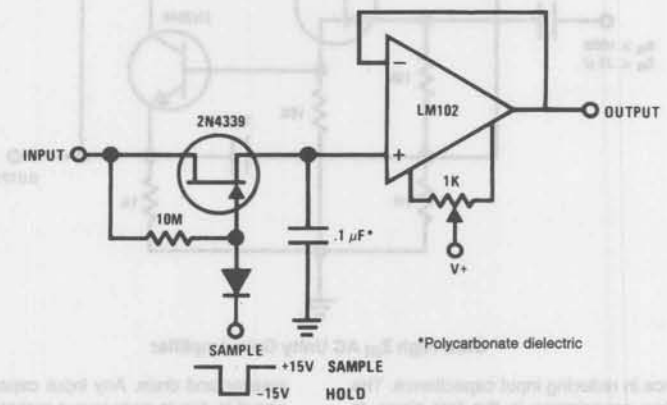
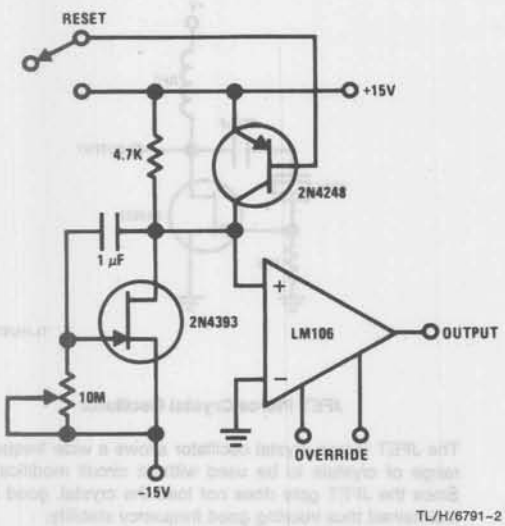
FET Circuit Applications

National Semiconductor
Application Note 32



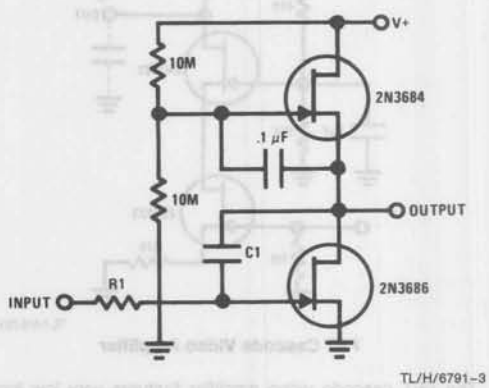
Sample and Hold With Offset Adjustment

The 2N4339 JFET was selected because of its low I_{GSS} (<100 pA), very-low $I_{D(OFF)}$ (<50 pA) and low pinchoff voltage. Leakages of this level put the burden of circuit performance on clean, solder-resin free, low leakage circuit layout.



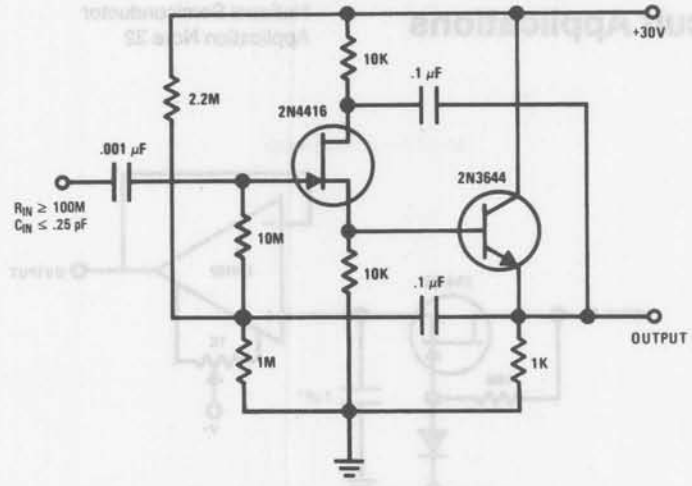
Long Time Comparator

The 2N4393 is operated as a Miller integrator. The high Y_{fs} of the 2N4393 (over 12,000 μmhos @ 5 mA) yields a stage gain of about 60. Since the equivalent capacitance looking into the gate is C times gain and the gate source resistance can be as high as 10 MΩ, time constants as long as a minute can be achieved.



JFET AC Coupled Integrator

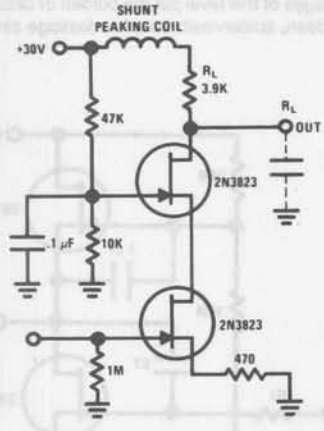
This circuit utilizes the "μ-amp" technique to achieve very high voltage gain. Using C_1 in the circuit as a Miller integrator, or capacitance multiplier, allows this simple circuit to handle very long time constants.



TL/H/6791–4

Ultra-High Z_{IN} AC Unity Gain Amplifier

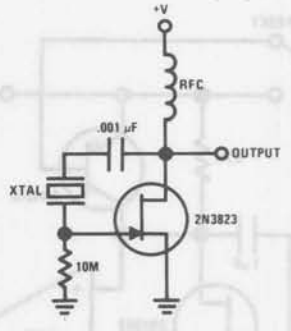
Nothing is left to chance in reducing input capacitance. The 2N4416, which has low capacitance in the first place, is operated as a source follower with bootstrapped gate bias resistor and drain. Any input capacitance you get with this circuit is due to poor layout techniques.



