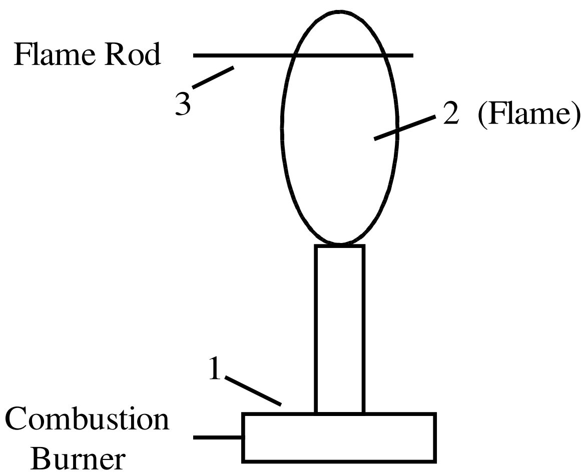


Figure 1

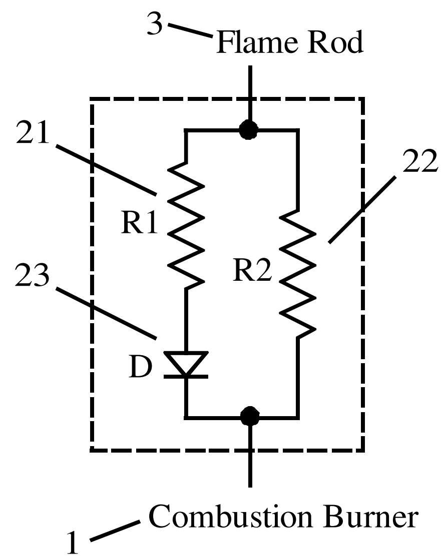


Figure 2

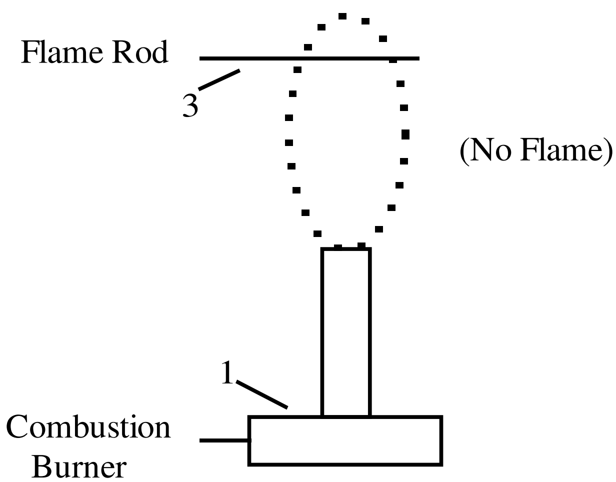


Figure 3

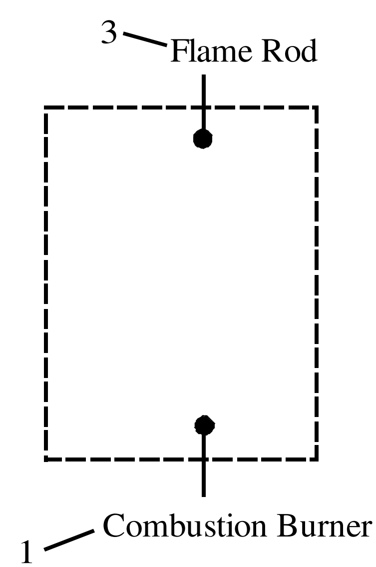


Figure 4

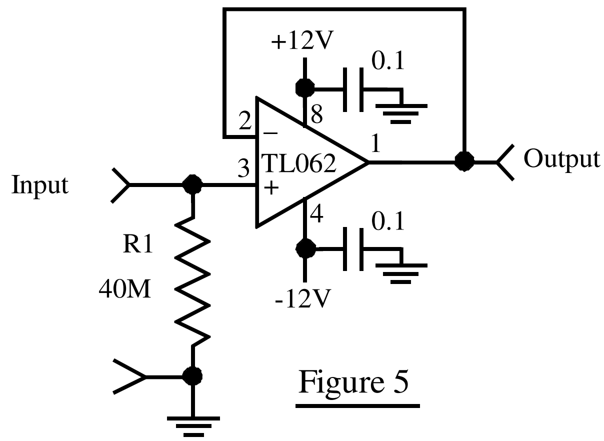
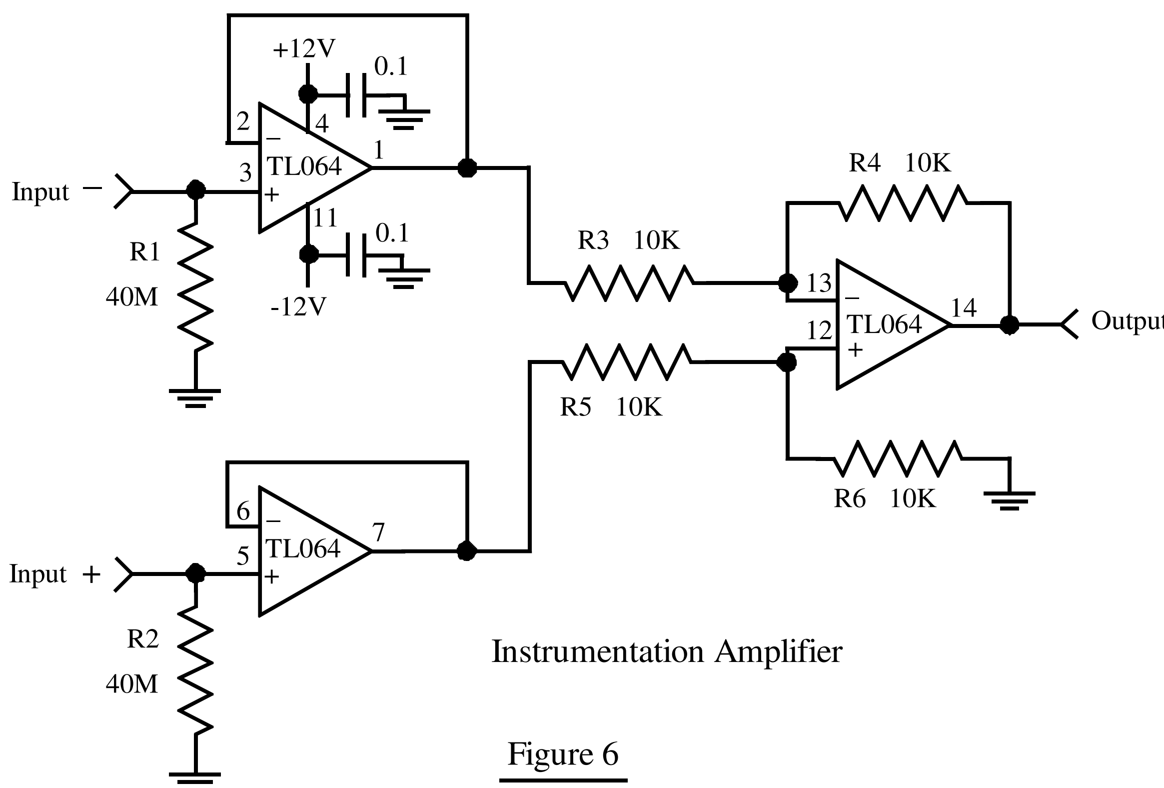


Figure 5



Instrumentation Amplifier

Figure 6

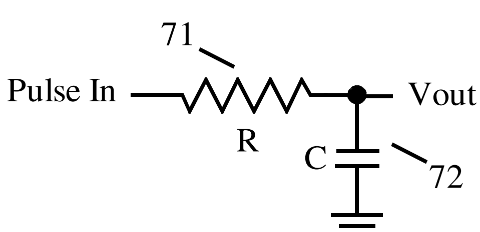


Figure 7

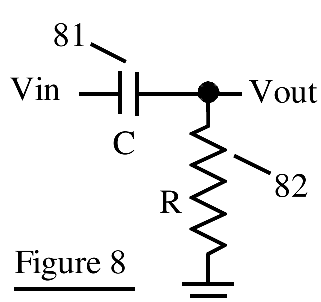


Figure 8

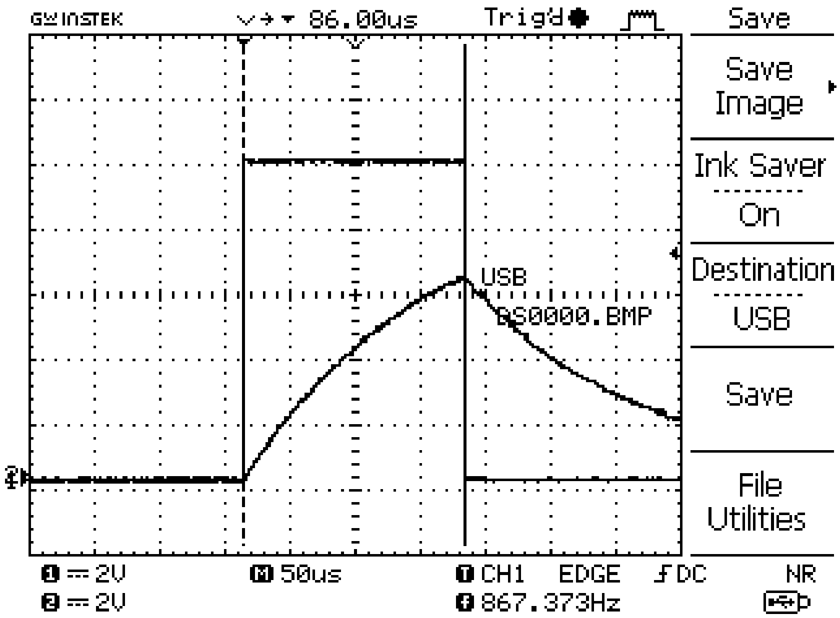


Figure 9

Table 2

$$\frac{Vout}{Vin} = \frac{R}{R + 1/(s*C)} \qquad H(s) = \frac{s}{s + 1/(R*C)}$$

Substitute s = jω

$$H(j\omega) = \frac{j\omega}{j\omega + 1/(R*C)}$$

The magnitude response $|H(j\omega)| = \dfrac{\omega}{Sqrt(\omega^2 + 1/(R*C)^2)}$

The Phase Response $\theta(j\omega) = 90^o - \tan^{-1}(\omega*R*C)$

Where ω = 2 * pi * Frequency

Therefore, for

Vin = 120 VAC	(120)
R = 10 megohm	$(10*10^6)$
C = 160 pF/10*2.5	$(40*10^{-12})$
Frequency = 60 Hz	(60)

The magnitude of Vout is approximately 17.9 VAC
The phase response is a phase lead of approximately 8.5 degrees.

Figure 10

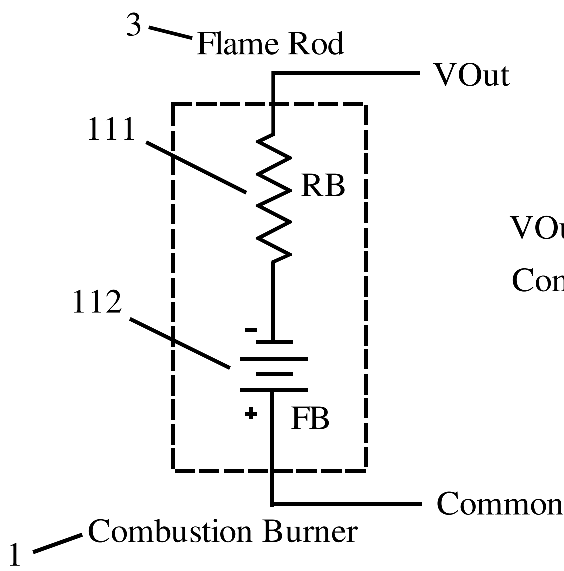


Figure 11

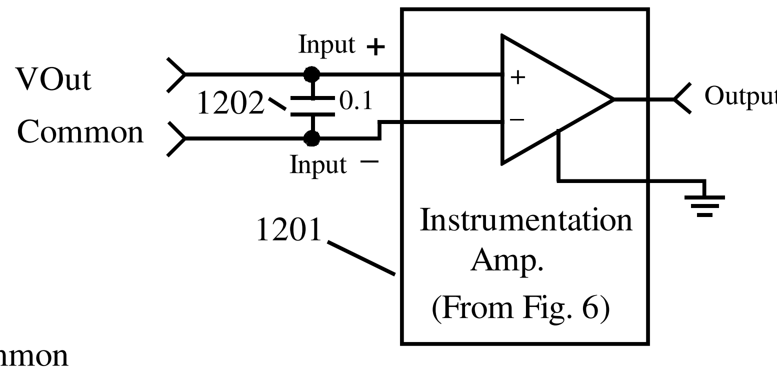


Figure 12

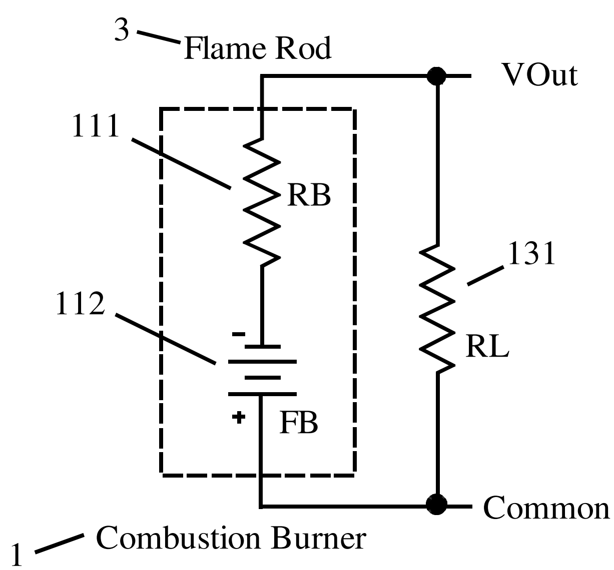


Figure 13

Table 5.4 (continued)

No.	Reaction	Forward Rate Coefficient[a] A	b	E
N-Containing Reactions (continued)				
201	$NH_2 + O \rightarrow H + HNO$	3.9E + 13	0.0	0.0
202	$NH_2 + H \rightarrow NH + H_2$	4.00E + 13	0.0	3,650
203	$NH_2 + OH \rightarrow NH + H_2O$	9.00E + 07	1.5	–460
204	$NNH \rightarrow N_2 + H$	3.30E + 08	0.0	0.0
205	$NNH + M \rightarrow N_2 + H + M$	1.30E + 14	–0.1	4,980
206	$NNH + O_2 \rightarrow HO_2 + N_2$	5.00E + 12	0.0	0.0
207	$NNH + O \rightarrow OH + N_2$	2.50E + 13	0.0	0.0
208	$NNH + O \rightarrow NH + NO$	7.00E + 13	0.0	0.0
209	$NNH + H \rightarrow H_2 + N_2$	5.00E + 13	0.0	0.0
210	$NNH + OH \rightarrow H_2O + N_2$	2.00E + 13	0.0	0.0
211	$NNH + CH_3 \rightarrow CH_4 + N_2$	2.50E + 13	0.0	0.0
212	$H + NO + M \rightarrow HNO + M$	4.48E + 19	–1.3	740
213	$HNO + O \rightarrow NO + OH$	2.50E + 13	0.0	0.0
214	$HNO + H \rightarrow H_2 + NO$	9.00E + 11	0.7	660
215	$HNO + OH \rightarrow NO + H_2O$	1.30E + 07	1.9	–950
216	$HNO + O_2 \rightarrow HO_2 + NO$	1.00E + 13	0.0	13,000
217	$CN + O \rightarrow CO + N$	7.70E + 13	0.0	0.0
218	$CN + OH \rightarrow NCO + H$	4.00E + 13	0.0	0.0
219	$CN + H_2O \rightarrow HCN + OH$	8.00E + 12	0.0	7,460
220	$CN + O_2 \rightarrow NCO + O$	6.14E + 12	0.0	–440
221	$CN + H_2 \rightarrow HCN + H$	2.95E + 05	2.5	2,240
222	$NCO + O \rightarrow NO + CO$	2.35E + 13	0.0	0.0
223	$NCO + H \rightarrow NH + CO$	5.40E + 13	0.0	0.0
224	$NCO + OH \rightarrow NO + H + CO$	2.50E + 12	0.0	0.0
225	$NCO + N \rightarrow N_2 + CO$	2.00E + 13	0.0	0.0
226	$NCO + O_2 \rightarrow NO + CO_2$	2.00E + 12	0.0	20,000
227	$NCO + M \rightarrow N + CO + M$	3.10E + 14	0.0	54,050
228	$NCO + NO \rightarrow N_2O + CO$	1.90E + 17	–1.5	740
229	$NCO + NO \rightarrow N_2 + CO_2$	3.80E + 18	–2.0	800
230	$HCN + M \rightarrow H + CN + M$	1.04E + 29	–3.3	126,600
231	$HCN + O \rightarrow NCO + H$	2.03E + 04	2.6	4,980
232	$HCN + O \rightarrow NH + CO$	5.07E + 03	2.6	4,980
233	$HCN + O \rightarrow CN + OH$	3.91E + 09	1.6	26,600
234	$HCN + OH \rightarrow HOCN + H$	1.10E + 06	2.0	13,370
235	$HCN + OH \rightarrow HNCO + H$	4.40E + 03	2.3	6,400
236	$HCN + OH \rightarrow NH_2 + CO$	1.60E + 02	2.6	9,000
237	$H + HCN + M \rightarrow H_2CN + M$		pressure dependent	
238	$H_2CN + N \rightarrow N_2 + CH_2$	6.00E + 13	0.0	400
239	$C + N_2 \rightarrow CN + N$	6.30E + 13	0.0	46,020
240	$CH + N_2 \rightarrow HCN + N$	3.12E + 09	0.9	20,130
241	$CH + N_2 (+ M) \rightarrow HCNN (+ M)$		pressure dependent	
242	$CH_2 + N_2 \rightarrow HCN + NH$	1.00E + 13	0.0	74,000
243[b]	$CH_2(S) + N_2 \rightarrow NH + HCN$	1.00E + 11	0.0	65,000

Figure 14 (from Turns)

Table 1

Table 17.12 Composition (mol%) and properties of natural gas from sources in the United States [28][a]

Location	**CH_4**	**C_2H_6**	**C_3H_8**	**C_4H_{10}**	**CO_2**	**N_2**	**Density[c] (kg/m^3)**	**HHV[d] (kJ/M^3)**	**HHV[d] (kJ/hg)**
Alaska	99.6	—	—	—	—	0.4	0.686	37,590	54,800
Birmingham,	90.0	5.0	—	—	—	5.0	0.735	37,260	50,690
East Ohio[b]	94.1	3.01	0.42	0.28	0.71	1.41	0.723	38,260	52,940
Kansas City,	84.1	6.7	—	—	0.8	8.4	0.772	36,140	46,830
Pittsburgh,	83.4	15.8	—	—	—	0.8	0.772	41,840	54,215

[a] Although not explicitly stated in Ref. [28], these gases appear to be pipeline gases.
[b] Also contains 0.01 % H_2 and 0.01% O_2.
[c] At 1 atm and 15.6°C (60 F).
[d] Higher heating values for 1 atm and 15.6°C (60 F) [28].

Figure 15 (Turns Table 17.12)

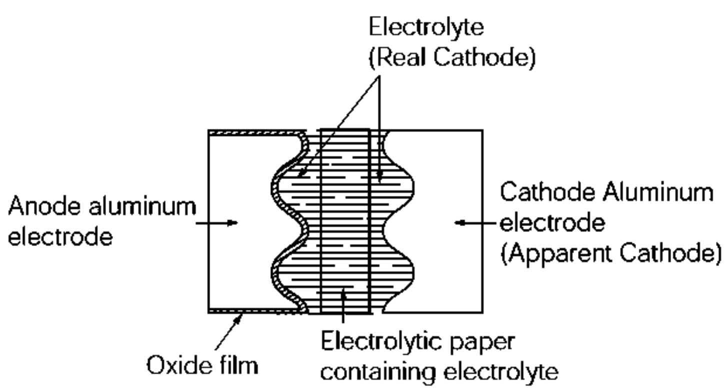


Fig. 1 - 1

Figure 16 (Nichicon Figure 1-1)

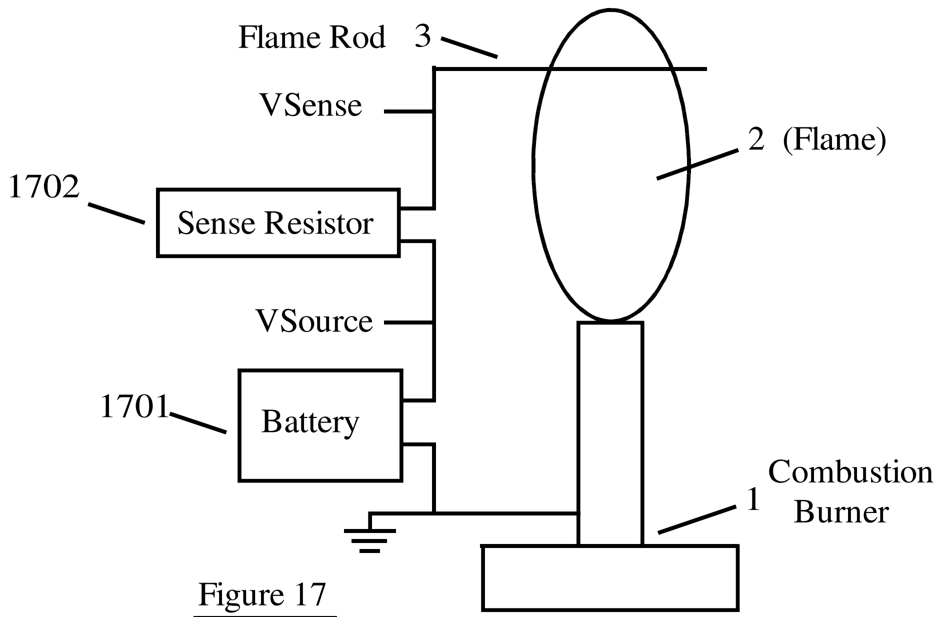


Figure 17

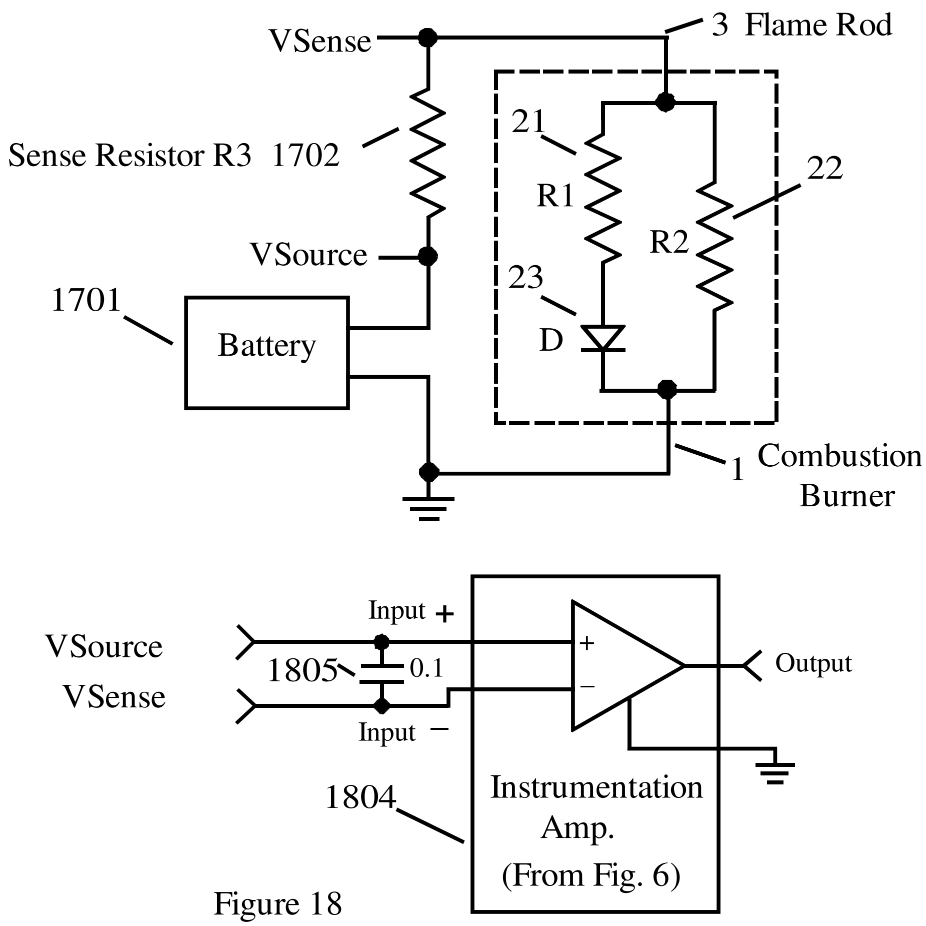


Figure 18

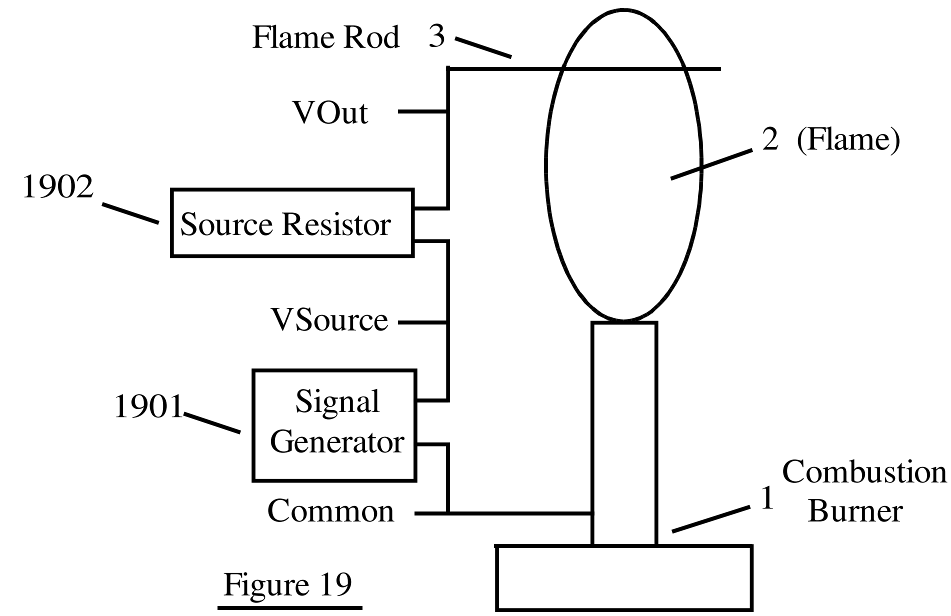


Figure 19

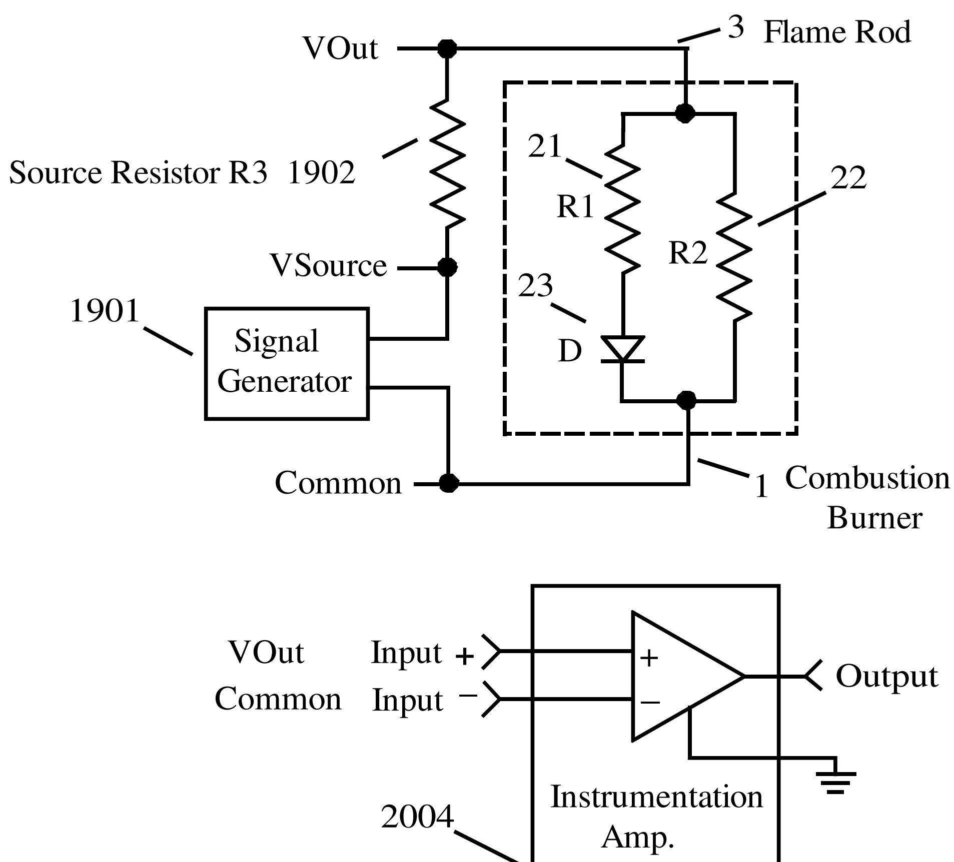


Figure 20

Experiment 2 -1.27V open circuit

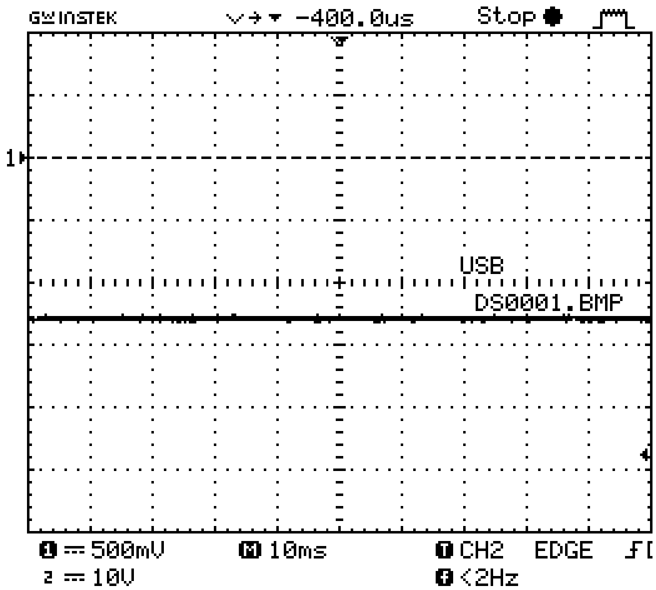


Figure 21a

Experiment 2 0.68 V (4.3 megohm load)

