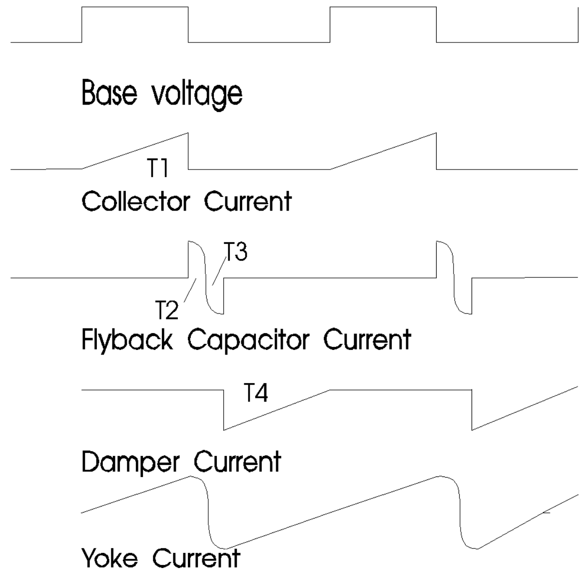
HORIZONTAL

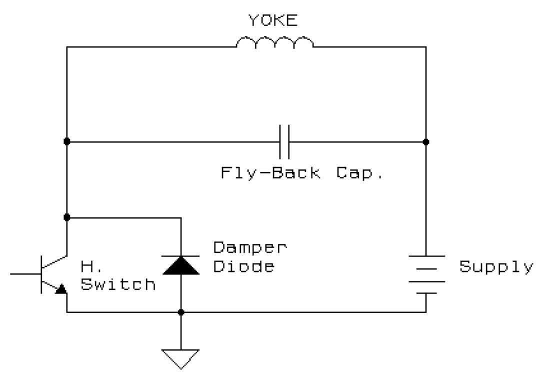
Basics:

HORIZONTAL WAVE FORMS



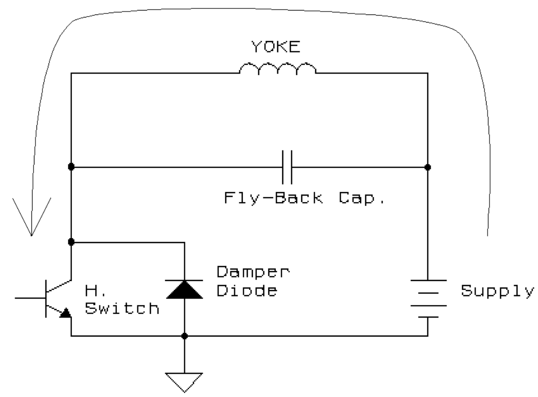
A horizontal deflection circuit makes a sawtooth current flow through a deflection coil. The current will have equal amounts of positive and negative current. The horizontal switch transistor conducts for the right hand side of the picture. The damper diode conducts for the left side of the picture. Current only flows through the fly back capacitor during retrace time.

Simplified horizontal section.

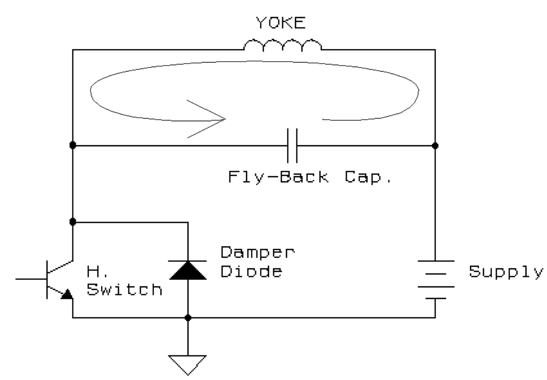


For time 1 the transistor is turned on. Current ramps up in the yoke. The beam is moved from the center of the picture to the right edge. Energy is stored on the inductance of the yoke.

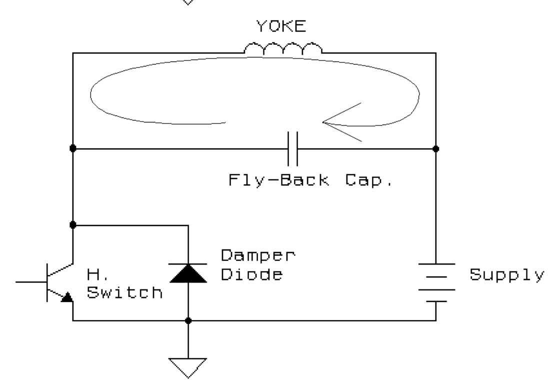
$E=I^2L/2$



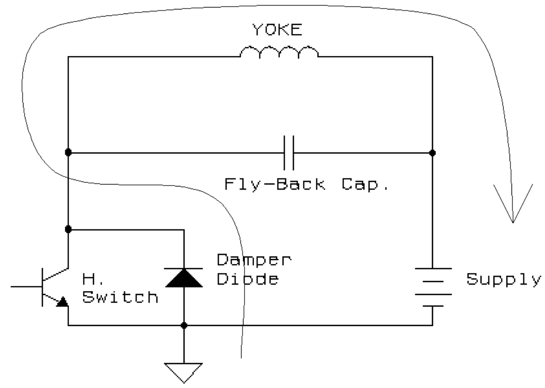
For time 2 the transistor is turned off. Energy transfers from the yoke to the flyback capacitor. At the end of time two all the energy from the yoke is placed on the flyback capacitor. There is zero current in the yoke and a large voltage on the capacitor. The beam is quickly moved from the right edge back to the middle of the picture.



During time 3 the energy on the capacitor flows back into the yoke. The voltage on the flyback capacitor decreases while the current in the yoke builds until there is no voltage on the capacitor. By the end of time 3 the yoke current is at it's maximum amount but in the negative direction. The beam is quickly deflected form the center to the left edge.