TL/H/6791–5

FET Cascode Video Amplifier

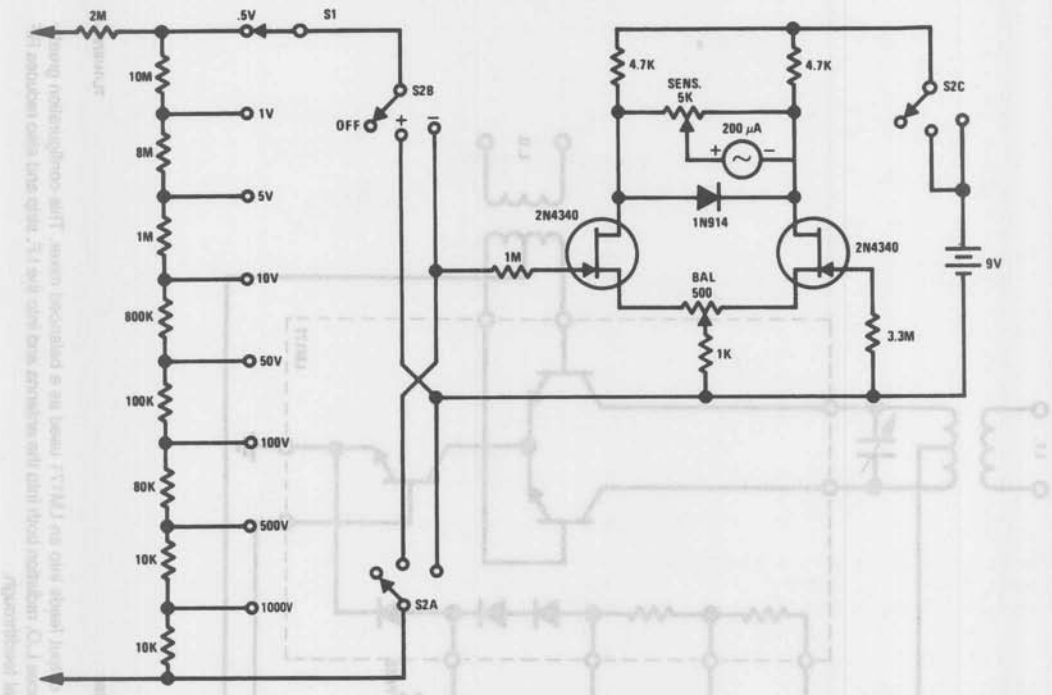
The FET cascode video amplifier features very low input loading and reduction of feedback to almost zero. The 2N3823 is used because of its low capacitance and high Y_{fs}. Bandwidth of this amplifier is limited by R_L and load capacitance.



TL/H/6791–6

JFET Pierce Crystal Oscillator

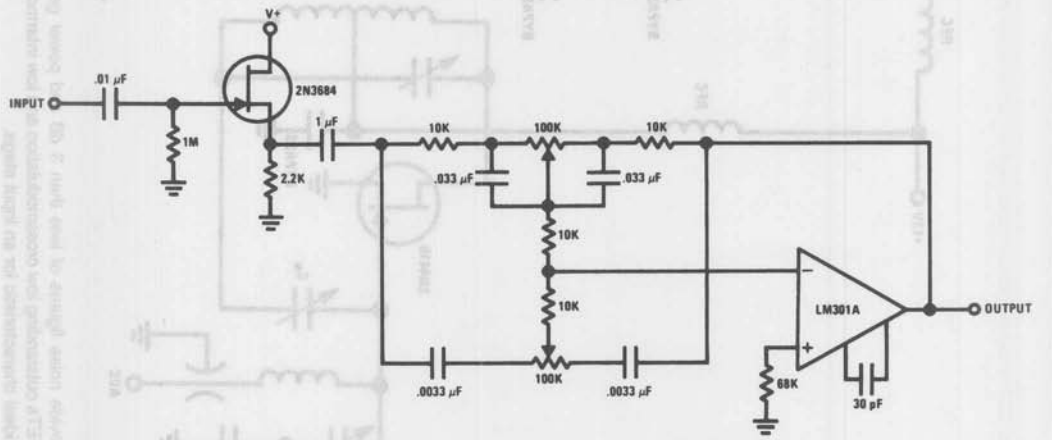
The JFET Pierce crystal oscillator allows a wide frequency range of crystals to be used without circuit modification. Since the JFET gate does not load the crystal, good Q is maintained thus insuring good frequency stability.



TL/H/6791–7

FETVM-FET Voltmeter

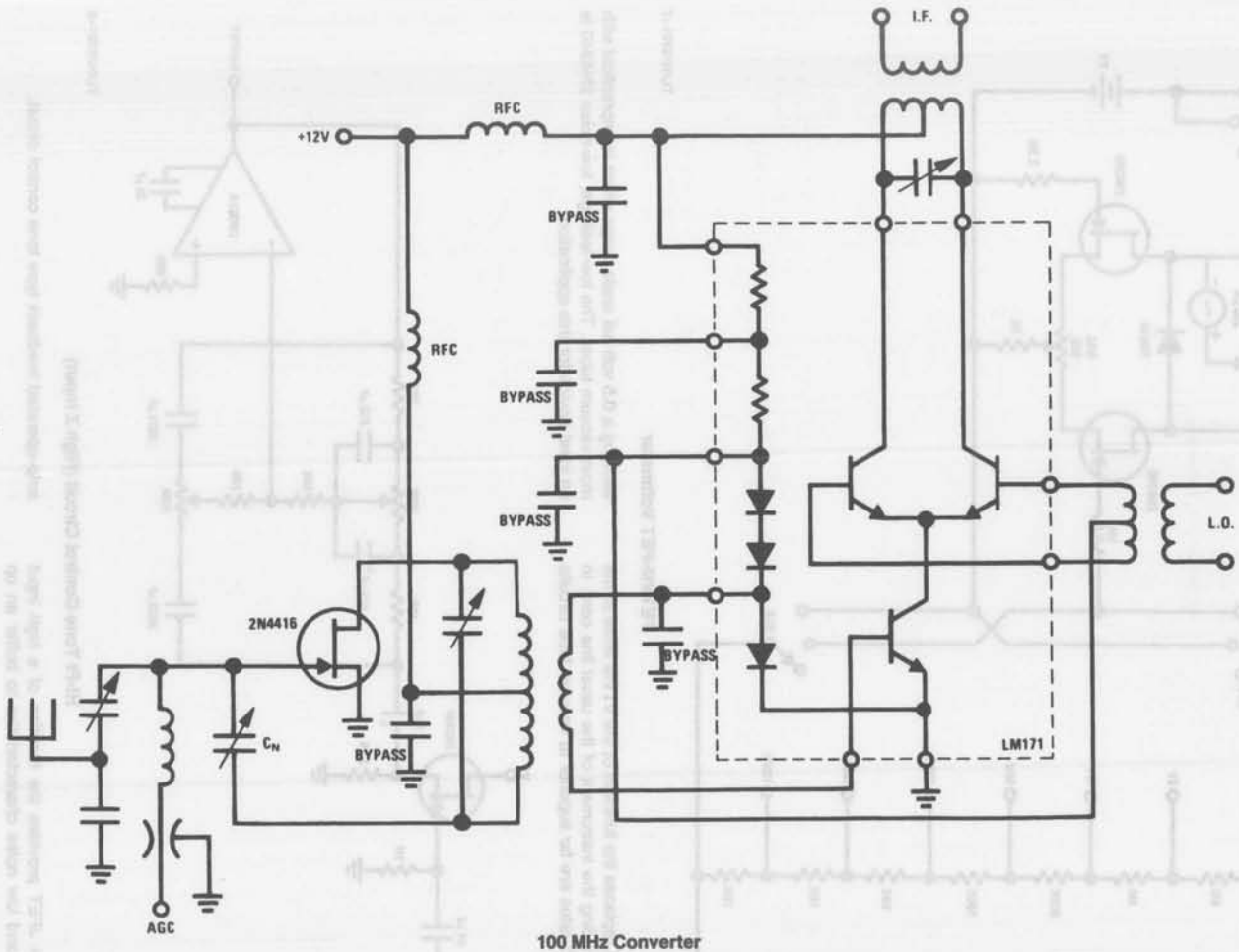
This FETVM replaces the function ot the VTVM while at the same time ridding the instrument of the usual line cord. In addition, drift rates are far superior to vacuum tube circuits allowing a 0.5 volt full scale range which is impractical with most vacuum tubes. The low-leakage, low-noise 2N4340 is an ideal device for this application.