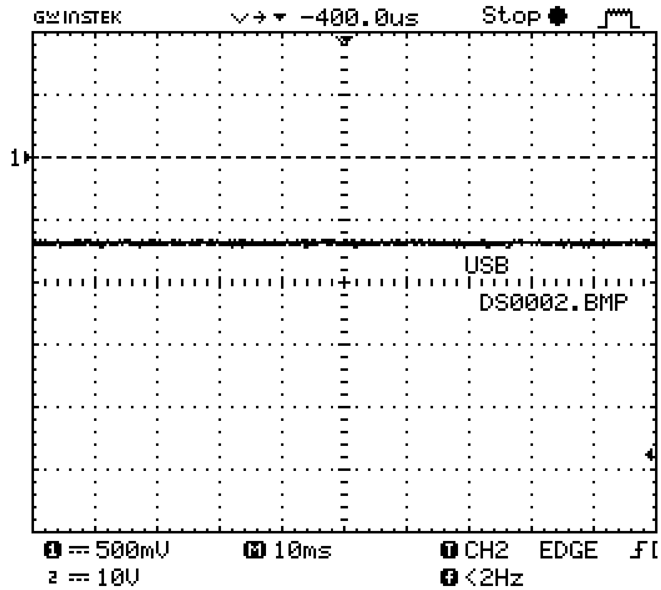


Figure 21b

Experiment 3 -40 mV

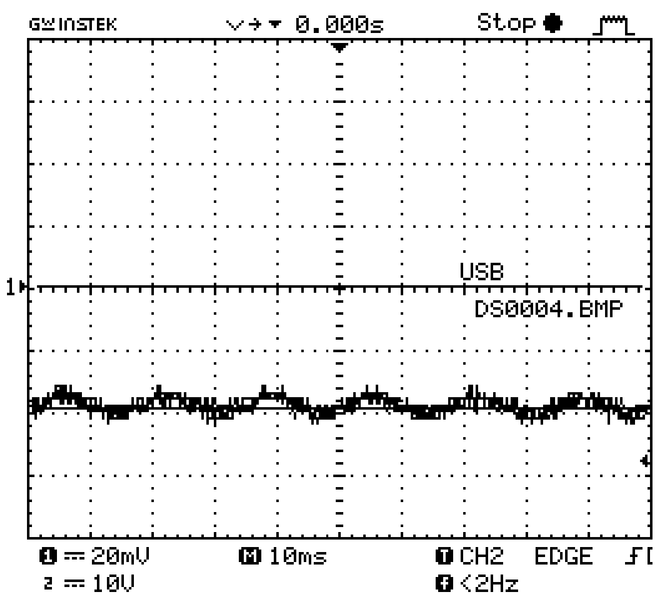


Figure 22a

Experiment 3 +1.39 V

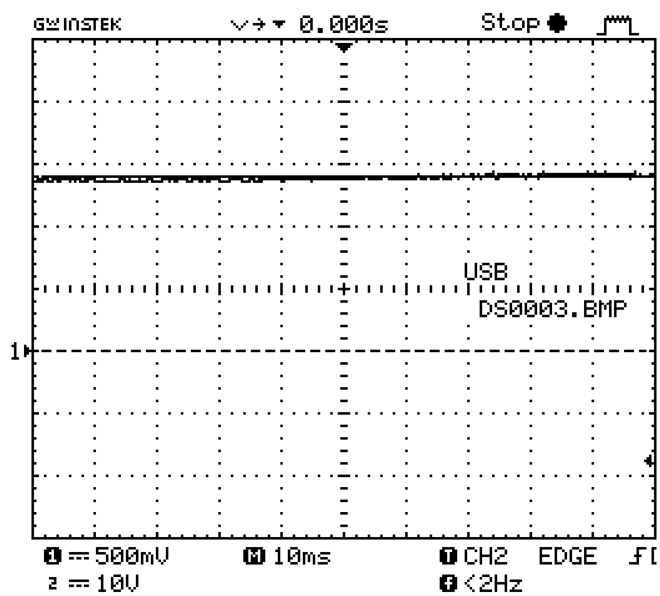


Figure 22b

Experiment 4 100 Hz +2.79 V to -7.2 V

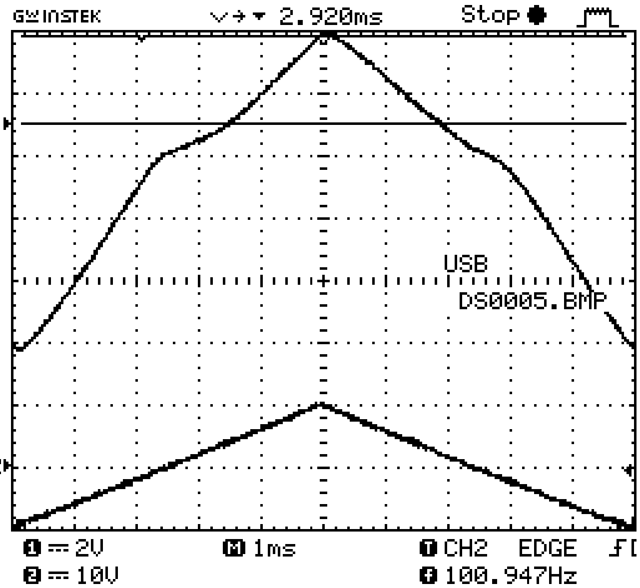


Figure 23a

Experiment 4 Leading Edge -960 mV to 0 V

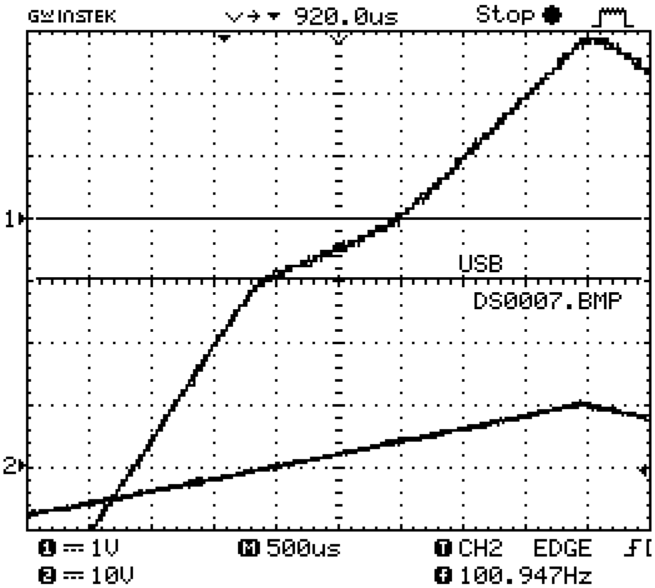


Figure 23b

Experiment 4 Trailing Edge -640 mV to -1.20 V

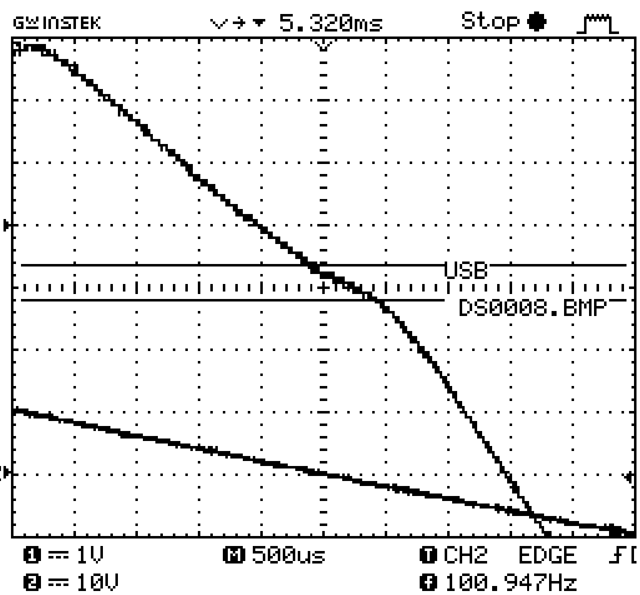


Figure 23c

Experiment 4 200 Hz +2.24 V to -6.88 V

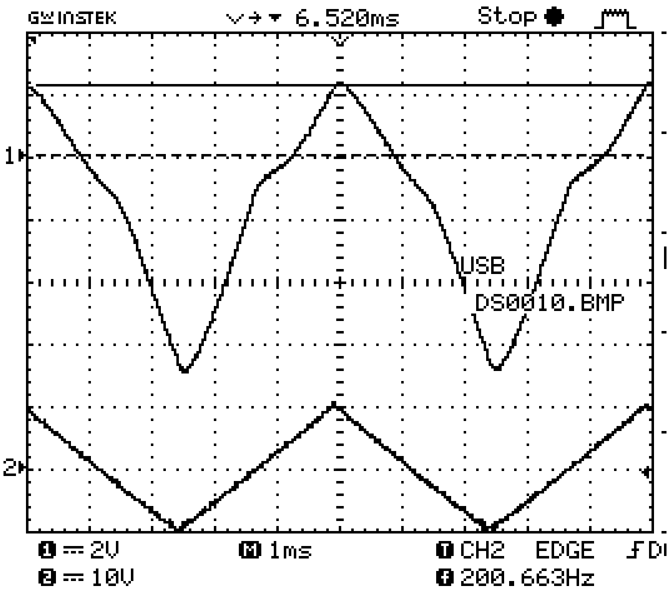


Figure 24a

Experiment 4 Leading Edge -760 mV to -120 mV

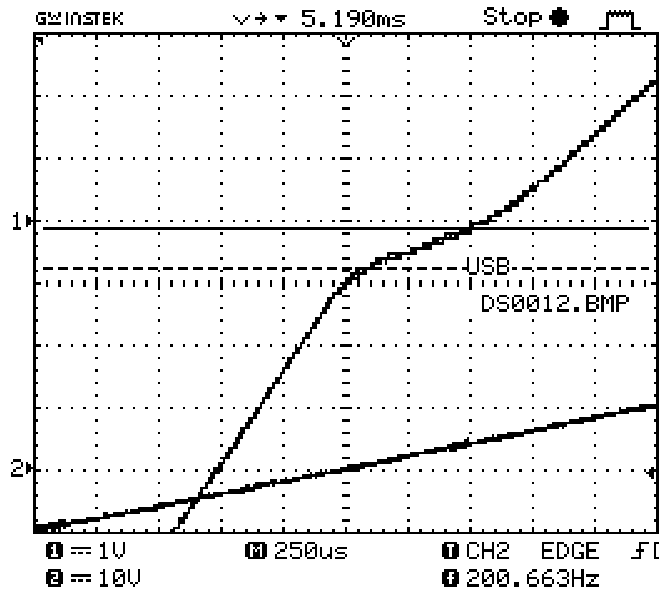


Figure 24b

Experiment 4 Trailing Edge -680 mV to -1.39 mV

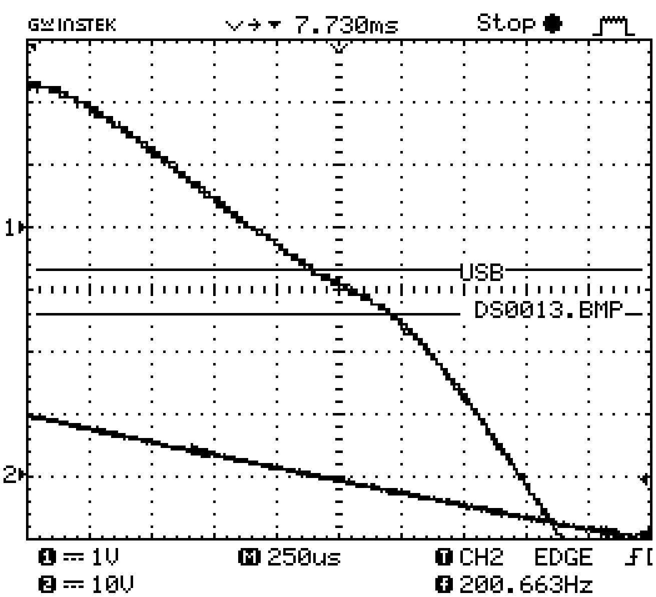


Figure 24c

Experiment 4 400 Hz +1.84 V to -6.32 V

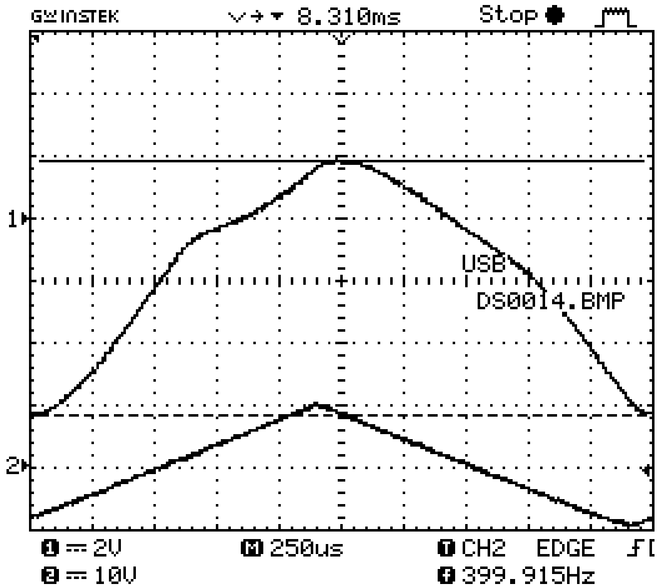


Figure 25a

Experiment 4 Leading Edge -440 mV to +200 mV

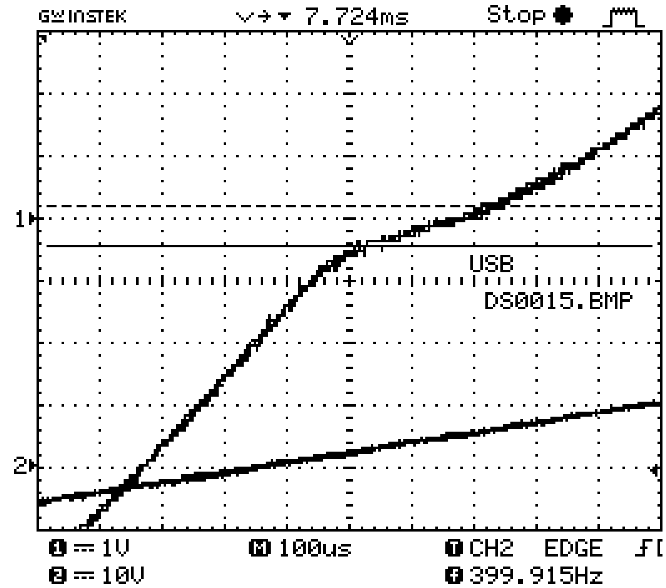


Figure 25b

Experiment 4 Trailing Edge -1.63 V to -2.0 V

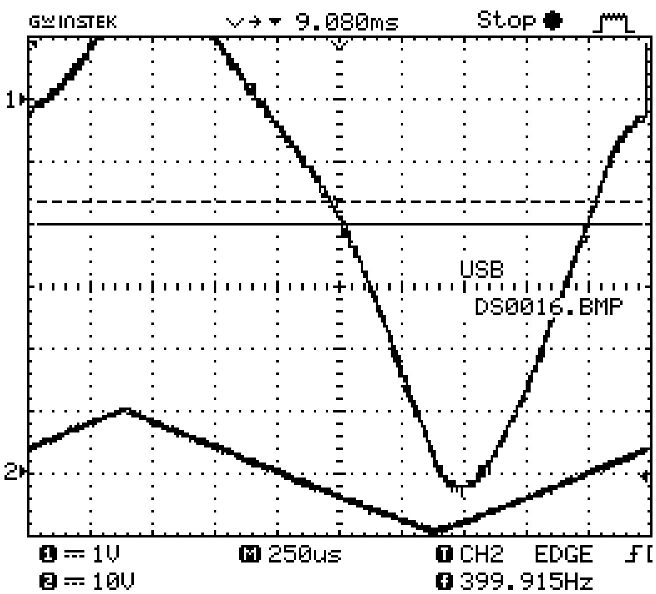


Figure 25c

Experiment 4 1KHz +0.920 V to -4.88 V

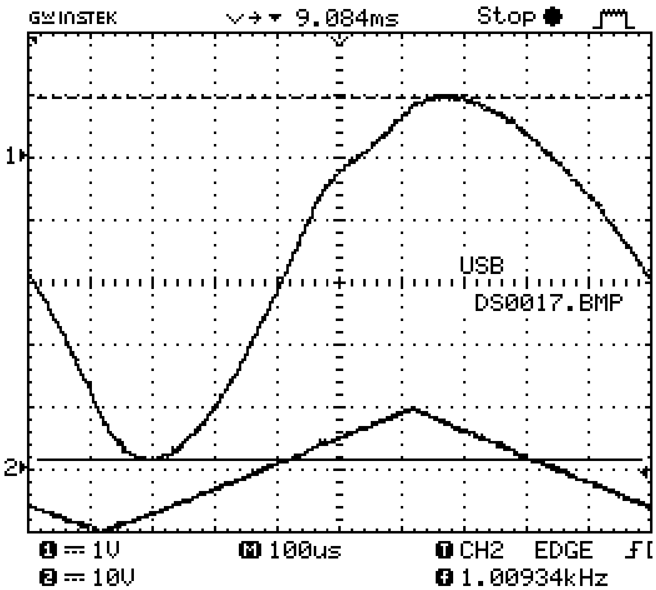


Figure 26a

Experiment 4 Leading Edge -340 mV to +440 mV

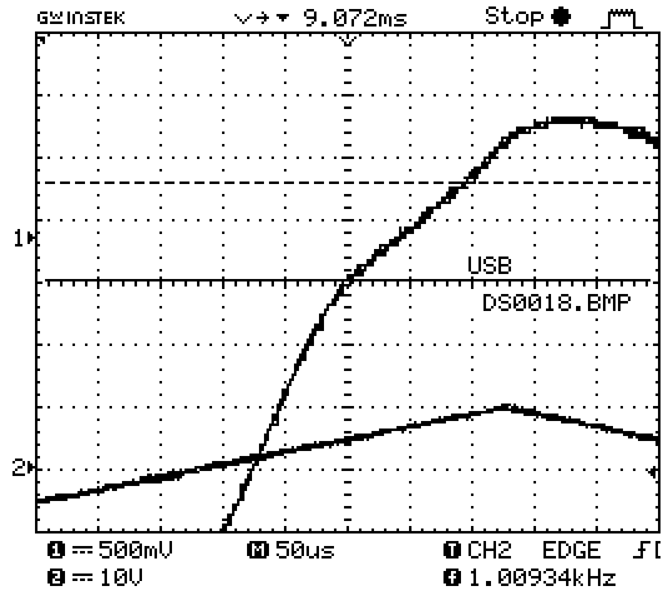


Figure 26b

Experiment 4 Trailing Edge – Indistinct

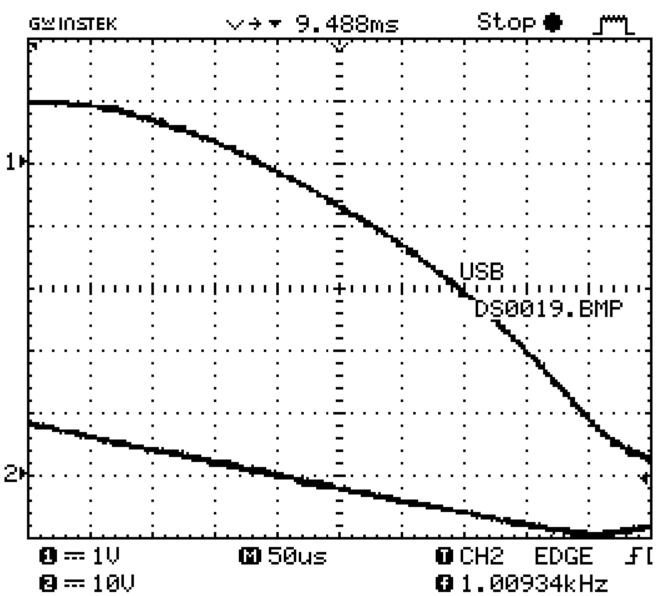


Figure 26c

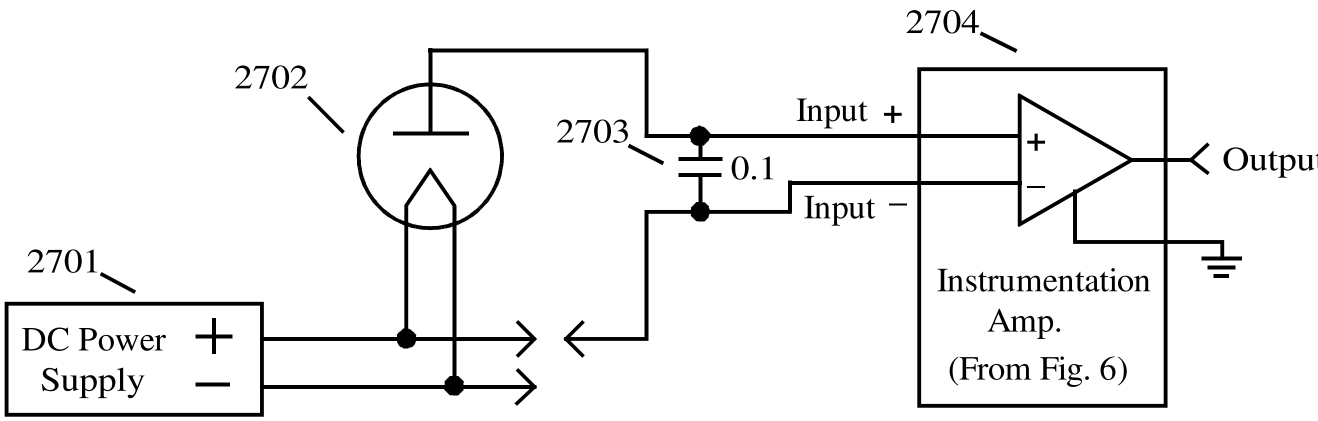


Figure 27

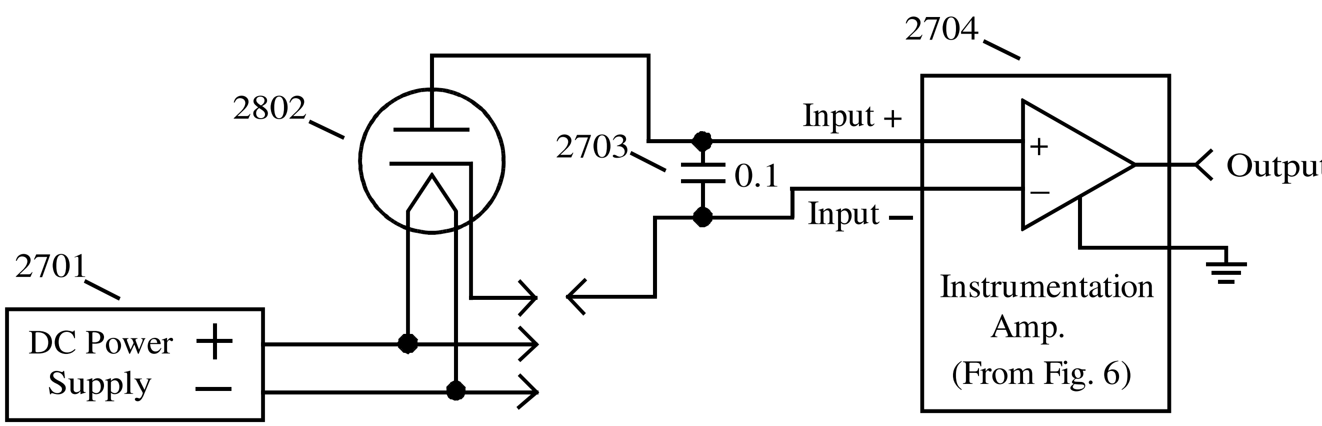


Figure 28

Table 4 - Thermionic Emission Test – 5U4GB Vacuum Tube

5U4GB	#1 Westinghouse		1/12/14		jm
2	Filament(2)		0V		+5 VDC 2.94A
8	Filament(8)		+5 VDC 2.93A		0V
2	Filament(2)		Ref		Ref
4	Plate 1		-0.93V		-3.46V
6	Plate 2		-0.01V		-5.59V
8	Filament(8)		Ref		Ref
4	Plate 1		-5.68V		-0.09V
6	Plate 2		-3.30V		-0.84V

Figure 29

Table 5 - Thermionic Emission Test – 5Y3 Vacuum Tube

5Y3	#1 RCA		1/12/2014		jm
2	Filament(2)		0V		+5 VDC 2.00A
8	Filament(8)		+5 VDC 1.98A		0V
2	Filament(2)		Ref		Ref
4	Plate 1		-0.61V		-3.04V
6	Plate 2		0.0V		-5.25V
8	Filament(8)		Ref		Ref
4	Plate 1		-5.37V		0.0V
6	Plate 2		-3.00V		-0.51V

Figure 30

Table 6 - Thermionic Emission Test – 6X4 Vacuum Tube

6X4	#1 Raytheon	1/13/14 jm			
3	Filament(3)	0V	3	Filament(3)	+6.3DC 0.60A
4	Filament(4)	+6.3VDC 0.59A	4	Filament(4)	0V
7	Cathode	Ref	7	Cathode	Ref
6	Plate 1	-0.91V	6	Plate 1	-0.92V
1	Plate 2	-1.14V	1	Plate 2	-1.17V
7,3	Cathode, Filament(3)	Ref	7,3	Cathode, Filament(3)	Ref
6	Plate 1	-0.91V	6	Plate 1	-0.93V
1	Plate 2	-1.16V	1	Plate 2	-1.18V
7,4	Cathode, Filament(4)	Ref	7,4	Cathode, Filament(4)	Ref
6	Plate 1	-0.91V	6	Plate 1	-0.93V
1	Plate 2	-1.16V	1	Plate 2	-1.19V
3	Filament(3)	Ref	3	Filament(3)	Ref
7	Cathode	+2.50V	7	Cathode	-3.67V
4	Filament(4)	Ref	4	Filament(4)	Ref
7	Cathode	-3.66V	7	Cathode	+2.52V

Figure 31

Table 7 - Thermionic Emission Test – 12X4 Vacuum Tube

12X4 #1 RCA	01/13/2014 jm					
3	Filament	0V		3	Filament	+12.6 VDC 0.32A
4	Filament	+12.6 VDC 0.32A		4	Filament	0V
7	Cathode	Ref		7	Cathode	Ref
6	Plate 1	-1.17V		6	Plate 1	-1.17V
1	Plate 2	-1.04V		1	Plate 2	-1.05V
7,3	Cathode, Filament(3)	Ref		7,3	Cathode, Filament(3)	Ref
6	Plate 1	-1.17V		6	Plate 1	-1.17V
1	Plate 2	-1.04V		1	Plate 2	-1.05V
7,4	Cathode, Filament(4)	Ref		7,4	Cathode, Filament(4)	Ref
6	Plate 1	-1.17V		6	Plate 1	-1.17V
1	Plate 2	-1.05V		1	Plate 2	-1.05V
3	Filament(3)	Ref		3	Filament(3)	Ref
7	Cathode	+1.66V		7	Cathode	-4.70V
4	Filament(4)	Ref		4	Filament(4)	Ref
7	Cathode	-4.70V		7	Cathode	+1.83V