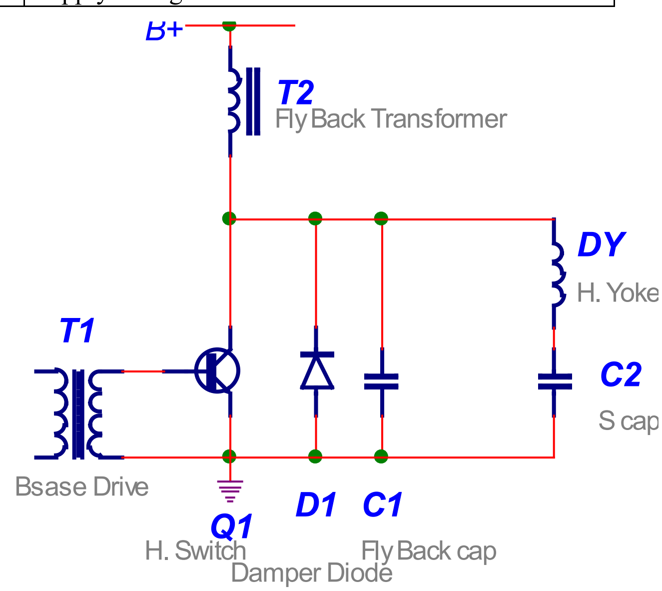
Time 4 represents the left hand half of the picture. Yoke current is negative and ramping down. The beam moves from the left to the center of the picture.



The current that flows when the horizontal switch is closed is approximately: Ipk ≅ Vcc T / Ldy	Ipk = collector current T = 1/2 trace time Ldy = total inductance (yoke + lin coil + size coil) note:The lin coil inductance varies with current.
$Tr \cong 3.14 \sqrt{LC}$	The current that flows during retrace is produced by the C and L oscillation. The retrace time is 1/2 the oscillation frequency of the L and C.
$I^2L/2 \cong V^2C/2$ or $I^2L = V^2C$	As stated earlier the energy in the yoke moves to the flyback capacitor during time 2. V= the amount of the flyback pulse that is above the supply voltage.

First lets D.C. annualize this circuit. The rule for D.C. annualizes is inductors are considered shores, capacitors are open and generally semiconductors are removed. The voltage at the point "B+" is the supply voltage. The collector voltage of Q1 is also at the supply voltage. The voltage across C2 is equal to the supply voltage. When we A.C. annualize this circuit we will find that the collector of Q1 has a voltage that ranges from slightly negative to 1000 volts positive. The average voltage must remain the same as the D.C. value.

In the A.C. annualizes of the circuit, the inductance of the yoke (DY) and the inductance of the flyback transformer are in parallel. The inductance of T2 is much larger than that if the DY. This results is a total system inductance of about 10% to 20% less than that of the DY it's self.



The voltage across the Q1 is a half sinusoid pulse during the flyback or retrace period and close to zero at all other times. It is not possible or safe to observe this point on an oscilloscope without a proper high frequency high voltage probe. Normally use a 100:1 probe suitable for 2,000V peak. The probe must have been high frequency calibrated recently.

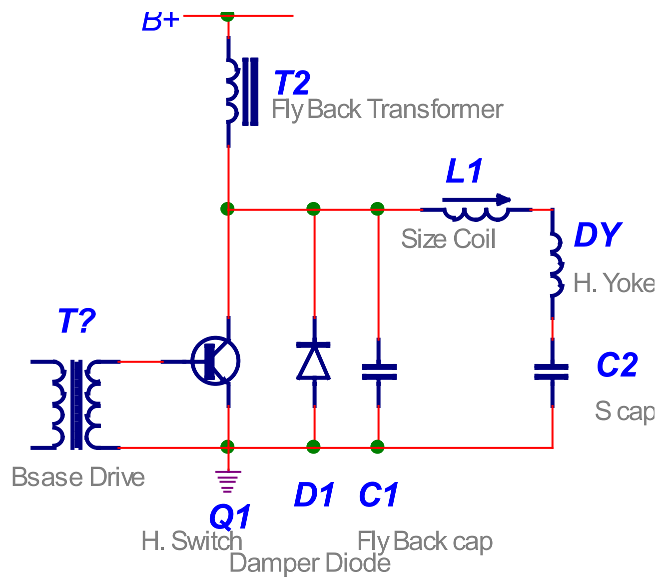
HORIZONTAL SIZE

There are several different methods of adjusting horizontal size.

SIZE COIL

Add a variable coil to the yoke current path causes the total inductance to vary with the coils setting.

The yoke current is related to supply voltage, trace time and total inductance. This method has a limited range!



The horizontal section uses a PWM to set the horizontal size. One DAC sets the horizontal size and another DAC sets the pincushion and trap.