TL/H/6791–8

HI-FI Tone Control Circuit (High Z Input)

The 2N3684 JFET provides the function of a high input impedance and low noise characteristics to buffer an op amp-operated feedback type tone control circuit.

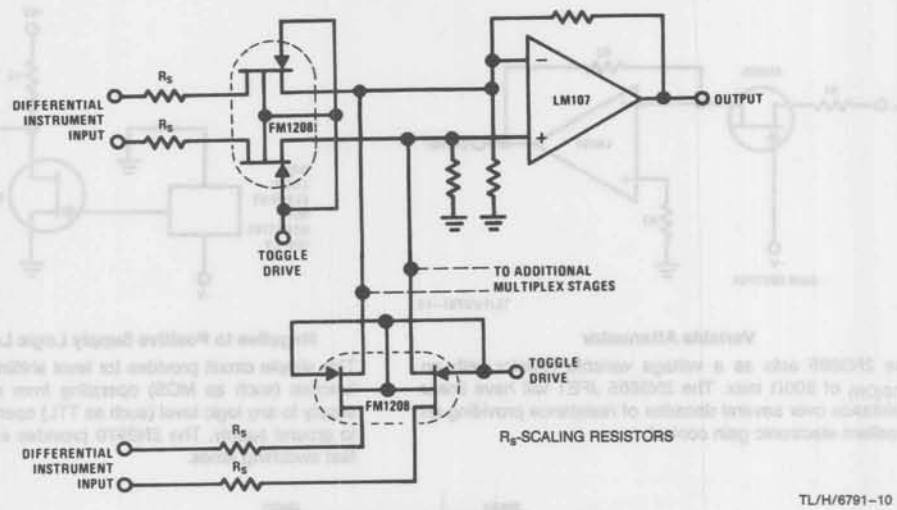


100 MHz Converter

TL/H/6791–9

The 2N4416 JFET will provide noise figures of less than 3 dB and power gain of greater than 20 dB. The JFETs outstanding low crossmodulation and low intermodulation distortion provides an ideal characteristic for an input stage.

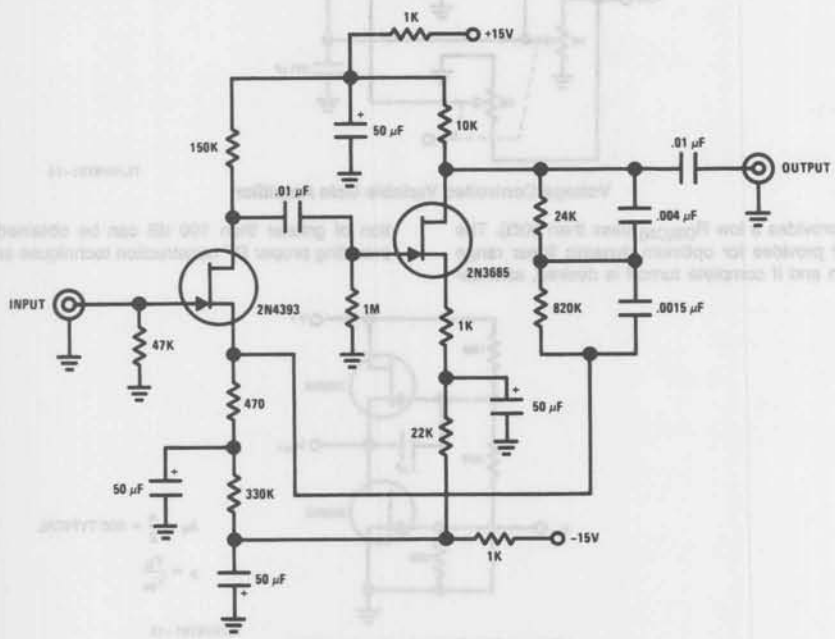
The output feeds into an LM171 used as a balanced mixer. This configuration greatly reduces L.O. radiation both into the antenna and into the I.F. strip and also reduces RF signal feedthrough.



TL/H/6791–10

Differential Analog Switch

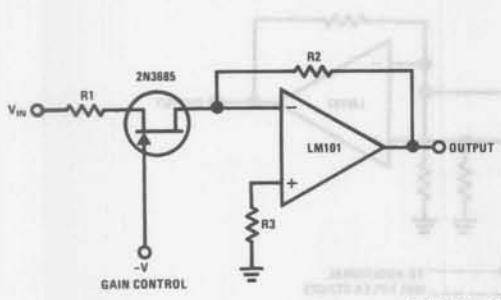
The FM1208 monolithic dual is used in a differential multiplexer application where $R_{DS(ON)}$ should be closely matched. Since $R_{DS(ON)}$ for the monolithic dual tracks at better than ±1% over wide temperature ranges (−25 to +125°C), this makes it an unusual but ideal choice for an accurate multiplexer. This close tracking greatly reduces errors due to common mode signals.