Figure 32

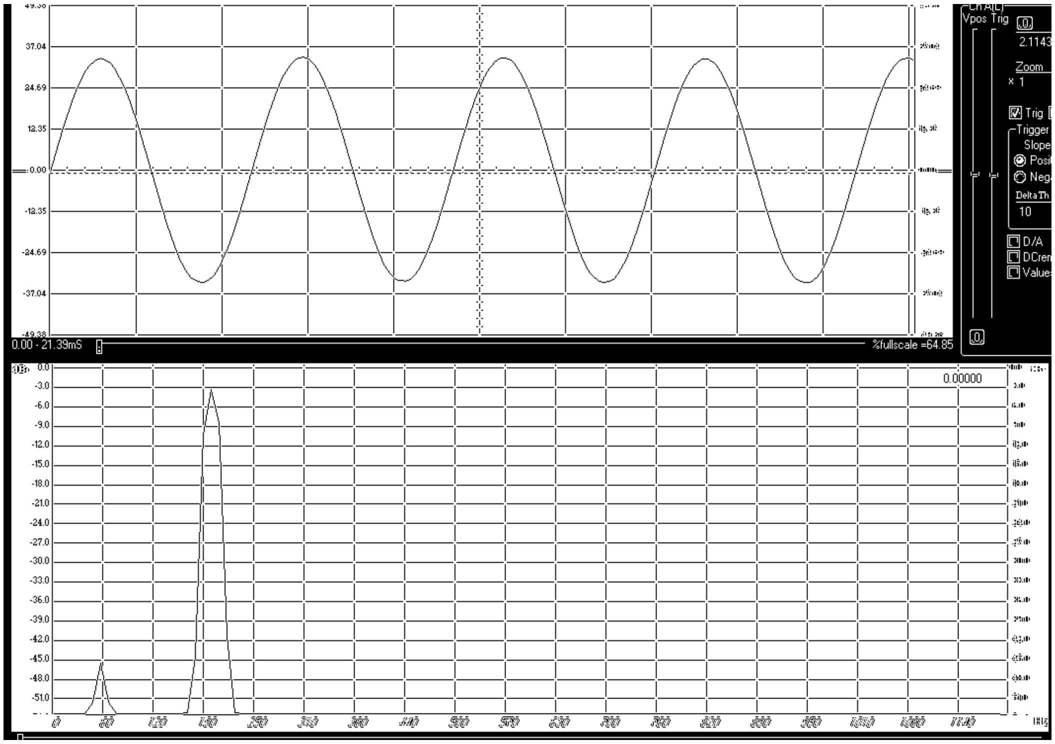


Figure 33a 200 Hz; 10 Megohm Source; Sine Wave; No Flame

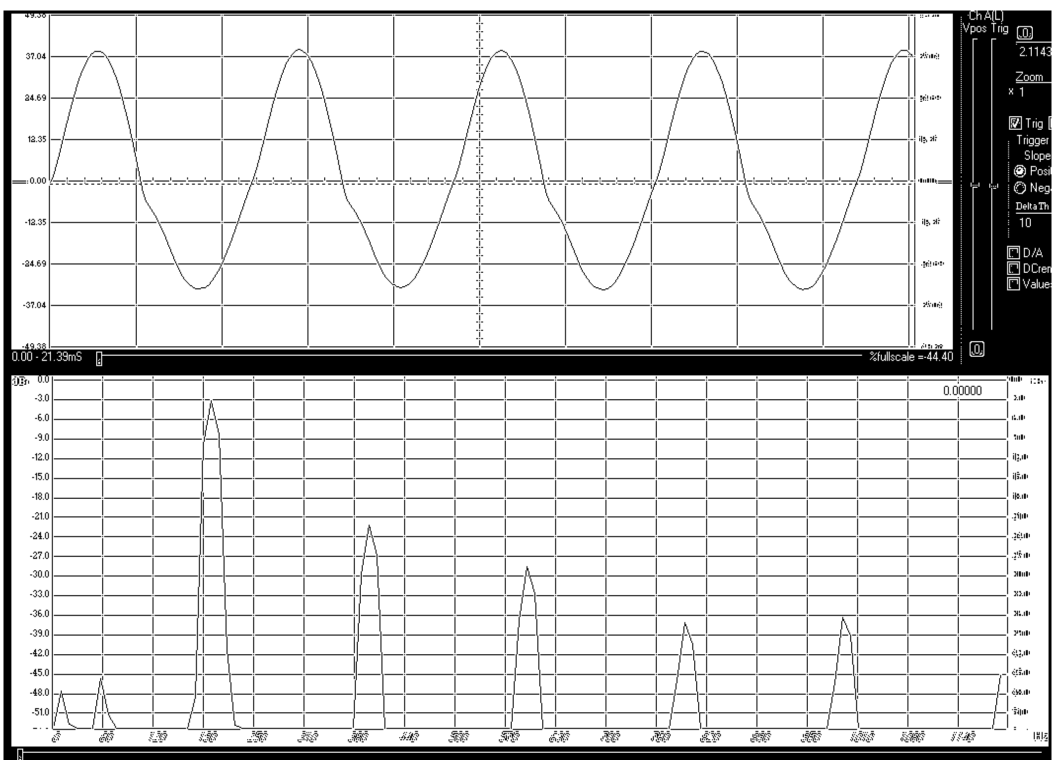


Figure 33b 200 Hz; 10 Megohm Source; Sine Wave; Flame

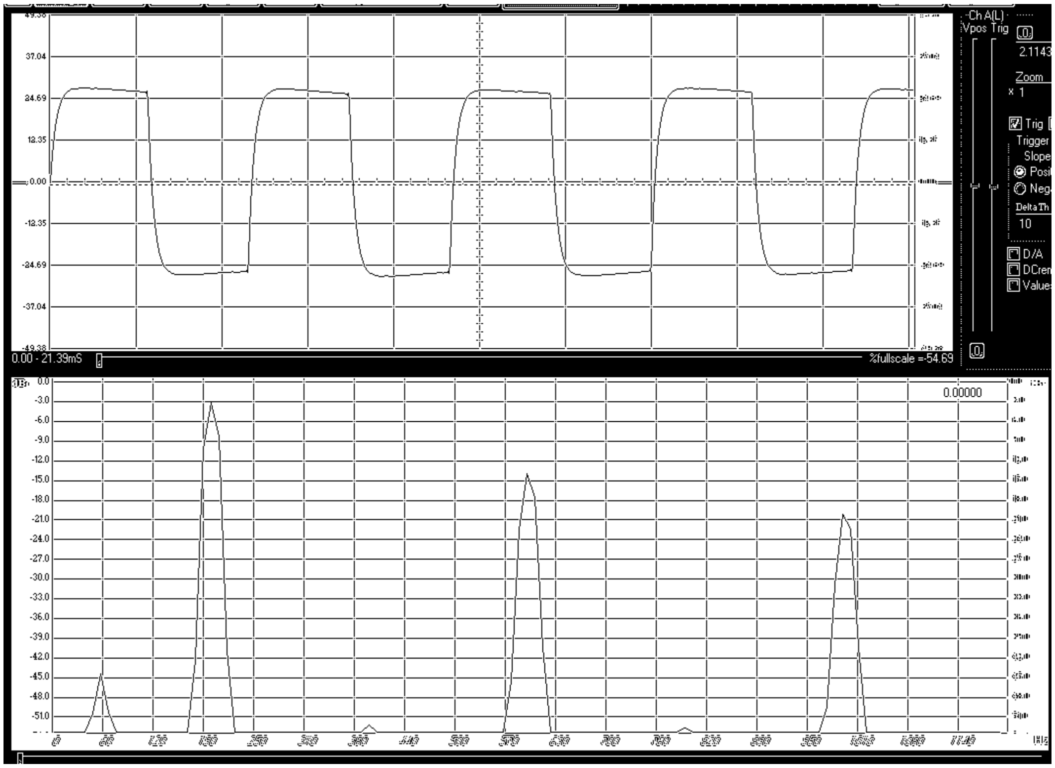


Figure 34a 200 Hz; 10 Megohm Source; Square Wave; No Flame

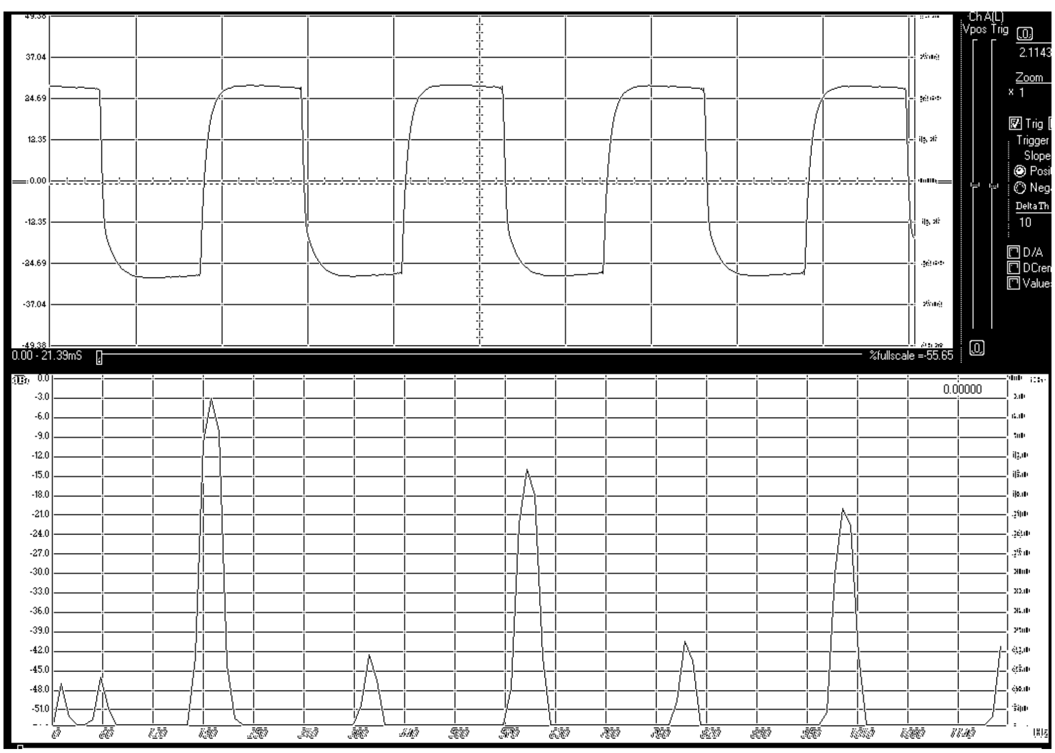
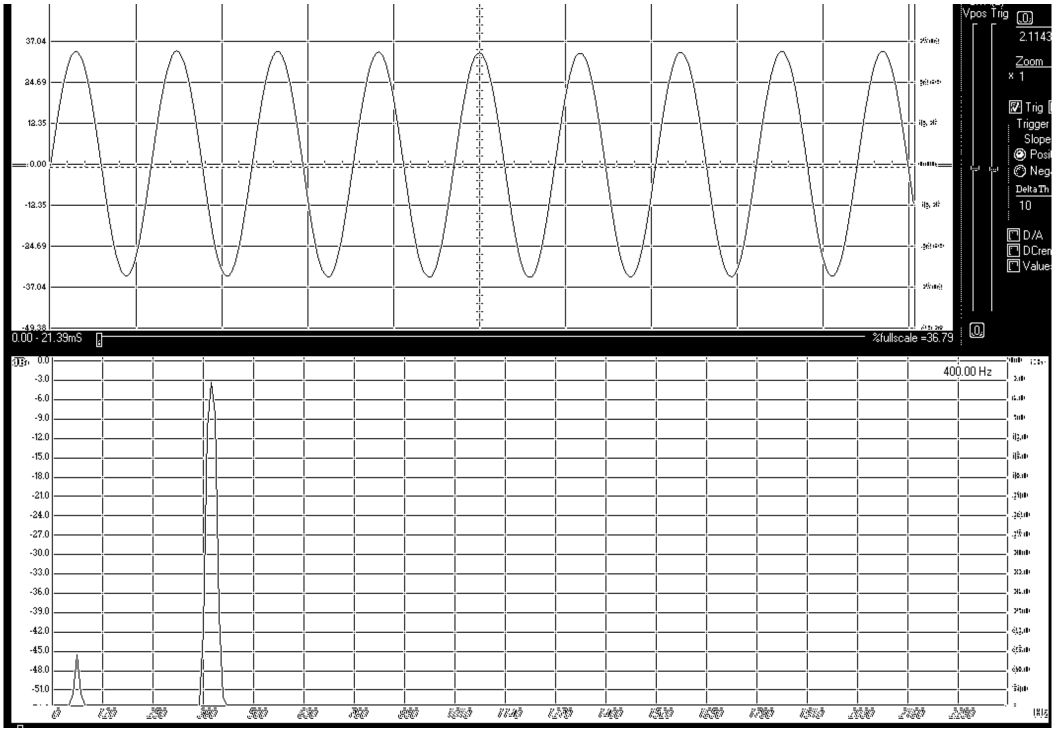
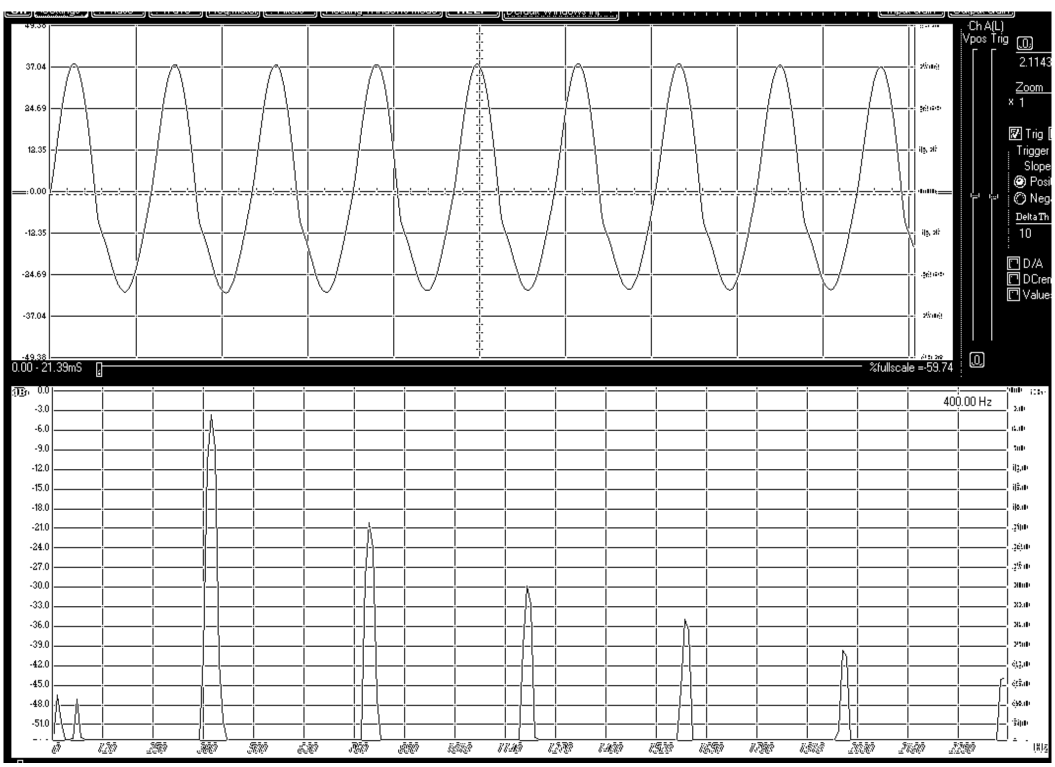


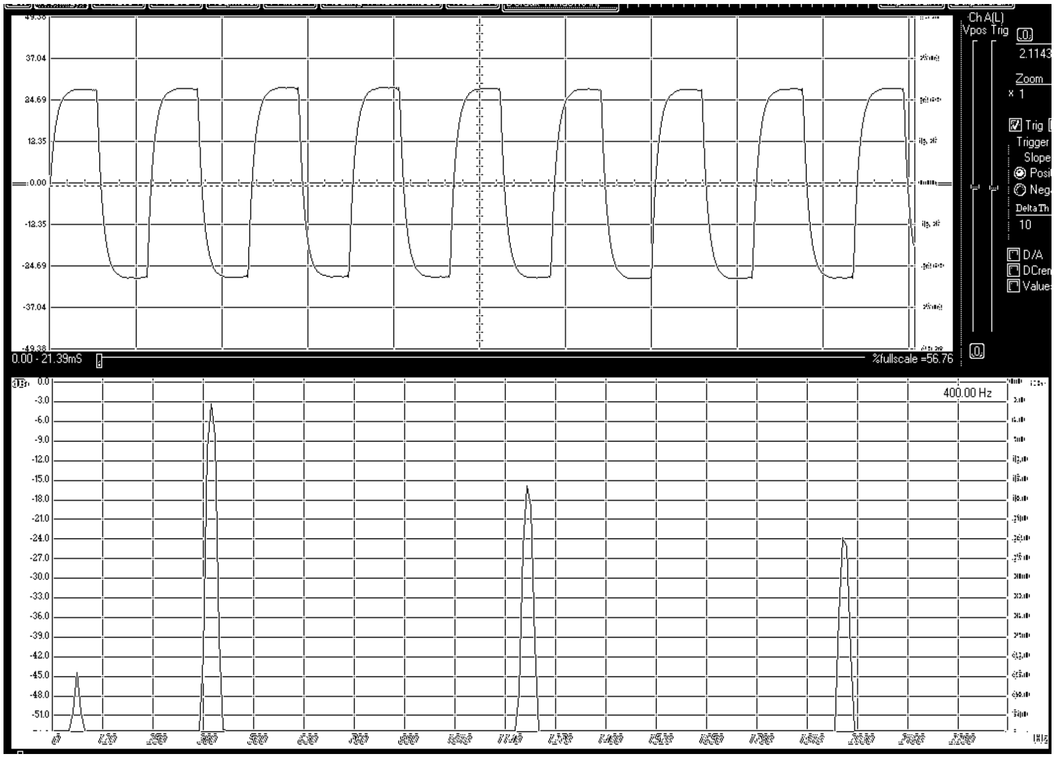
Figure 34b 200 Hz; 10 Megohm Source; Square Wave; Flame



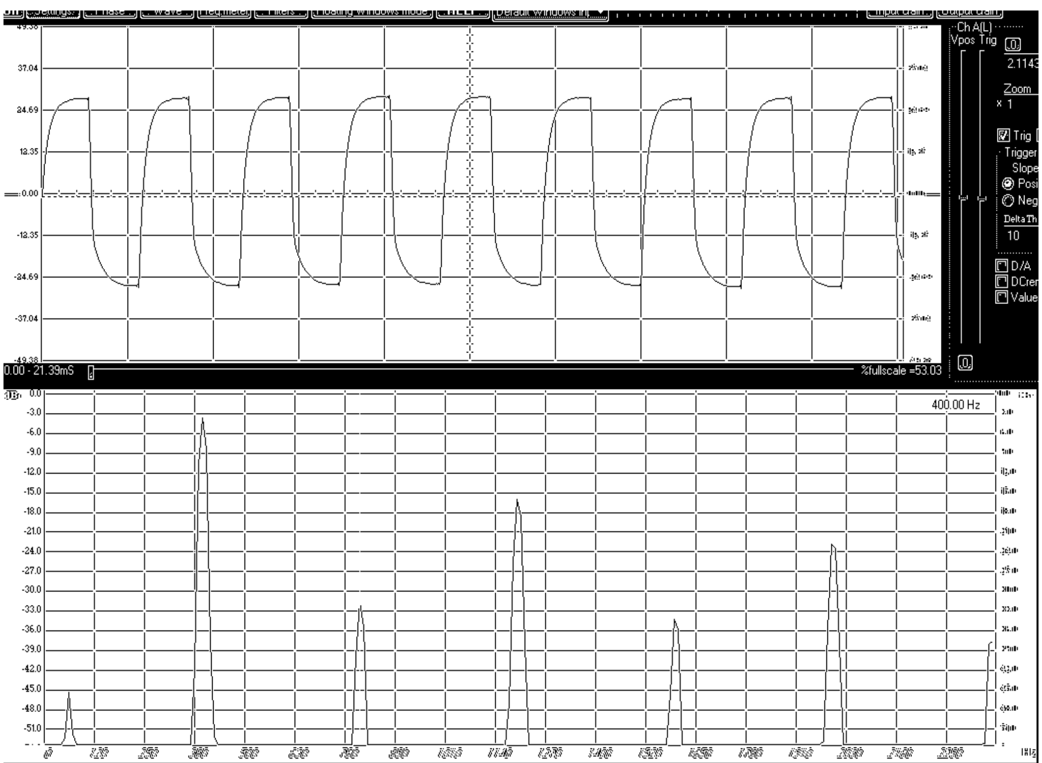
<u>Figure 35a</u> 400 Hz; 10 Megohm Source; Sine Wave; No Flame



<u>Figure 35b</u> 400 Hz; 10 Megohm Source; Sine Wave; Flame



<u>Figure 36a</u> 400 Hz; 10 Megohm Source; Square Wave; No Flame



<u>Figure 36b</u> 400 Hz; 10 Megohm Source; Square Wave; Flame

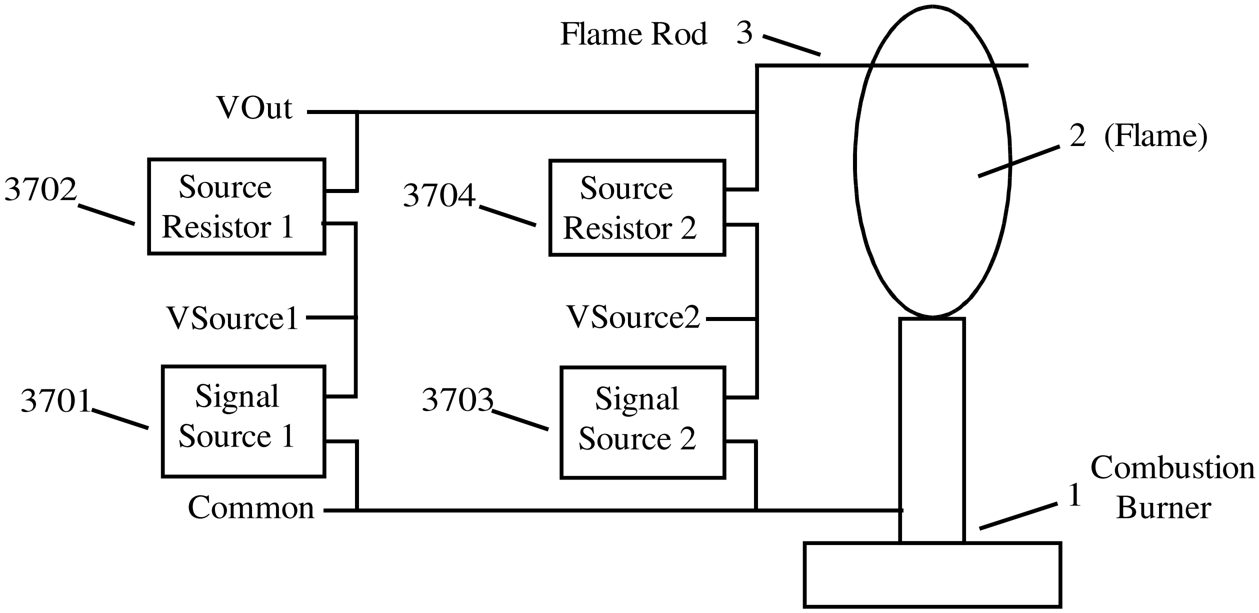


Figure 37

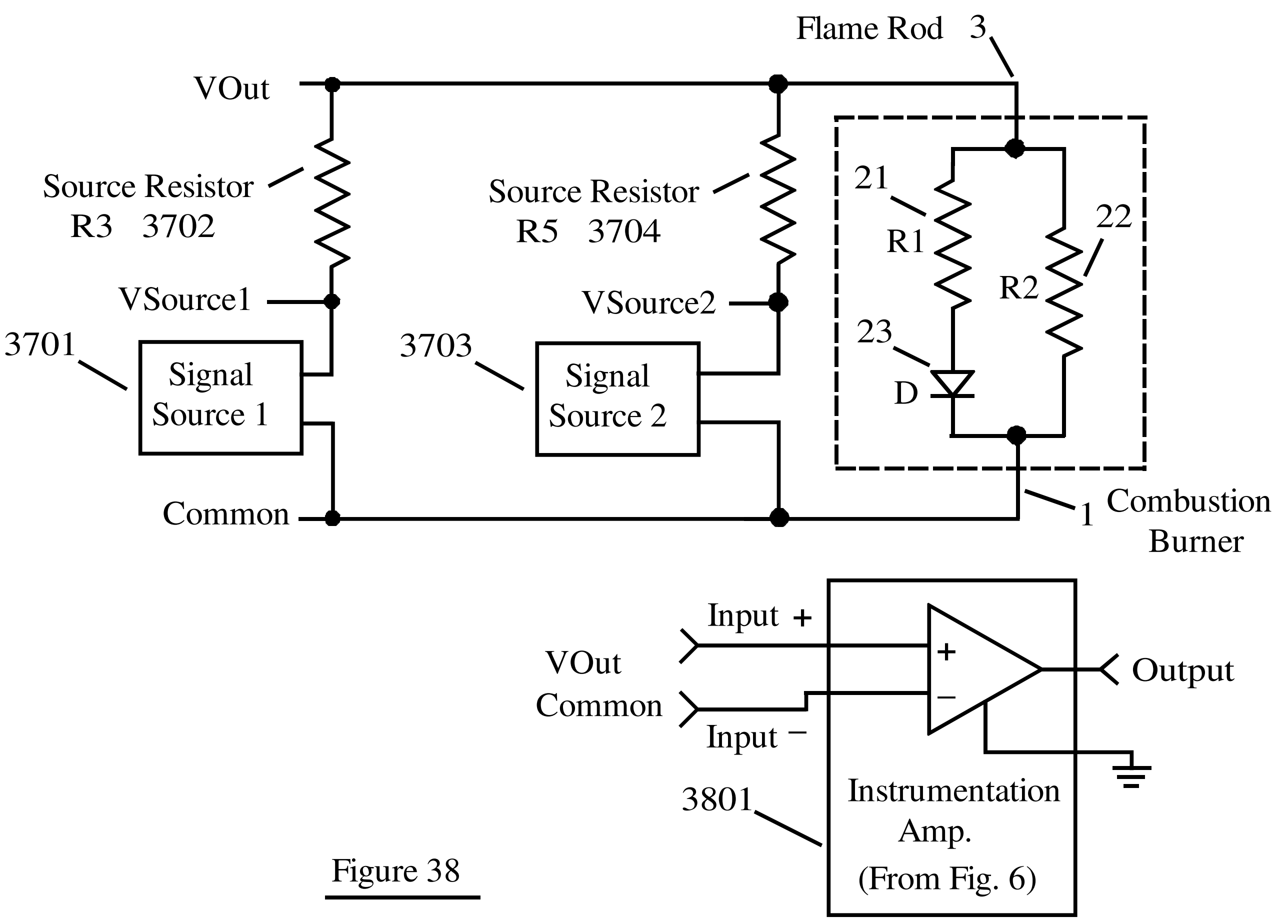
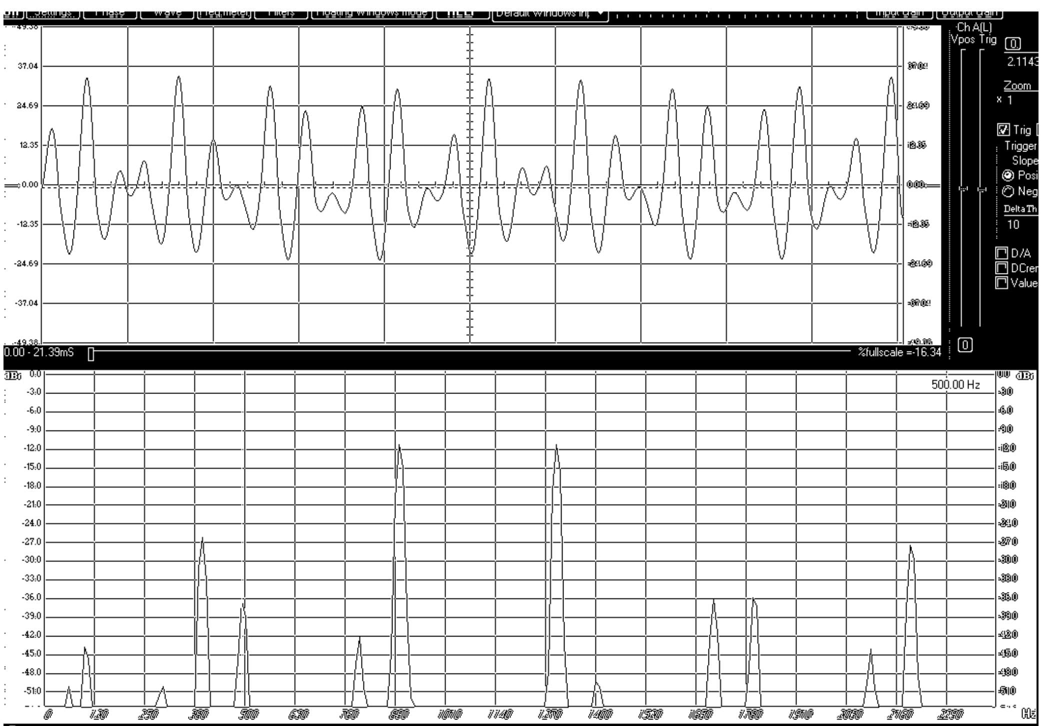


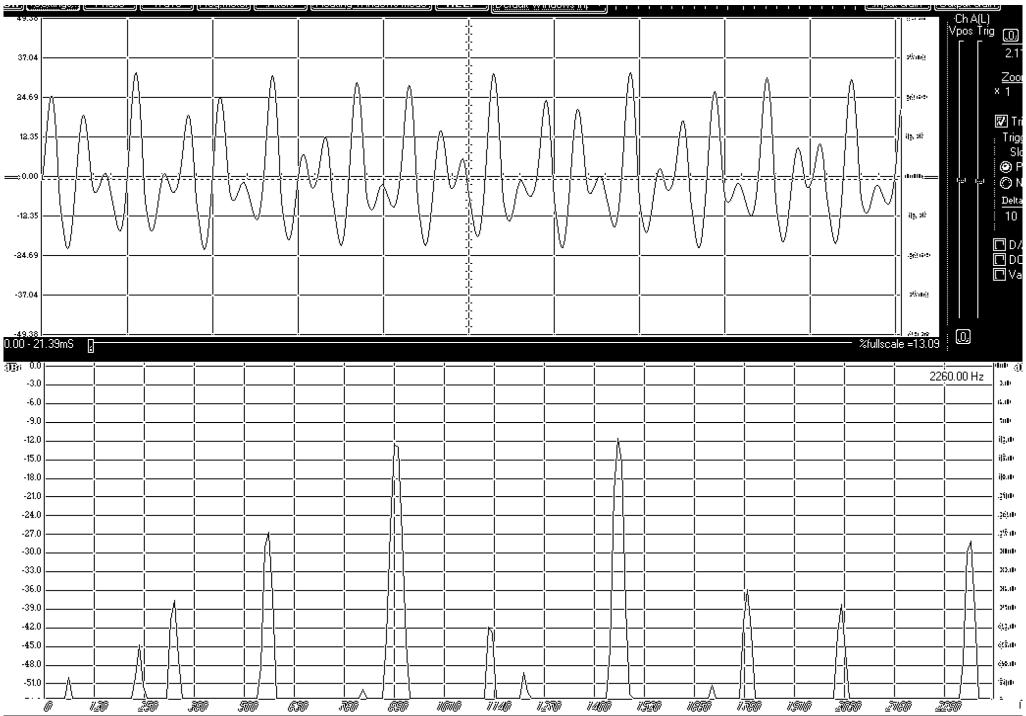
Figure 38

Figure 39a Mixer Test; Sine Waves (No Flame): 900 Hz (-7 dB); 1,300 Hz (-7 dB)



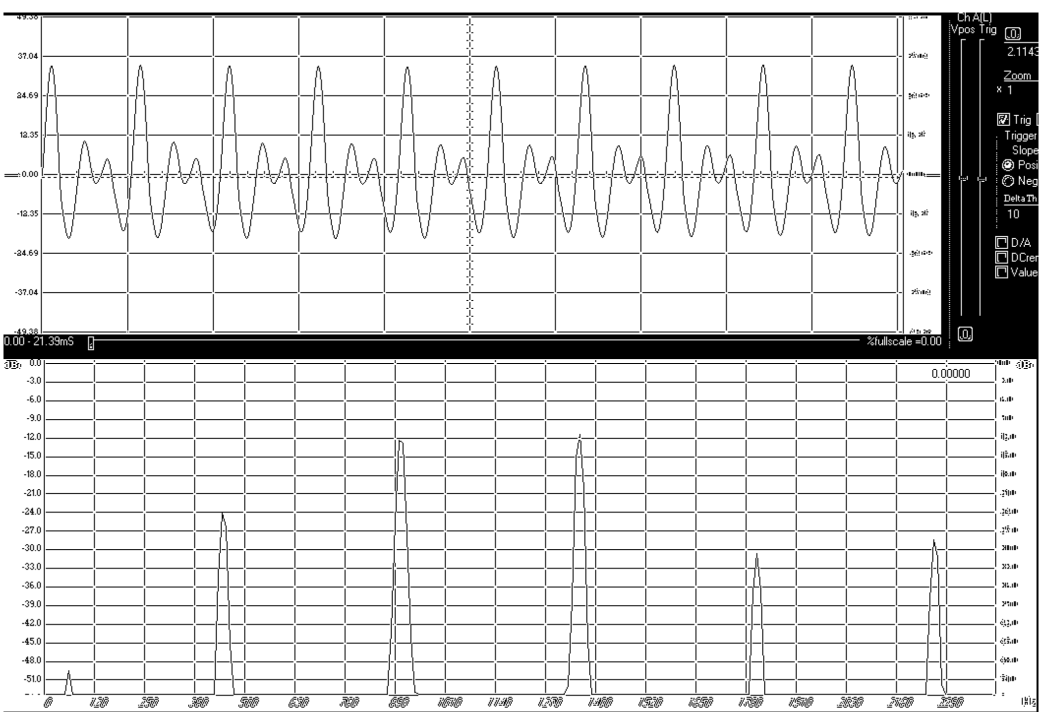
900 Hz (-12 dB); 1,300 Hz (-12 dB); 400 Hz (-27 dB); 2,200 Hz (-27 dB); 500 Hz (-39 dB)

Figure 39b Mixer Test; Sine Waves (Flame):



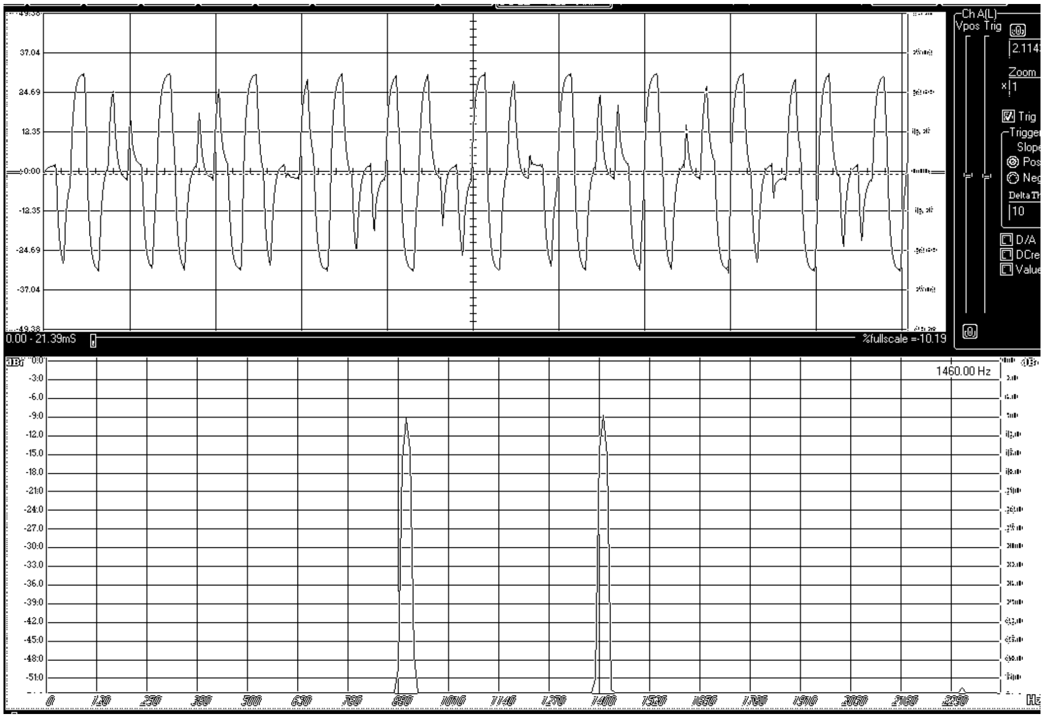
900 Hz (-12dB); 1,460 Hz (-12 dB); 560 Hz (-27 dB); 2,360 Hz (-28 dB); 340 Hz (-37 dB)

Figure 40 Mixer Test; Sine Waves (Flame)



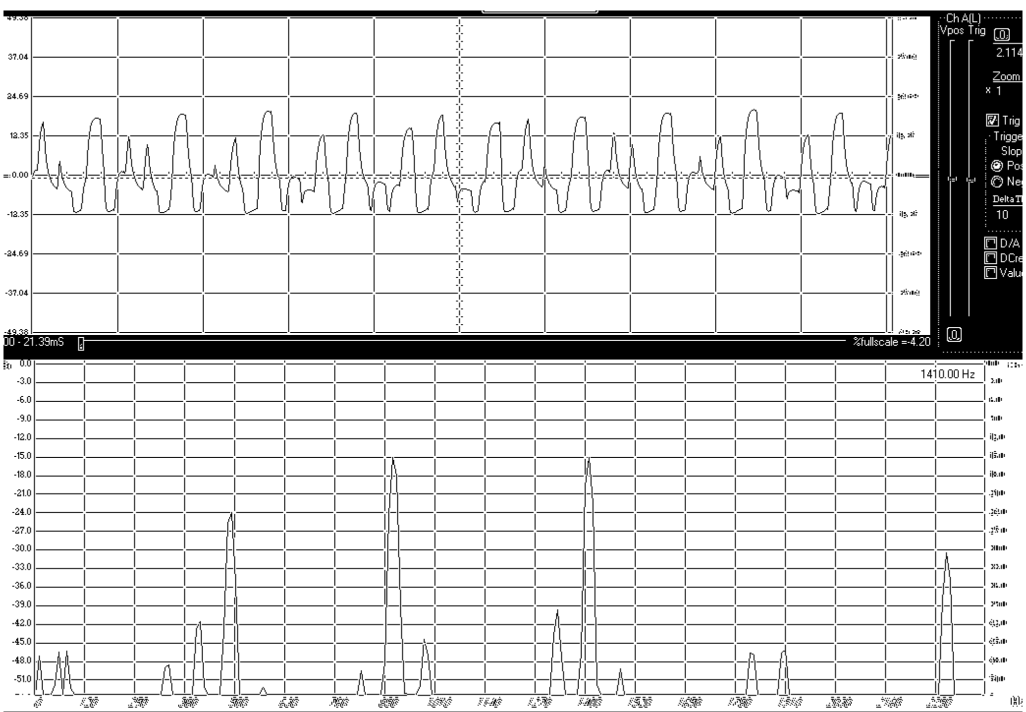
900 Hz (-12dB); 1,350 Hz (-12 dB); 450 Hz (-24 dB); 1,810 Hz (-32 dB); 2,260 Hz (-28 dB)

Figure 41 Mixer Test; Sine Waves (Flame)



910 Hz (-9 dB); 1,410 Hz (-9 dB)

Figure 42a Mixer Test; Square Waves (No Flame)



910 Hz (-15 dB); 1410 Hz (-15 dB); 500 Hz (-24 dB); 2,320 (-30 dB); 410 Hz (-41 dB)

Figure 42b Mixer Test; Square Waves (Flame)

