UNIVERSITY OF ILLINOIS AT URBANA CHAMPAIGN

FLANGE PEDAL FINAL PROJECT

PHYSICS 398 EMI

BY

ARIC HERMANN

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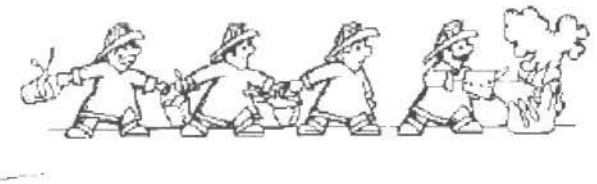
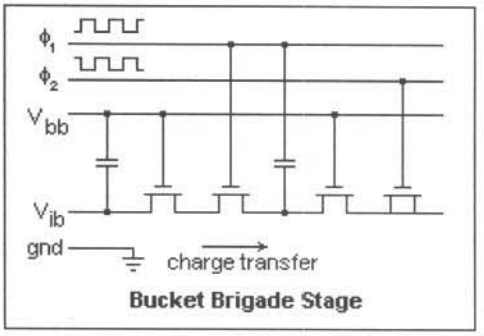
Opening: For my project I decided to build a flange pedal for guitar. The pedal is designed to produce sounds for flanging, reverb, and echo/delay. The pedal has three variable controls and two switches to control the sound it produces. By looking at the schematic, one can follow the electrical signal through the pedal.

Background: The term flange, reverb, and echo are often misunderstood. Flange was initially created from early electronic music involving reel to reel analog tape. Analog tape is stored on a reel that had a center, which the tape was wrapped around, and the two sides or flanges that kept the tape lined up. Early electronic music composers found an interesting technique that they called flanging. When they started two identical tapes at the same time, the amplitudes would add together to double volume; however, by placing their finger on the flange of one of the tapes, that tape would be slowed down a small amount simply from the added mechanical friction. This caused the signals to come out of phase, and the phase interaction caused constructive and deconstructive interference creating a new, effected sound described as being flanged. Echo is when the sound is repeated, but the delay time is so great, the phases don't interact. When one yells, "hello" across the Grand Canyon, they hear, "hello, hello, hello" back in decreasing volume. They do not here a different sounding hello like flanging creates. Reverb is basically a mix of the two. When one says, "hello" in a parking deck, the sound seems to hang in the air. That is because there are so many echoes: some coming from the far walls, the near walls, cars, ceiling, floor, etc. All of the echoes' phases interact so that a single "hello" is not heard back.

Delay circuitry is useful in several applications besides audio. Digital delay is easily created by feeding an input into a shift register, and having its output appear N clock periods later. Analog delay was slightly more difficult to realize. The first analog delay devices simply used the relationship that wave propagation velocity is equal to distance divided by time. In order to increase the time for a wave to propagate, an increase in distance and a smaller velocity is needed. With an approximate velocity of one foot per second, speed of light, chains of LC circuits were used to significantly decrease the propagation velocity while increasing the distance the wave needed to propagate. This worked well for delays from one to several hundred nanoseconds, but this delay was to short for audio application. For delays that could last several hundred milliseconds, a BBD, bucket brigade device, was needed. It gets is name by alluding to the old fire bucket brigades, only in this case analog values are shifted from one cell to the next every clock cycle with CMOS, NMOS or PMOS devices functioning as those cells. BBD chips are used to create the delay necessary for flange effects.





Circuit: The circuit can be easily traced through. First there is a switch that either allows the pedal to be used or bypassed. By going through the effects part, first is a unity gain op amp so that the circuitry of the pedal will not affect the circuitry of the guitar. The next component is another op amp that has two inputs: the signal and a feedback

signal. This feedback signal can be controlled with a variable resistor, and can also be shut off by a switch. The next element is the BBD chip. This BBD chip also has a built in clock generator. The clock signal is created with pins 2, 7, 8, 9, 13, and its period can be changed by the variable resistor. The BBD part of the IC has three outputs: a 3 stage, 5 stage, and 190 stage output. There is a switch to select between the 5 stage or the 190 stage output. Once the output is selected, that goes back through a unity gain op amp. That is low pass filtered with a capacitor hooked to ground, and another capacitor is used to make the signal be centered at zero volts. After all of that, the signal was not as strong so the next op amp gives the signal a gain of 5 to make its peak to peak value the same as before the BBD. The output of op amp 4 goes to the variable feedback loop and is used in op amp 5 where it is mixed with the dry, unaffected signal to produce the overall output.