TL/H/6791–11

Magnetic-Pickup Phono Preamplifier

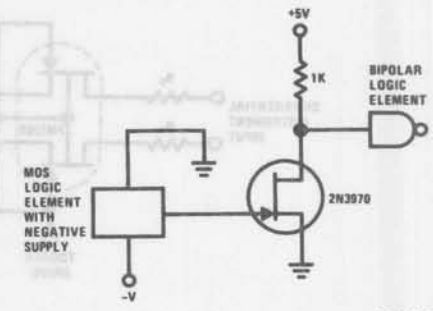
This preamplifier provides proper loading to a reluctance phono cartridge. It provides approximately 25 dB of gain at 1 kHz (2.2 mV input for 100 mV output), it features S + N/N ratio of better than −70 dB (referenced to 10 mV input at 1 kHz) and has a dynamic range of 84 dB (referenced to 1 kHz). The feedback provides for RIAA equalization.



TL/H/6791–12

Variable Attenuator

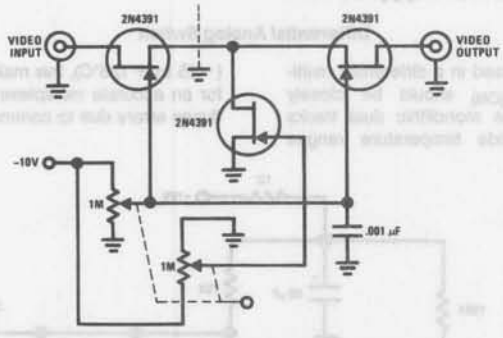
The 2N3685 acts as a voltage variable resistor with an $R_{DS(ON)}$ of 800Ω max. The 2N3685 JFET will have linear resistance over several decades of resistance providing an excellent electronic gain control.



TL/H/6791–13

Negative to Positive Supply Logic Level Shifter

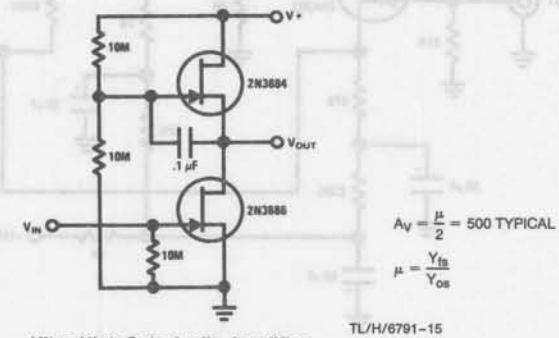
This simple circuit provides for level shifting from any logic function (such as MOS) operating from minus to ground supply to any logic level (such as TTL) operating from a plus to ground supply. The 2N3970 provides a low $r_{ds(ON)}$ and fast switching times.



TL/H/6791–14

Voltage Controlled Variable Gain Amplifier

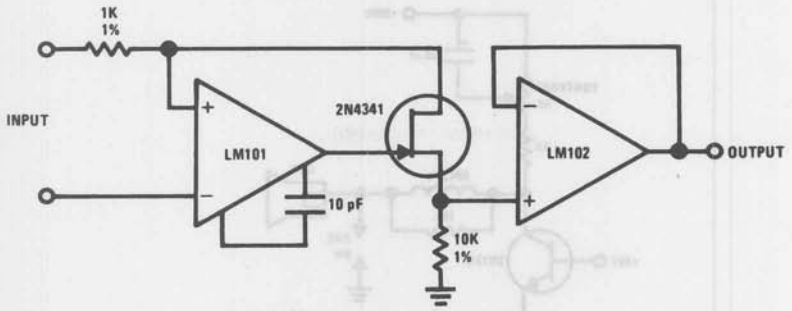
The 2N4391 provides a low $R_{DS(ON)}$ (less than 30Ω). The tee attenuator provides for optimum dynamic linear range for attenuation and if complete turnoff is desired, attenuation of greater than 100 dB can be obtained at 10 MHz providing proper RF construction techniques are employed.



TL/H/6791–15

Ultra-High Gain Audio Amplifier

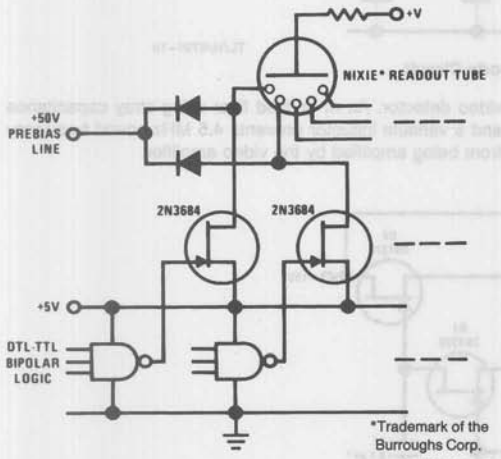
Sometimes called the "JFET" μ amp," this circuit provides a very low power, high gain amplifying function. Since μ of a JFET increases as drain current decreases, the lower drain current is, the more gain you get. You do sacrifice input dynamic range with increasing gain, however.



TL/H/6791–16

Level-Shifting-Isolation Amplifier

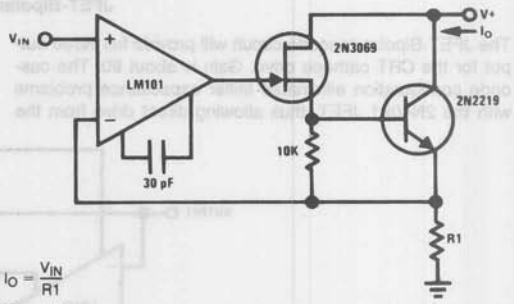
The 2N4341 JFET is used as a level shifter between two op amps operated at different power supply voltages. The JFET is ideally suited for this type of application because $I_D = I_S$.



TL/H/6791–17

FET Nixie* Drivers

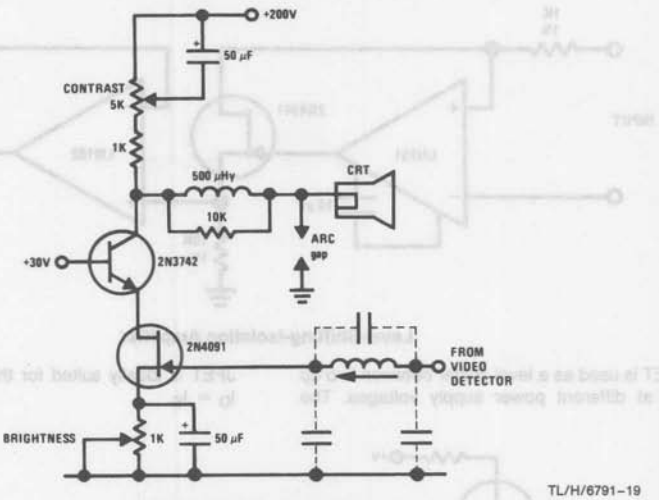
The 2N3684 JFETs are used as Nixie tube drivers. Their V_p of 2-5 volts ideally matches DTL-TTL logic levels. Diodes are used to a +50 volt prebias line to prevent breakdown of the JFETs. Since the 2N3684 is in a TO-72 (4 lead TO-18) package, none of the circuit voltages appear on the can. The JFET is immune to almost all of the failure mechanisms found in bipolar transistors used for this application.