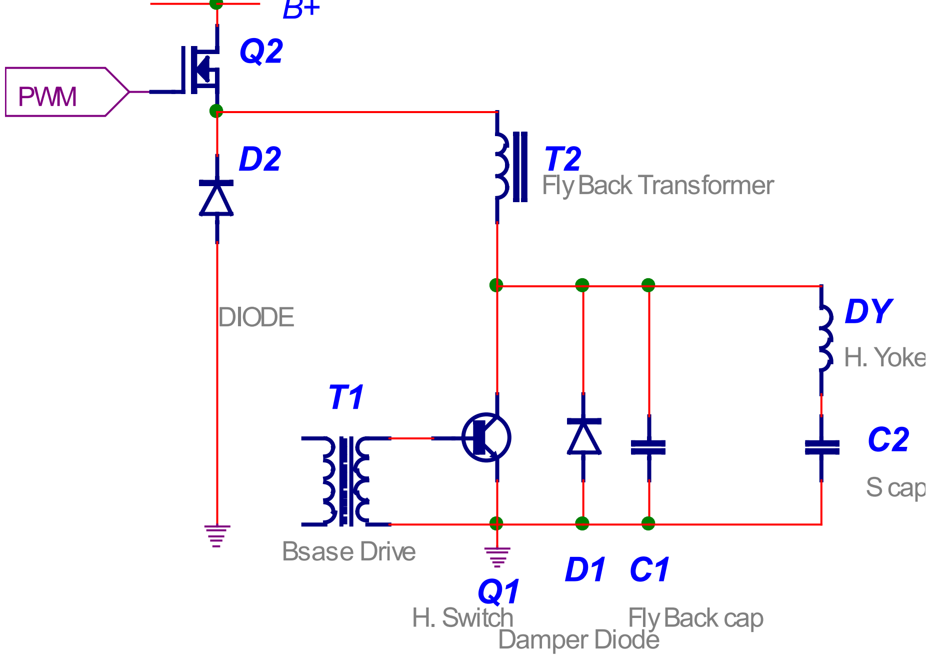
The Raster Centering (D.C. centering) is controlled by a DAC.

On small monitors the retrace time is fixed. On large monitors or wide frequency range monitors two different retrace times are available. The flyback time is set by the micro computer by selecting two different flyback capacitors. At slow frequencies the longer retrace time is selected.

Different S corrector capacitor values are selected by the micro computer. At the highest frequency the smallest capacitor is selected.

CHOPPER

The horizontal section does not have a horizontal power supply voltage like most monitors. A chopper is used to take the B+ supply and create the necessary power for the horizontal section. The duty cycle of the shopper is controlled by a pulse width modulator (PWM). The PWM watches the current in the horizontal yoke and adjusts the duty cycle to obtain the desired width.
Example: If the PWM is running at 50% duty cycle then a square wave is fed into thae gate of Q2. The junction of Q2 D2 will be at B+ for 50% of the time and ground for 50% of the time. The results is the top if the blyback transformer will appear to be at ½ of the supply voltage. The picture will be at about ½ the maximum size. This method has a large range.

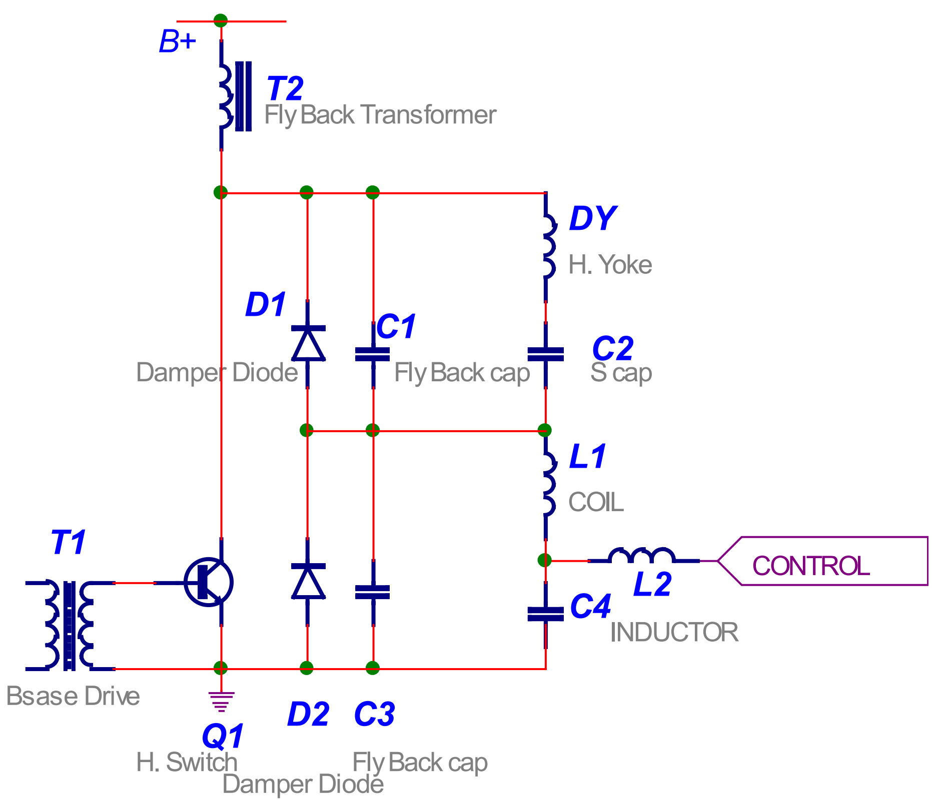


SPLIT DIODE MODULATIOR

This horizontal circuit consists of two parts. D1, C1, C2 and DY are the components as described above. D2, C3, C4 and L1 are a second "dummy" horizontal section that does not cause deflection current. By the D.C. analyzing this circuit the voltage across C2 + C4 must equal the supply voltage (B+). Deflection current in the DY is related to the supply voltage minus the voltage across C4. For a maximum horizontal size the control point must be held at ground. This causes the dummy section to not operate and the DY section will get full supply voltage. If the control point is at 1/3 supply then the DY section will be operating at 2/3 supply.