Design functions and suggestions: With three variable resistors and 2 switches, the peddle can have a wide range of effects on a sound. A choice from either the 5 stage or the 190 stage can have a great effect on the amount of delay desired. Because the clock period can vary the minimum delay is 5 times the minimum clock period while the maximum delay is 190 times the maximum clock period. In order to create flange, this requires a small amount of delay with no feedback. For an echo effect, the controls should be set for a large delay and the feedback can be on or off. If there is no feedback the output will have a Q&A effect with the original signal followed by the delayed signal. With feedback the sound will have more than one echo depending upon the attenuation

applied on the variable feedback. Reverb can be any medium to long delay with a certain amount of feedback depending upon the sound desired.

Problems: When assembling and testing this peddle many problems occurred. The first problem had to do with supplying power to the circuitry. The suggested circuit from the BBD chip manual used a power supply of +18V and 0V. This set up requires capacitors to correct the lack of positive and negative voltage. In order to not add those capacitors, a plus five and minus five voltage source was used during lab, and two nine volt batteries are hooked up for the stomp box for actual application.

Another problem with the design was making sure that the input signals are in the same phase when mixed together with an op amp. For example, the input to op amp 1 is in-phase, as well as the output of op amp 1. Because the dry signal to op amp 5 is in phase, the wet signal must also be in-phase. It is in phase because both op amps 2 and 4 are inverting while op amp 3 is not. This means the overall output of op amp 4 is in phase, which is necessary for mixing it with the other in-phase inputs for op amps 2 and 4.

The next problem was getting the clock circuitry to work. This was easily corrected by recreating the circuit suggested in the manual. This circuit however has limited uses because the delay could still be longer. This can be corrected by increasing the capacitor used for the clock circuitry from 200 pF to 400 or 500pF. The manual has a chart for theoretical clock frequencies given a certain capacitor and variable resistance used in the clock circuitry.

The output of the BBD had several problems associated with it. First, it has a large impedance output so that a unity gain op amp was required to counter that problem. The

signal was also not centered about zero volts. This was corrected by adding a 25 microfarad capacitor to correct the offset voltage. The chip also put out a large amount of noise associated with the original signal. That noise was filtered out by adding a capacitor to ground. Also, capacitors were added to the inverting side and the output of op amps 2 and 4 to further diminish the high frequency noise. However, the chip also had a large amount of clock noise. This could not get filtered out without filtering out the BBD output completely. The only theory for why the clock noise was so loud was because the MN3012 chip has the clock circuitry is in the same IC. After contacting the company, they could offer no reason for why the BBD had so much clock noise associated with it. In order to correct this problem, two different ICs should be used: one for the BBD and another chip for the clock.

Improvements: Despite fixing the unwanted clock noise by using a different kind of BBD and clock IC, other improvements can be made to the circuit. Most professional effects boxes have a LED that shows when the effect is active, and do not engage the power source unless an input is connected. Also, depending upon the BBD IC used, several stages could be mixed together. For example, the wet signal could be a variable mixture of a 512, 190, and 5 stage delay as opposed to a switch that picks only one output. Another suggestion is including a sweep rate that modulates the clock frequency. With FM on the clock, a wha effect is heard. Even if circuitry for a sweep rate is not implemented, the variable clock frequency could be controlled by a foot lever, making the sweep rate a manual operation.

Conclusion: This circuit can create varied delay effects from echo, flange, and reverb. After using a better BBD IC, other improvements can be made to further increase the functions. The circuit presented here is a great foundation to build upon.