TL/H/6791–18

Precision Current Sink

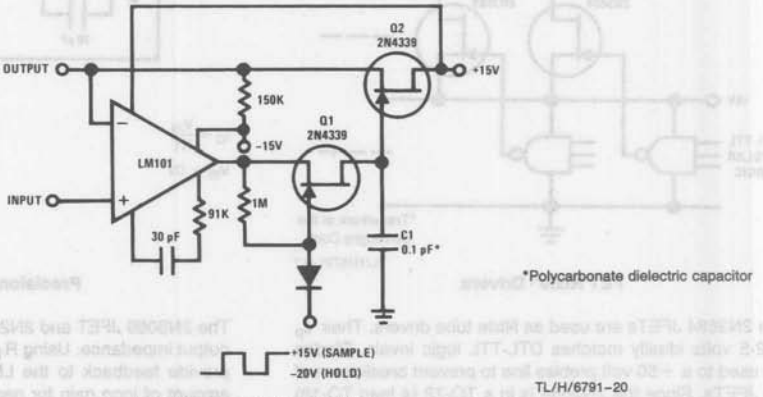
The 2N3069 JFET and 2N2219 bipolar have inherently high output impedance. Using R_1 as a current sensing resistor to provide feedback to the LM101 op amp provides a large amount of loop gain for negative feedback to enhance the true current sink nature of this circuit. For small current values, the 10k resistor and 2N2219 may be eliminated if the source of the JFET is connected to R_1.



TL/H/6791–19

JFET-Bipolar Cascode Circuit

The JFET-Bipolar cascode circuit will provide full video output for the CRT cathode drive. Gain is about 90. The cascode configuration eliminates Miller capacitance problems with the 2N4091 JFET, thus allowing direct drive from the video detector. An m derived filter using stray capacitance and a variable inductor prevents 4.5 MHz sound frequency from being amplified by the video amplifier.

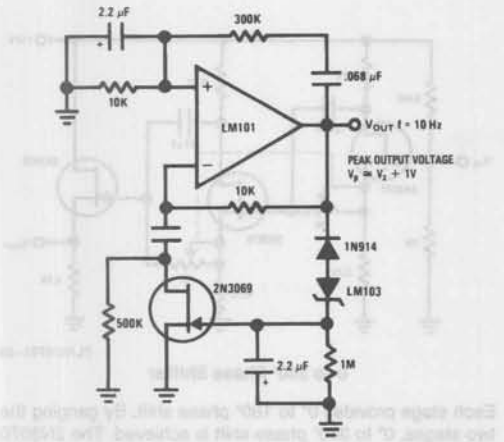


*Polycarbonate dielectric capacitor

TL/H/6791–20

Low Drift Sample and Hold

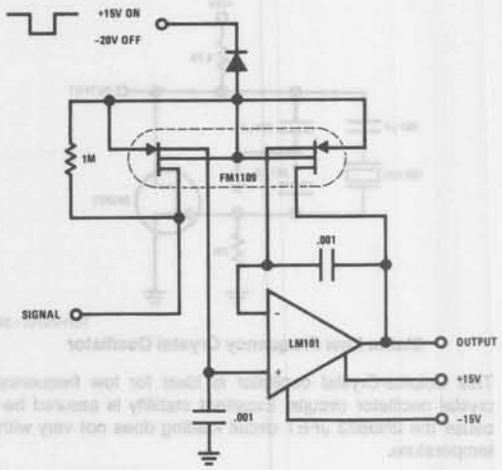
The JFETs, Q_1 and Q_2, provide complete buffering to C_1, the sample and hold capacitor. During sample, Q_1 is turned on and provides a path, $r_{ds(ON)}$, for charging C_1. During hold, Q_1 is turned off thus leaving Q_1 $I_{D(OFF)}$ (<50 pA) and Q_2 I_{GSS} (<100 pA) as the only discharge paths. Q_2 serves a buffering function so feedback to the LM101 and output current are supplied from its source.



TL/H/6791–21

Wein Bridge Sine Wave Oscillator

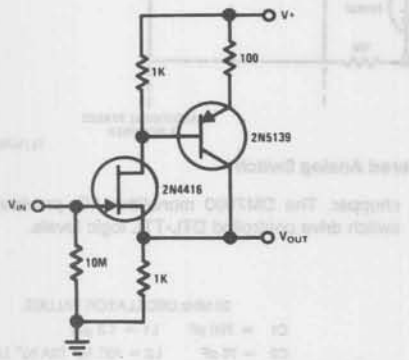
The major problem in producing a low distortion, constant amplitude sine wave is getting the amplifier loop gain just right. By using the 2N3069 JFET as a voltage variable resistor in the amplifier feedback loop, this can be easily achieved. The LM103 zener diode provides the voltage reference for the peak sine wave amplitude; this is rectified and fed to the gate of the 2N3069, thus varying its channel resistance and, hence, loop gain.



TL/H/6791–22

JFET Sample and Hold Circuit

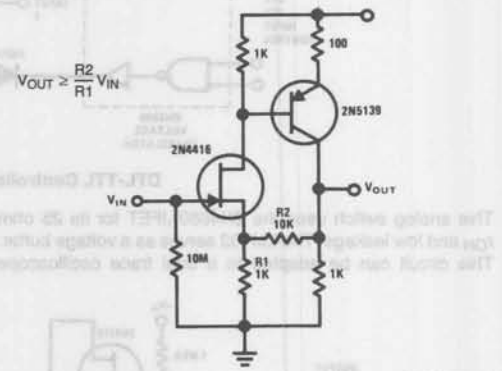
The logic voltage is applied simultaneously to the sample and hold JFETs. By matching input impedance and feedback resistance and capacitance, errors due to $r_{ds(ON)}$ of the JFETs is minimized. The inherent matched $r_{ds(ON)}$ and matched leakage currents of the FM1109 monolithic dual greatly improve circuit performance.