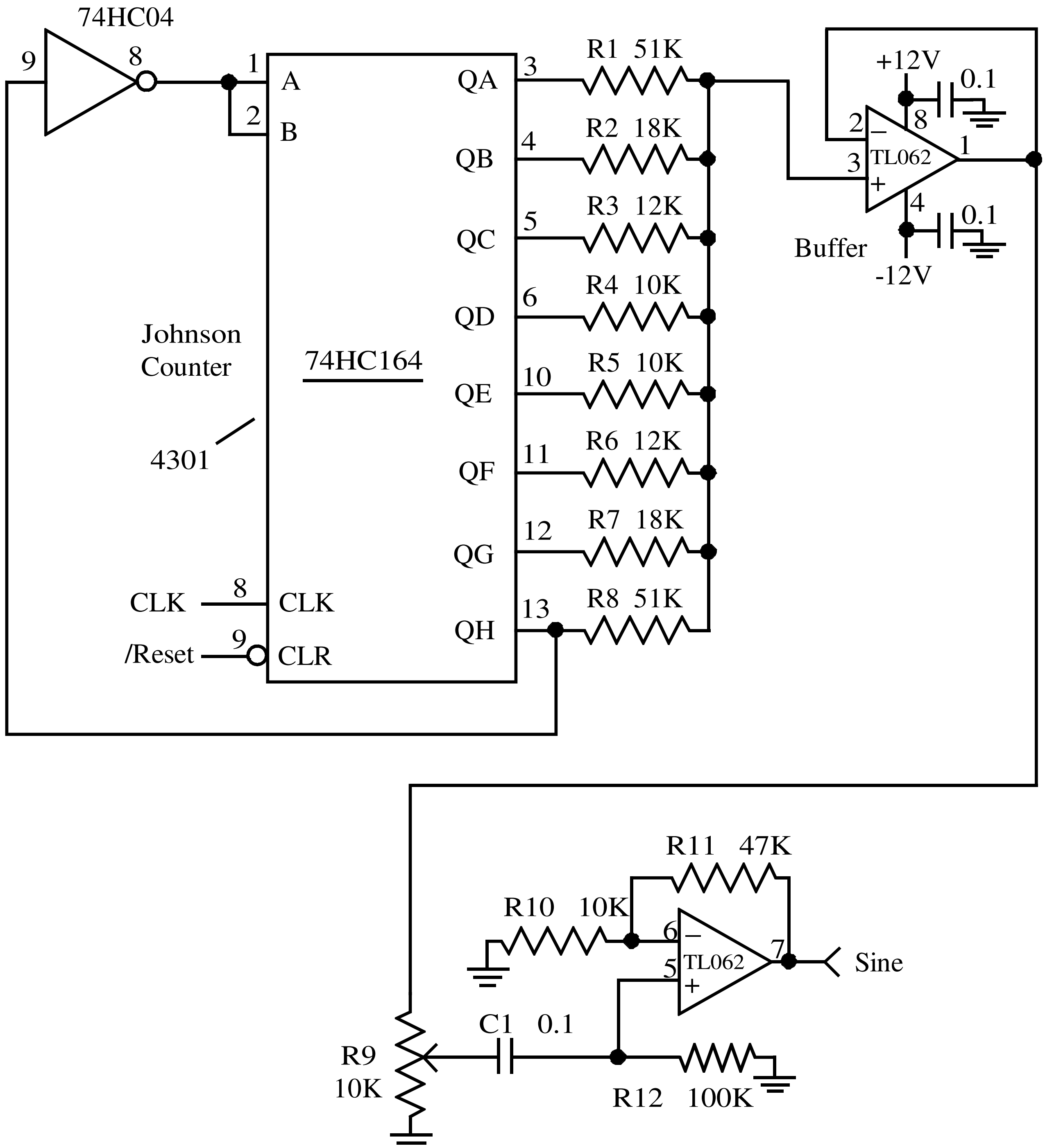


Figure 43a Sine Wave Generator

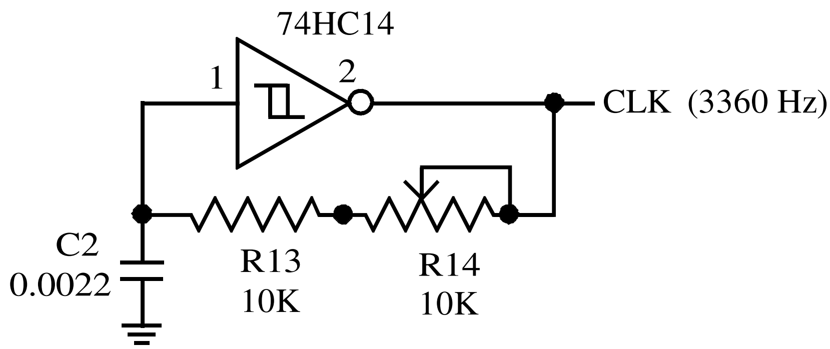


Figure 43b Oscillator

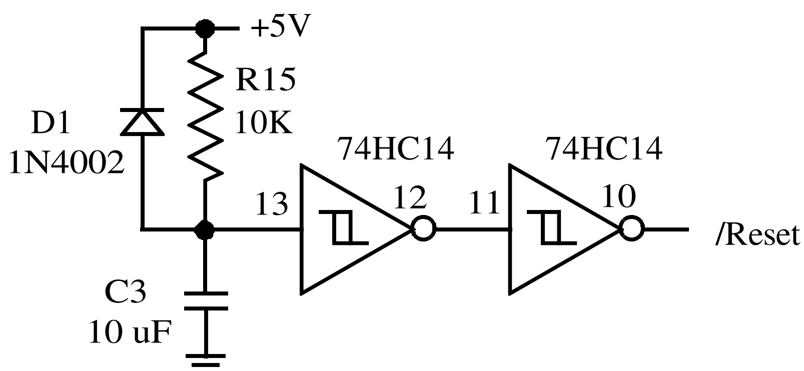
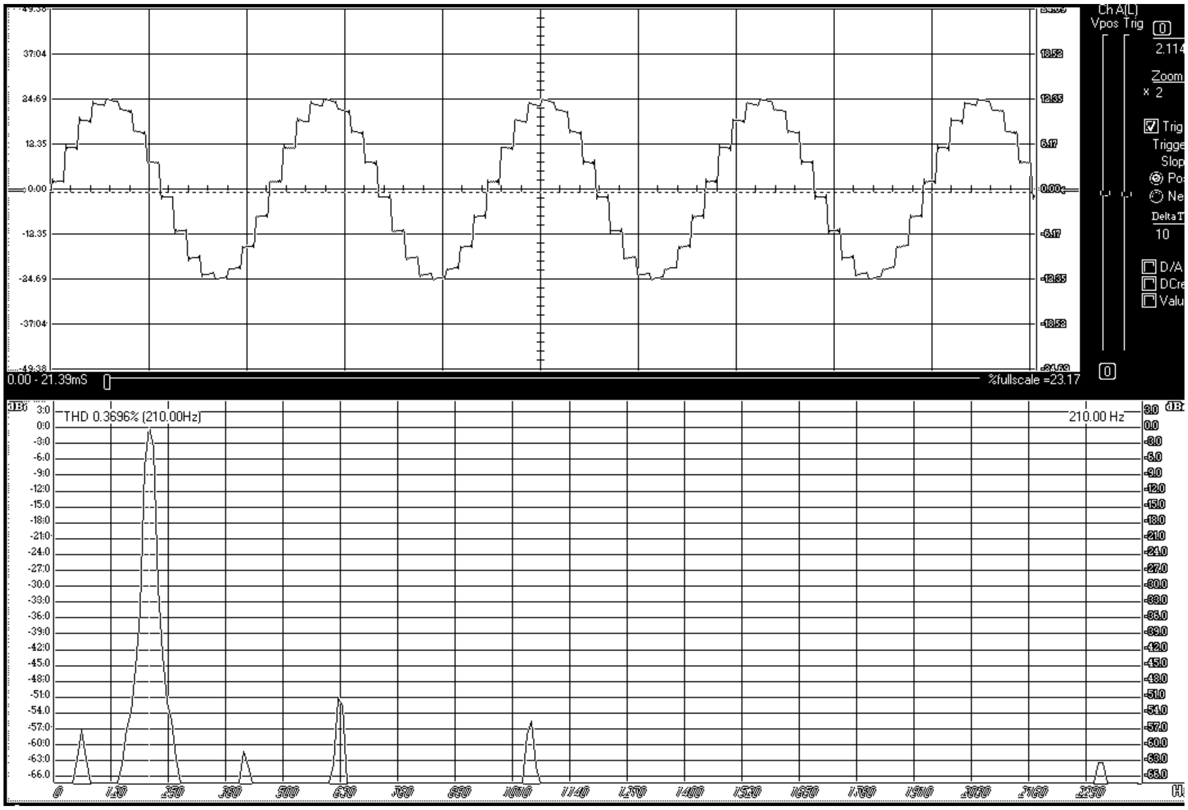


Figure 43c Reset



210 Hz Fundamental 0 dB; 2nd Harmonic -61 dB; 3rd Harmonic -51 dB;
5th Harmonic -54 dB; 60 Hz -57 dB

<u>Figure 44</u> - Johnson Counter Results

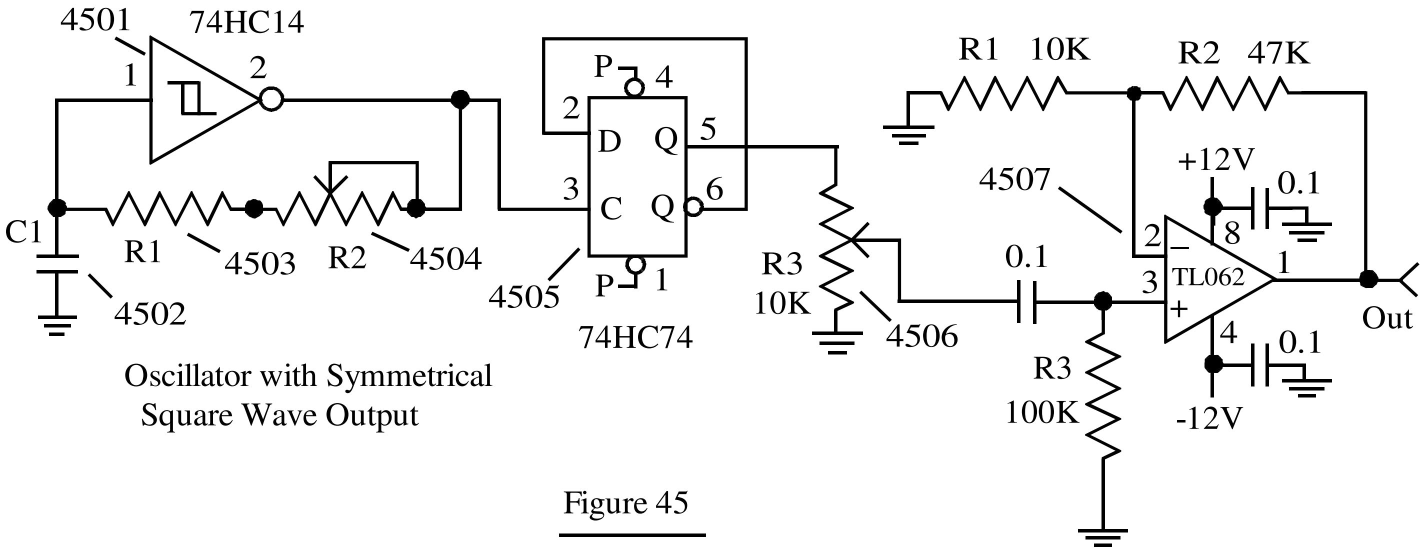


Figure 45

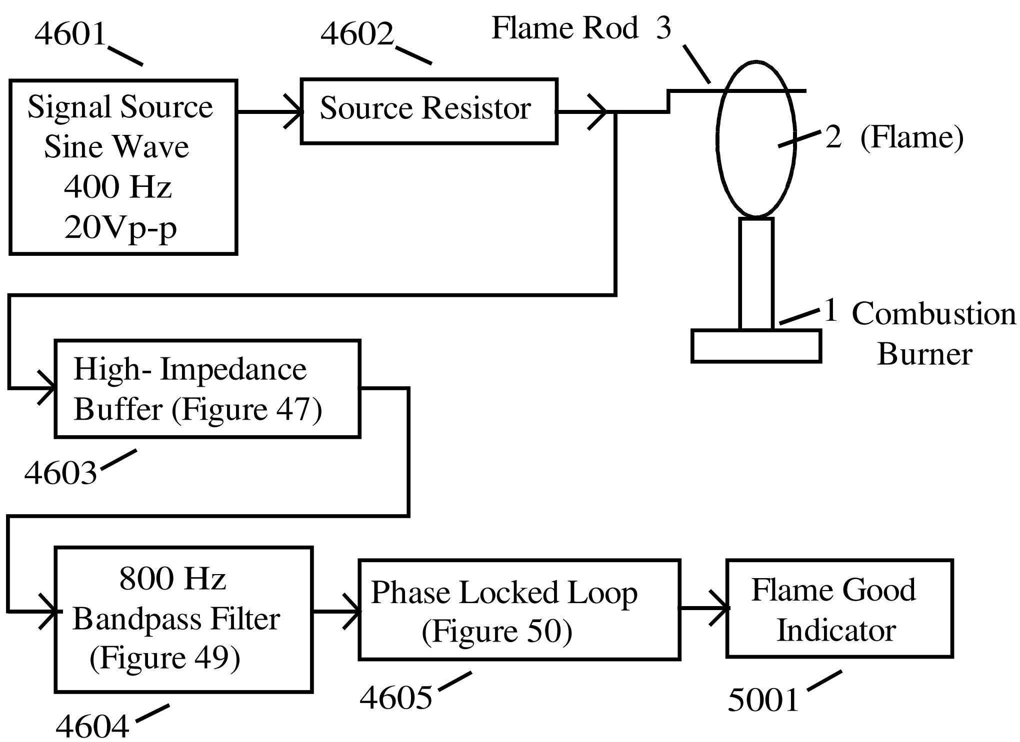


Figure 46

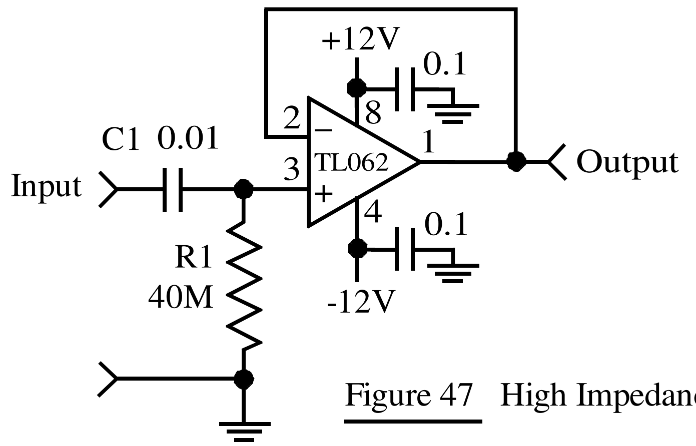


Figure 47 High Impedance Buffer

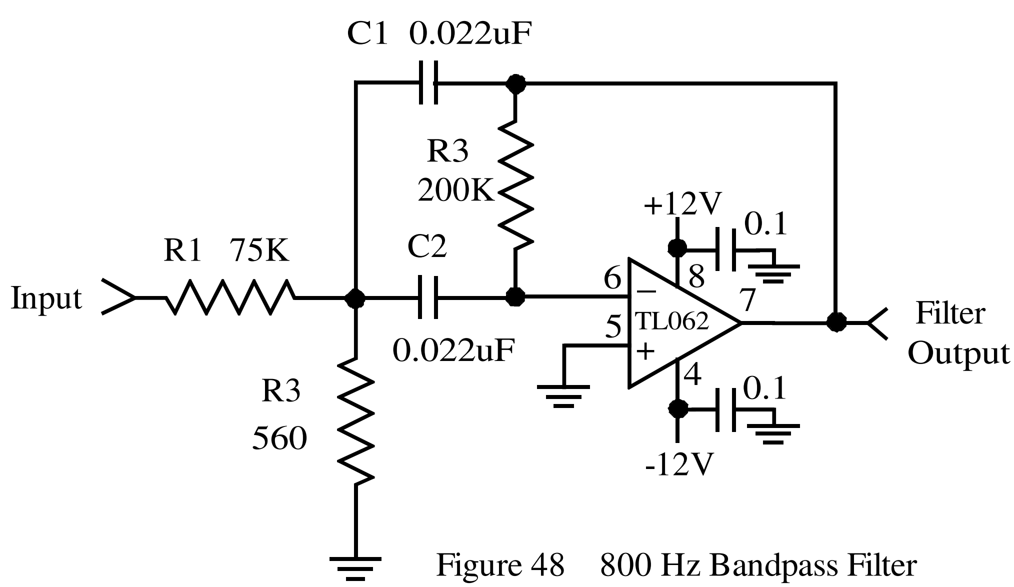


Figure 48 800 Hz Bandpass Filter

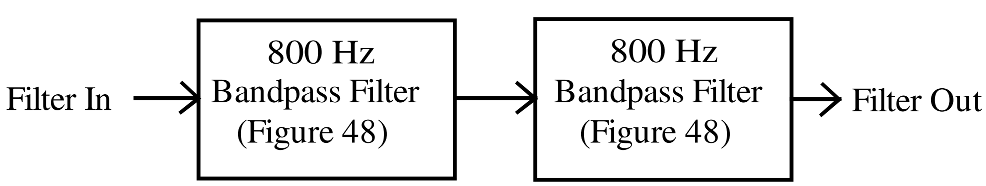
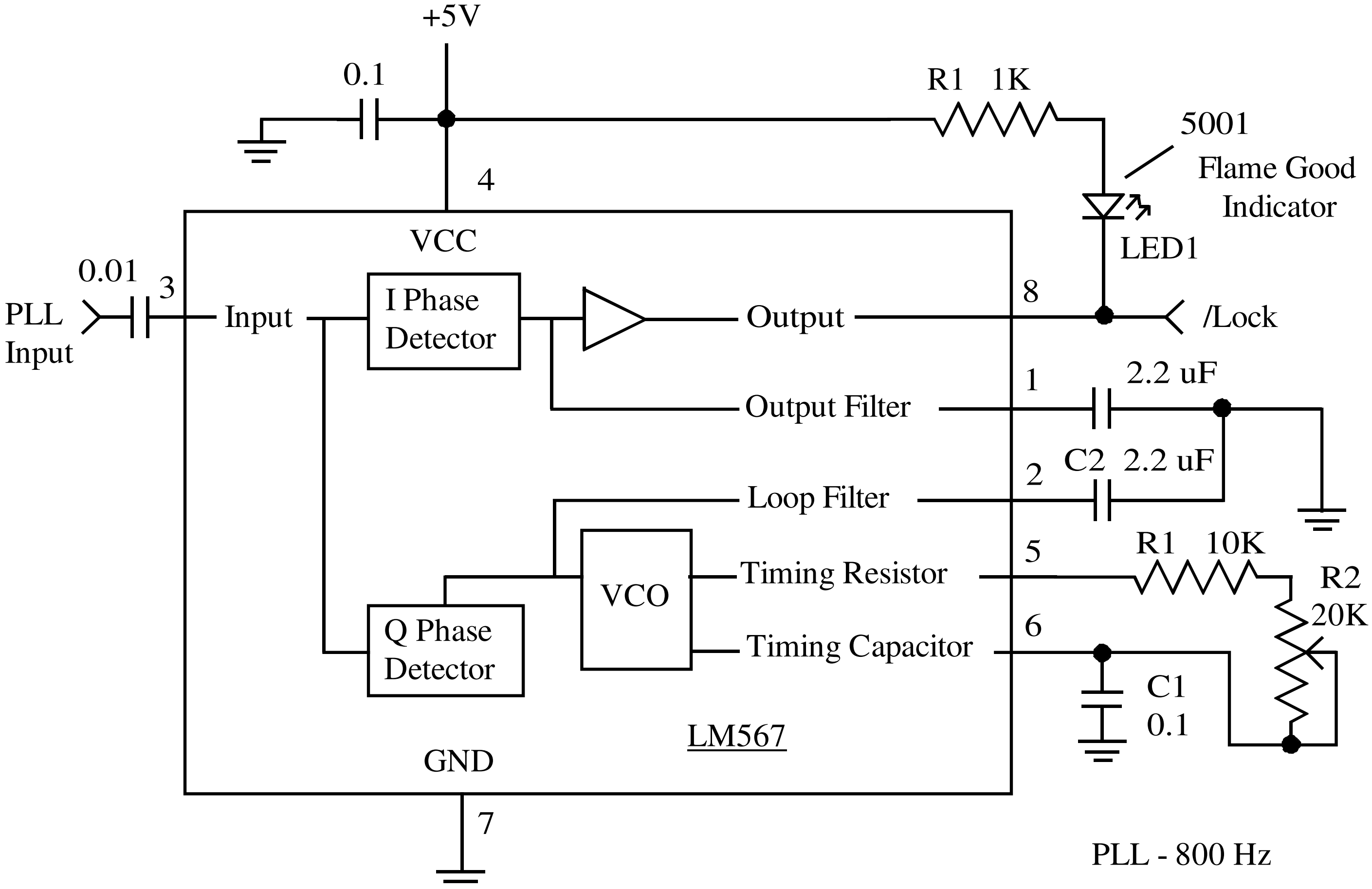


Figure 49 Two Cascaded Bandpass Filters



+5V
0.1
R1 1K
5001
Flame Good
Indicator
LED1
4
VCC
0.01
3
PLL
Input
Input
I Phase
Detector
Output
8
/Lock
Output Filter
1
2.2 uF
C2 2.2 uF
2
Loop Filter
VCO
Timing Resistor
5
R1 10K
R2
20K
Q Phase
Detector
Timing Capacitor
6
C1
0.1
LM567
GND
7
PLL - 800 Hz

Figure 50

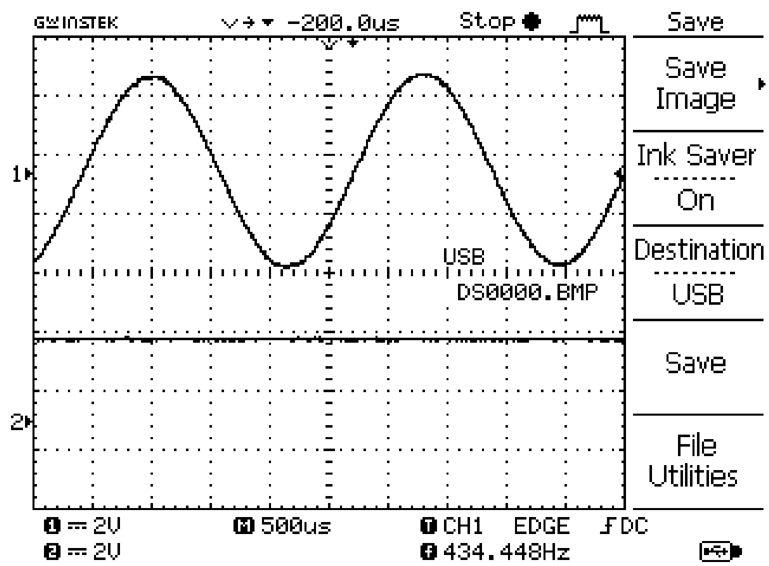


Figure 51a Sine Wave; 435 Hz; Flame Off

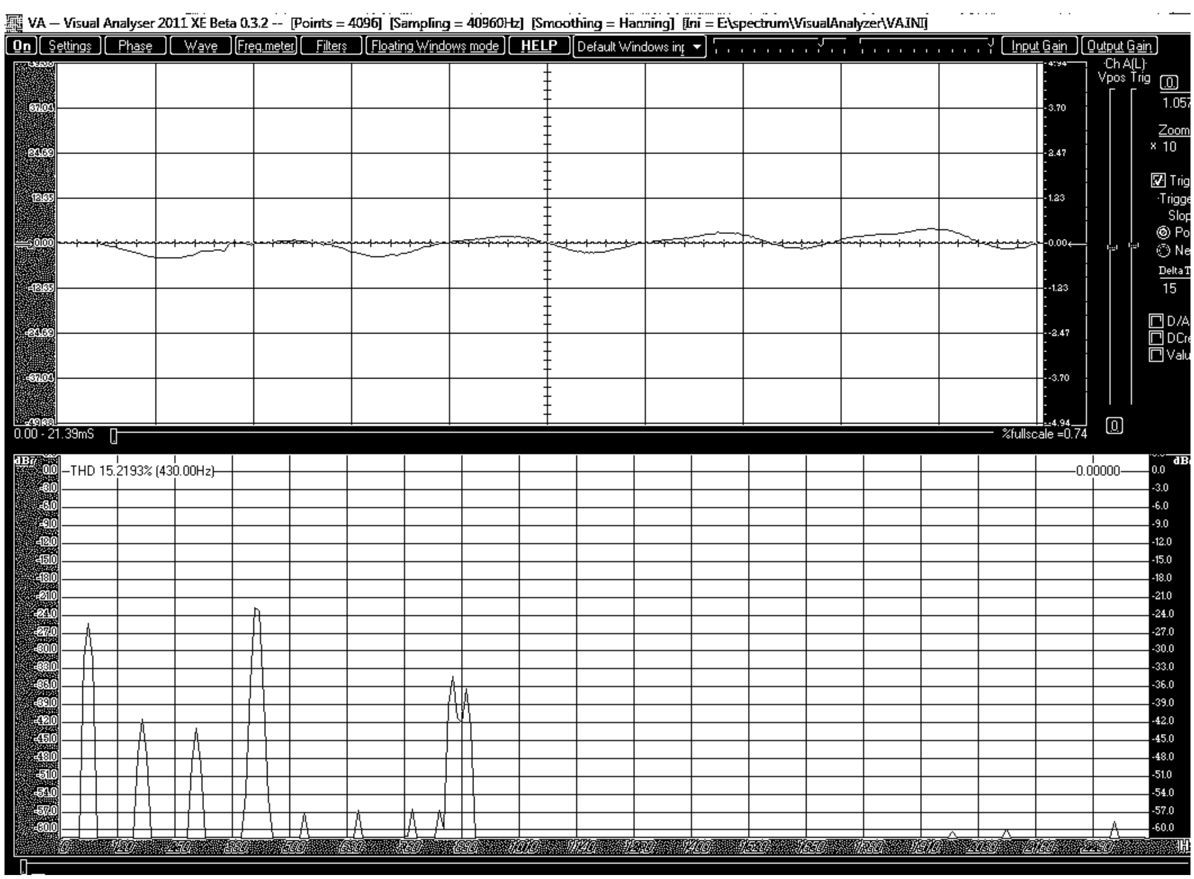


Figure 51b Sine Wave; 435 Hz; Flame Off

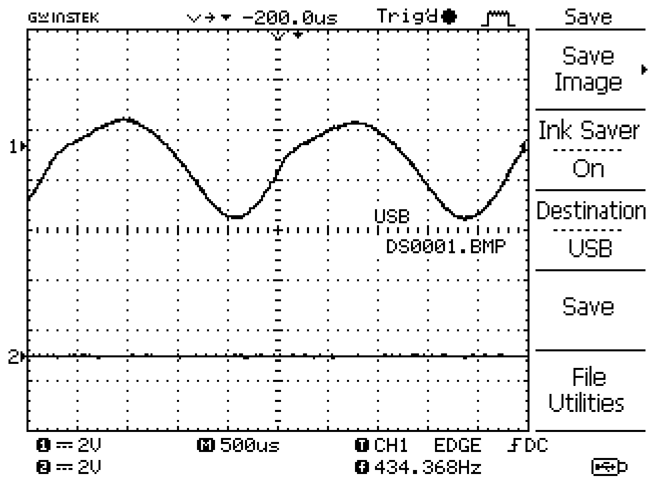


Figure 52a Sine Wave; 435 Hz; Flame On

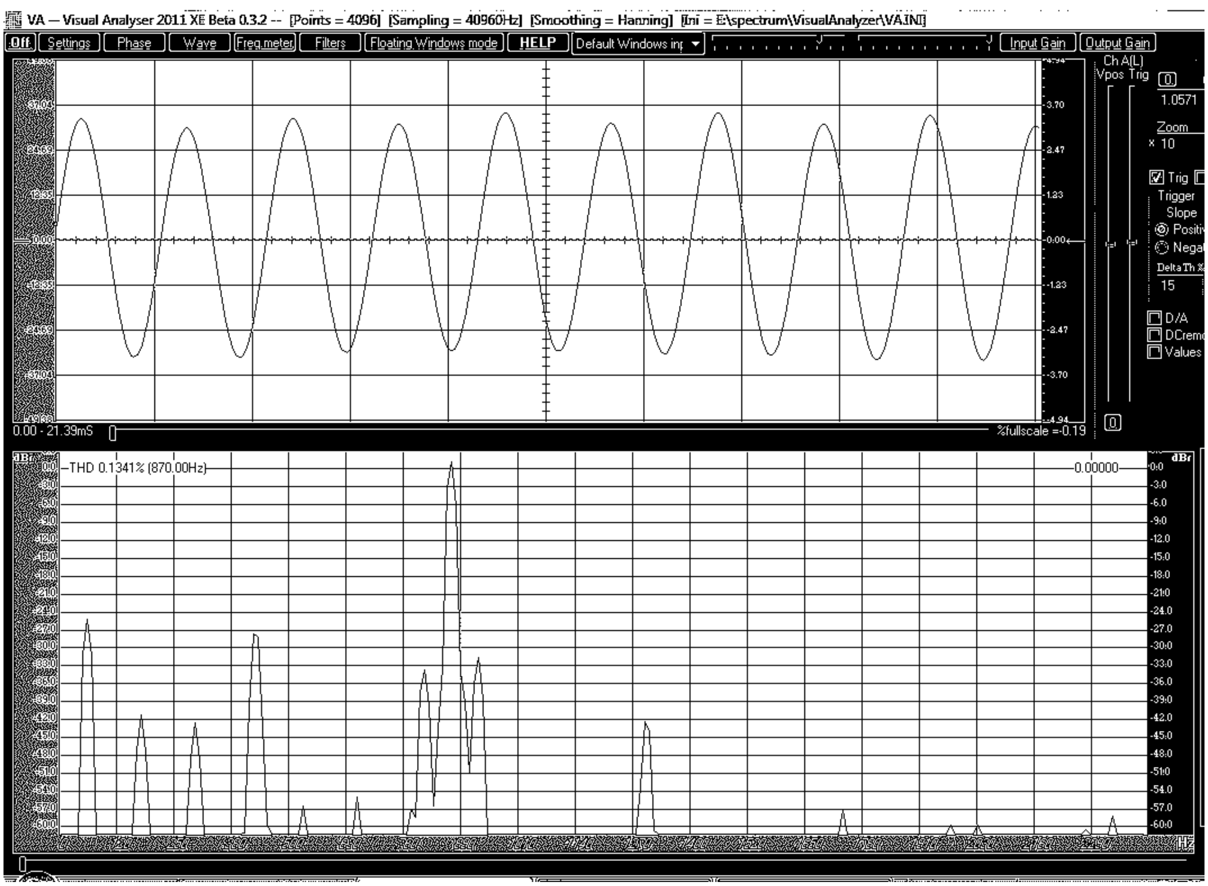


Figure 52b Sine 435 Hz; Flame On

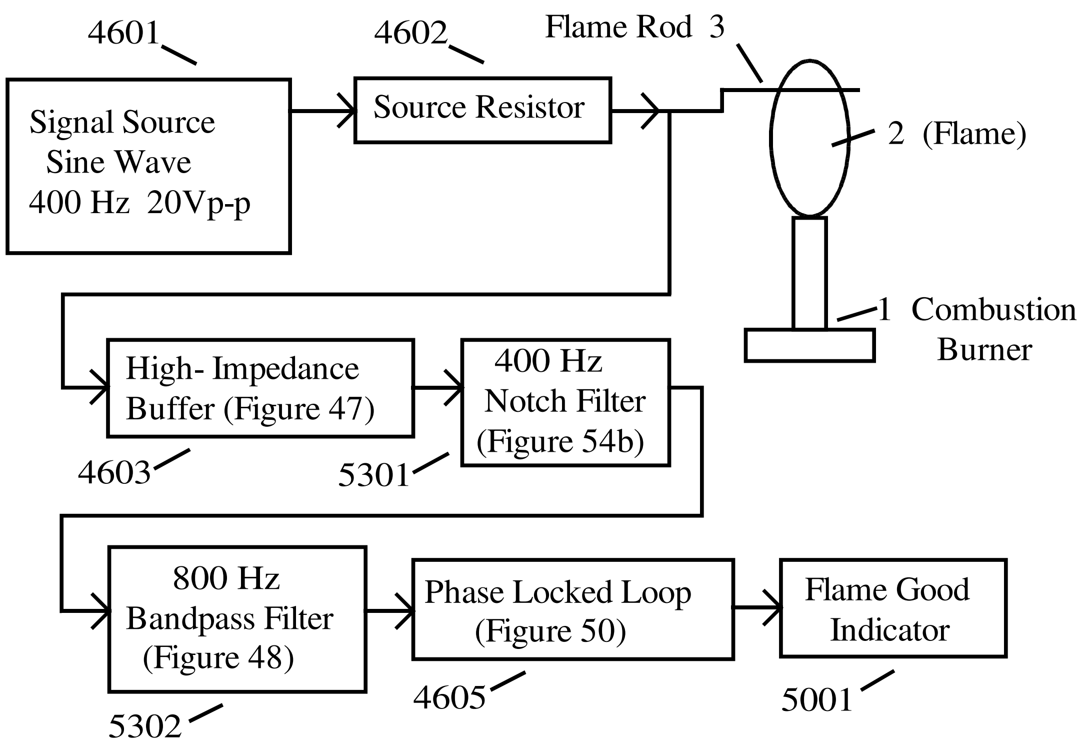
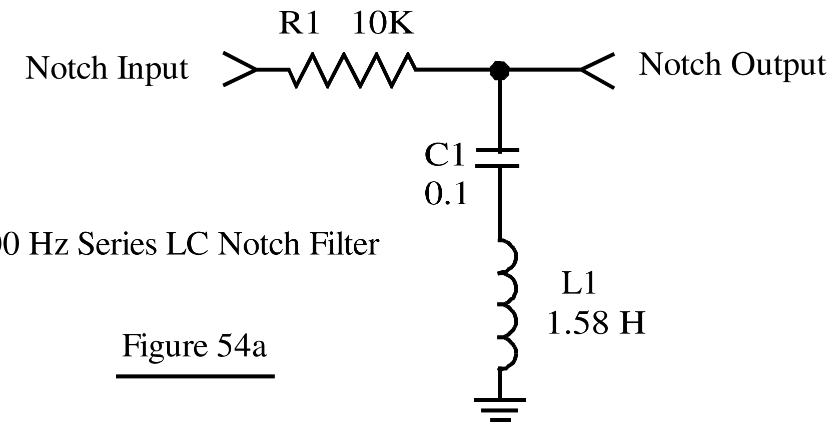
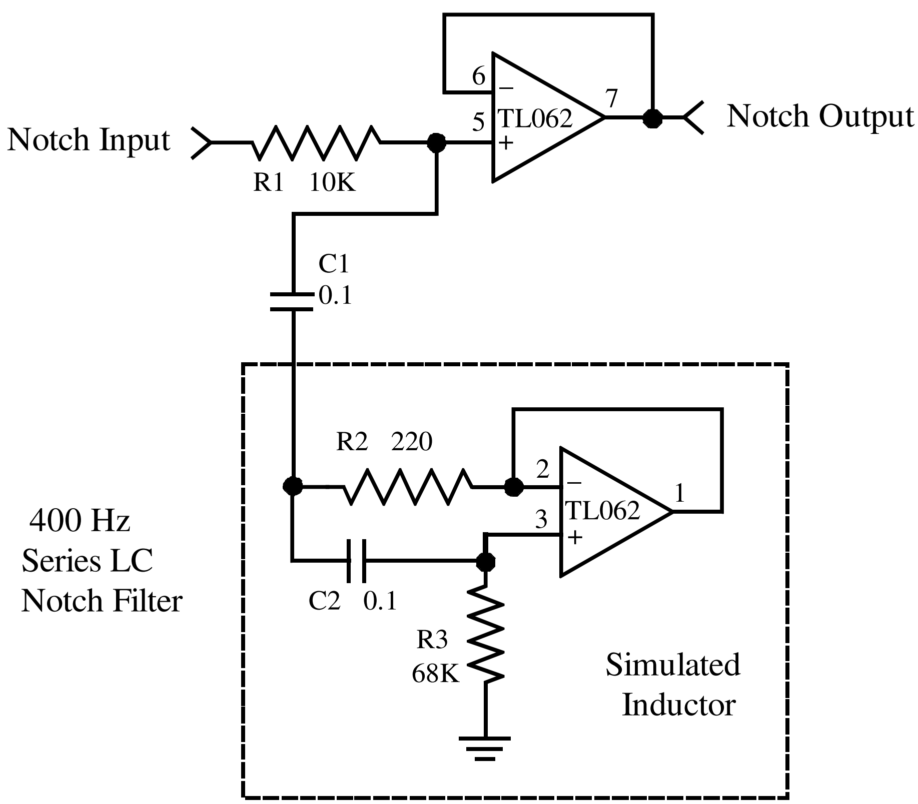