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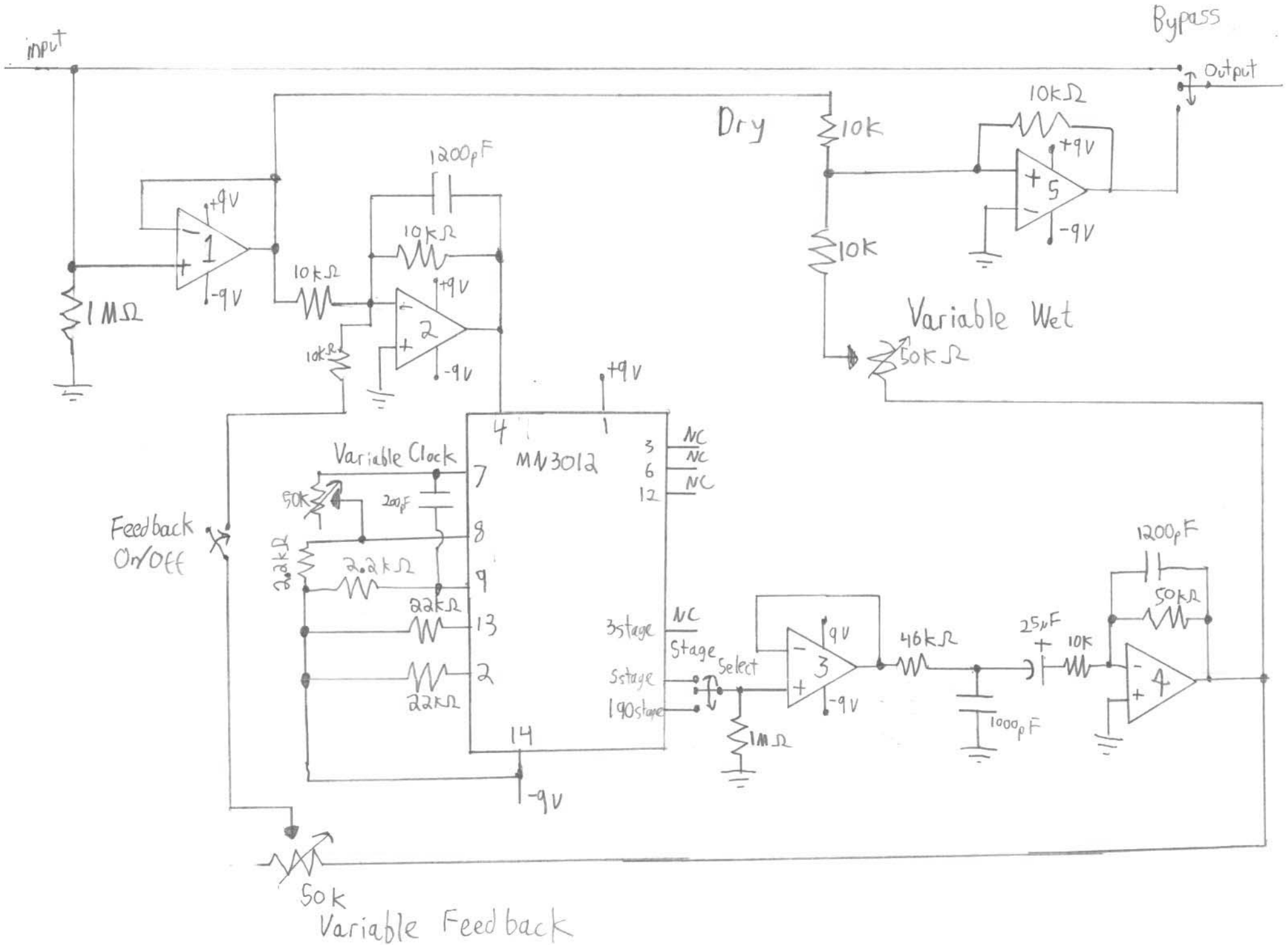