TL/H/6791–23

High Impedance Low Capacitance Wideband Buffer

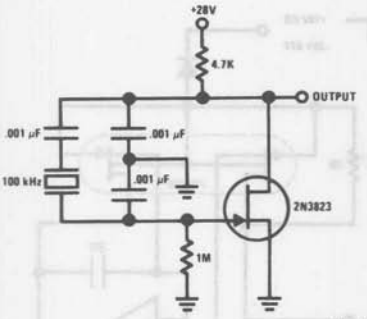
The 2N4416 features low input capacitance which makes this compound-series feedback buffer a wide-band unity gain amplifier.



TL/H/6791–24

High Impedance Low Capacitance Amplifier

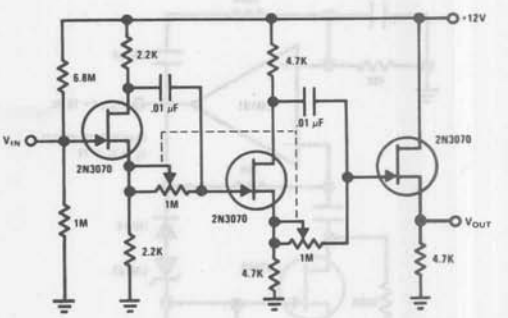
This compound series-feedback circuit provides high input impedance and stable, wide-band gain for general purpose video amplifier applications.



TL/H/6791–25

Stable Low Frequency Crystal Oscillator

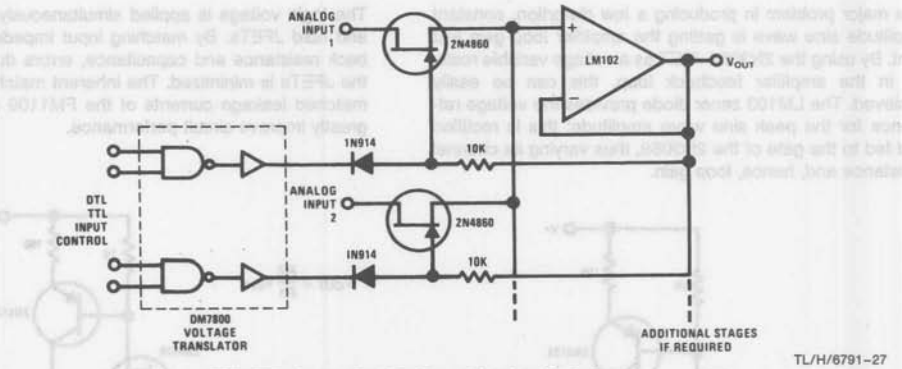
This Colpitts-Crystal oscillator is ideal for low frequency crystal oscillator circuits. Excellent stability is assured because the 2N3823 JFET circuit loading does not vary with temperature.



TL/H/6791–26

0 to 360° Phase Shifter

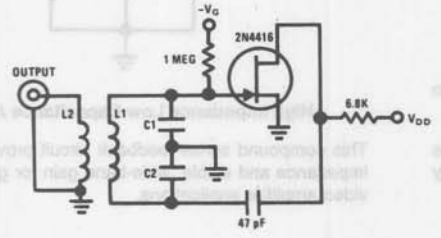
Each stage provides 0° to 180° phase shift. By ganging the two stages, 0° to 360° phase shift is achieved. The 2N3070 JFETs are ideal since they do not load the phase shift networks.



TL/H/6791–27

DTL-TTL Controlled Buffered Analog Switch

This analog switch uses the 2N4860 JFET for its 25 ohm r_{ON} and low leakage. The LM102 serves as a voltage buffer. This circuit can be adapted to a dual trace oscilloscope chopper. The DM7800 monolithic I.C. provides adequate switch drive controlled DTL-TTL logic levels.



20 MHz OSCILLATOR VALUES

C1 ≃ 700 pF L1 = 1.3 μH

C2 = 75 pF L2 = 10T 3/8" DIA 3/4" LONG

V_{DD} = 16V I_D = 1 mA

20 MHz OSCILLATOR PERFORMANCE

LOW DISTORTION 20 MHz OSC.

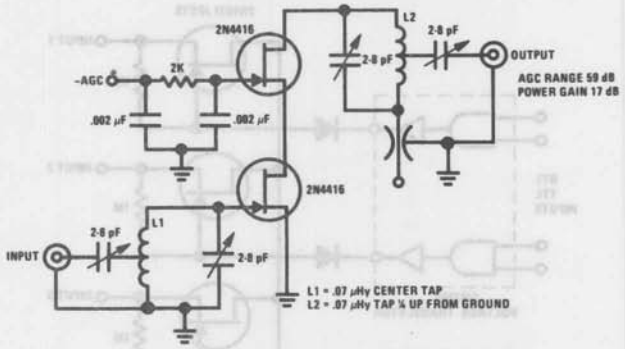
2ND HARMONIC −60 dB

3RD HARMONIC > −70 dB

TL/H/6791–28

Low Distortion Oscillator

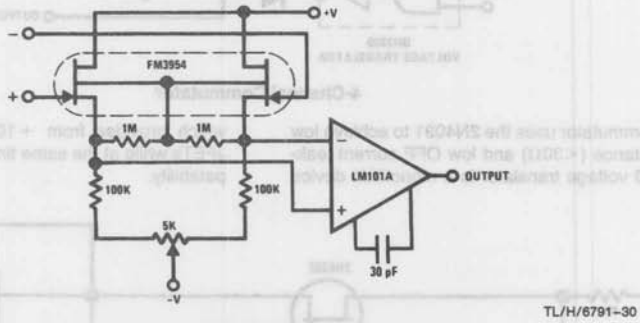
The 2N4416 JFET is capable of oscillating in a circuit where harmonic distortion is very low. The JFET local oscillator is excellent when a low harmonic content is required for a good mixer circuit.



TL/H/6791–29

200 MHz Cascode Amplifier

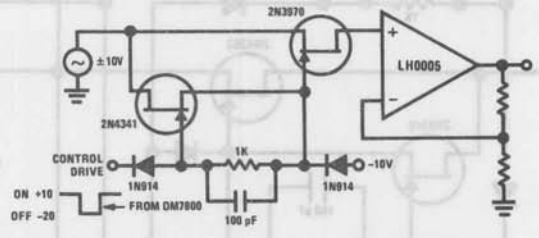
This 200 MHz JFET cascode circuit features low crossmodulation, large-signal handling ability, no neutralization, and AGC controlled by biasing the upper cascode JFET. The only special requirement of this circuit is that I_{DSS} of the upper unit must be greater than that of the lower unit.