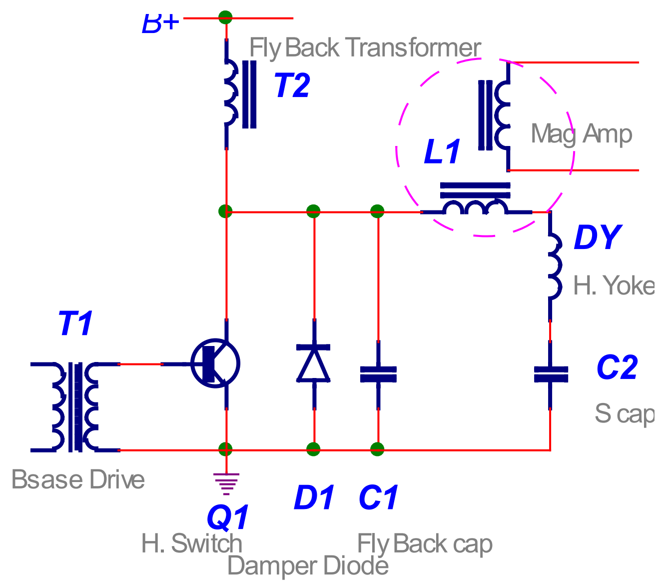
Note: The impedance of (D1,C1,C2 and DY) and (D2,C3,C4 and L1) makes a voltage divider. If the control point is not connected then there is some natural voltage on C4. Most split diode monitors are built to pull power from the dummy section through L2 to ground. A single power transistor shunts from the control point to ground. It is true that power can be supplied from some other supply through L2 to rise the voltage on C4. For maximum range a bi-directional power amplifier can drive the control point.

The most exciting feature if the split diode modulator is that the flyback pulse, as seen by the flyback



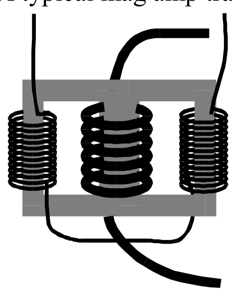
transformer, is the same size at all horizontal size settings.

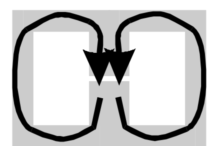
Mag Amp



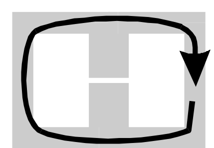
A mag amp controlled horizontal circuit has the addition of a ‘size coil’ that is controlled by current through a control winding. The mag amp looks to the horizontal section like a size coil. A control winding is used to vary the inductance as seen by the yoke current. The two windings (yoke current) and (control current) do not cross couple energy because of the way they are wound.

A typical mag amp transformer looks like:





The large yoke current passes through a small number of turns of heavy wire. The flux from the yoke current makes a loop with an air gap in it. These two factors will give this coil little inductance and very high current handling ability. The flux density is far from saturation.



The control current passes through many turns of very small wire. The flux path does not have an air gap. The resulting coil will have high inductance and can be easily saturated by D.C. current. The outer legs of the transformer are saturation (in whole or in part) by the control current. Saturation in the outer legs causes a reduction in inductance in both coils.

HORIZONTAL SWITCH/DAMPER DIODE

On the right hand side of the screen, the H. switch transistor conducts current through the deflection yoke. This current comes from the S correction capacitors, which have a charge equal to the effective supply voltage. The damper diode allows current for the left hand side of the screen to flow back through the deflection yoke to the S capacitors.

FLYBACK CAPACITOR

The flyback capacitor connects the hot side of the yoke to ground. This component determines the size and length of the flyback pulse. ‘Tuning the flyback capacitor’ is done to match the timing of the flyback pulse to the video blanking time of the video signal. The peak flyback voltage on the horizontal switch must be set to less that 80% if the Vces specification. The two conditions of time and voltage can be set by three variables (supply voltage, retrace capacitor and yoke inductance) .

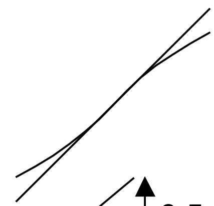
S CAPACITOR

The S capacitors corrects outside versus center linearity in the horizontal scan. The voltage on the S cap has a parabola plus the DC horizontal supply. Reducing the value of S cap increases this parabola thus reducing the size of the outside characters and increasing the size of the center characters.

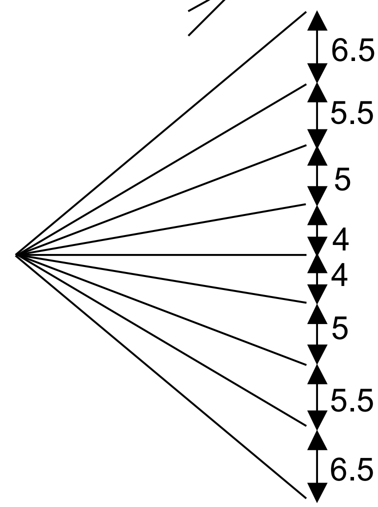
S Capacitor value: Too low: picture will be squashed towards edges.

Too high: picture will be stretched towards edges.

By simply putting a capacitor in series with each coil, the sawtooth waveform is modified into a slightly sine-wave shape. This reduces the scanning speed near the edges where the yoke is more sensitive. Generally the deflection angle of the electron beam and the yoke current are closely related. The problem is the deflection angle verses the distance of movement on the CRT screen does not have a linear effect.



In this example an electron beam is deflected with nine different current values. (4,3,2,1,0,-1,-2,-3,-4 amps) A current in the range of 0 to 1 amp causes the beam to move 4cms. Current changing from 3 to 4 amps causes 6.5cm movement. The yoke appears to be 1.5 times more sensitive at the edge of the picture.



The amount of S-correction needed is related to the flatness of the tube and the deflection angle. If the yoke is at the radius of the curvature of the tube then no S-correction is needed. As the yoke is pushed toward the face of the tube deflection angles get large. This problem is compounded by very flat tubs.