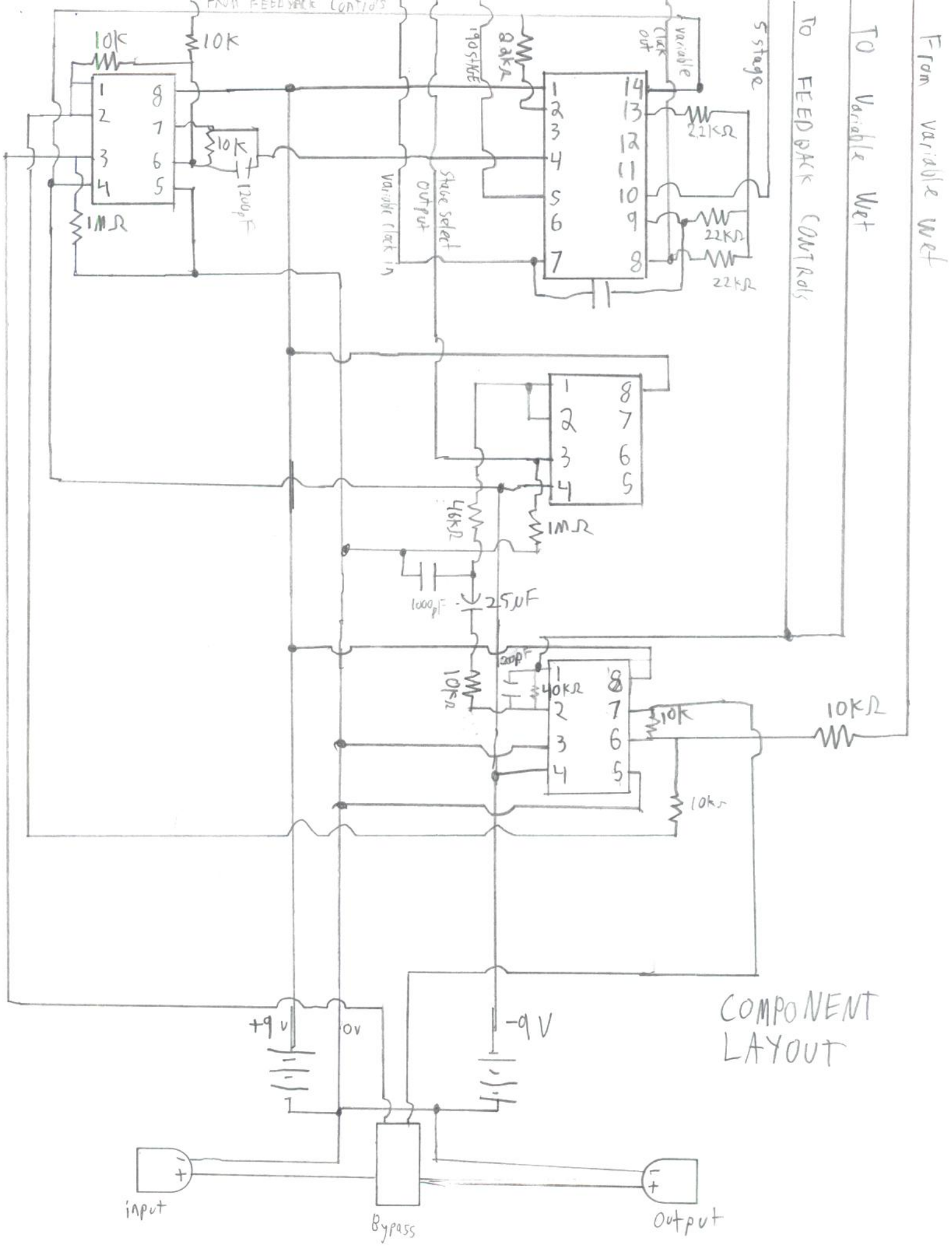
Internet. http://www.fortunecity.com/tinpan/humperdinck/223/ehmist.htm.