TL/H/6791–30

FET Op Amp

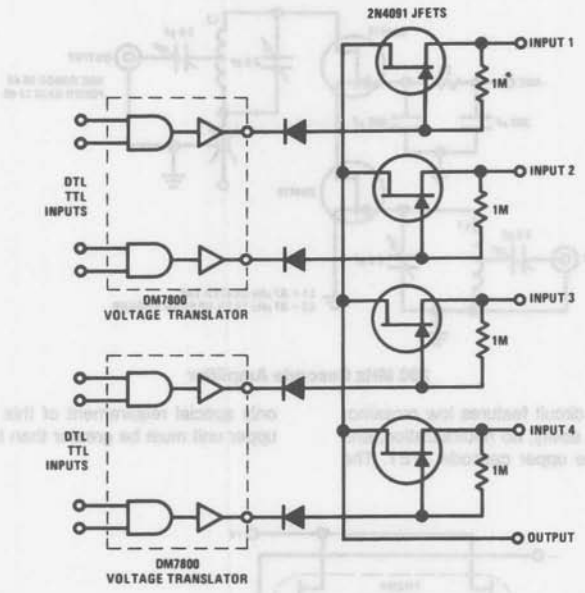
The FM3954 monolithic-dual provides an ideal low-offset, low-drift buffer function for the LM101A op amp. The excellent matching characteristics of the FM3954 track well over its bias current range thus improving common mode rejection.



TL/H/6791–31

High Toggle Rate High Frequency Analog Switch

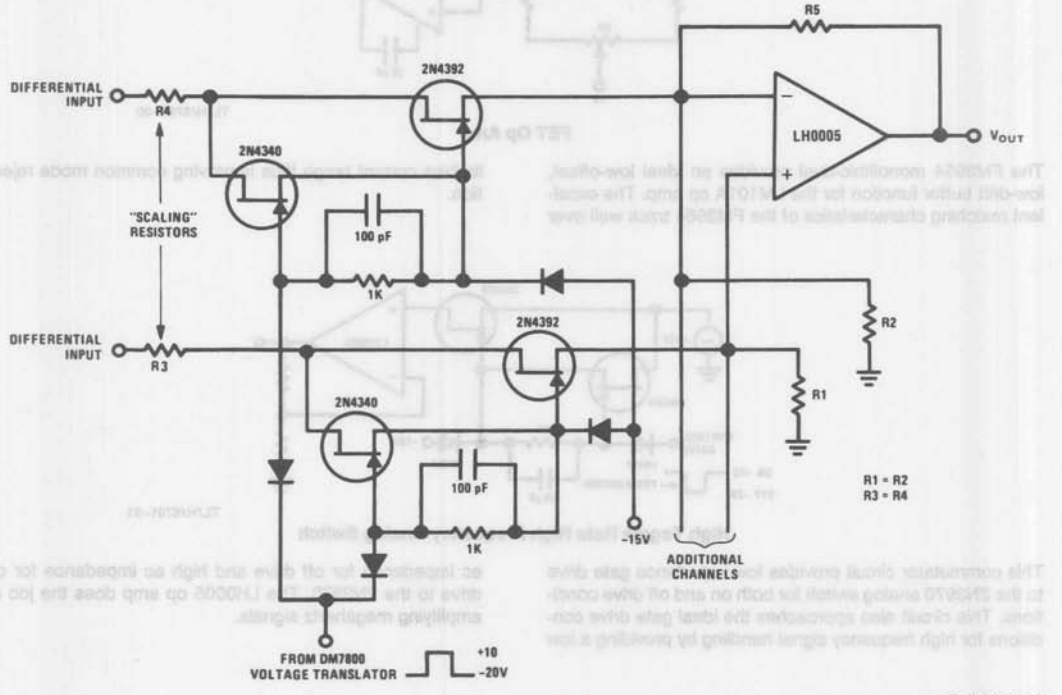
This commutator circuit provides low impedance gate drive to the 2N3970 analog switch for both on and off drive conditions. This circuit also approaches the ideal gate drive conditions for high frequency signal handling by providing a low ac impedance for off drive and high ac impedance for on drive to the 2N3970. The LH0005 op amp does the job of amplifying megahertz signals.



TL/H/6791–32

4-Channel Commutator

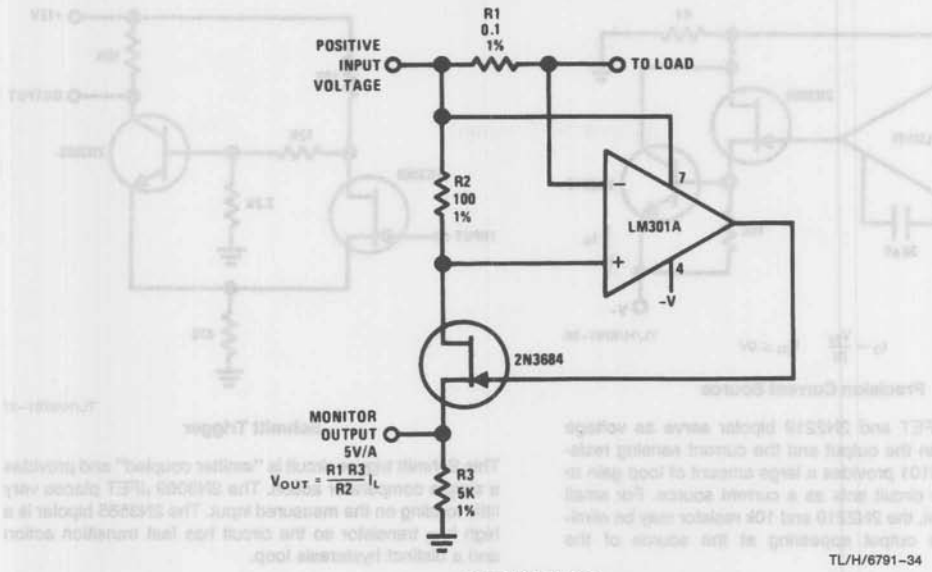
This 4-channel commutator uses the 2N4091 to achieve low channel ON resistance (<30Ω) and low OFF current leakage. The DM7800 voltage translator is a monolithic device which provides from +10V to −20V gate drive to the JFETs while at the same time providing DTL-TTL logic compatability.