When the scan begins, at the left side of the picture, the voltage on the S-cap is low causing less voltage to be placed across the deflection yoke and the beam to move slowly. The yoke current is at the maximum value in the direction to charge the S-cap. As the beam moves toward the center of the screen the yoke current decreases and the voltage across the S-cap increases. The larger S-cap voltage will cause more voltage across the DY and the beam will move faster. By middle of the picture, the yoke current has rum down to zero. The S-cap has charged to it's maximum value. The beam speed is at it's maximum. The current now reverses direction causing right side deflection. The current flows out of the S-cap through the DY. The S-cap voltage drops reducing the speed of deflection as the beam approaches the right edge. The voltage on the S-cap is varying by the right amount to compensate for the geometry error.

The S-cap value is very dependant on the scan rate. For multiscan monitors, S-caps must be selected for each scan range. These are only approximate corrections but good enough for most purposes. MOSFETs or relays switch in the correct S-cap for each range of scanning frequencies.

INNER PIN-CUSHION

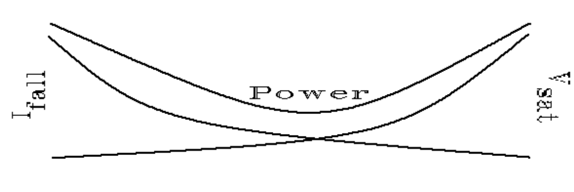
Many CRTs, especially flatter ones, need geometry correction that goes beyond simple S-correction. Most tubes need inner pin-cushion correction, which is also called "dynamic S-correction". Some tubes need more S-correction only at the extreme edges, this is called "higher-order S-correction". This requires another resonant circuit, tuned to a higher frequency, which is more difficult to implement. Most sets will not have such circuit.

BASE DRIVE

The base drive FET when turned on, turns off the horizontal switch. At the same time, current is stored on the transformer. When the FET opens up this stored power supplies turn-on current for the H. switch. Snubbing circuits surround the base drive transformer.

BASE DRIVE CURRENT

The base drive resistor determines the amount of base drive. If the transistor is over driven the Vsat looks very good, but the current fall time is poor. If the base current is too small the current fall



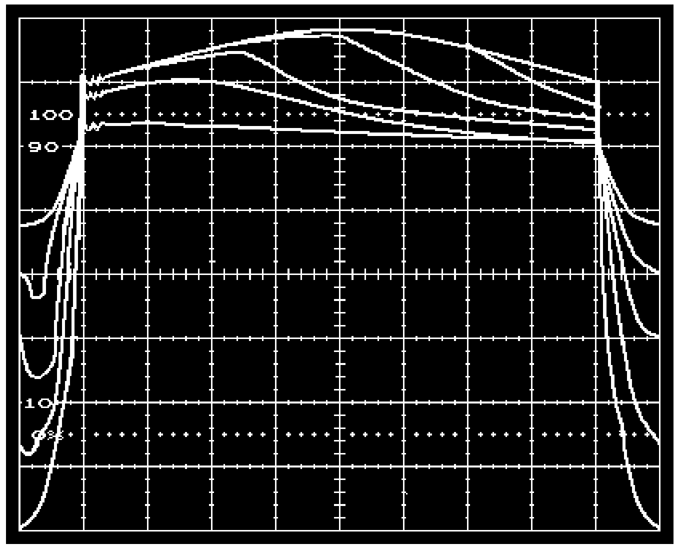
time is very fast. The problem is that the transistor will have many volts across C-E when closed.

The best condition is found by placing the transistor in the heaviest load condition. Adjust the base resistor for the **least** power consumption then increase the base drive a small amount. This will slightly over drive the base.

Through the base drive DAC the micro computer can make changes in base drive current to compensate for frequency changes. This option is only available on the larger monitors.

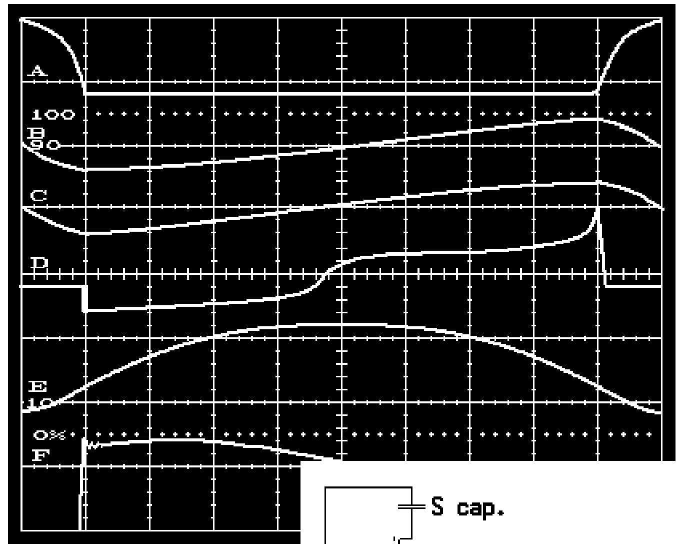
HORIZONTAL LINEARITY

In the yoke current path there is a saturable coil. Just like a size coil, any inductance in series with the yoke will reduce the size of the picture. This saturable coil will change inductance depending on the amplitude and direction of current flow. At the start of a trace the linearity coil has an inductance of 20 percent of that of the yoke. By the center of the trace, the linearity inductance has decreased to about 4 percent of the yoke where it remains for the rest of the trace. Adjust this variable inductor so the right and left sides of the picture are the same size.



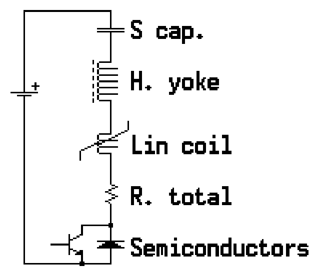
Voltage from two turns of wire added around the linearity coil. When the coil saturates the voltage drops to near zero.

Trace A is the yoke voltage at about 1000 volts peak to peak. Trace B is the yoke current. Trace C is the voltage across the total of all resistance in the horizontal loop. Trace D is the voltage loss due to the semiconductors in the loop. Trace E is the voltage across the S capacitor. Trace F is the voltage across the linearity coil.