CIRCUIT


Bypass
input
Output
Dry
10kΩ
10kΩ
10kΩ
+9V
-9V
1
2
5
1200pF
1MΩ
10kΩ
10kΩ
Variable Wet
50kΩ
+9V
4
1
MN3012
Variable Clock
7
50K
200pF
8
2.2kΩ
2.2kΩ
9
22kΩ
13
22kΩ
2
14
-9V
3
NC
6
NC
12
NC
3stage
NC
Stage Select
5stage
190stage
Feedback On/Off
50k
Variable Feedback
9V
3
-9V
1MΩ
46kΩ
25μF
10K
1000pF
1200pF
50kΩ
4


From Variable Wet
TO Variable Wet
TO FEEDBACK CONTROLS
5 stage
10K
10K
10K
1MΩ
1200pF
Variable clock in
Stage select output
8 aka
variable clock out
22KΩ
22KΩ
22KΩ
46KΩ
1MΩ
1000pF
.25uF
20pF
40KΩ
10KΩ
10K
10KΩ
10KΩ
+9V
0V
-9V
input
Bypass
Output
COMPONENT LAYOUT

MN3012

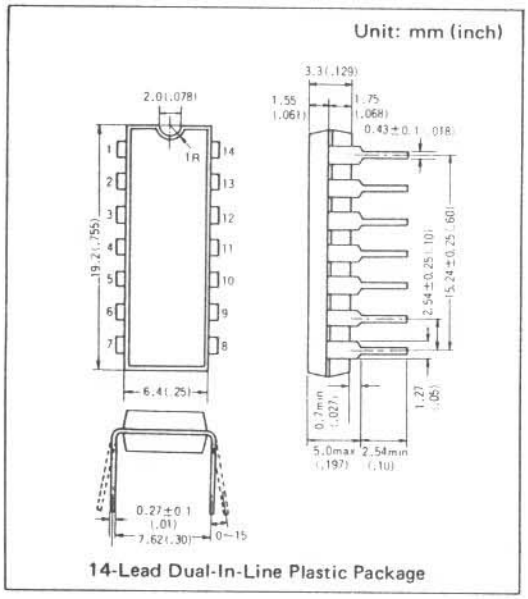
BBD with 3 outputs (190-STAGE, 5-STAGE, 3-STAGE)

■ General description

The MN3012 is a BBD comprised of 190,5 and 3-stages in parallel with 3 outputs incorporating a clock generator suitably designed for sound effect generator such as chorus, fading, vibrato and reverberation effects of audio equipments.

Clock generating frequency can be freely controlled by the value of external resistors and capacitors connected to CG_1, CG_2 and CG_3 terminals. Also delay time can be set by changing the clock frequency.

Output signal of differernt delay time can be obtained simultaneously from 3 output terminals (OUT1, OUT2, OUT3) against input sinal.



14-Lead Dual-In-Line Plastic Package

■ Features

- Single power supply (V_{DD} terminal): −8.5 ~ −16V.
- Dynamic range: S/N = 98dB typ.
- No insertion loss: L_i = 0dB typ.
- Low distortion: THD = 0.4% typ.
- Built-in clock genrator.
- Clock frequency range %: 10 ~ 200KHz.
- Built-in clock component cancellation circuit.
- P channel silicon gate process.
- 14-Lead Dual-In-Line Plastic Package.

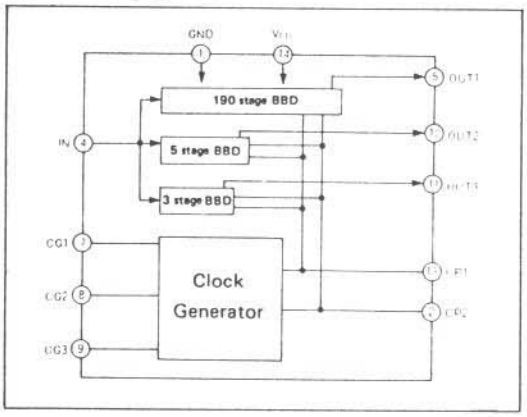
■ Applications

- Chorus, fading, vibrato and reverberation effects of audio equipments.
- Sound effect of electronic musical instruments.