4601
4602
Flame Rod 3
Signal Source
Sine Wave
400 Hz 20Vp-p
Source Resistor
2 (Flame)
1 Combustion
Burner
High- Impedance
Buffer (Figure 47)
4603
400 Hz
Notch Filter
(Figure 54b)
5301
800 Hz
Bandpass Filter
(Figure 48)
5302
Phase Locked Loop
(Figure 50)
4605
Flame Good
Indicator
5001

Figure 53



400 Hz Series LC Notch Filter

Figure 54a



400 Hz
Series LC
Notch Filter

Figure 54b

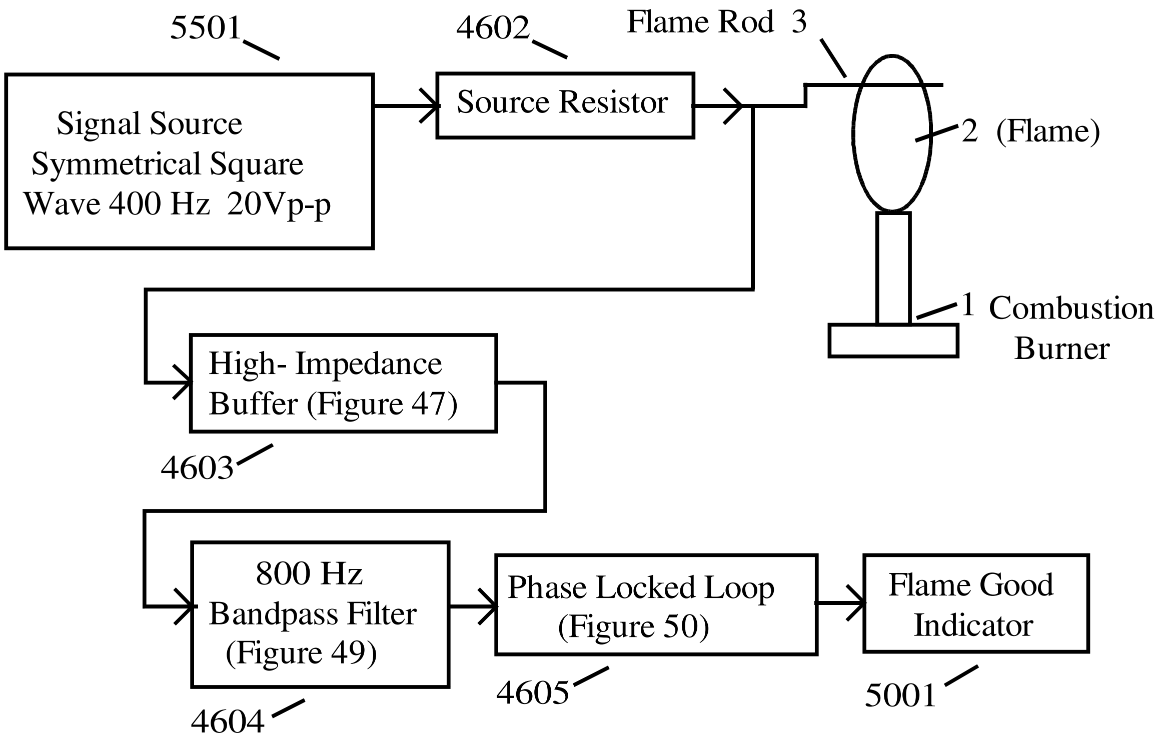

5501
4602
Flame Rod 3
Signal Source
Symmetrical Square
Wave 400 Hz 20Vp-p
Source Resistor
2 (Flame)
1 Combustion
Burner
High- Impedance
Buffer (Figure 47)
4603
800 Hz
Bandpass Filter
(Figure 49)
4604
Phase Locked Loop
(Figure 50)
4605
Flame Good
Indicator
5001

Figure 55

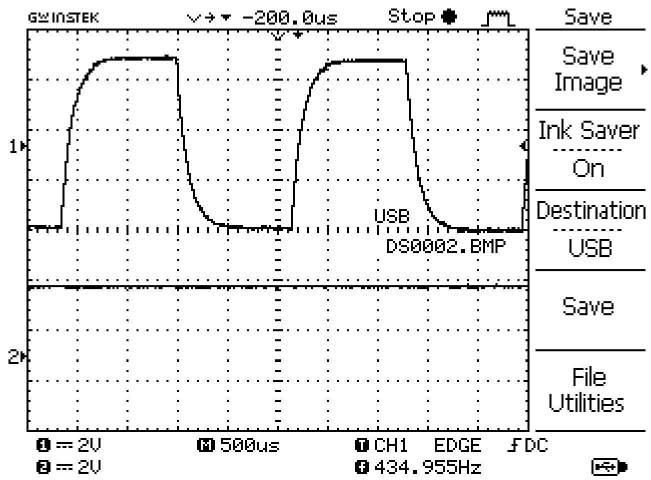


Figure 56a Square Wave; 435 Hz; Flame Off

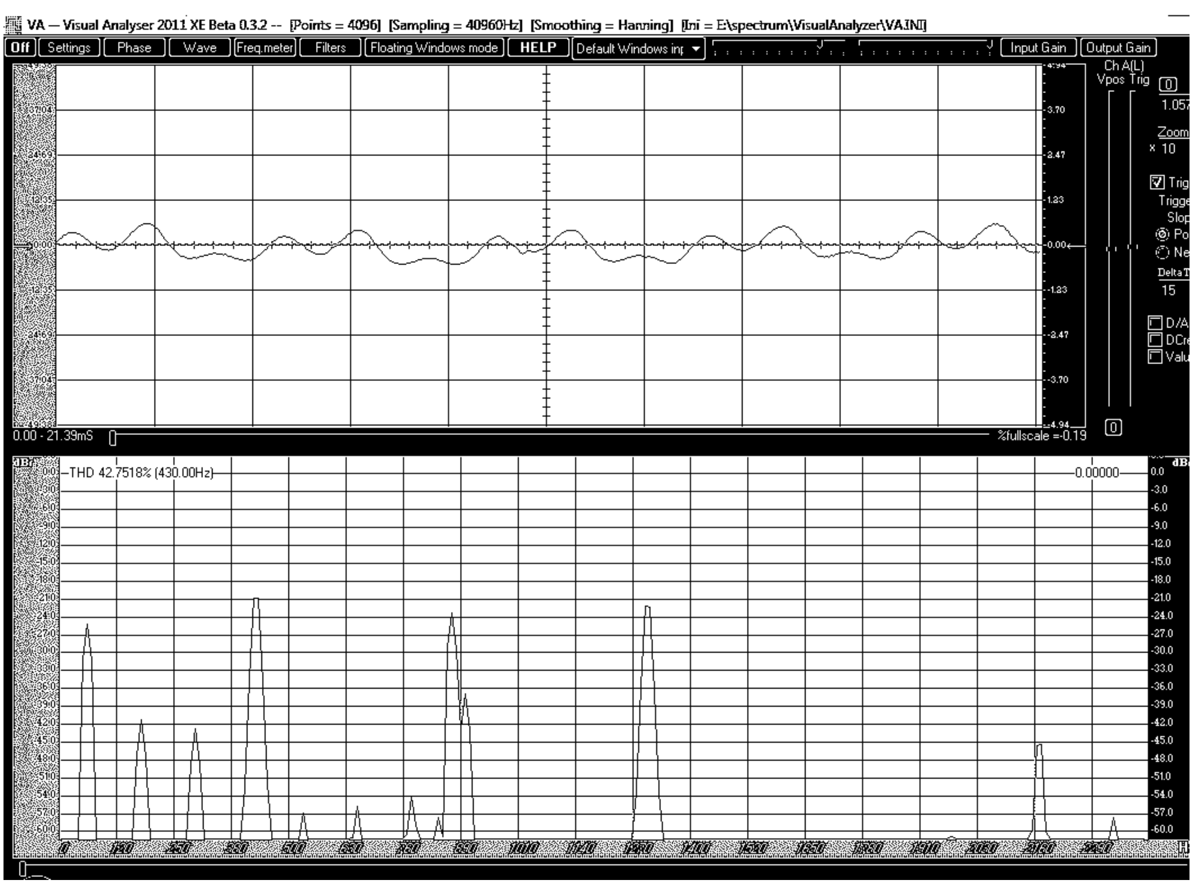


Figure 56b Square Wave; 435 Hz; Flame Off

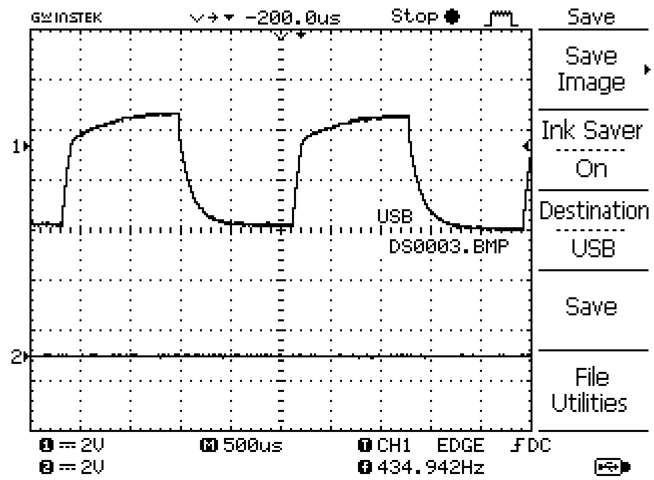


Figure 57a Square Wave; 435 Hz; Flame On

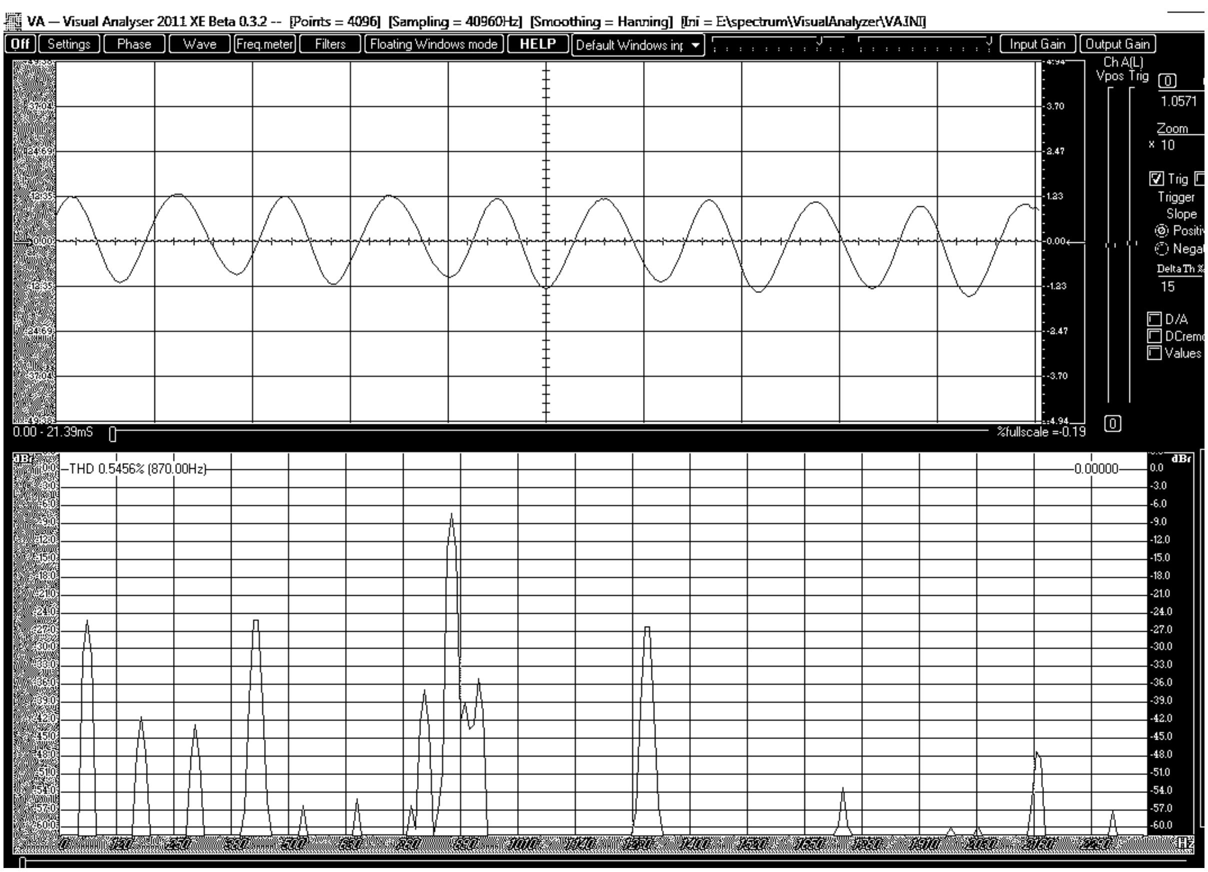


Figure 57b Square Wave; 435 Hz; Flame On

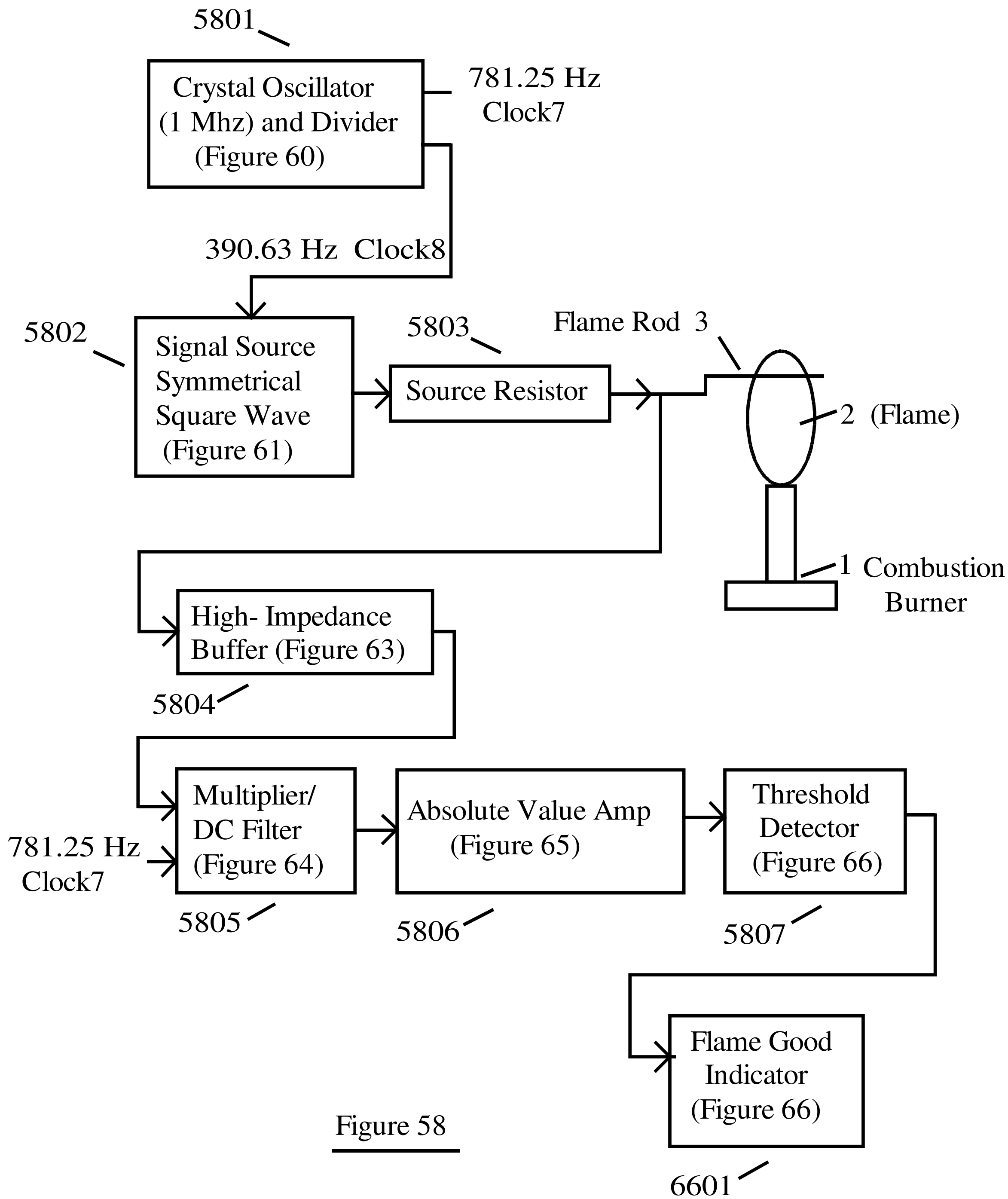

5801
Crystal Oscillator (1 Mhz) and Divider (Figure 60)
781.25 Hz Clock7
390.63 Hz Clock8
5802
Signal Source Symmetrical Square Wave (Figure 61)
5803
Source Resistor
Flame Rod 3
2 (Flame)
1 Combustion Burner
High- Impedance Buffer (Figure 63)
5804
Multiplier/ DC Filter (Figure 64)
781.25 Hz Clock7
Absolute Value Amp (Figure 65)
Threshold Detector (Figure 66)
5805
5806
5807
Flame Good Indicator (Figure 66)
6601

Figure 58

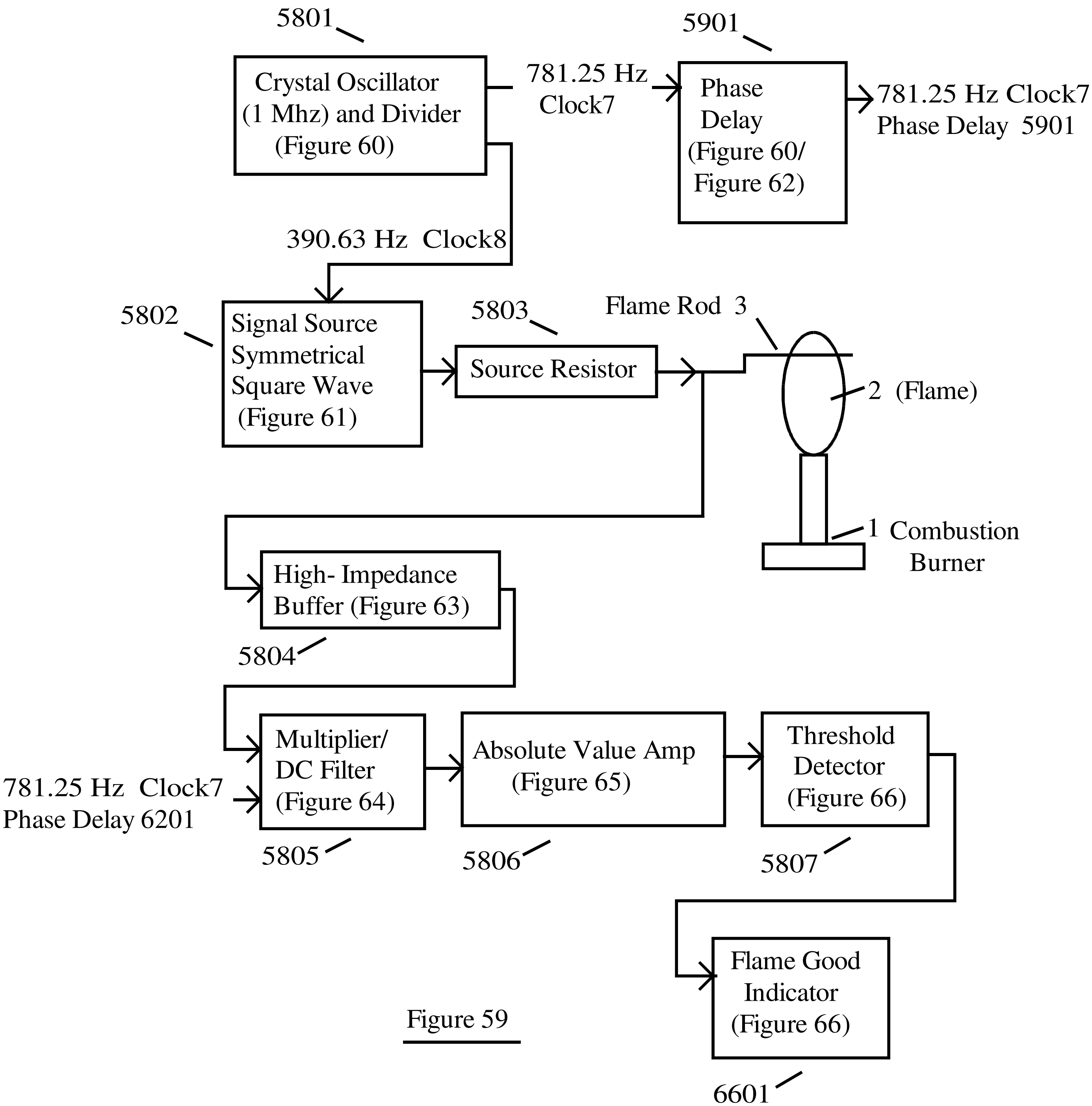

5801
Crystal Oscillator (1 Mhz) and Divider (Figure 60)
781.25 Hz Clock7
5901
Phase Delay (Figure 60/ Figure 62)
781.25 Hz Clock7 Phase Delay 5901
390.63 Hz Clock8
5802
Signal Source Symmetrical Square Wave (Figure 61)
5803
Source Resistor
Flame Rod 3
2 (Flame)
1 Combustion Burner
High- Impedance Buffer (Figure 63)
5804
781.25 Hz Clock7 Phase Delay 6201
Multiplier/ DC Filter (Figure 64)
5805
Absolute Value Amp (Figure 65)
5806
Threshold Detector (Figure 66)
5807
Flame Good Indicator (Figure 66)
6601

Figure 59

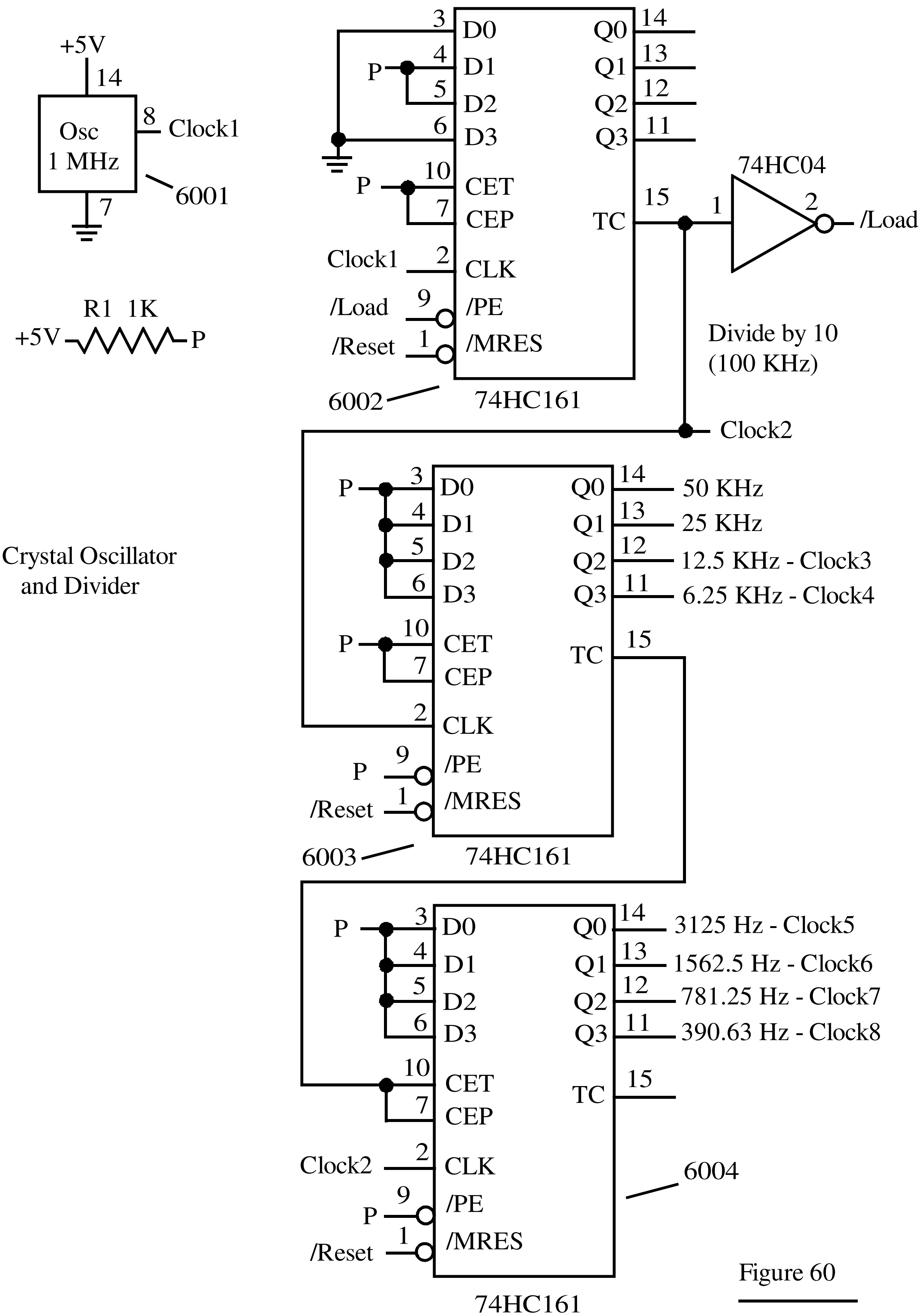

+5V
14
Osc
1 MHz
8
Clock1
7
6001
R1 1K
+5V
P
Crystal Oscillator
and Divider
D0
D1
D2
D3
CET
CEP
CLK
/PE
/MRES
Q0
Q1
Q2
Q3
TC
Clock1
/Load
/Reset
6002
74HC161
74HC04
/Load
Divide by 10
(100 KHz)
Clock2
50 KHz
25 KHz
12.5 KHz - Clock3
6.25 KHz - Clock4
6003
74HC161
3125 Hz - Clock5
1562.5 Hz - Clock6
781.25 Hz - Clock7
390.63 Hz - Clock8
Clock2
/Reset
6004
74HC161