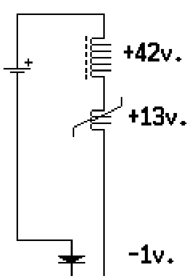


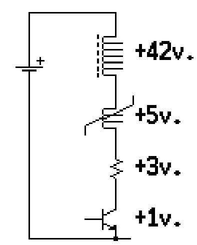
The linearity coil should have a waveform like the inverse of trace C+D. Thus the loss seen in traces C+D+F should equal a straight line.

Horizontal deflection schematic to show losses that cause linearity problems. The ‘R. total’ is the combination of deflection yoke resistance + resistance of the linearity coil + resistance of any size coil + yoke wires + printed circuit traces + ESR of the S-cap.



The losses in the resistance and semiconductors cause the left side of the picture to be larger than the right side. As can be seen in the diagram above the effective left side supply voltage is 50 volts + the diode drop + the voltage across the resistor. this equals 54 volts. The supply voltage in the right side is 50-3-1=46 volts. The linearity coil has high inductance on the left side of the picture causing the left side to shrink. The right side inductance is small thus causing the right side to appear to grow larger. The voltage across the lin coil should balance out the voltage across the semiconductors and resistance.

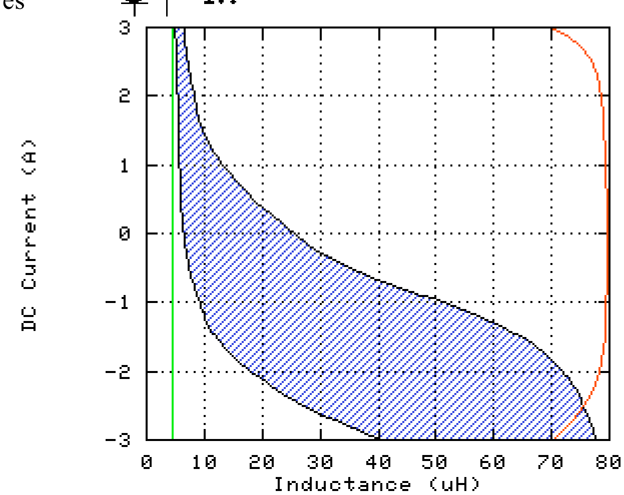




The shaded area covers a family of possible curves that are obtainable by adjusting the magnet on a linearity coil. The left side of the screen (represented by –3 amps) is where the most inductance is needed. The right side (+3 amps) has the least inductance.

If the magnet was removed the natural inductance verses current curve is shown at the right. The inductance is 80 uH for most of the graph.

The left side line shows the inductance if the core was removed from the linearity coil, leaving a air wound coil.

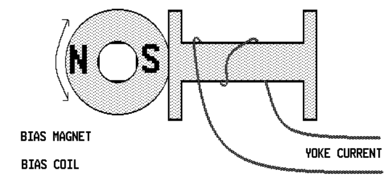


MICRO CONTROLED LIN COIL

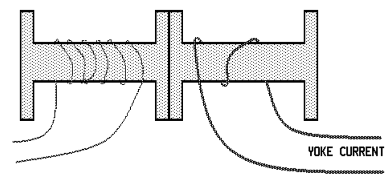
Many simple monitors have a saturable core glued to a magnet. More advanced monitors have an adjustable magnet. By rotating the magnet the saturation point can be moved. It is very common to combine a fixed magnet and a adjustable magnet.

By the time multi-sync monitors became popular design engineers were placing multiple linearity coils in the deflection circuits. The problem is how to switch in the right coil. Relays and FETs have been used with varying degrees of success. If a monitor has two lin coils then there is only really only two horizontal frequencies where the linearity is correct.

Now with microprocessor controlled monitors, the design engineer has the option of building a lin coil that can be adjusted with out the need of high power switches. The coil has an infinite number of settings. In the micro code the microprocessor will determine what lin coil setting is best for a particular horizontal frequency.

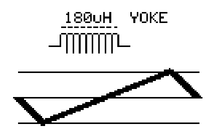


In this lin coil the adjustable magnet is replaced with an elector magnet. A small amplifier drives current into the control winding changing the saturation point.

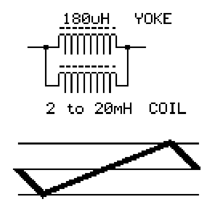


HORIZONTAL DC CENTERING

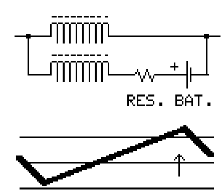
In the horizontal section of a monitor, the yoke has DC on the cold end and a flyback pulse on the hot side. The current ramps in a sawtooth fashion centering around zero.



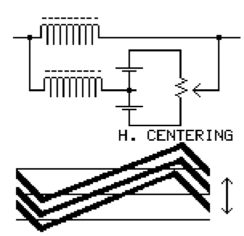
If a parallel coil is added the current through the yoke is not effected.



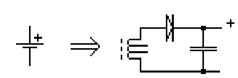
With the addition of a battery and limiting resistor a DC current is added to the current ramp.



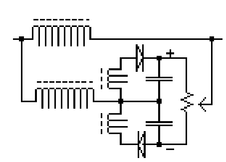
A plus and minus supply gives full control of the DC offset current.



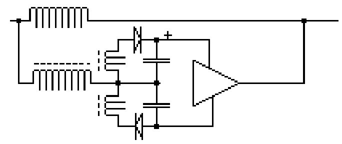
The batteries or power sources are created off small secondary windings.