■ Maximum Delay Time by Tap Output

Terminal of the Tap Output	OUT 1	OUT 2	OUT 3
Stages of BBD (Stage)	190	5	3
Maximum Delay Time (mS)	0.475 ~9.5	0.0125 ~0.25	0.0075 ~0.15

■ Block Diagram



■ Absolute Maximum Ratings (Ta = 25°C)

Item	Symbol	Rating	Unit	Remarks
Terminal Voltage	V_{DD}	−18~+0.3	V	GND = 0V
Input Terminal Voltage	V_I	−18~+0.3	V	〃
Output Terminal Voltage	V_O, V_{CP}	−18~+0.3	V	〃
Operating Ambient Temperature	Topr	−20~+70	℃	
Storage Temperature	Tstg	−55~+125	℃	

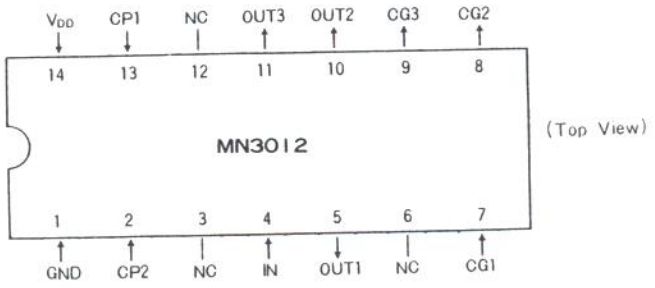
■ Operating Condition (Ta = 25°C)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Drain Supply Voltage	V_{DD}		−8.5	−15	−16	V
Clock Voltage "H" Level	V_{CPH}		0		−0.4	V
Clock Voltage "L" Level	V_{CPL}			V_{DD}		V
Clock Frequency	f_{CP}		10		200	kHz
Clock Input Capacitance	C_{CP}				180	pF
Input DC Bias	V_{Bias}		− 3		−12	V

■ Electrical Characteristics ($Ta = 25°C$, $V_{DD} = -15V$, $V_{CPL} = -15V$, $V_{CPH} = 0V$, $R_L = 56k\Omega$, $C = 100pF$, $R_2 = R_3 = 22k\Omega$, $R_4 = R_5$ 2.2kΩ, $f_{cp} = 1/2f_{OSC}$ (Adjusted by R1))

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Signal Delay Time						
OUT 1 Terminal	t_{D1}	f_{CP}=10kHz~200kHz	0.475		9.5	ms
OUT 2 Terminal	t_{D2}		0.0125		0.25	ms
OUT 3 Terminal	t_{D3}		0.0075		0.15	ms
Input Signal Frequency						
OUT 1 Terminal	f_{i1}	f_{cp} = 40kHz Output −3dB	12			kHz
OUT 2 Terminal	f_{i2}		12			kHz
OUT 3 Terminal	f_{i3}		12			kHz
Input Signal Voltage	V_i	THD≦2.5%	1.2			Vrms
Insertion Loss	L_i	f_{CP}=40kHz, f_i= 1 kHz	−4	0	4	dB
Total Harmonic Distortion	THD	V_i=0.775Vrms		0.4	2.5	%
Noise Voltage						
OUT 1 Terminal	V_{NO1}	f_{cp} = 100kHz Weighted by "A" curve			0.14	mVrms
OUT 2 Terminal	V_{NO2}				0.14	mVrms
OUT 3 Terminal	V_{NO3}				0.14	mVrms
Signal to Noise Ratio						
OUT 1 Terminal	S/N_1	f_{cp} = 100kHz Weighted by "A" curve		90		dB
OUT 2 Terminal	S/N_2			97		dB
OUT 3 Terminal	S/N_3			98		dB