Figure 60

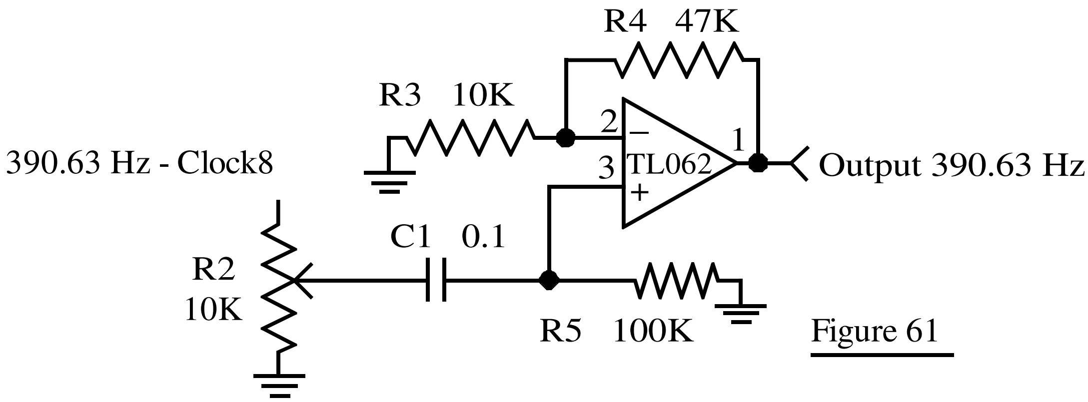


Figure 61

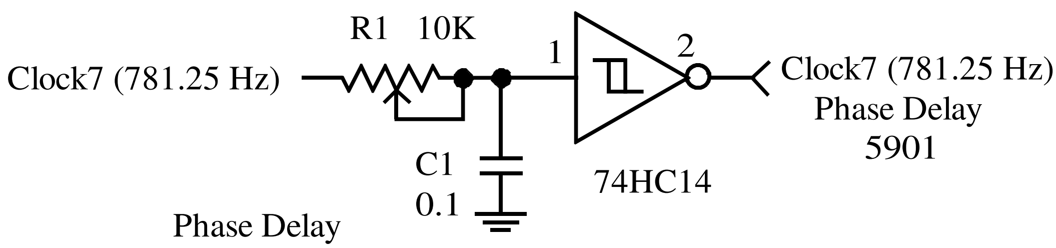


Figure 62

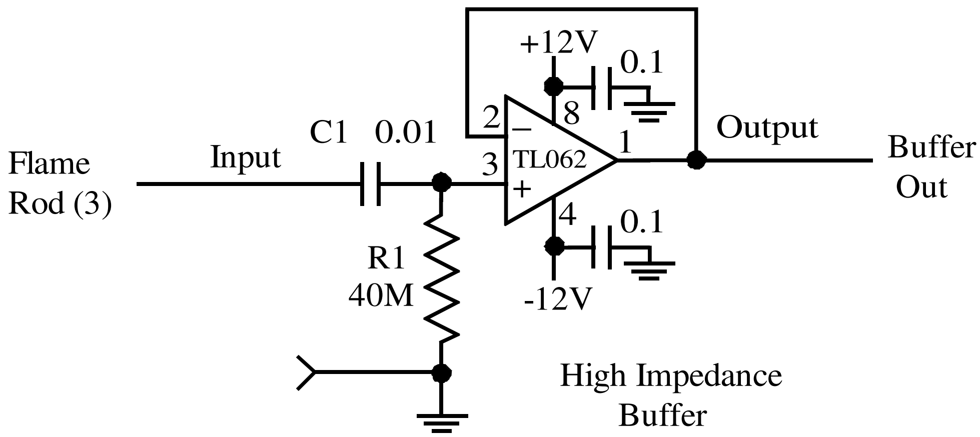


Figure 63

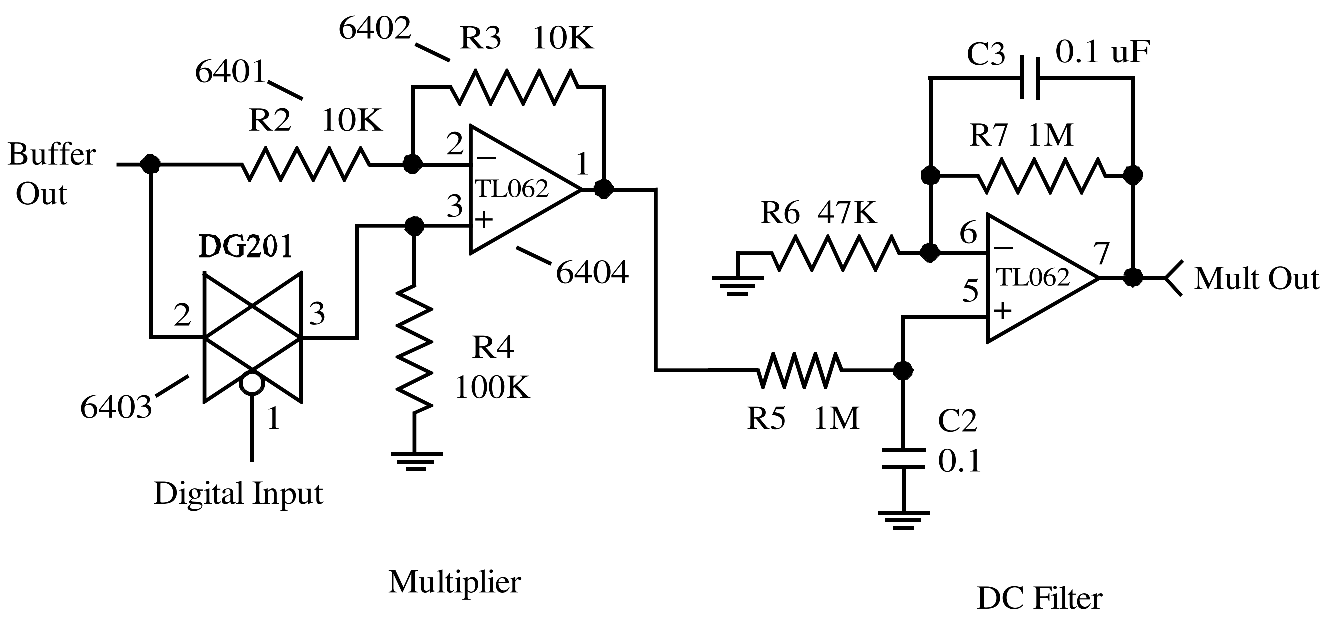


Figure 64 Multiplier and DC Filter

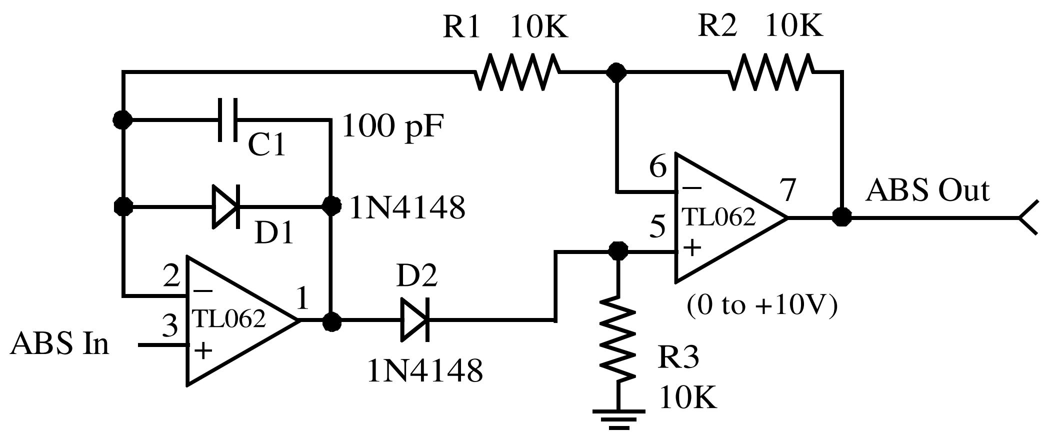


Figure 65 Absolute Value Amp

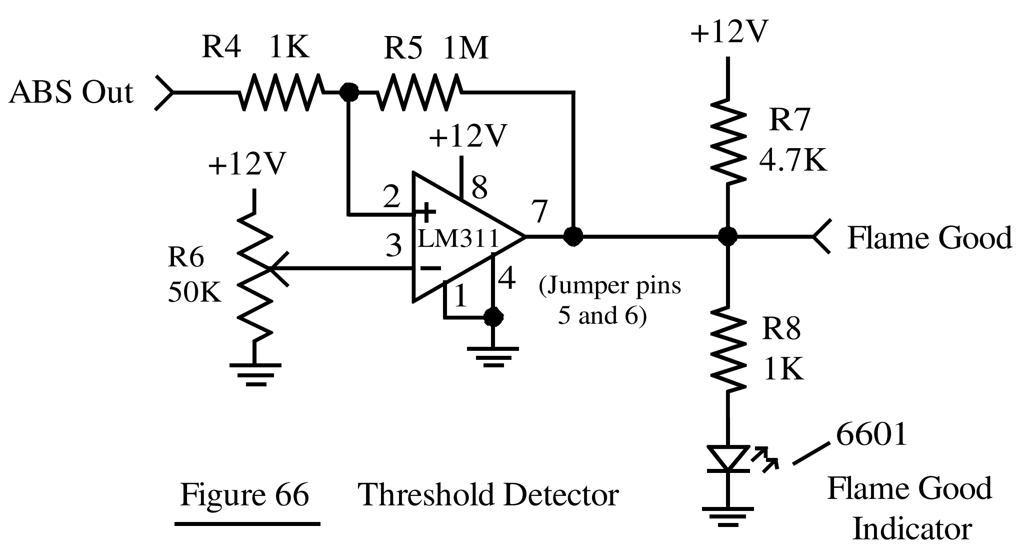


Figure 66 Threshold Detector

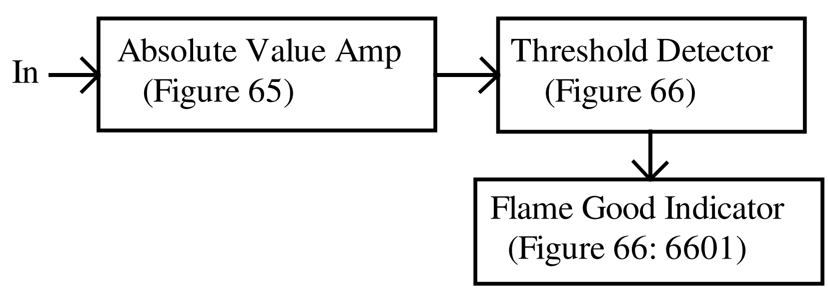
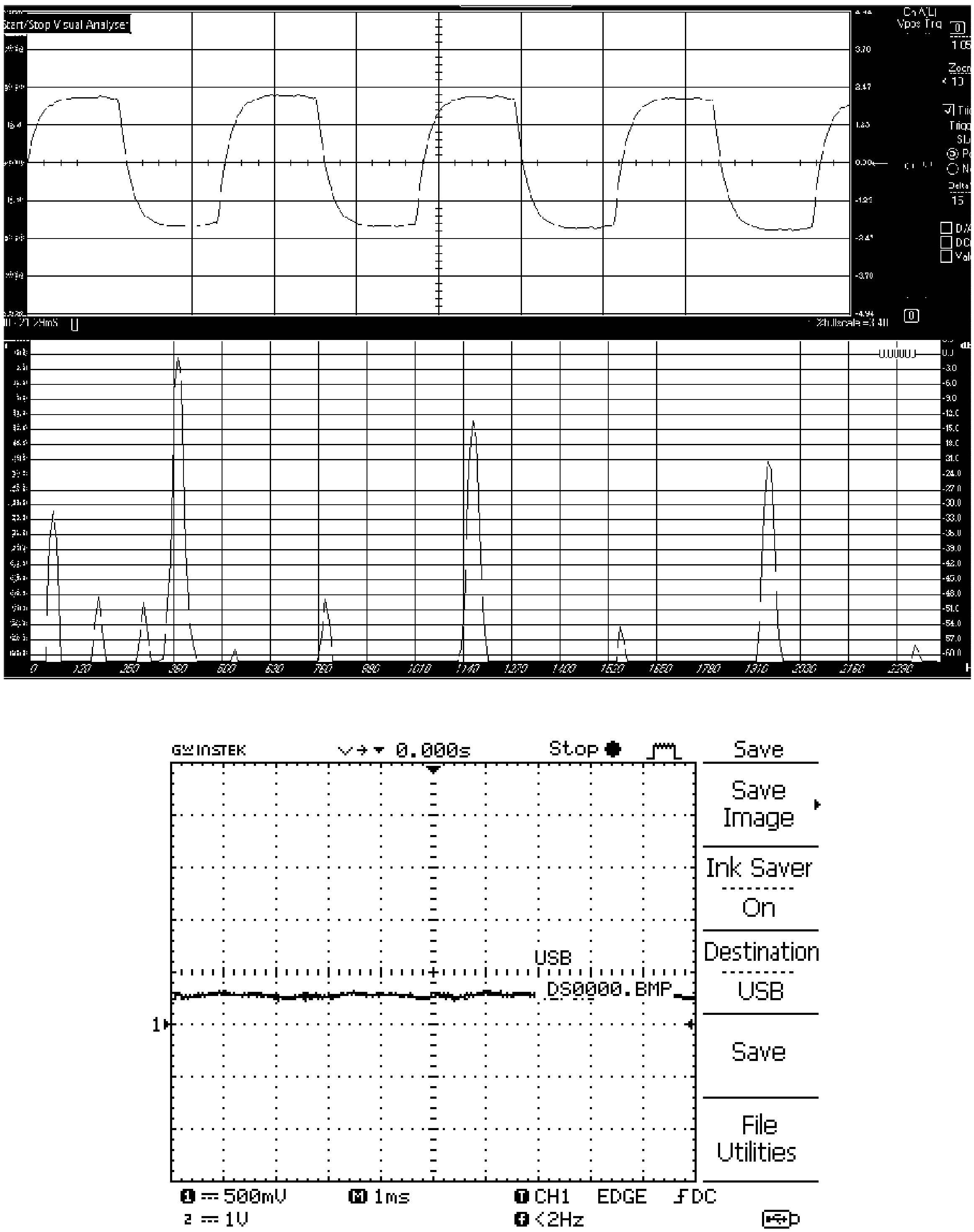
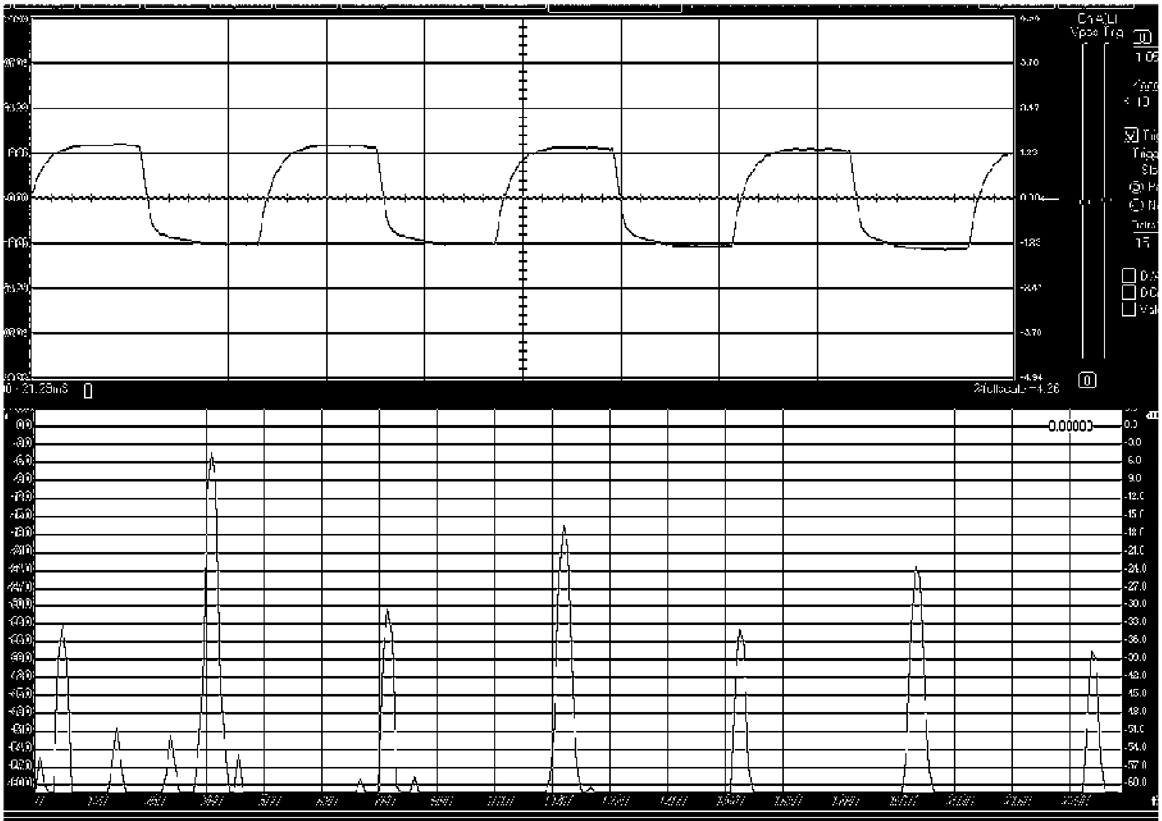


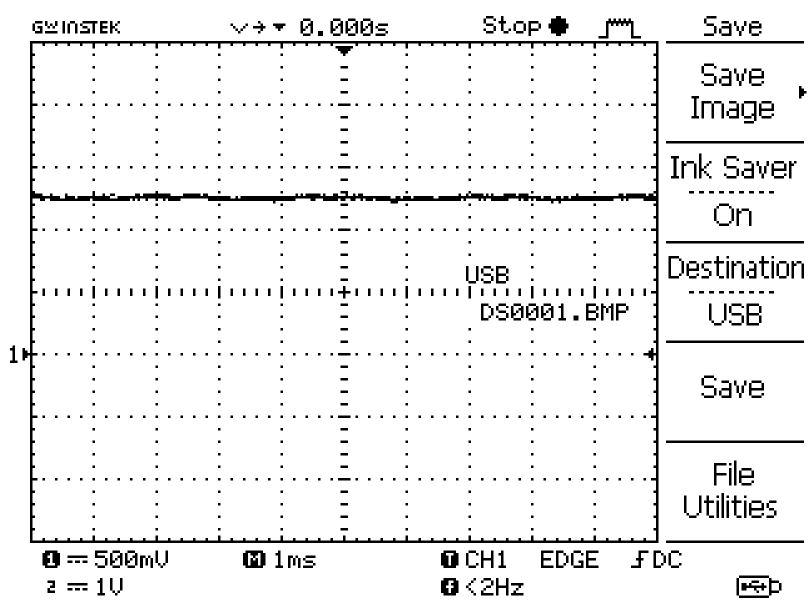
Figure 67 Threshold Detector



Experiment 14 Detecting a harmonic signal produced by flame rectification;
Signal Source: Symmetrical Square Wave
Detector: Simple Synchronous Detector
Flame: Off

Figure 68a





Experiment 14 Detecting a harmonic signal produced by flame rectification;
Signal Source: Symmetrical Square Wave
Detector: Simple Synchronous Detector
Flame: On

<u>Figure 68b</u>

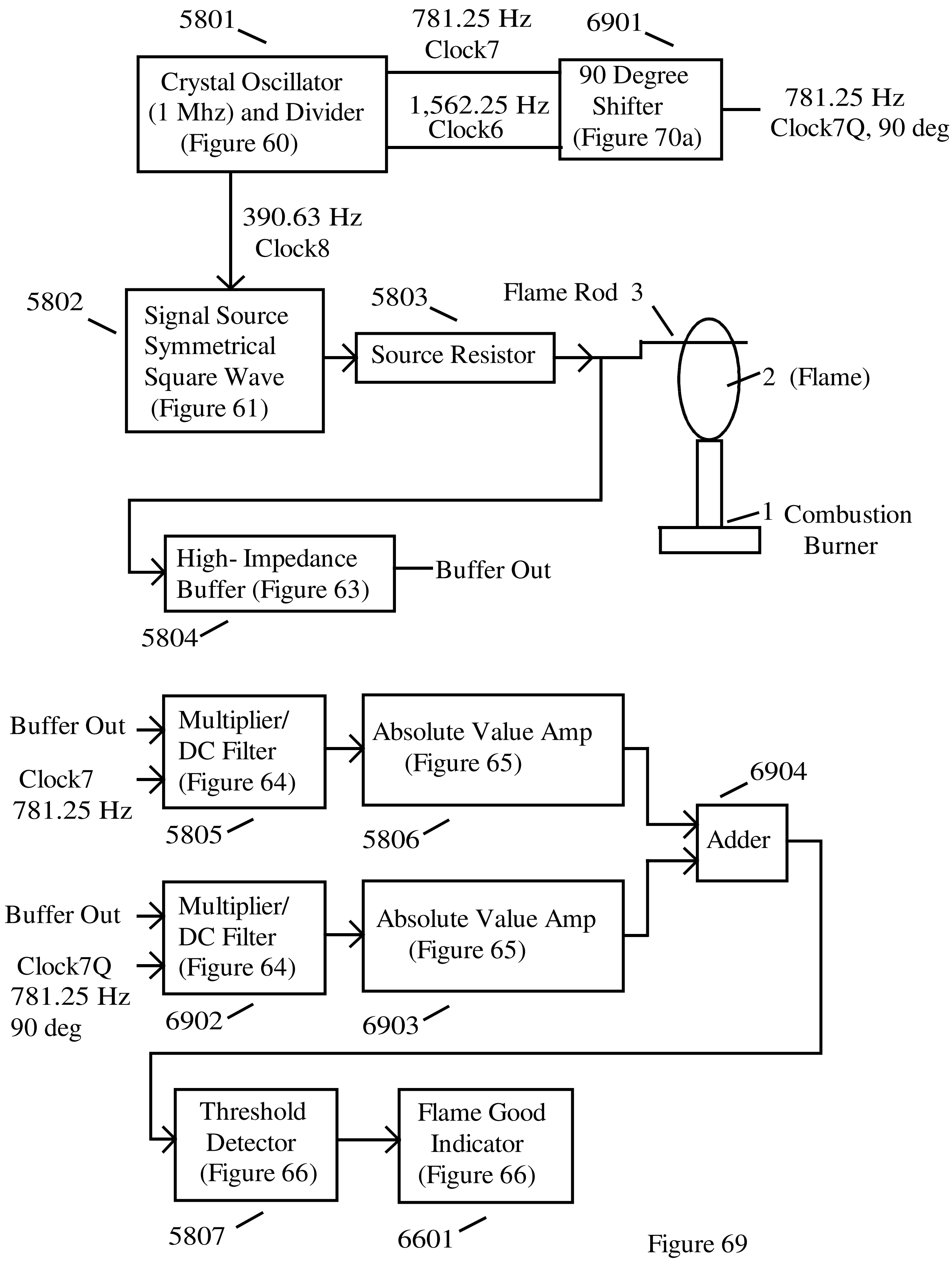
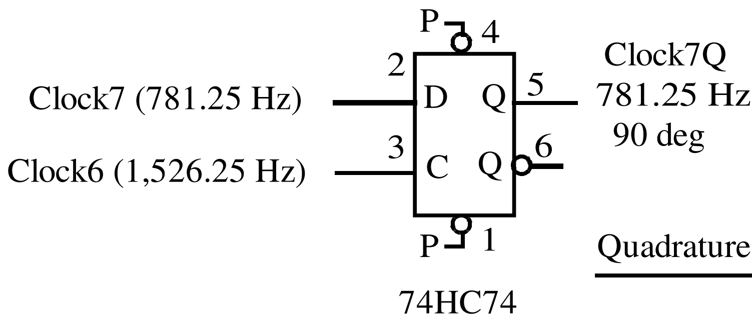

5801
781.25 Hz
Clock7
6901
Crystal Oscillator
(1 Mhz) and Divider
(Figure 60)
1,562.25 Hz
Clock6
90 Degree
Shifter
(Figure 70a)
781.25 Hz
Clock7Q, 90 deg
390.63 Hz
Clock8
5802
Signal Source
Symmetrical
Square Wave
(Figure 61)
5803
Source Resistor
Flame Rod 3
2 (Flame)
1 Combustion
Burner
High- Impedance
Buffer (Figure 63)
Buffer Out
5804
Buffer Out
Clock7
781.25 Hz
Multiplier/
DC Filter
(Figure 64)
5805
Absolute Value Amp
(Figure 65)
5806
6904
Adder
Buffer Out
Clock7Q
781.25 Hz
90 deg
Multiplier/
DC Filter
(Figure 64)
6902
Absolute Value Amp
(Figure 65)
6903
Threshold
Detector
(Figure 66)
5807
Flame Good
Indicator
(Figure 66)
6601

Figure 69



Quadrature Clock

Figure 70a

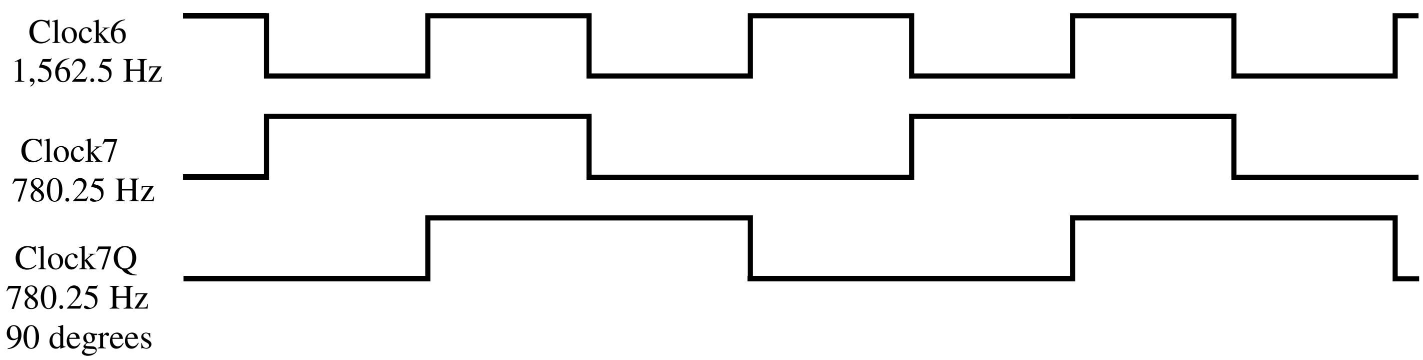


Figure 70b

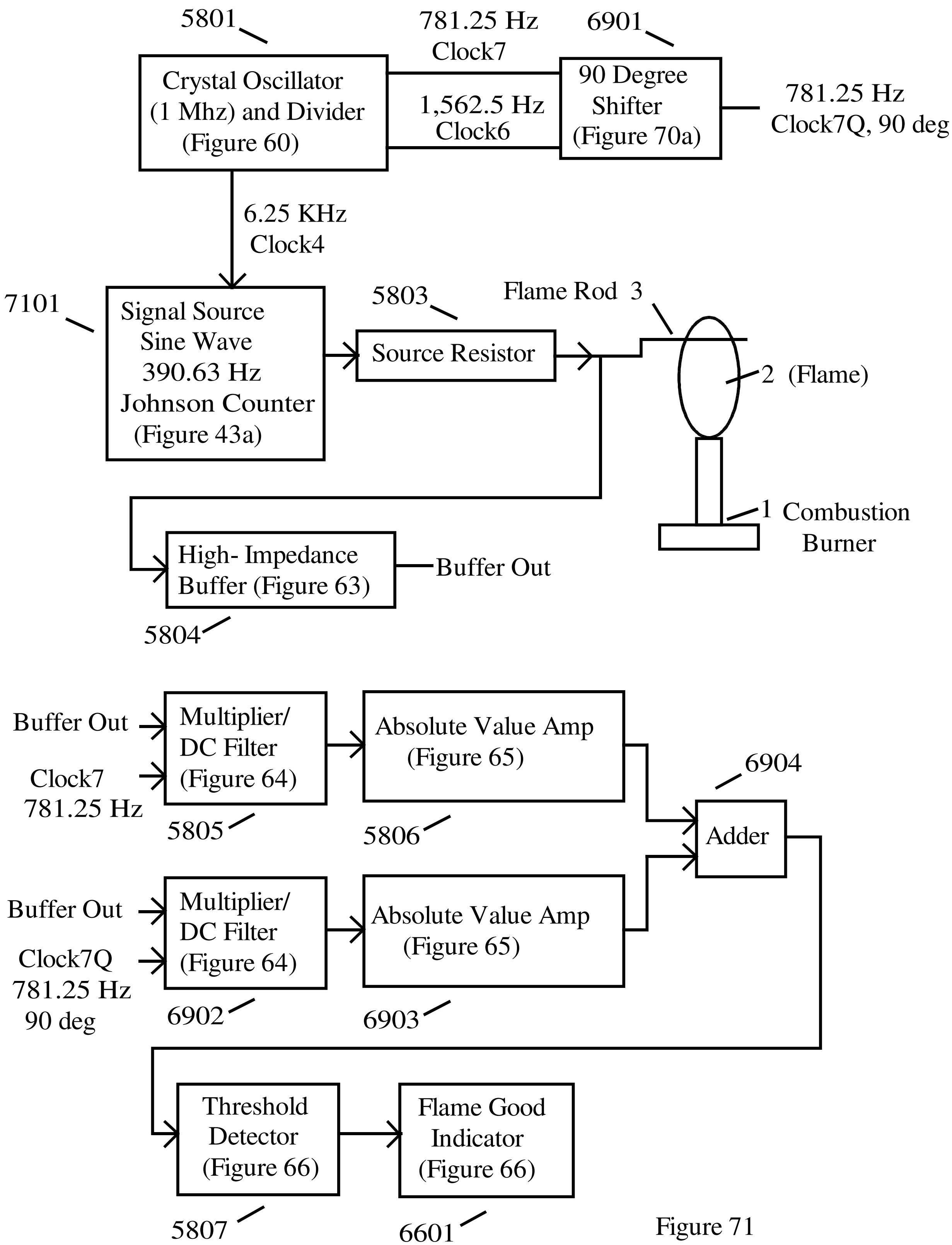
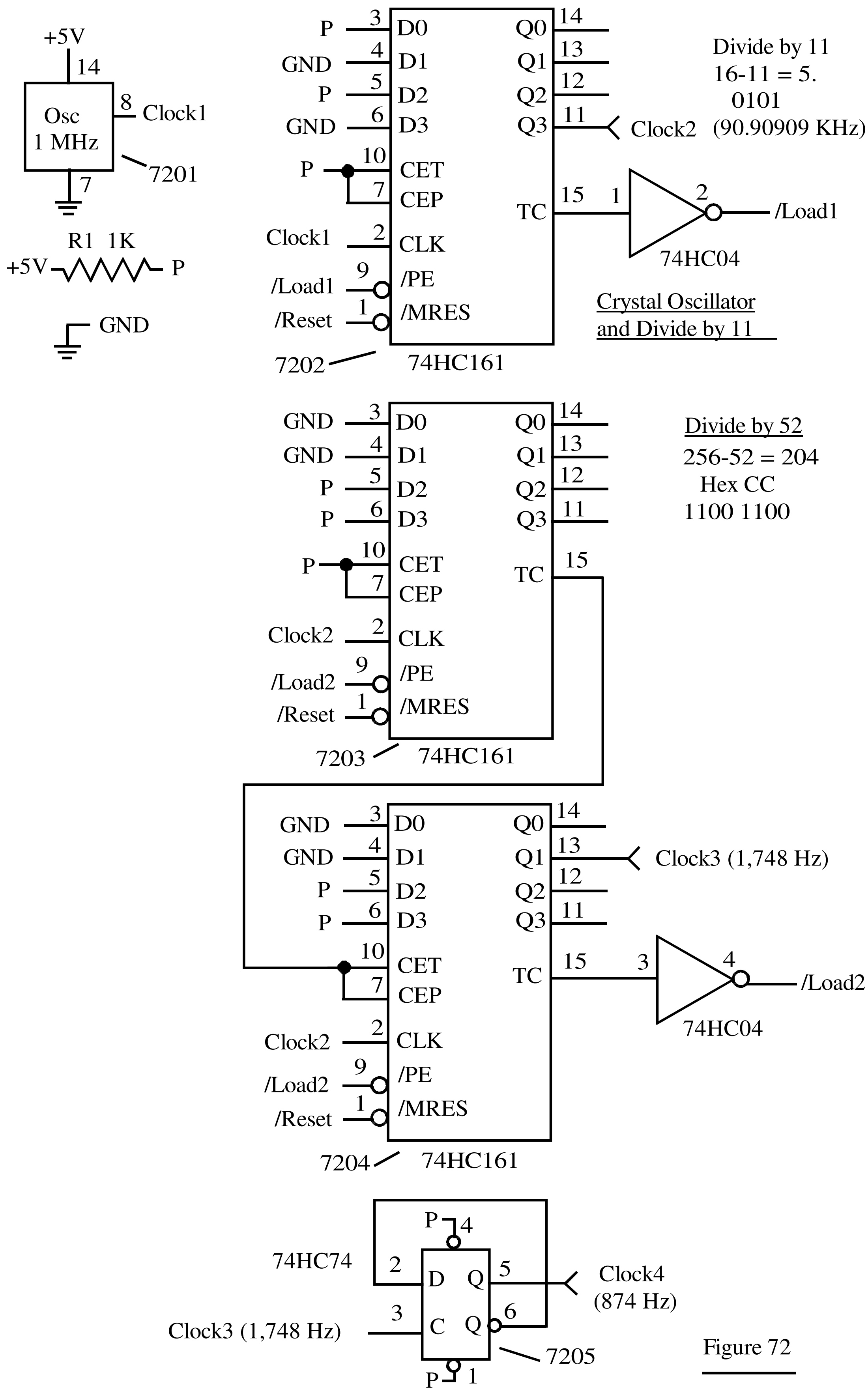

5801
781.25 Hz
Clock7
6901
Crystal Oscillator
(1 Mhz) and Divider
(Figure 60)
1,562.5 Hz
Clock6
90 Degree
Shifter
(Figure 70a)
781.25 Hz
Clock7Q, 90 deg
6.25 KHz
Clock4
7101
Signal Source
Sine Wave
390.63 Hz
Johnson Counter
(Figure 43a)
5803
Source Resistor
Flame Rod 3
2 (Flame)
1 Combustion
Burner
High- Impedance
Buffer (Figure 63)
Buffer Out
5804
Buffer Out
Clock7
781.25 Hz
Multiplier/
DC Filter
(Figure 64)
5805
Absolute Value Amp
(Figure 65)
5806
6904
Adder
Buffer Out
Clock7Q
781.25 Hz
90 deg
Multiplier/
DC Filter
(Figure 64)
6902
Absolute Value Amp
(Figure 65)
6903
Threshold
Detector
(Figure 66)
5807
Flame Good
Indicator
(Figure 66)
6601

Figure 71



+5V
14
Osc
1 MHz
8
Clock1
7
7201
R1 1K
+5V
P
GND
P
GND
P
GND
D0
D1
D2
D3
CET
CEP
CLK
/PE
/MRES
Q0
Q1
Q2
Q3
TC
Clock1
/Load1
/Reset
7202
74HC161
Clock2
Divide by 11
16-11 = 5.
0101
(90.90909 KHz)
/Load1
74HC04
Crystal Oscillator
and Divide by 11
Divide by 52
256-52 = 204
Hex CC
1100 1100
Clock2
/Load2
/Reset
7203
74HC161
Clock3 (1,748 Hz)
/Load2
74HC04
7204
74HC161
74HC74
D
Q
C
Clock4
(874 Hz)
Clock3 (1,748 Hz)
7205