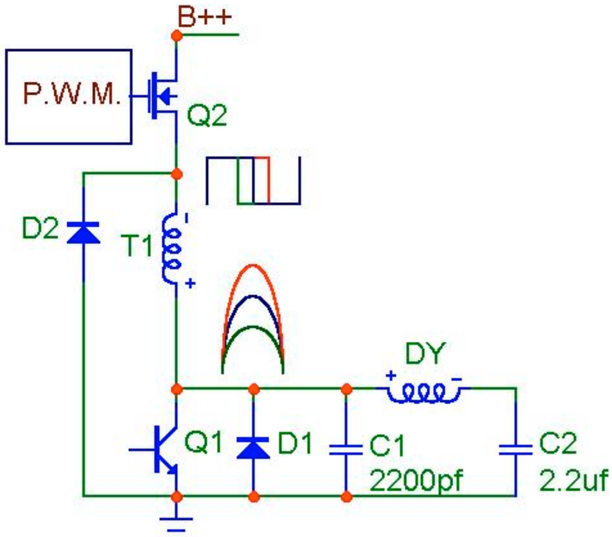


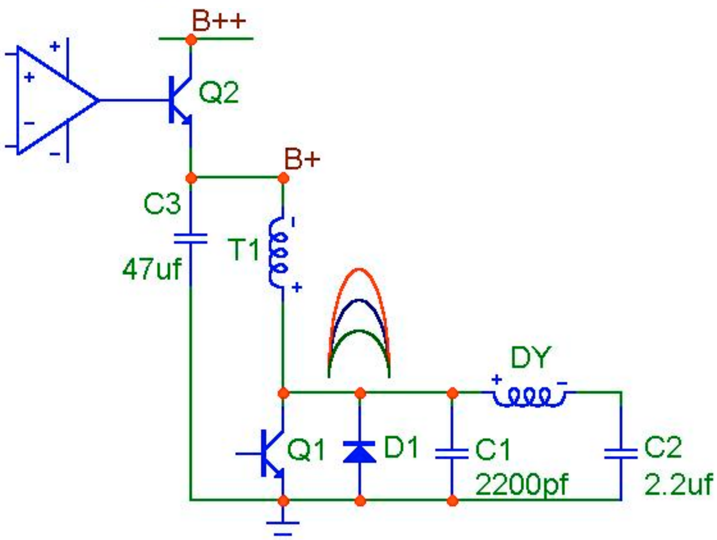
The final circuit has no AC effect on the yoke but can cause a +/- current flow through the yoke.

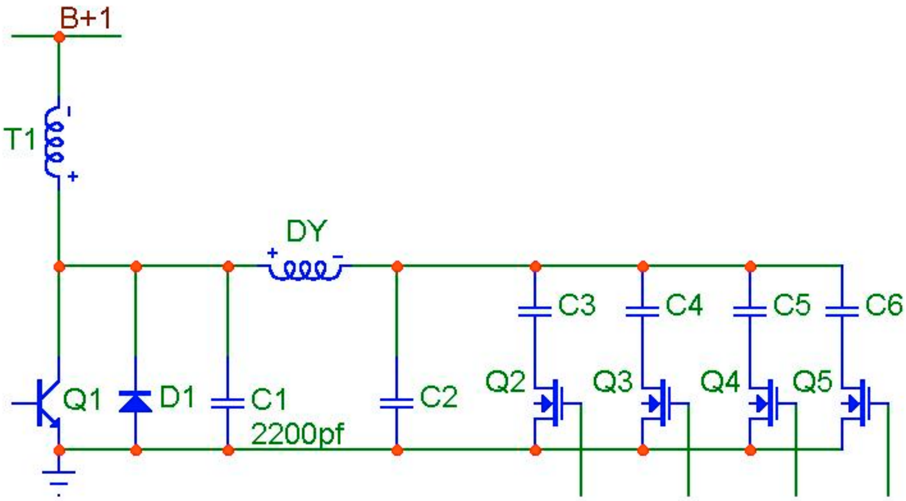


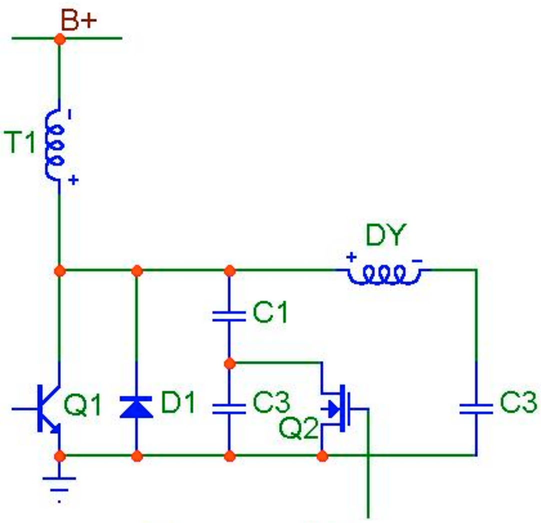
The DC current in the horizontal yoke is controlled by a floating linear amplifier

