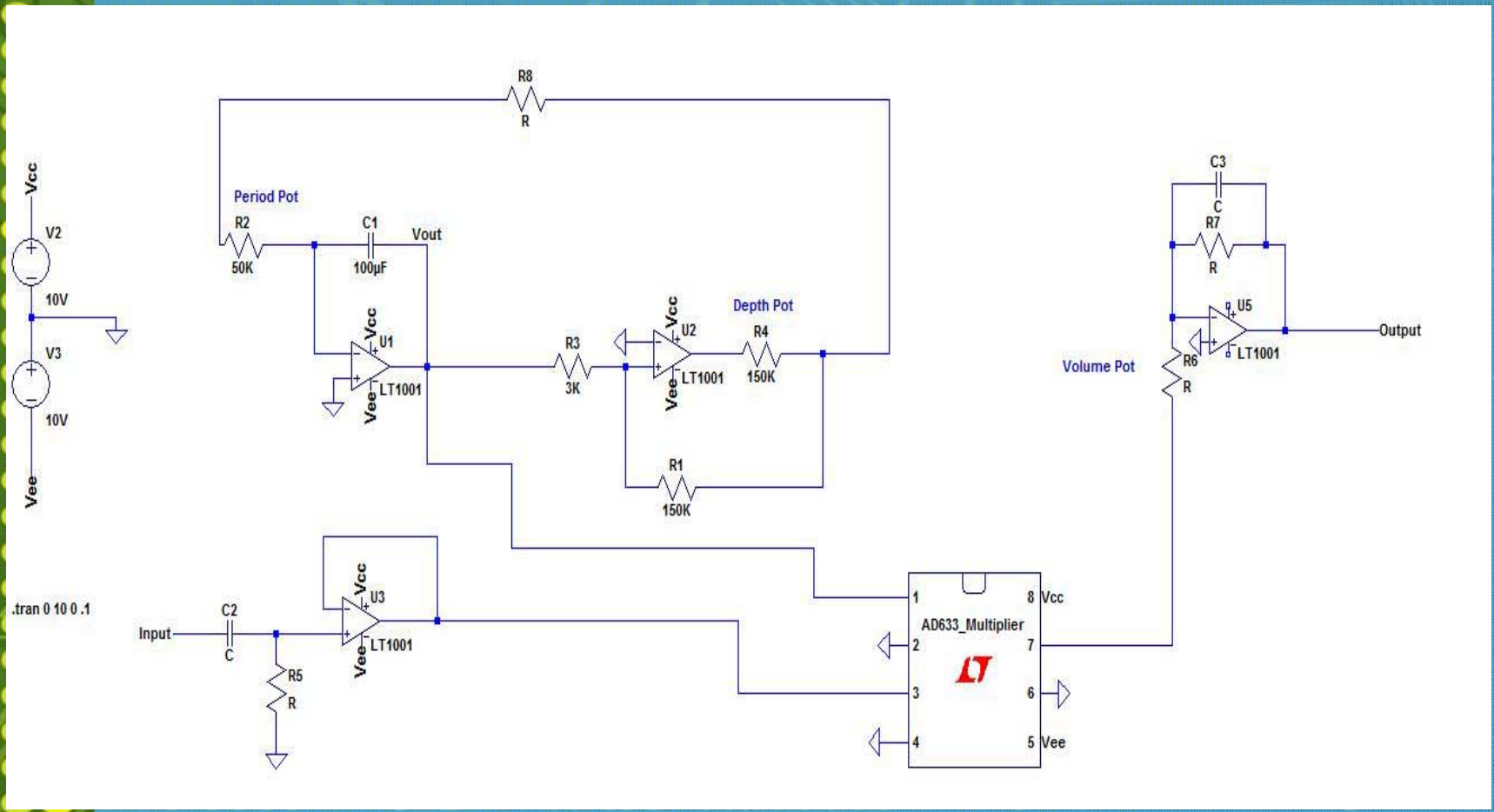


Distortion

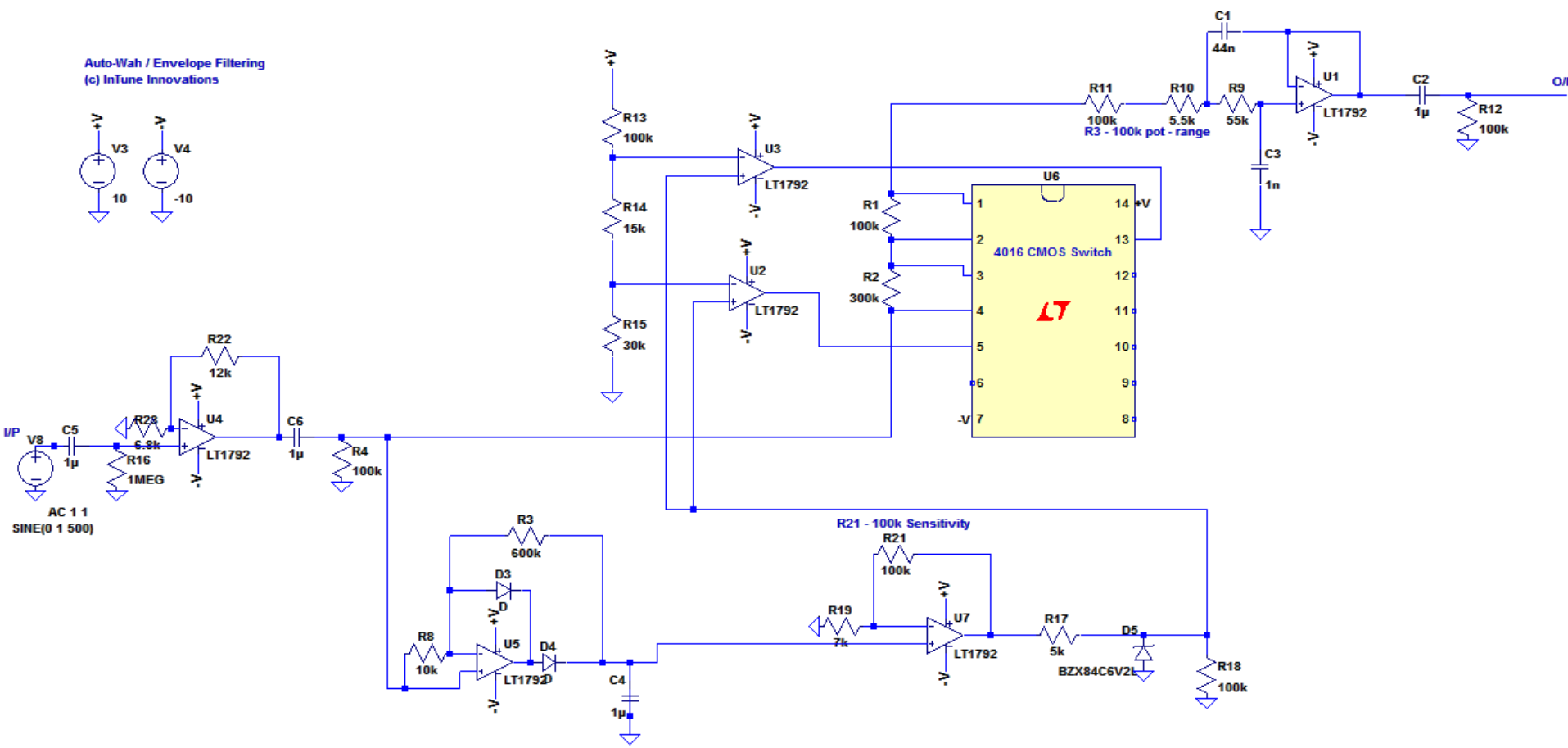
- Distortion waveform



Tremolo

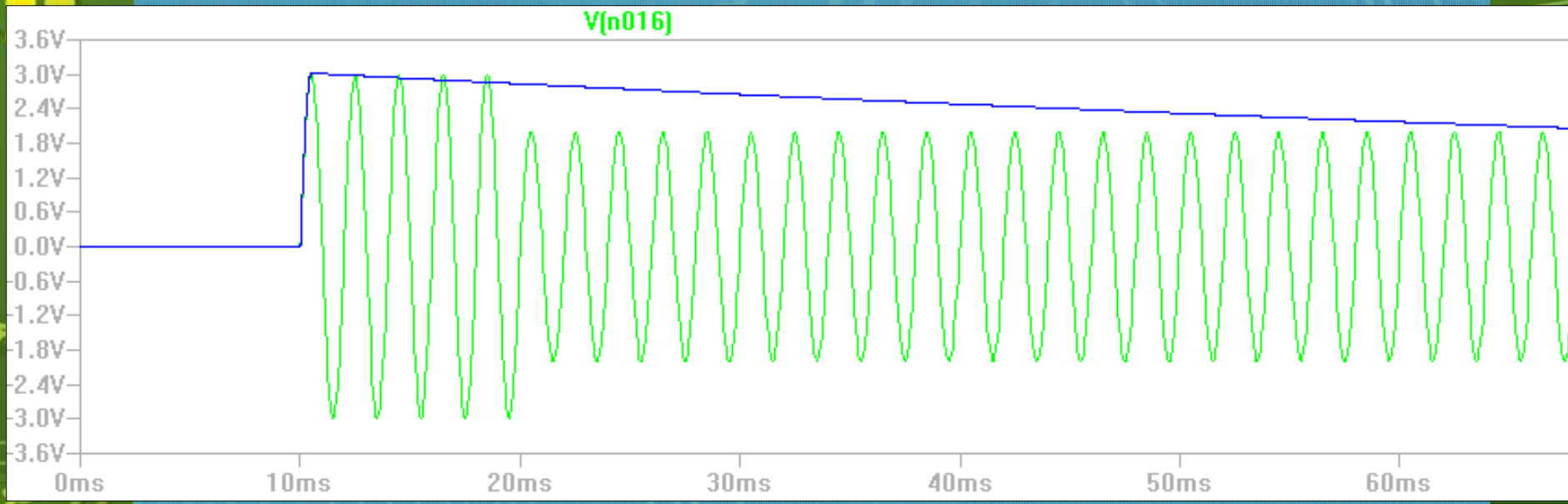

R8
R
Period Pot
R2
50K
C1
100µF
Vout
Vcc
V2
10V
V3
10V
Vee
U1
LT1001
R3
3K
U2
LT1001
Depth Pot
R4
150K
R1
150K
.tran 0 10 0 .1
Input
C2
C
R5
R
U3
LT1001
AD633_Multiplier
1
2
3
4
8 Vcc
7
6
5 Vee
C3
C
R7
R
U5
LT1001
Output
Volume Pot
R6
R

Auto-Wah


Auto-Wah / Envelope Filtering
(c) InTune Innovations
V3
10
V4
-10
R13
100k
R14
15k
R15
30k
U3
LT1792
U2
LT1792
C1
44n
R11
100k
R10
5.5k
R9
55k
R3 - 100k pot - range
C3
1n
U1
LT1792
C2
1µ
R12
100k
U6
4016 CMOS Switch
R1
100k
R2
300k
R22
12k
I/P
V8
C5
1µ
R23
6.8k
R16
1MEG
U4
LT1792
C6
1µ
R4
100k
AC 1 1
SINE(0 1 500)
R3
600k
D3
D
R8
10k
U5
LT1792
D4
D
C4
1µ
R21 - 100k Sensitivity
R21
100k
R19
7k
U7
LT1792
R17
5k
D5
BZX84C6V2L
R18
100k