Figure 72

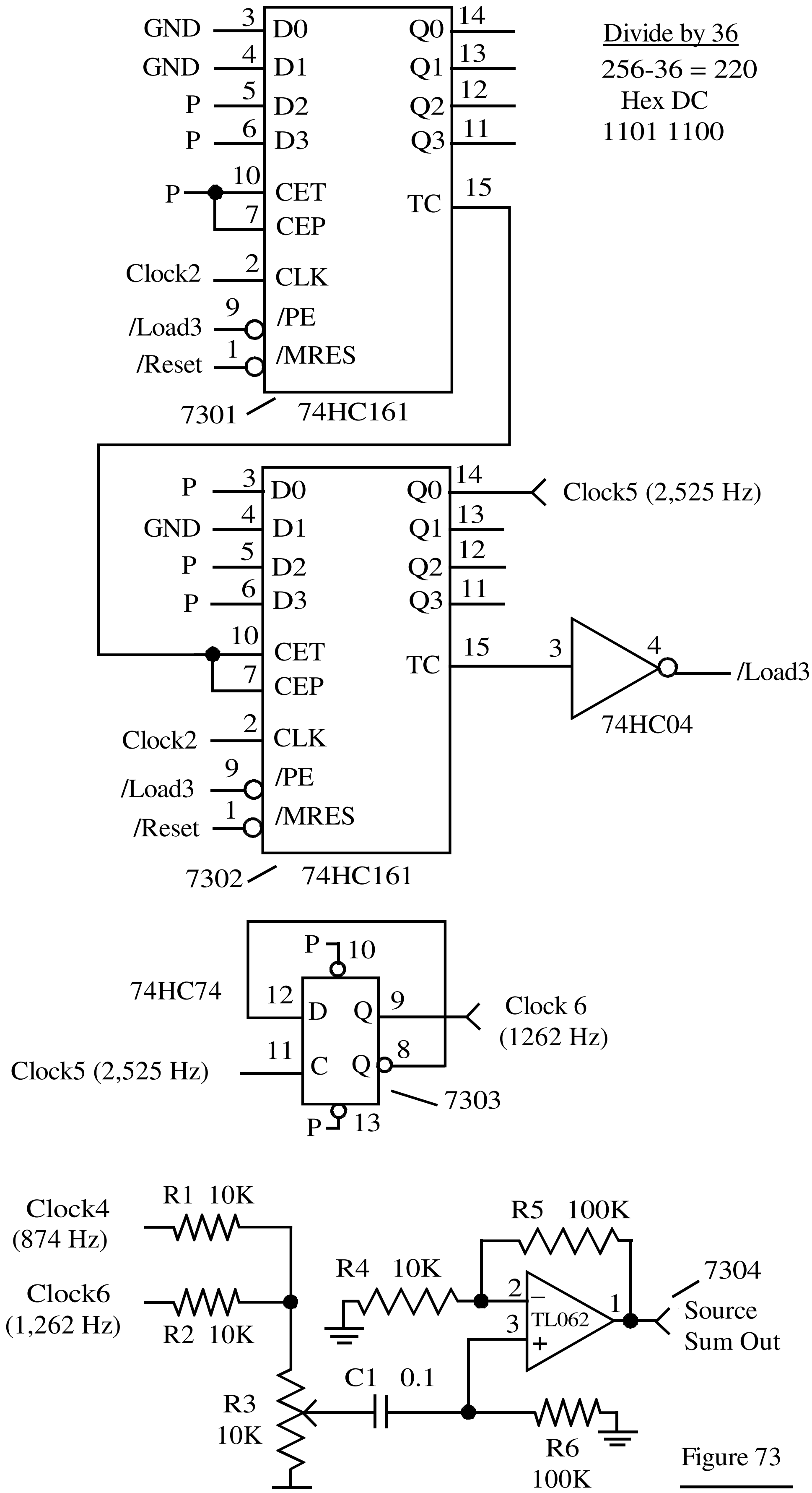

GND
GND
P
P
P
Clock2
/Load3
/Reset
D0
D1
D2
D3
CET
CEP
CLK
/PE
/MRES
Q0
Q1
Q2
Q3
TC
7301
74HC161
Divide by 36
256-36 = 220
Hex DC
1101 1100
Clock5 (2,525 Hz)
74HC04
/Load3
7302
74HC161
74HC74
D
Q
C
Q
Clock 6
(1262 Hz)
Clock5 (2,525 Hz)
7303
Clock4
(874 Hz)
R1 10K
Clock6
(1,262 Hz)
R2 10K
R3
10K
C1 0.1
R4 10K
R5 100K
TL062
R6
100K
7304
Source
Sum Out

Figure 73

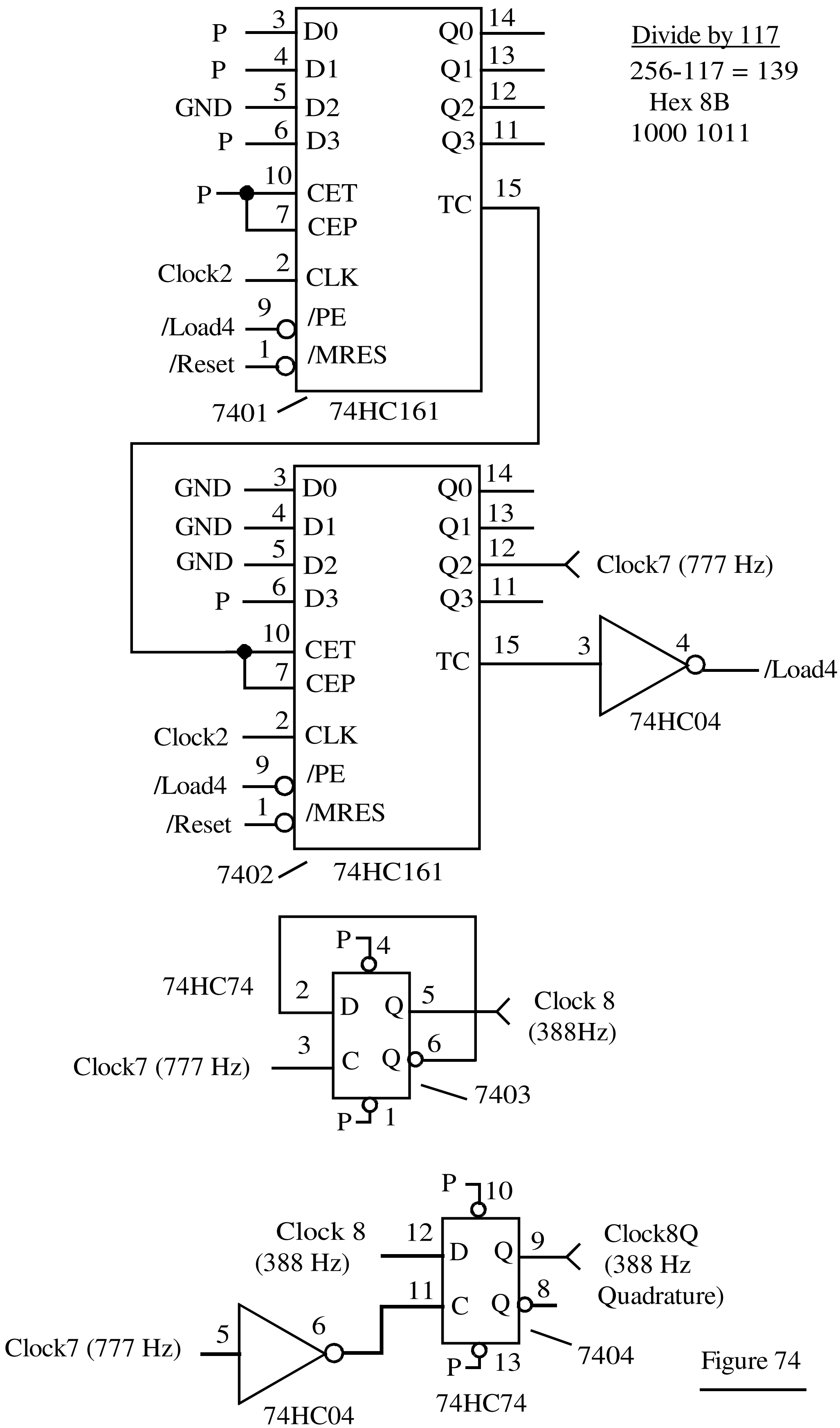

Divide by 117
256-117 = 139
Hex 8B
1000 1011
P
P
GND
P
P
Clock2
/Load4
/Reset
D0
D1
D2
D3
CET
CEP
CLK
/PE
/MRES
Q0
Q1
Q2
Q3
TC
7401
74HC161
GND
GND
GND
P
Clock2
/Load4
/Reset
7402
74HC161
Clock7 (777 Hz)
/Load4
74HC04
74HC74
Clock 8
(388Hz)
Clock7 (777 Hz)
7403
Clock 8
(388 Hz)
Clock8Q
(388 Hz
Quadrature)
Clock7 (777 Hz)
74HC04
74HC74
7404

Figure 74

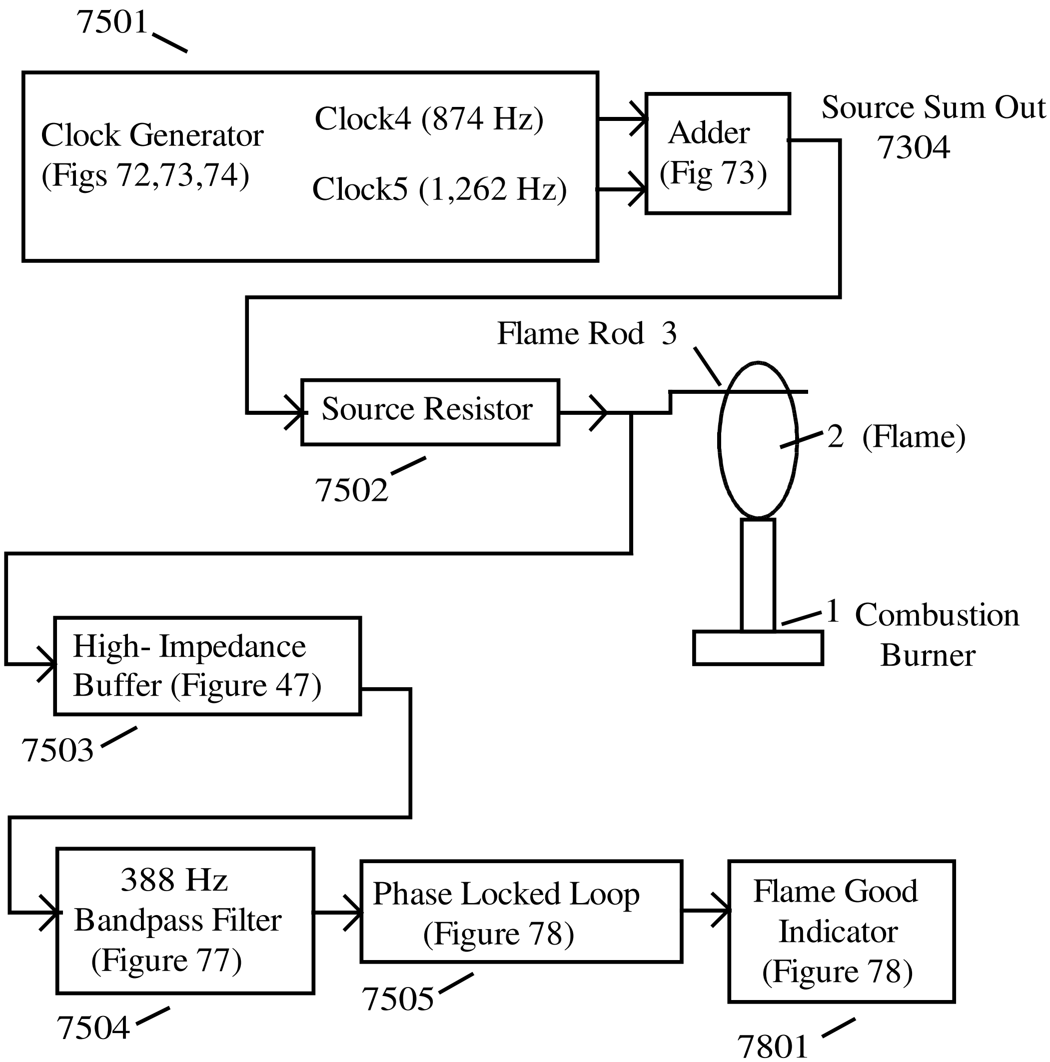

7501
Clock Generator
(Figs 72,73,74)
Clock4 (874 Hz)
Clock5 (1,262 Hz)
Adder
(Fig 73)
Source Sum Out
7304
Flame Rod 3
Source Resistor
7502
2 (Flame)
1 Combustion
Burner
High- Impedance
Buffer (Figure 47)
7503
388 Hz
Bandpass Filter
(Figure 77)
7504
Phase Locked Loop
(Figure 78)
7505
Flame Good
Indicator
(Figure 78)
7801

Figure 75

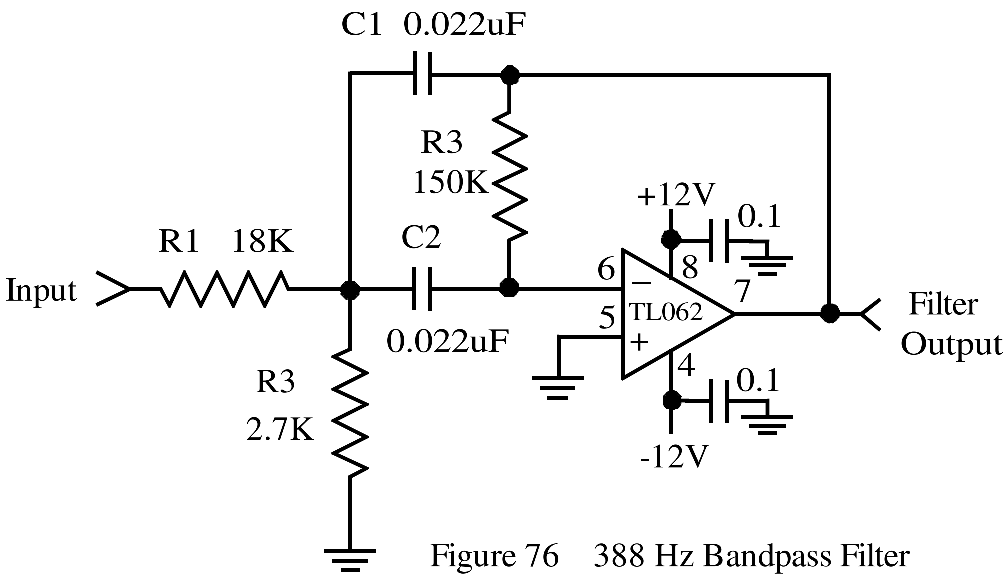


Figure 76 388 Hz Bandpass Filter

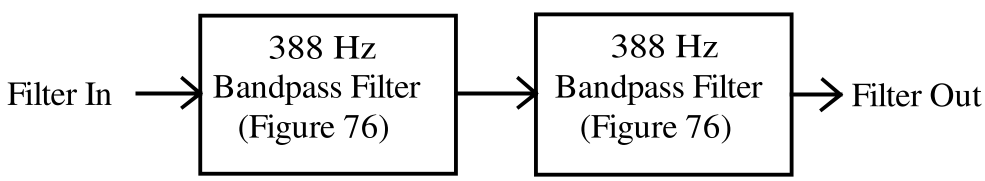


Figure 77 Two Cascaded Bandpass Filters

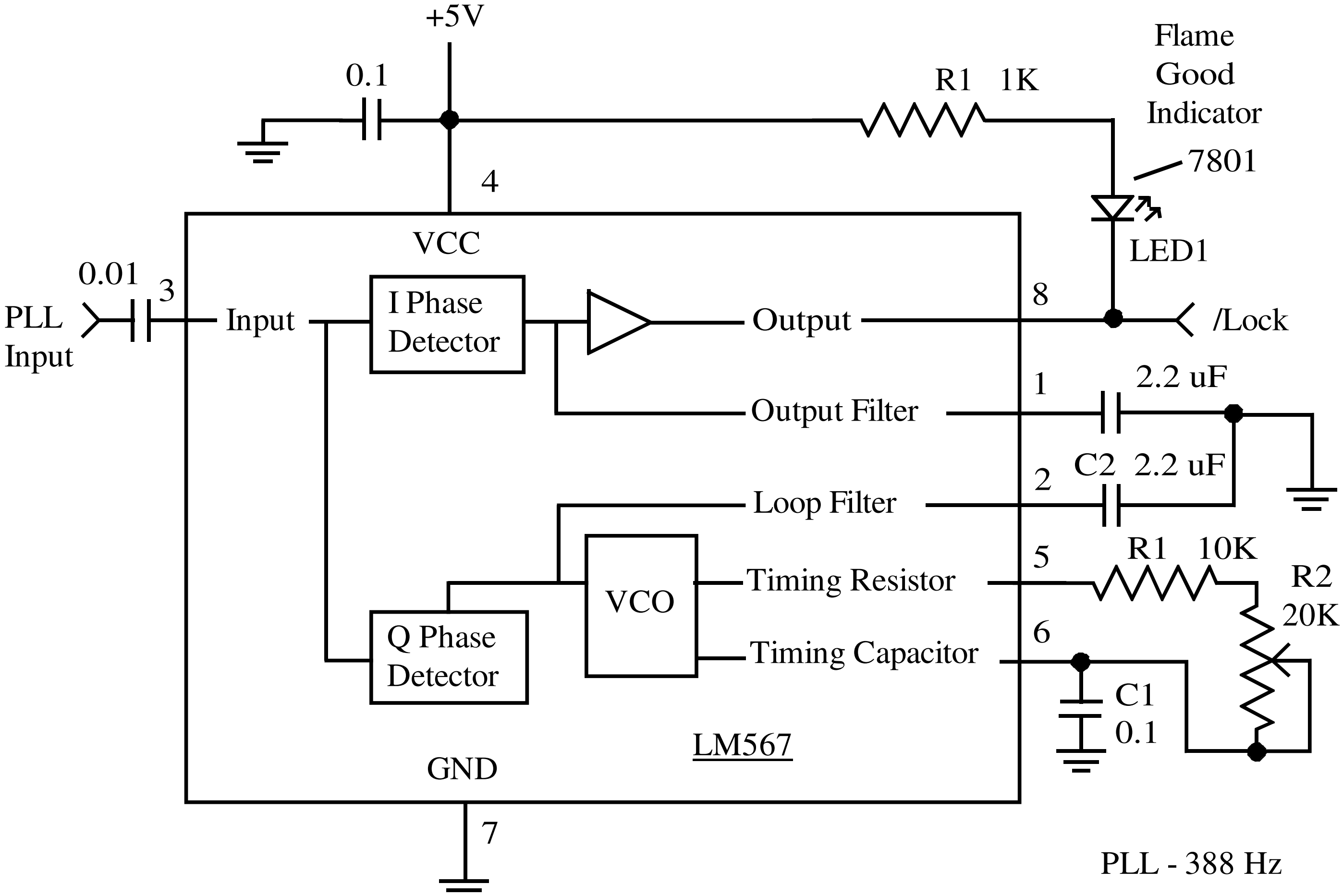

+5V
0.1
R1 1K
Flame
Good
Indicator
7801
LED1
4
VCC
0.01
3
PLL
Input
Input
I Phase
Detector
Output
8
/Lock
Output Filter
1
2.2 uF
Loop Filter
2
C2 2.2 uF
VCO
Timing Resistor
5
R1 10K
R2
20K
Q Phase
Detector
Timing Capacitor
6
C1
0.1
LM567
GND
7
PLL - 388 Hz

Figure 78

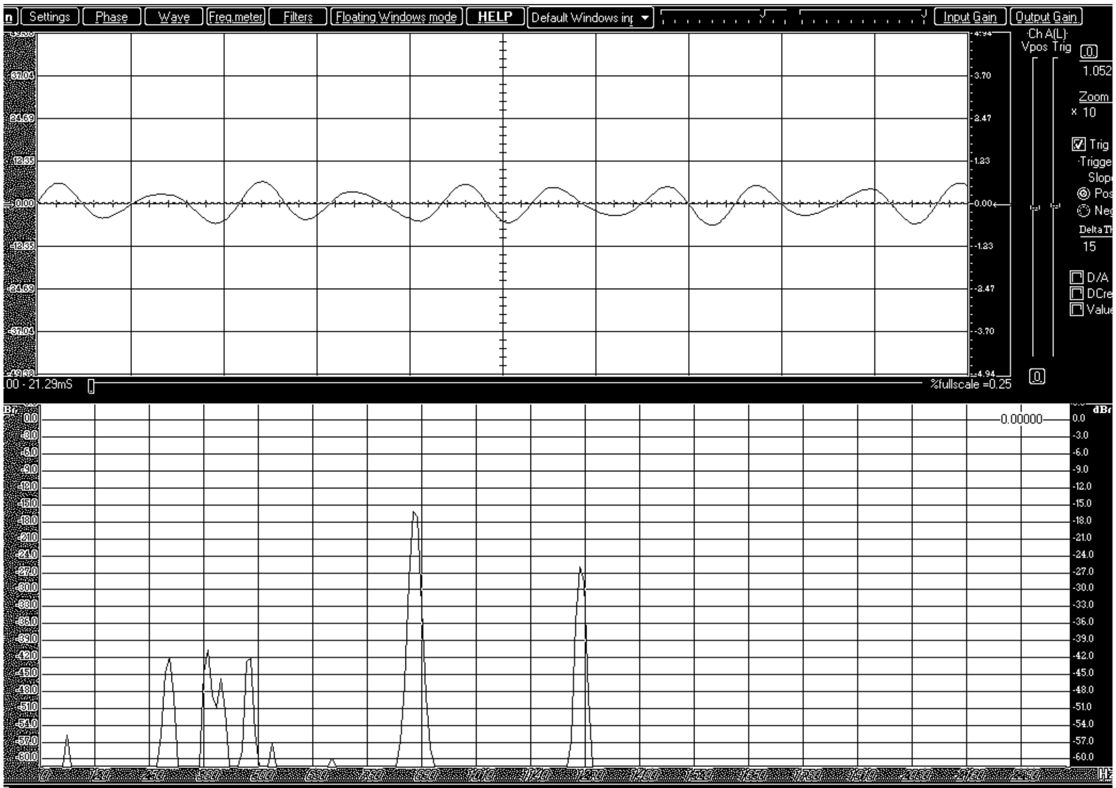


Figure 79a – Heterodyne Test – PLL Detector – Flame Off

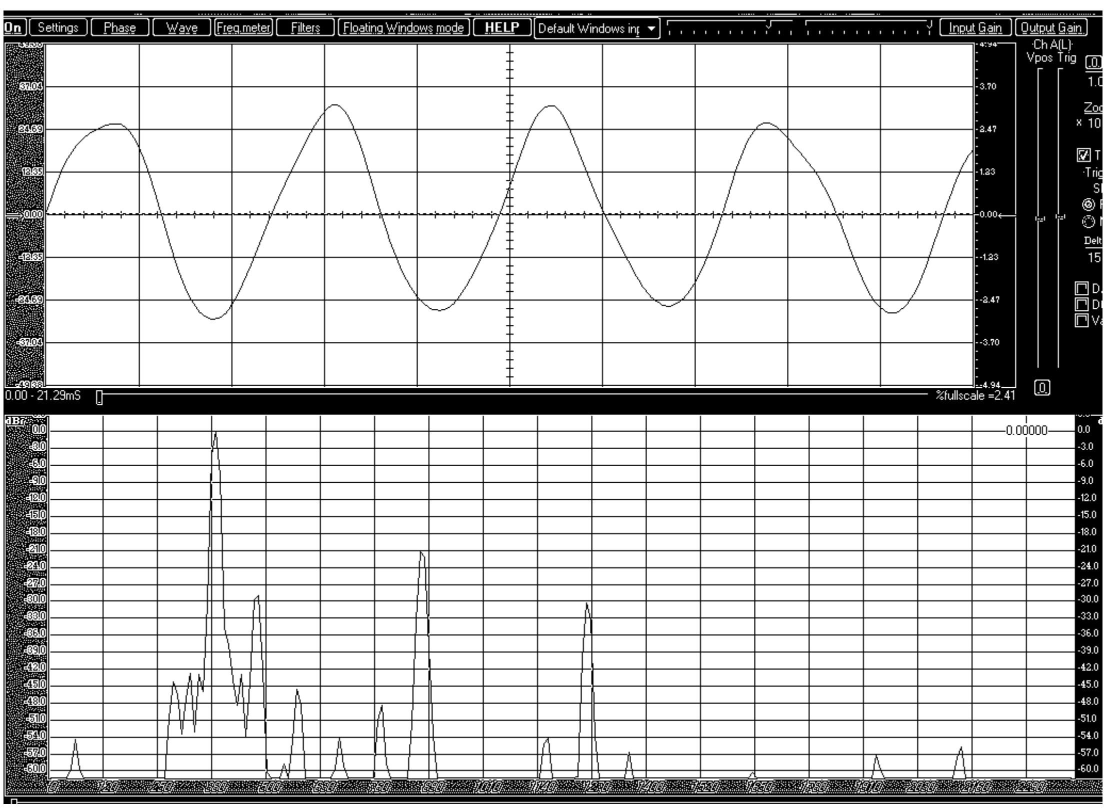


Figure 79b – Heterodyne Test – PLL Detector – Flame On

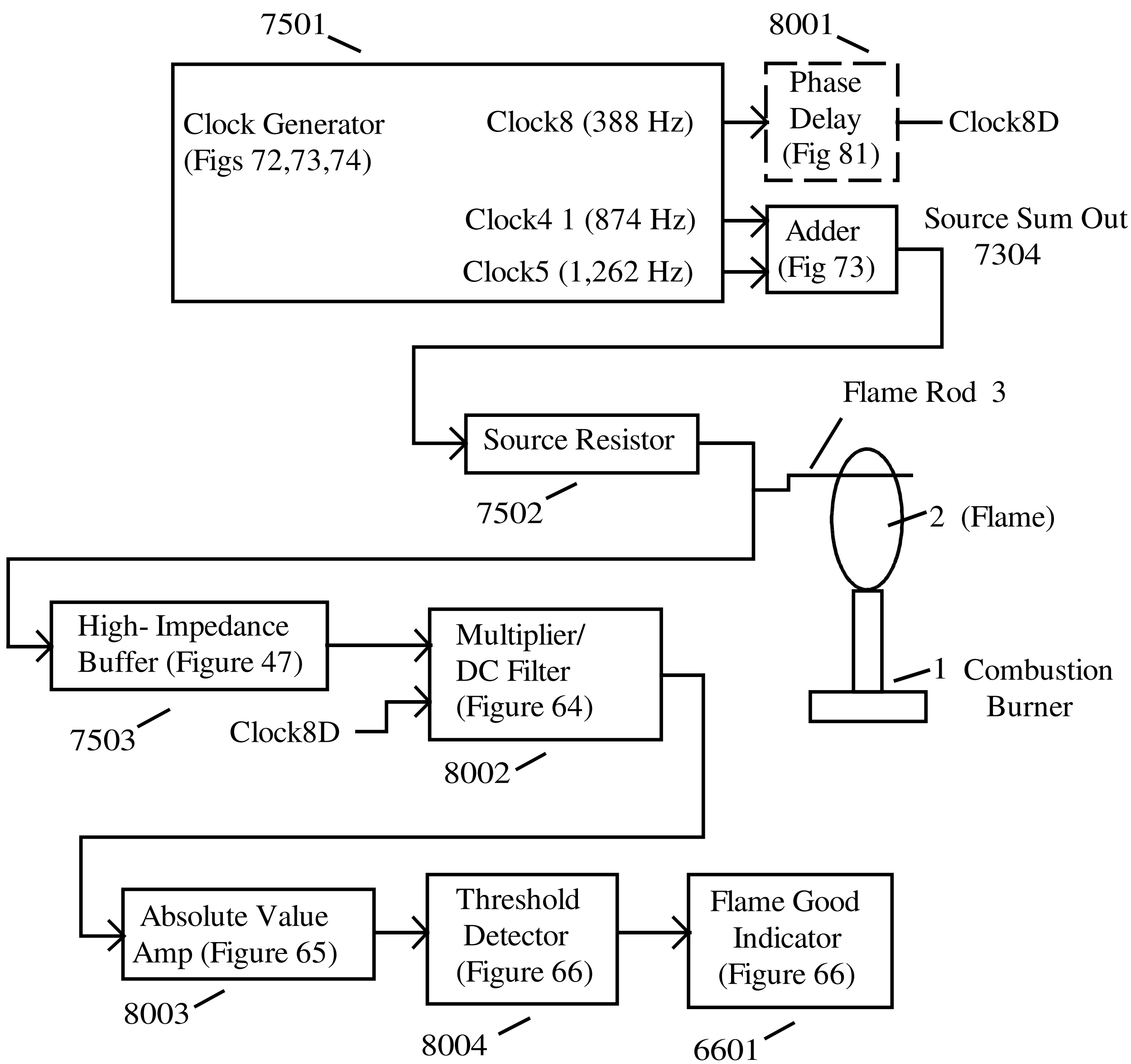


Figure 80

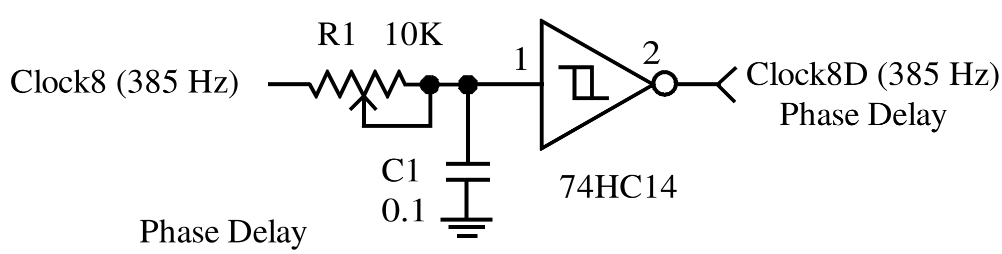


Figure 81

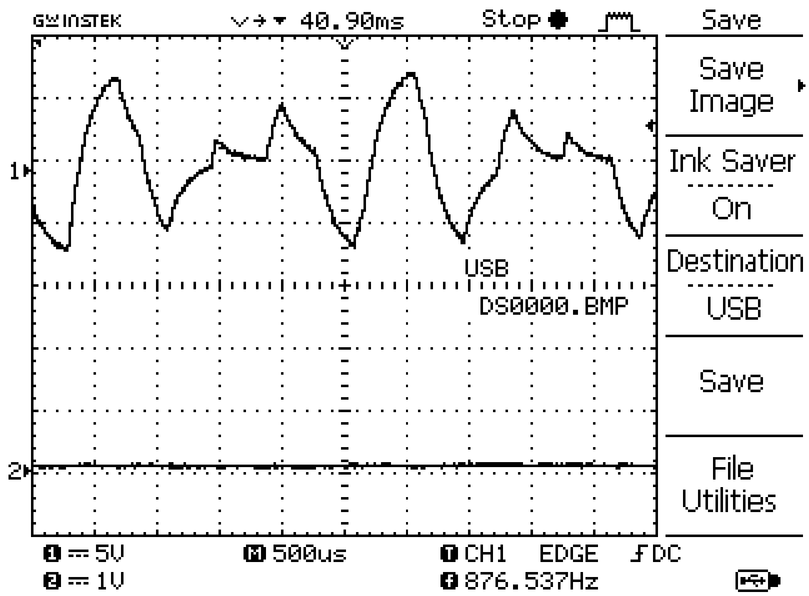


Figure 82a – Heterodyne Test – Simple Synchronous Detector – Flame Off

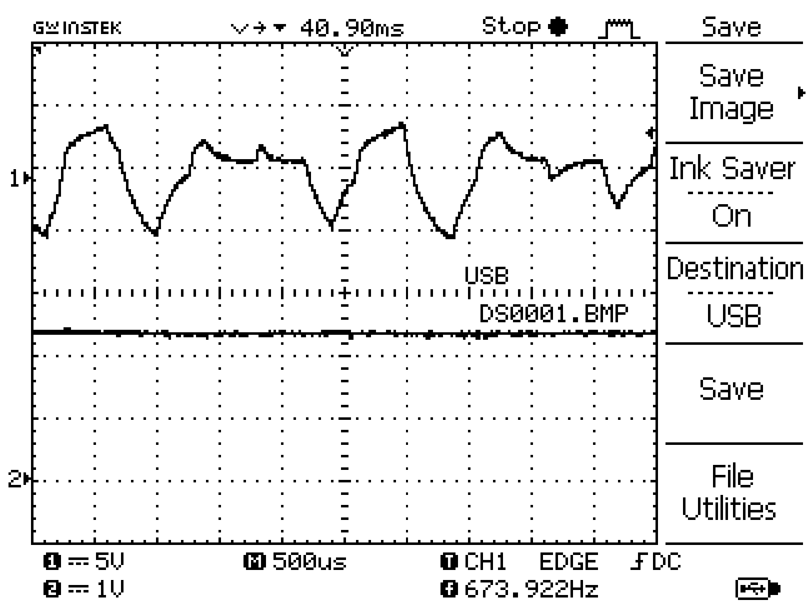
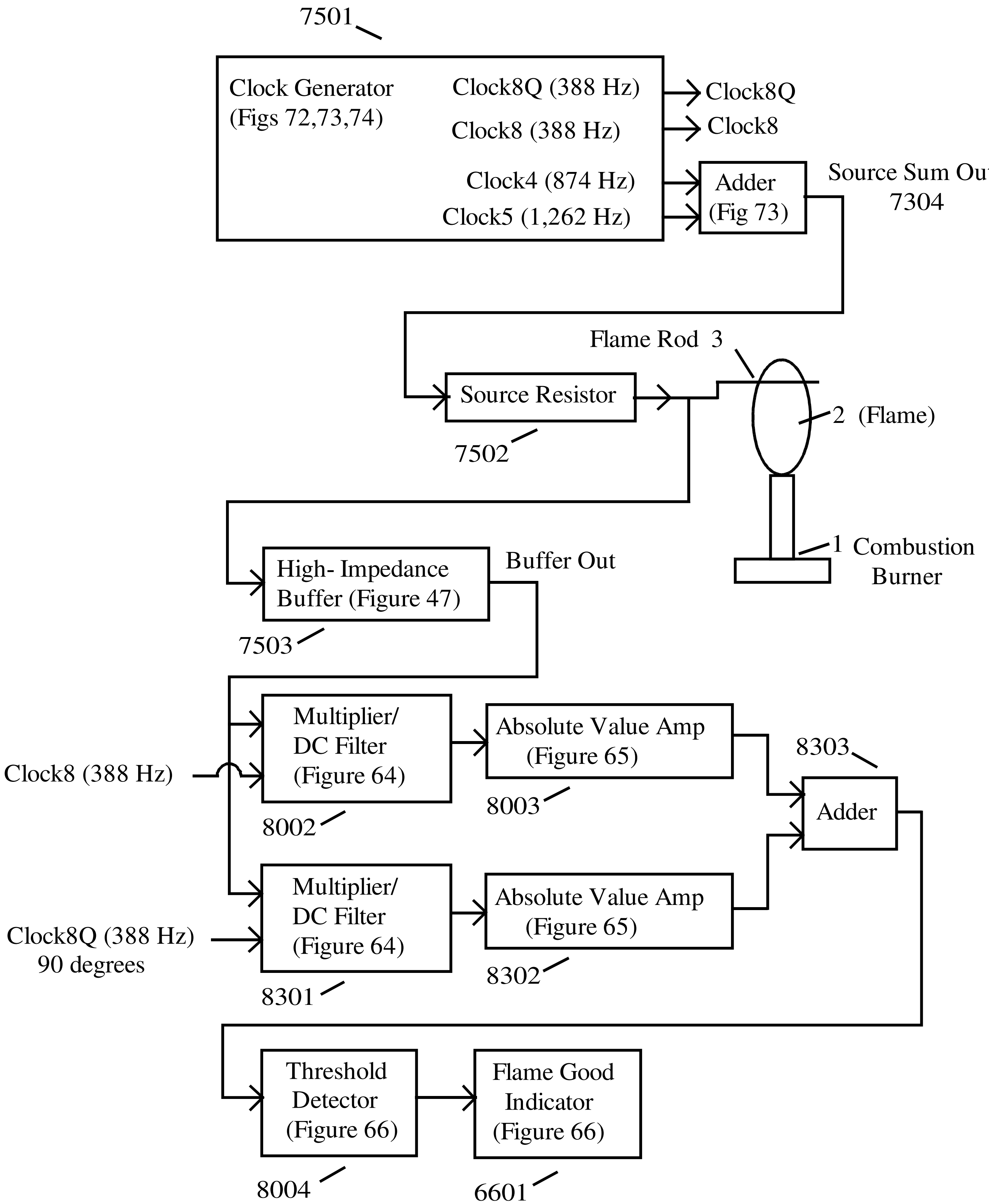