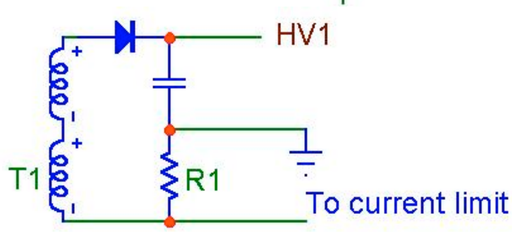




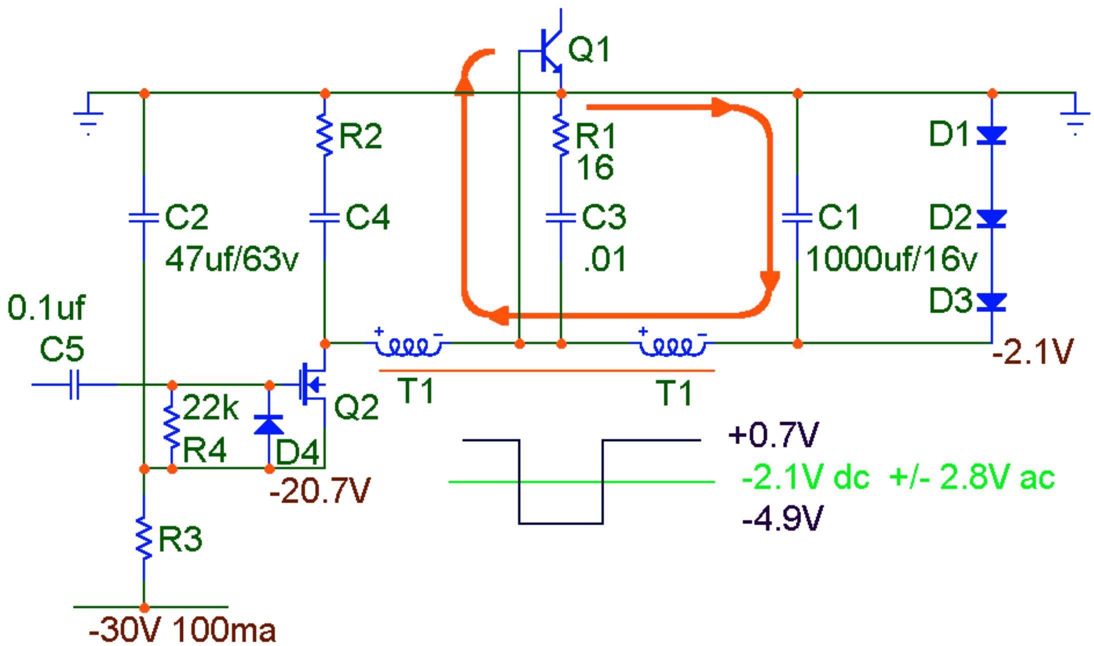




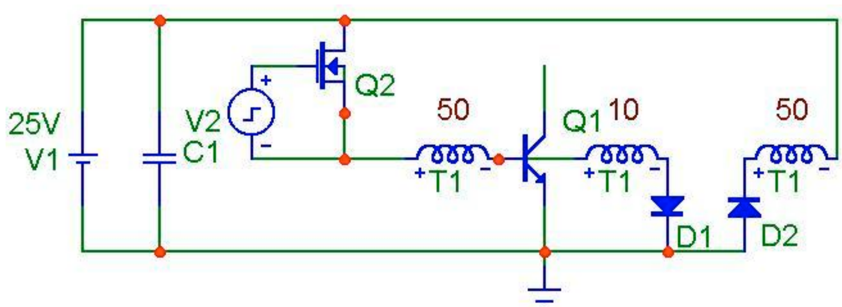




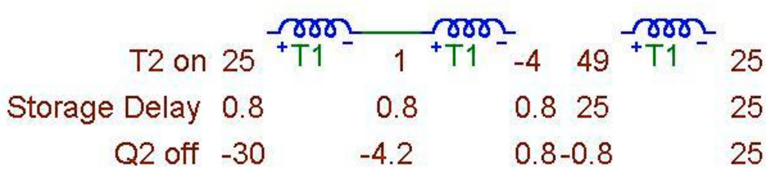
Set R1 for 5 volts at full current.



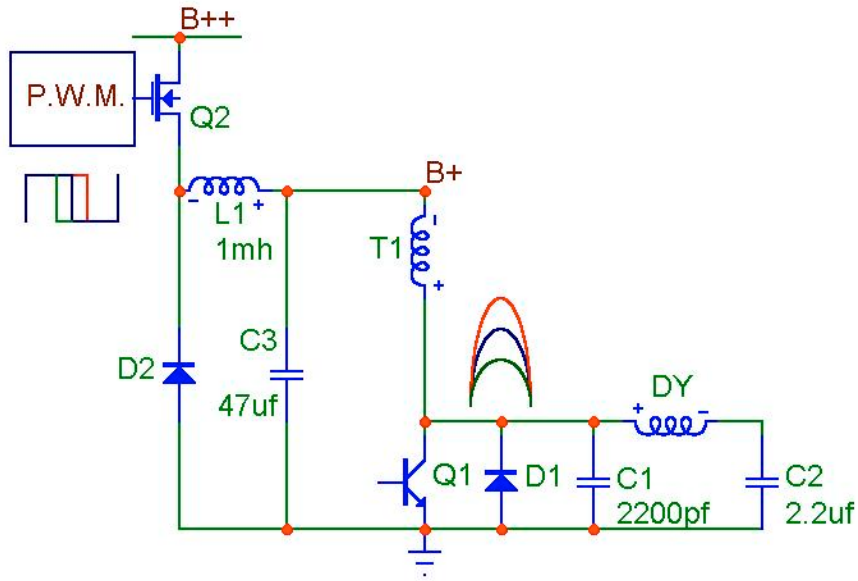
Q1
R2
R1
16
D1
C2
47uf/63v
C4
C3
.01
C1
1000uf/16v
D2
D3
0.1uf
C5
-2.1V
T1
T1
22k
R4
Q2
D4
-20.7V
+0.7V
-2.1V dc +/- 2.8V ac
-4.9V
R3
-30V 100ma



Q2
25V
V1
V2
C1
50
Q1
10
50
T1
T1
T1
D1
D2



T2 on 25 T1 1 T1 -4 49 T1 25
Storage Delay 0.8 0.8 0.8 25 25
Q2 off -30 -4.2 0.8-0.8 25


B++
P.W.M.
Q2
L1
1mh
B+
T1
C3
47uf
D2
DY
Q1
D1
C1
2200pf
C2
2.2uf