■ Terminal Assignments



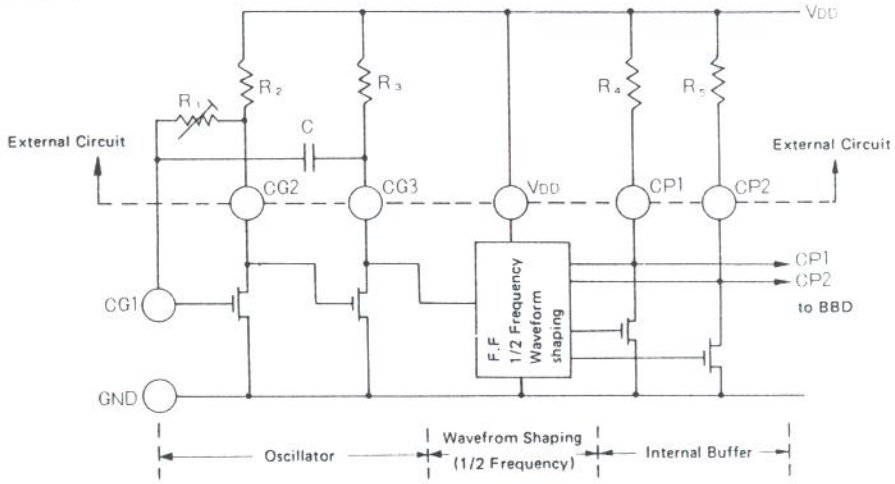
(Top View)

■ Terminal Description

Terminal No.	Symbol	Terminal name	Description
1	GND	Earth terminal	Connected to GND of the circuit.
2	CP2	Clock 2	Load resistor connection terminal of the driver that drives basic clock pulse to transfer electron of BBD.
4	IN	Signal input terminal	Analog signal to be delayed is input. Most suitable DC bias is applied to this terminal.
5	OUT 1	Output terminal 1	BBD output of 190 and 191 stages are composed and output is obtained by cancelling the clock components.
7	CG1	Clock osc. terminal 1	Input terminal for clock oscillator. Note) Refer to clock generating circuit.
8	CG2	Clock osc. terminal 2	
9	CG3	Clock osc. terminal 3	
10	OUT 2	Output terminal 2	Composed output of 5 and 6-stage BBD.
11	OUT 3	Output terminal 3	Composed output of 3 and 4-stage BBD.
13	CP1	Clock 1	Load resistor connection terminal of the driver to drive reverse clock pulse against CP 2.
14	V_{DD}	V_{DD} apply terminal	−15 volt is applied.

Note) No connection for the terminal No. 3, 6 and 12.

■ Clock Generator Circuit



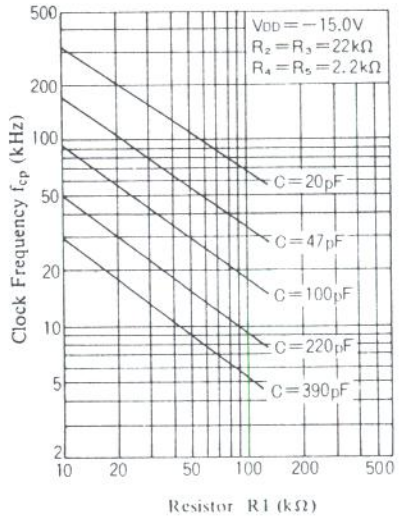
Note: when external clock is used, remove R_1 and C_1, and apply clock input to CG1.