TL/H/6791–33

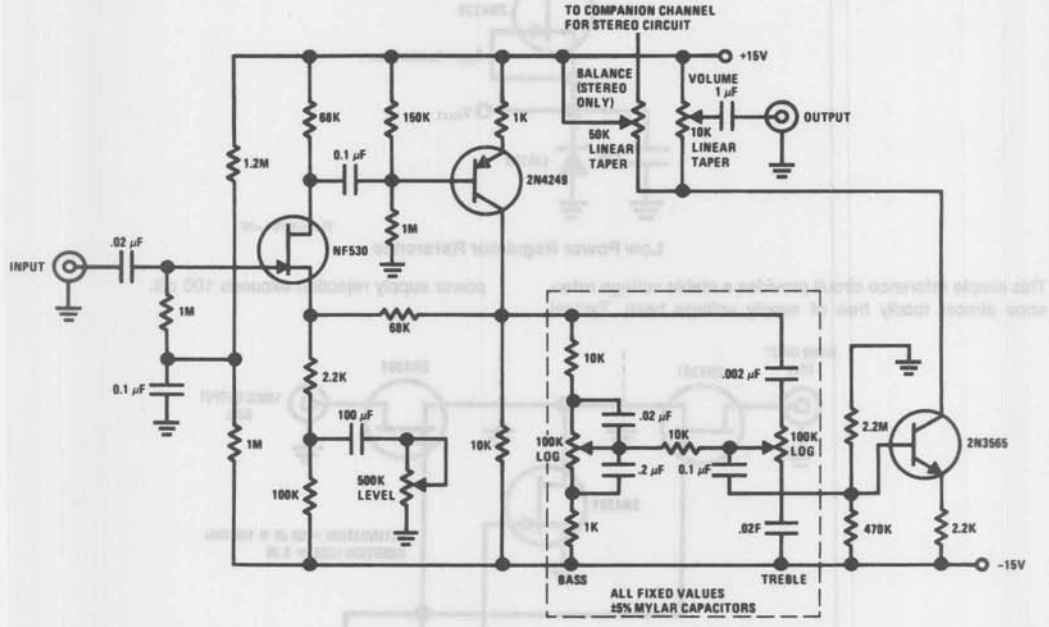
Wide Band Differential Multiplexer

This design allows high frequency signal handling and high toggle rates simultaneously. Toggle rates up to 1 MHz and MHz signals are possible with this circuit.



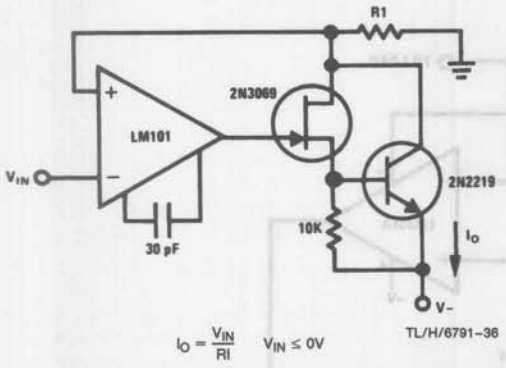
Current Monitor

R_1 senses current flow of a power supply. The JFET is used as a buffer because $I_D = I_S$, therefore the output monitor voltage accurately reflects the power supply current flow.



Low Cost High Level Preamp and Tone Control Circuit

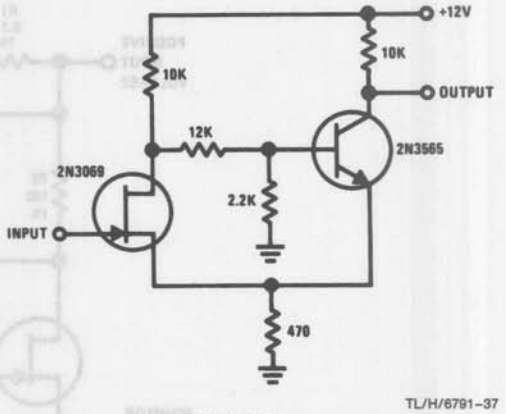
This preamp and tone control uses the JFET to its best advantage; as a low noise high input impedance device. All device parameters are non-critical yet the circuit achieves harmonic distortion levels of less than 0.05% with a S/N ratio of over 85 dB. The tone controls allow 18 dB of cut and boost; the amplifier has a 1 volt output for 100 mV input at maximum level.



$$I_O = \frac{V_{IN}}{RI} \quad V_{IN} \leq 0V$$

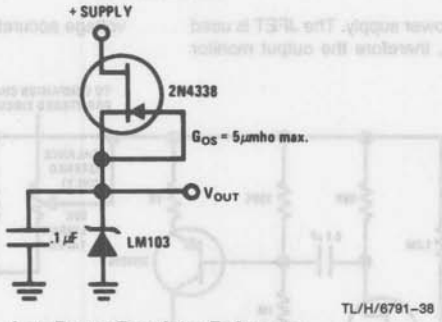
Precision Current Source

The 2N3069 JFET and 2N2219 bipolar serve as voltage devices between the output and the current sensing resistor, R_1. The LM101 provides a large amount of loop gain to assure that the circuit acts as a current source. For small values of current, the 2N2219 and 10k resistor may be eliminated with the output appearing at the source of the 2N3069.



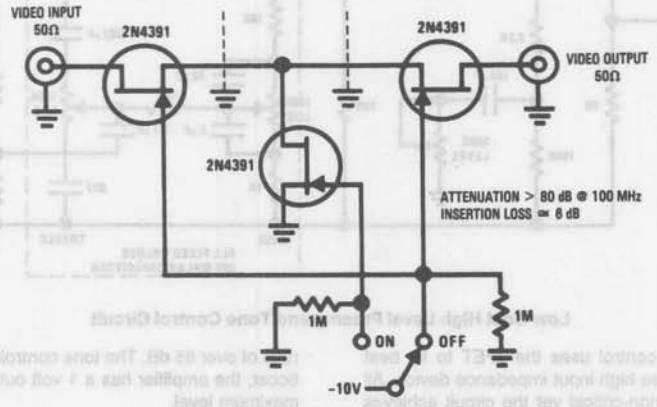
Schmitt Trigger

This Schmitt trigger circuit is "emitter coupled" and provides a simple comparator action. The 2N3069 JFET places very little loading on the measured input. The 2N3565 bipolar is a high h_{FE} transistor so the circuit has fast transition action and a distinct hysteresis loop.



Low Power Regulator Reference

This simple reference circuit provides a stable voltage reference almost totally free of supply voltage hash. Typical power supply rejection exceeds 100 dB.



High Frequency Switch

The 2N4391 provides a low on-resistance of 30 ohms and a high off-impedance (<0.2 pF) when off. With proper layout and an "ideal" switch, the performance stated above can be readily achieved.