Figure 82b – Heterodyne Test – Simple Synchronous Detector – Flame On



7501
Clock Generator
(Figs 72,73,74)
Clock8Q (388 Hz)
Clock8 (388 Hz)
Clock4 (874 Hz)
Clock5 (1,262 Hz)
Clock8Q
Clock8
Adder
(Fig 73)
Source Sum Out
7304
Flame Rod 3
Source Resistor
7502
2 (Flame)
1 Combustion
Burner
High- Impedance
Buffer (Figure 47)
Buffer Out
7503
Multiplier/
DC Filter
(Figure 64)
Clock8 (388 Hz)
8002
Absolute Value Amp
(Figure 65)
8003
8303
Adder
Multiplier/
DC Filter
(Figure 64)
Clock8Q (388 Hz)
90 degrees
8301
Absolute Value Amp
(Figure 65)
8302
Threshold
Detector
(Figure 66)
8004
Flame Good
Indicator
(Figure 66)
6601

Figure 83

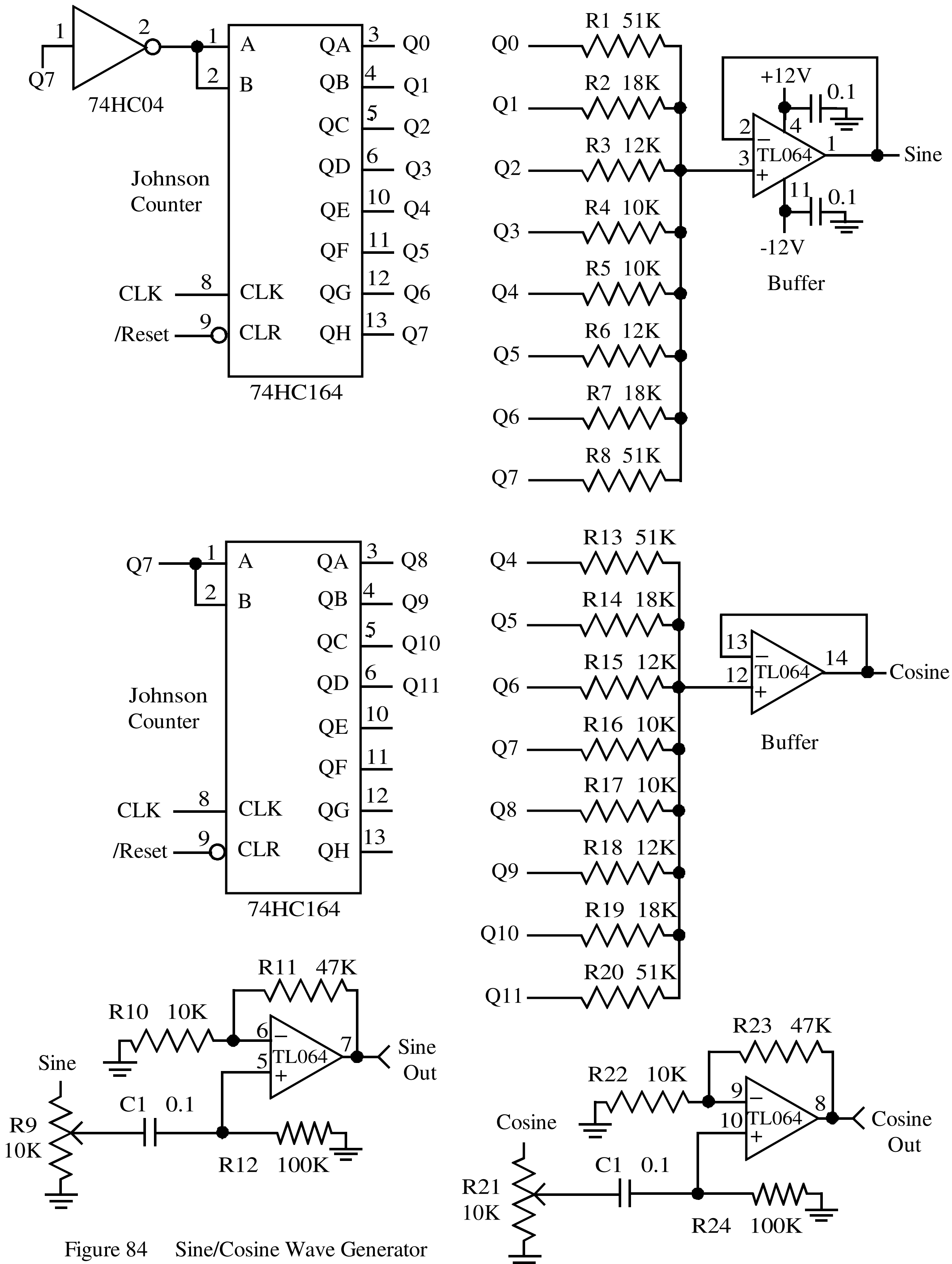


Figure 84 Sine/Cosine Wave Generator

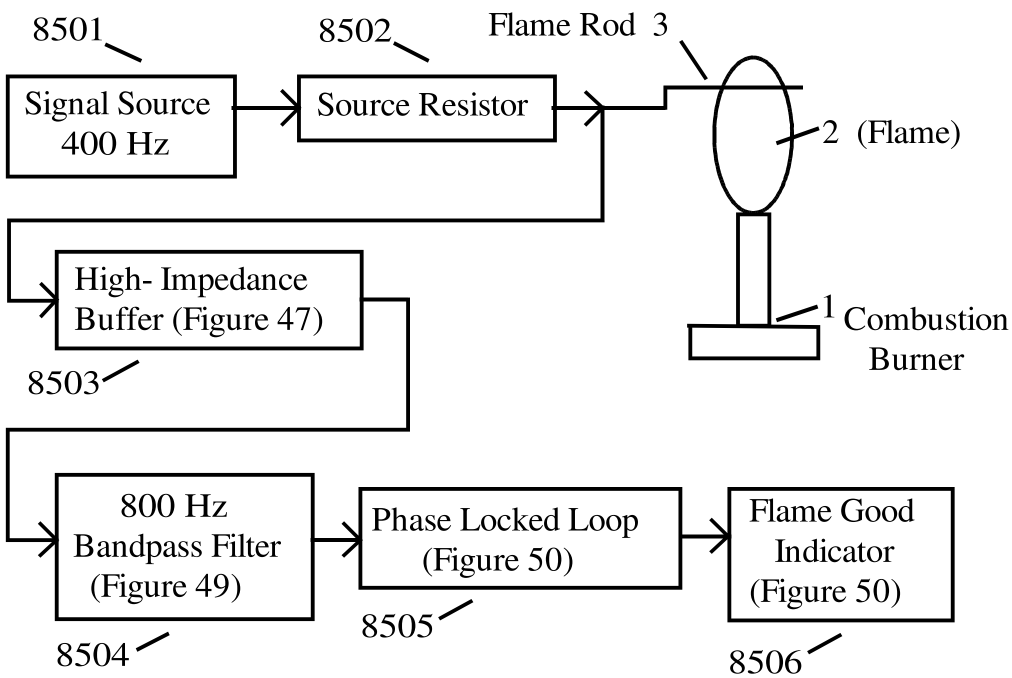

8501
Signal Source
400 Hz
8502
Source Resistor
Flame Rod 3
2 (Flame)
High- Impedance
Buffer (Figure 47)
8503
1 Combustion
Burner
800 Hz
Bandpass Filter
(Figure 49)
8504
Phase Locked Loop
(Figure 50)
8505
Flame Good
Indicator
(Figure 50)
8506

Figure 85

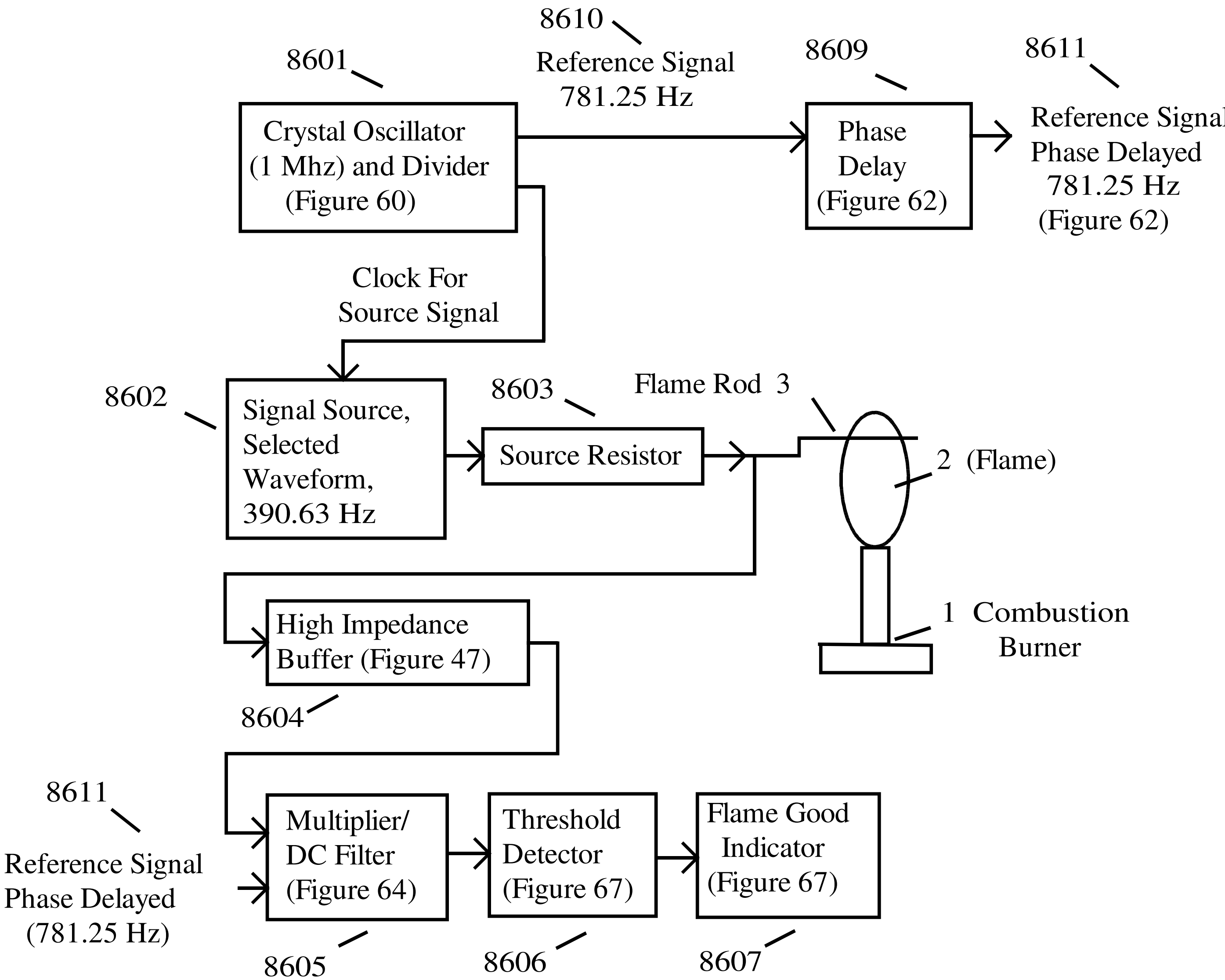
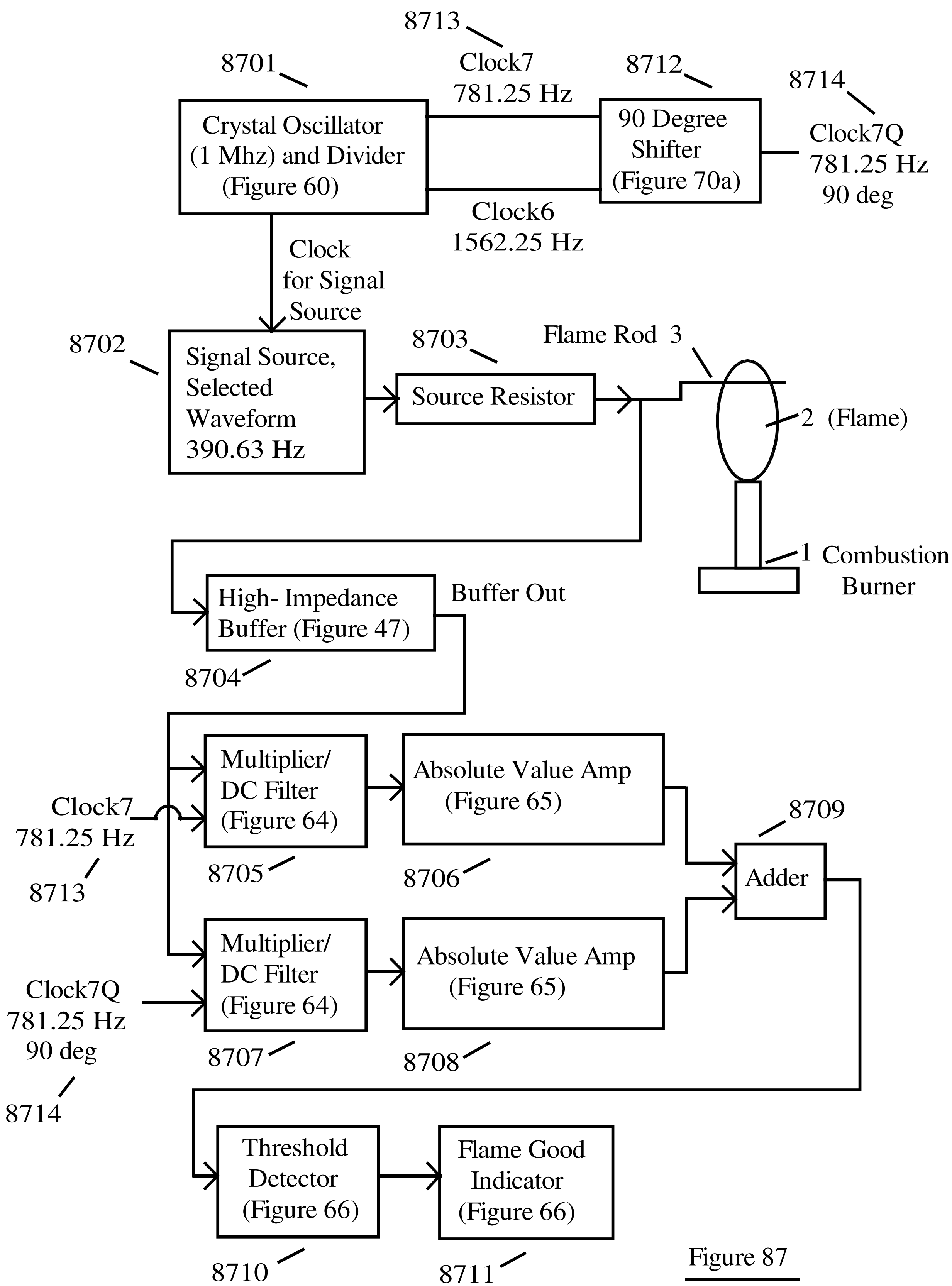

8610
Reference Signal
781.25 Hz
8601
Crystal Oscillator
(1 Mhz) and Divider
(Figure 60)
8609
Phase
Delay
(Figure 62)
8611
Reference Signal
Phase Delayed
781.25 Hz
(Figure 62)
Clock For
Source Signal
8602
Signal Source,
Selected
Waveform,
390.63 Hz
8603
Source Resistor
Flame Rod 3
2 (Flame)
1 Combustion
Burner
High Impedance
Buffer (Figure 47)
8604
8611
Reference Signal
Phase Delayed
(781.25 Hz)
Multiplier/
DC Filter
(Figure 64)
Threshold
Detector
(Figure 67)
Flame Good
Indicator
(Figure 67)
8605
8606
8607

Figure 86



8713
Clock7
781.25 Hz
8701
8712
8714
Crystal Oscillator
(1 Mhz) and Divider
(Figure 60)
90 Degree
Shifter
(Figure 70a)
Clock7Q
781.25 Hz
90 deg
Clock6
1562.25 Hz
Clock
for Signal
Source
8702
Signal Source,
Selected
Waveform
390.63 Hz
8703
Source Resistor
Flame Rod 3
2 (Flame)
1 Combustion
Burner
High- Impedance
Buffer (Figure 47)
Buffer Out
8704
Multiplier/
DC Filter
(Figure 64)
Absolute Value Amp
(Figure 65)
Clock7
781.25 Hz
8713
8705
8706
8709
Adder
Multiplier/
DC Filter
(Figure 64)
Absolute Value Amp
(Figure 65)
Clock7Q
781.25 Hz
90 deg
8714
8707
8708
Threshold
Detector
(Figure 66)
Flame Good
Indicator
(Figure 66)
8710
8711

Figure 87

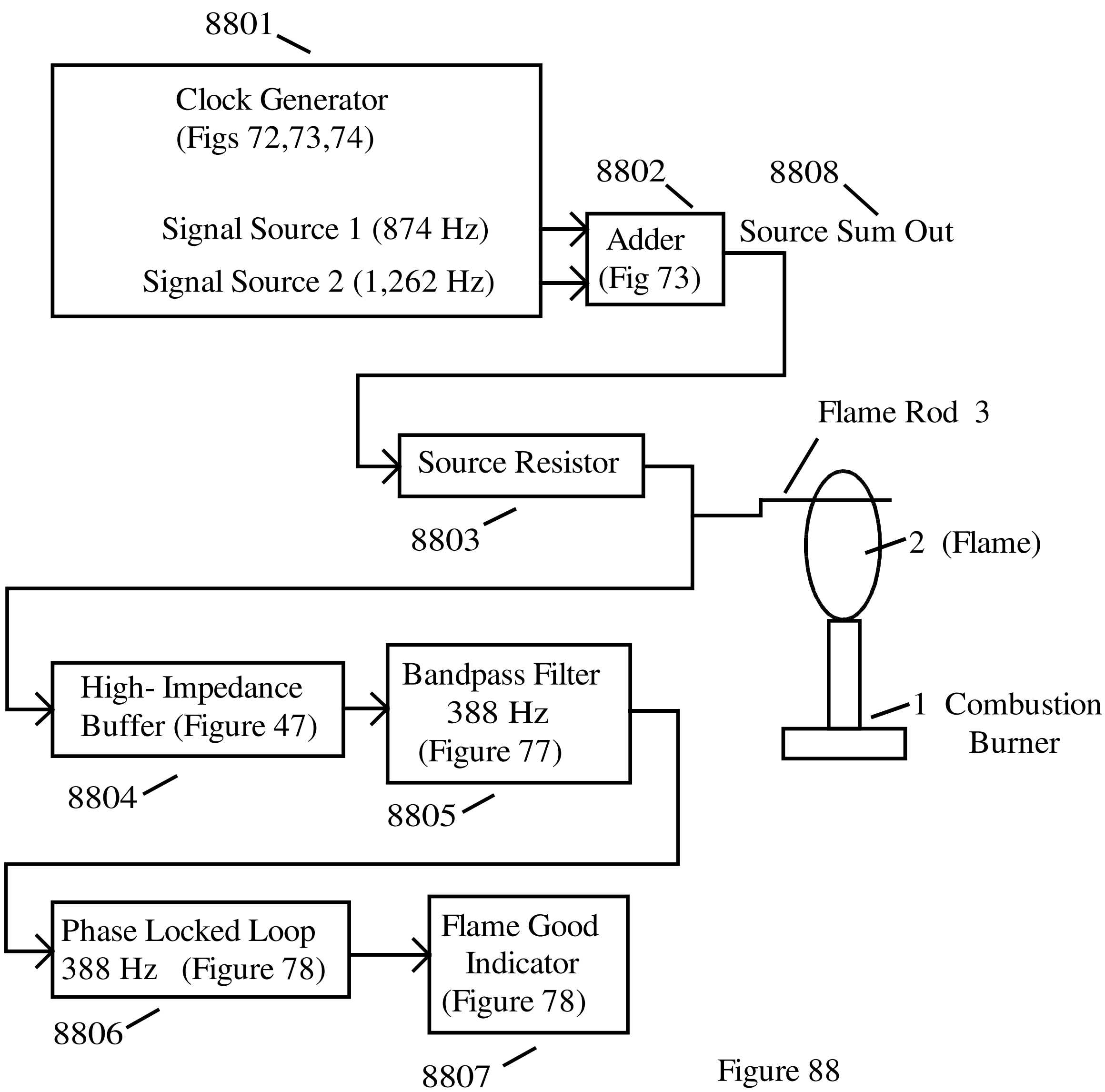

8801
Clock Generator
(Figs 72,73,74)
Signal Source 1 (874 Hz)
Signal Source 2 (1,262 Hz)
8802
Adder
(Fig 73)
8808
Source Sum Out
Source Resistor
8803
Flame Rod 3
2 (Flame)
1 Combustion
Burner
High- Impedance
Buffer (Figure 47)
8804
Bandpass Filter
388 Hz
(Figure 77)
8805
Phase Locked Loop
388 Hz (Figure 78)
8806
Flame Good
Indicator
(Figure 78)
8807

Figure 88

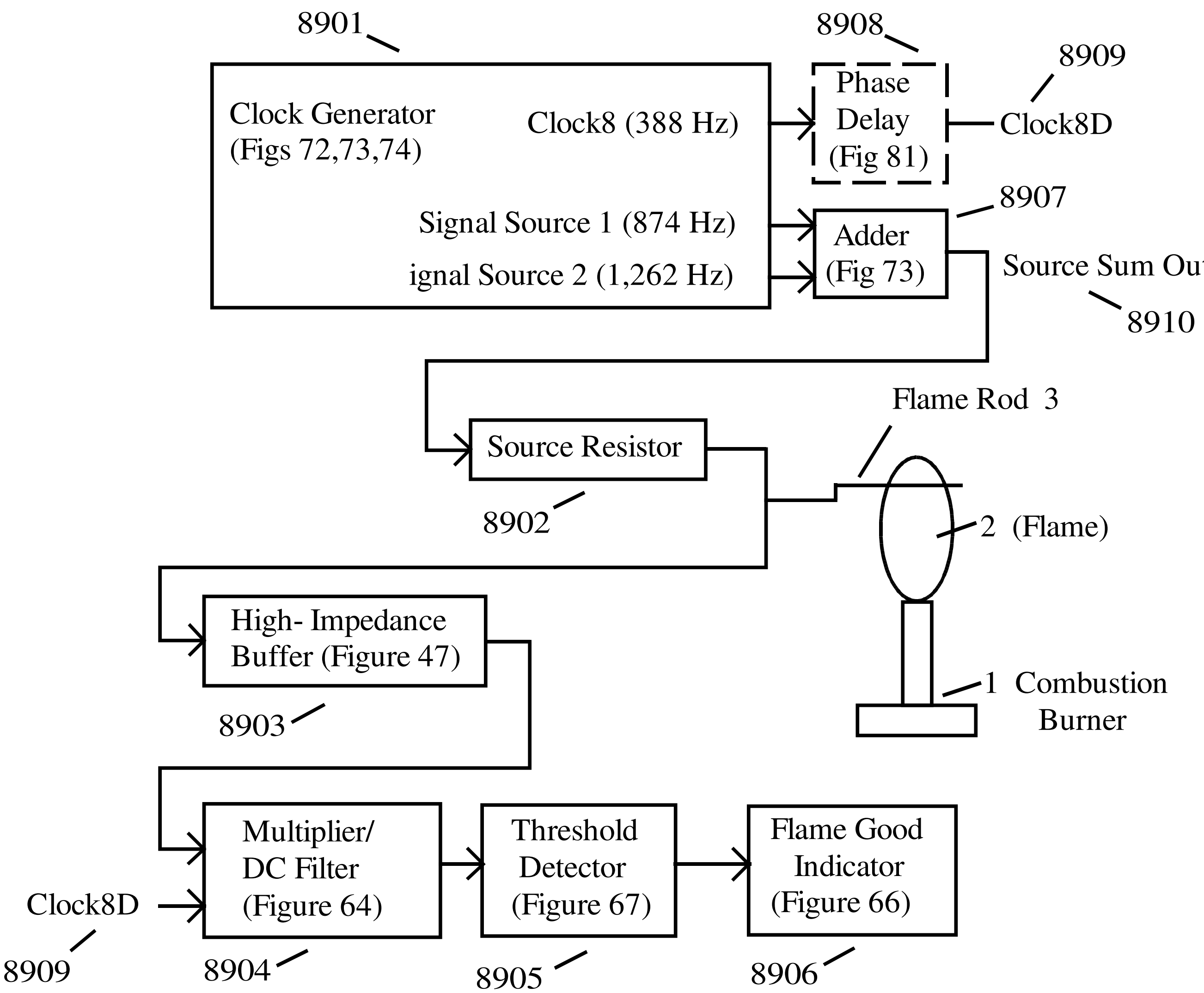

8901
Clock Generator
(Figs 72,73,74)
Clock8 (388 Hz)
Signal Source 1 (874 Hz)
ignal Source 2 (1,262 Hz)
8908
Phase
Delay
(Fig 81)
8909
Clock8D
8907
Adder
(Fig 73)
Source Sum Out
8910
Flame Rod 3
Source Resistor
8902
2 (Flame)
High- Impedance
Buffer (Figure 47)
8903
1 Combustion
Burner
Multiplier/
DC Filter
(Figure 64)
Threshold
Detector
(Figure 67)
Flame Good
Indicator
(Figure 66)
Clock8D
8909
8904
8905
8906

Figure 89

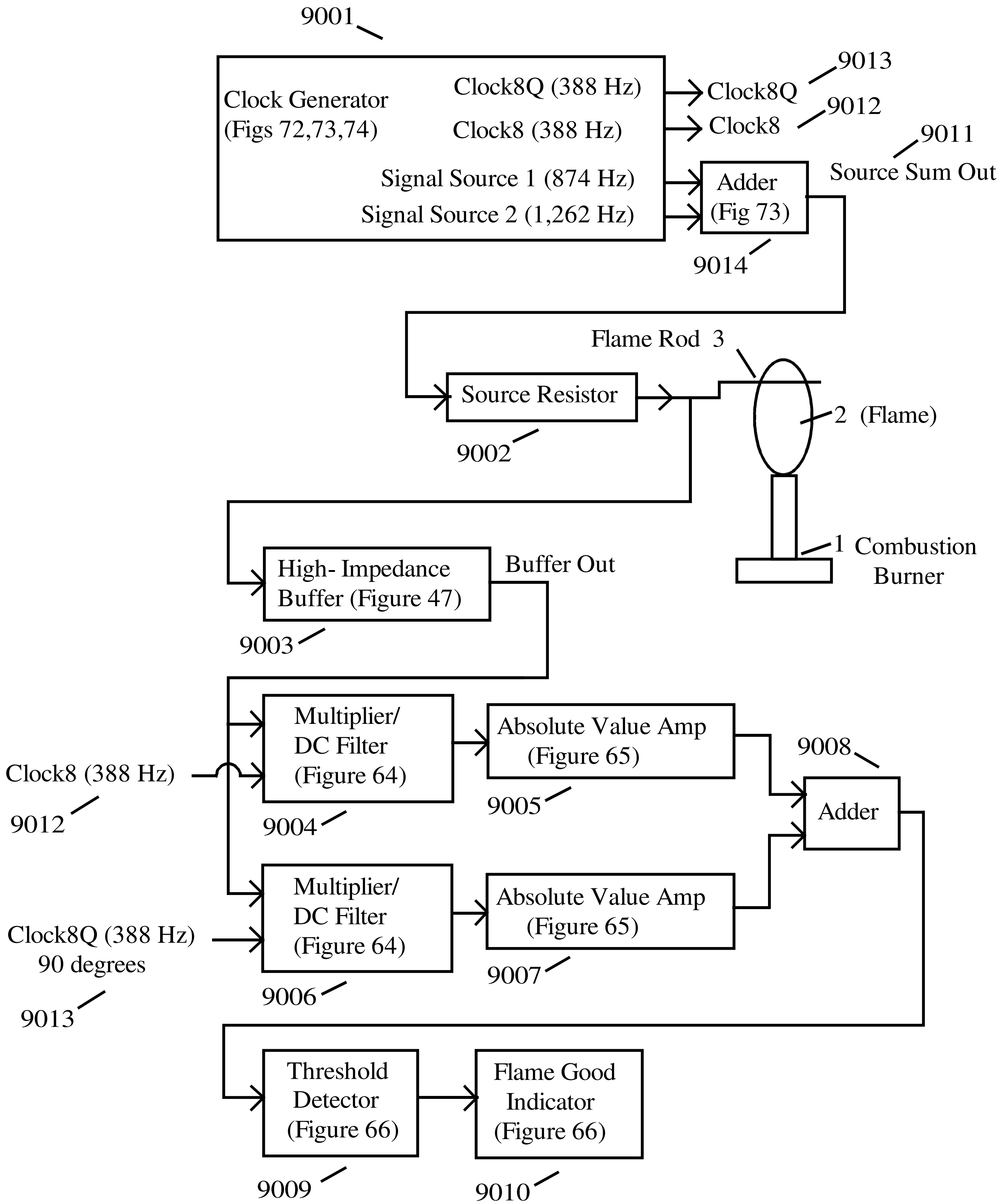

9001
Clock Generator
(Figs 72,73,74)
Clock8Q (388 Hz)
Clock8 (388 Hz)
Signal Source 1 (874 Hz)
Signal Source 2 (1,262 Hz)
Clock8Q
9013
Clock8
9012
9011
Source Sum Out
Adder
(Fig 73)
9014
Flame Rod 3
Source Resistor
9002
2 (Flame)
1 Combustion
Burner
High- Impedance
Buffer (Figure 47)
Buffer Out
9003
Multiplier/
DC Filter
(Figure 64)
Absolute Value Amp
(Figure 65)
9008
Clock8 (388 Hz)
9012
9004
9005
Adder
Multiplier/
DC Filter
(Figure 64)
Absolute Value Amp
(Figure 65)
Clock8Q (388 Hz)
90 degrees
9006
9007
9013
Threshold
Detector
(Figure 66)
Flame Good
Indicator
(Figure 66)
9009
9010

Figure 90