Auto-WAH

- Envelope Follower

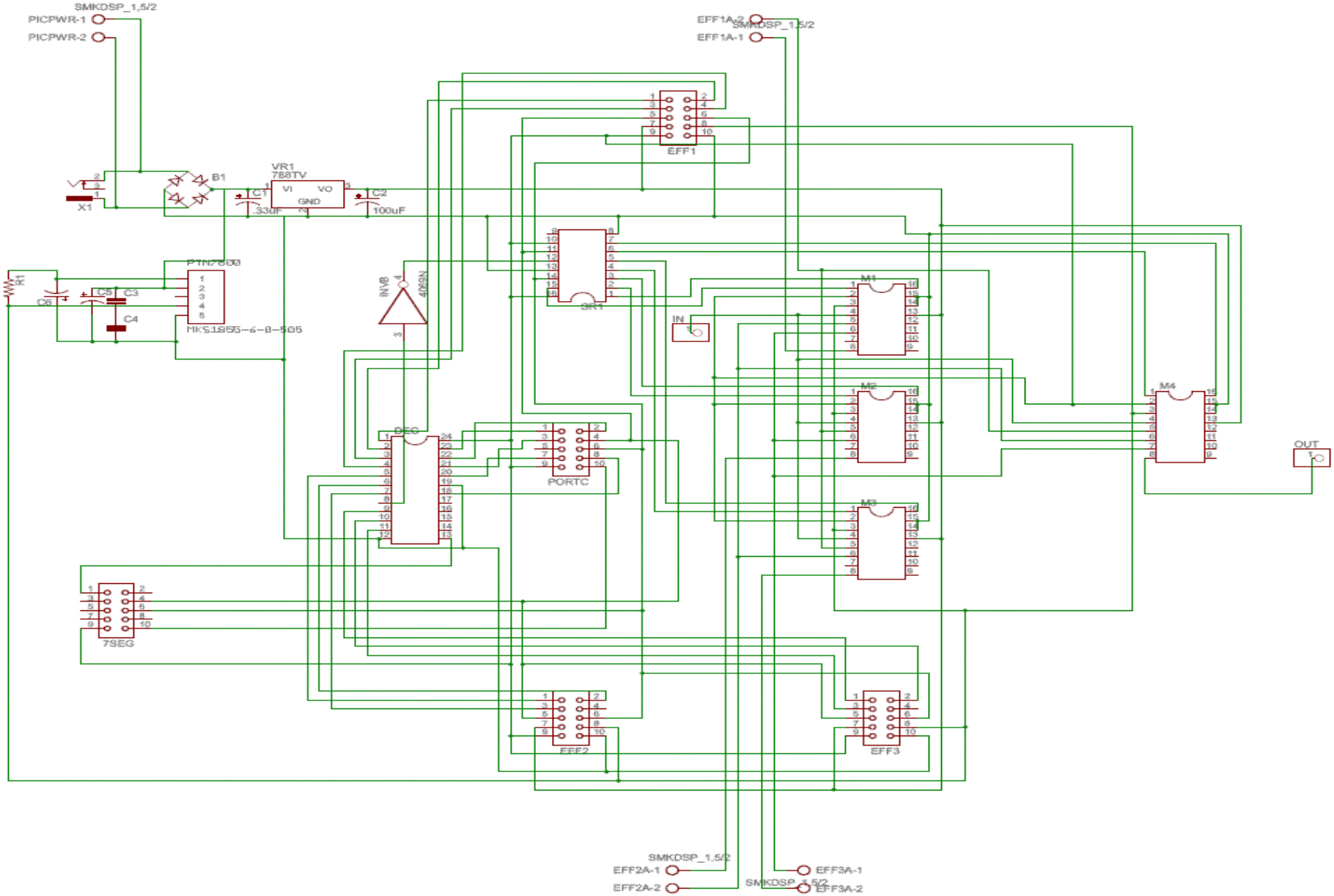


Actual Costs

Expenses	Michael				
Date:					
01/18/09	Placed order at circuit-ed.com:				
	Item	Price	Quantity		
	PICFLASH2 PIC USB Programmer	$115.00	1		
	LCD 4-BIT MODE ADAPTER Board	$8.00	2		
	KEYPAD 4x4 Accessory Board	$12.00	2		
	16x2 LCD Bl/Wh w/ Soldered Connector	$10.00	2		
	SERIAL 7-SEGMENT 2 Accessory Board	$29.00	1		
	PIC-READY Mini Board	$31.00	2		
	Order Total with shipping	$335.68 USD			
	GST	$37.63			
	Total (in CAD)	$432.57 CAD			
		$432.57 CAD			
01/29/09	Digikey order #1	$86.70	CAD		
02/14/09	Digikey order #2	$72.56	CAD		
02/17/09	Stomp switches	$30.00	CAD		
03/08/2009	Digikey order #3	$105.83	CAD		
	(subtract sam's order)	-$10.96			
03/24/09	Digikey order # 4	$58.07	CAD		
04/06/2009	Hos Electronics: 3 Foot switches	$50.40	CAD		
Expenses	Tom				
RP ITEMS					
	ITEM	Price Per	QTY	TOTAL w/ SFU Discount	
	IDC CON	0.88	22	18.48	
	Terminal Block	7.1	1	6.74	
	Protoboard	12.8	3	32.64	
	Wire	.37/ft	10	3.5	
	IDC Header	2	3	6	
			TOTAL	67.36	
Cumulative Total:	$952.53				

Project CPU

LCD 4-BIT MODE ADAPTER Board	$8.00	
16x2 LCD Bl/Wh w/ Soldered Connector	$10.00	
PIC-READY Mini Board	$31.00	
Hos Electronics: 3 Foot switches	$50.40	
Dig Pot (3 per feat)	$9	
Multiplier	$8	
Case	$60	
Voltage Regulator	$13	
OpAmps and Bilateral Switch (3 per feat)	$5	
Decoder	$1	
Voltage Convertor	$3.50	
Misc. Electrical	$20.00	
PCB Creation	$5	
Multiplexor (4)	$10	
7 Seg Pads	$2.50	
Shop Supplies	$10.00	
Total	$246.40	


SMKDSP_1,5/2
PICPWR-1
PICPWR-2
X1
B1
VR1
7805TV
VI
VO
GND
C1
330uF
C2
100uF
R1
D6
C5
C3
C4
PTN7800
MKS1855--6--8--505
INV8
4069N
EFF1A-2
EFF1A-1
EFF1
SN1
IN
M1
M2
M3
M4
OUT
DEC
PORTC
7SEG
EFF2
EFF3
EFF2A-1
EFF2A-2
EFF3A-1
EFF3A-2