$R_2 = R_3 = 22k\Omega$

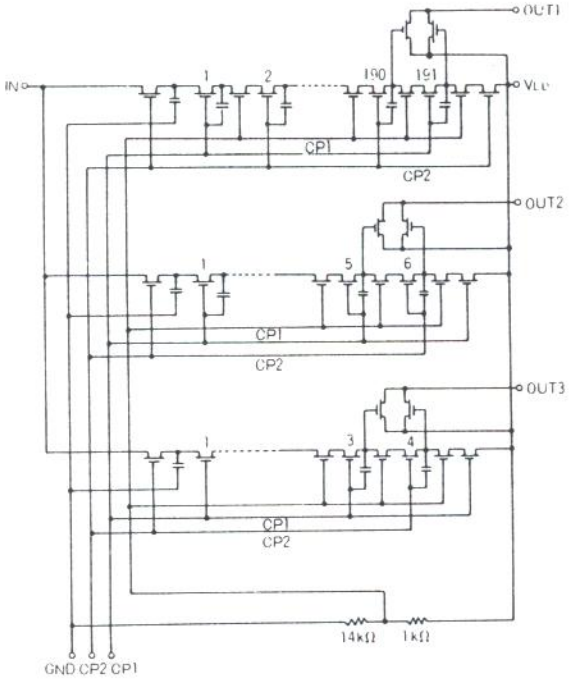
$R_4 = R_5 = 2.2k\Omega$

Adjusted by C, R1. $f_{cp} = 1/2\ f_{osc}$
Self-oscillation example should be refered to attached figure.

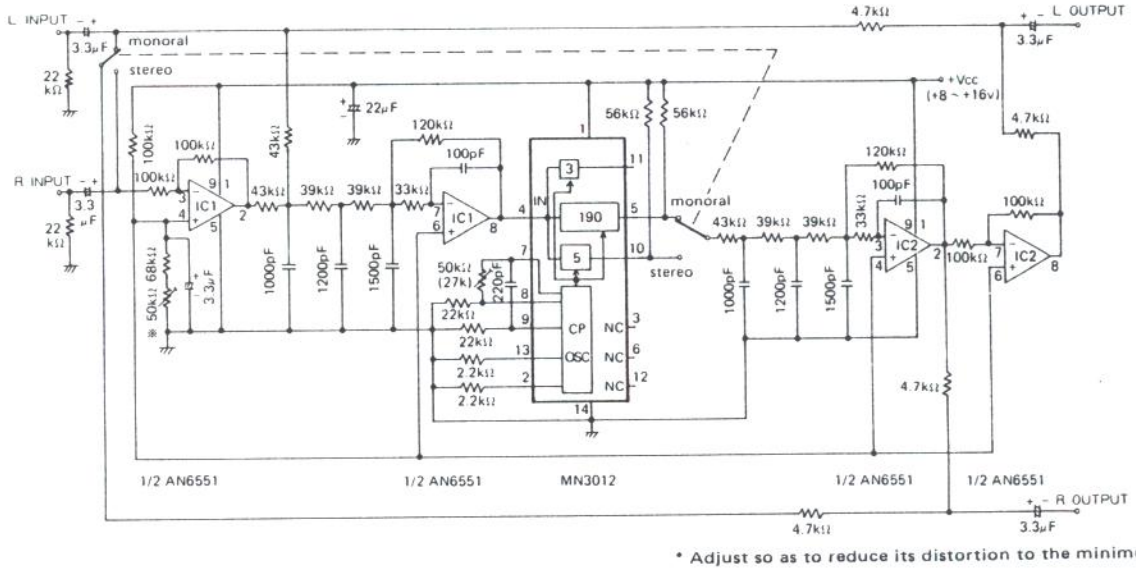
Attached Figure Example of Self-Oscillation



■ B B D Circuit Diagram



■ Example of application circuit



* Adjust so as to reduce its distortion to the minimum.

Sound field magnifying effect generating circuit (Stereo input)

Sound field magnifying effect generating circuit

Isn't it really wonderful if the speaker reproduction of sound for a grand hall can be got in the listening room or the car? Application of the sound image control technology and the delay characteristic of the BBD makes it possible to realize the above effect easily.

In listening through a speaker in the soom, the listener feels the distance and direction up to the speaker. As to the directional sense, for instance, there occurs some difference in the time for both direct and indirect sounds to reach his left and right ears depending on the position of the sound source, as well as the difference in the sound level, and from these differences the listener feels the "direction of sound". Further he feels the "distance of sound" from the energy ratio of the direct sound to the indirect sound (reverberation sound). The circuit for generating a sound field magnifying effect reproduces electronically the delicate time lag of these sounds, thereby makes it possible for the listener to feel as if he hears sounds from his surroundings other than the position of the speaker, and thus producing such effect that he is listening sounds in a large hall. Also the fatigue from listening for a long time through a conventional headphone is eliminated, and the effect similar to that of listening through an ordinary speaker is obtained.