MOTOROLA
# HEP®
Semiconductors

# TIPS ON USING IC's



- IC Cross-Reference Guide
- Eight IC Project Circuits
- Tips on Using IC's

## 8 PROJECTS

Build These 8 Projects Plus Many Other Published Projects

With These Prime Quality, Low Cost IC's.

- One J-K Flip Flop
- One 4-Input Gate
- One Dual Buffer
- Two Dual 2-Input Gates

Complete Schematic, Logic, and Characteristics are Included.

IC'S ARE HERE TO STAY AND THE NEXT FEW YEARS WILL SHOW A MASSIVE TRANSITION IN INDUSTRY AND CONSUMER PRODUCTS TO COMPLETE INTEGRATION.

Based on this assumption, this brochure has been prepared for the novice as well as professional user of Integrated Circuits (IC's). It includes tips on wiring, soldering, cross referencing, and eight simple projects using the IC's contained in the Motorola HEP HEK-1 kit.

A lengthy discussion of IC construction will not be covered in detail, as this information can be found in many IC textbooks. However, in order to be better able to know the advantages and limitations of these microcircuits, the reader should know what is contained in the basic IC and how these devices differ from other solid state components.

As the name implies, an Integrated Circuit is a collection of many different components. The quantity and types of components vary from one IC configuration to another. A particular IC could contain ACTIVE components (transistors, diodes) and PASSIVE components (resistors, capacitors). If all the components of the circuit are contained on the same "CHIP" or substrate, the unit is said to be "MONOLITHIC" (single crystal). The monolithic type is the most common and the least expensive to build. Other construction types are: thin film, thick film, hybrid, multi-chip. A discussion of these types can be found in almost any book that deals with the subject of IC's.

As an illustration of the extreme size reduction possible with Integrated Circuits, consider the new Motorola 4-bit memory core, which contains 524 different components on a chip 50 mils x 70 mils. The average IC is much smaller, usually 40 mils square (1 mil = .001"). As the above example indicates, the race is on to see how much circuitry can be crowded into the smallest space. This effort is known in the trade as LSI (large scale integration). Manufacturers are already starting to produce IC's that contain FETS, tuning diodes, and even power transistors!

It is unfortunate, but many people are resisting the change-over from discrete (individual) components to IC's. This resistance could largely be due to the fact that people tend to shy away from circuits they are not familiar with.

The advantages of IC's over discrete components greatly outweigh the disadvantages. Size and weight reduction are obvious advantages but cost savings should also be considered. Refer to the schematic of the HEP 583, which contains 21 transistors and 27 resistors. If you had to buy all these parts individually and build this unit using a breadboard or printed circuit board you would indeed feel the pinch on both your pocketbook and your time. Other disadvantages that are not so obvious are as follows:

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7165 PRINTED IN USA 8-72 IMPERIAL LITHO B31134

**REPETITION:** If you need a circuit containing twenty J-K flip flops, it would be a difficult task to build 20 of these, each containing 21 transistors and 27 resistors. This adds up to 420 transistors and 540 resistors! With IC's, only 20 TO-5 packages are necessary. Here is where cost, size, and time advantages come through again.

**REPEATABILITY:** Because of the way IC's are constructed with components located in close proximity to each other, tolerances are much finer and parts are better matched, thus making up a device that functions as a complete unit. Power drain is lowered, there is less spurious noise pick-up, and there is less noise generated within the unit.

**RELIABILITY:** Many manufacturers are turning to IC's because of their high reliability. Devices built under almost clinical conditions are bound to be better than a circuit built on a work bench. Referring to an example given previously, consider that building the electrical equivalent to the HEP 583, using the 21 transistors and 27 resistors, it would be necessary to make 80 to 90 solder connections, a real source for potential trouble.

In addition to the advantages listed, replacement is simple. Schematics are easy to read, especially for the beginner. Areas yet to be conquered in the construction of IC's are: How to build inductors, large value capacitors, and high value resistance on an IC chip. It is presently necessary to connect these components externally.

## GROUPS and SUBGROUPS

Broadly speaking, IC's can be divided into two categories, DIGITAL and LINEAR. IC's were born out of research for the space program where, for many years, their application was strictly in the field of DIGITAL work. ie, small computers on space craft where weight and power reductions were essential. Only in the last few years has the linear IC begun to blossom.

Table I shows some of the sub-groups to be found in IC's. The applications listed in Table I will be discussed later.

To further complicate matters, DIGITAL IC's are classified into logic families. The families and their construction are shown in table II.

TABLE I

| LINEAR | DIGITAL |
|---|---|
| Differential Amps | Adders |
| Power Amps | Drivers |
| Audio Amps | Gates |
| Video Amps | Expanders |
| RF/IF Amps | Buffers |
| Operational Amps | Inverters |
| Sense Amps | Flip Flops |

TABLE II

| | |
|---|---|
| RTL | Resistor Transistor Logic |
| mW RTL | Low Power Resistor Transistor Logic |
| DTL | Diode Transistor Logic |
| VTL | Variable Threshold Logic |
| HTL | High Threshold Logic |
| ECL | Emitter Coupled Logic, also called Current Mode Logic |
| TTL | Transistor Transistor Logic — more than one emitter to device. |

(NOTE: that VTL and HTL are forms of DTL)

Table III shows the familiar characteristics of each line. Motorola manufactures complete lines in each family listed. To signify Motorola, you may see RTL written as MRTL, ECL as MECL, etc. A quick glance at Table III will show that no one logic family has a clearcut advantage over any other family. For example, ECL is high frequency and internal noise immunity, where mW RTL has low power dissipation, etc.

TABLE III

| Logic | Form | Delay Time | Freq. of Flip Flop (mHZ) | Power Dissipation (MW) | Noise Internal | Immunity Noise Ext |
|---|---|---|---|---|---|---|
| RTL | $R_T$ | 24 | 8 | 12 | Fair | Fair |
| mW RTL | $R_T$ | 45 | 1 - 3 | 2.5 | Fair | Fair |
| DTL | $D_T$ | 30 | 10 | 9 | Fair | Good |
| VTL | $D_T$ | 50 - 60 | 1 | 12 - 80 | Good | Excellent |
| ECL | Current Mode | 6 | 30 | 35 | Excellent | Fair |
| $T^2T$ | $T_T$ | 10 | 20 | 15 | Good | Good |
| HTL | $D_T$ | 200 | 3 | 45 | Good | Excellent |

# MOUNTING IC's AND BREADBOARDING TECHNIQUES

IC's can be mounted on perforated board or printed circuit board by either soldering to terminals or by using sockets. Sockets are definitely recommended, especially for the hobbyist who will, generally, use the IC over and over in different applications. Constant soldering and unsoldering of the leads weaken them and could cause the wires to be broken, or internal damage could result due to excessive heat from the solder iron.

The HEP 580 thru 583 (devices included in this IC kit) are mW RTL's. This logic family is considered the easiest for the hobbist, experimenter, and IC novice to "cut their teeth" on.

The HEP 584, 570, 571, 572 are RTL's— also a good family for the beginner. The HEP 553, 554, 556, 558 are ECL's, — not the easiest to work with, but the best logic family for high frequency and noise rejection.

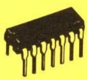
# IC PACKAGING

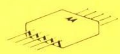
Integrated circuits can be found in a variety of packages. At the present time, there are more than 120 case types made by some 70 companies around the world. Of these many case styles, three types are dominent. (In terms of quantity of devices on the market, in a given case type, about 90% of their quantity can be found in some variation of one of these three case types). As yet, no definite standardization has been set up among the manufacturers regarding packaging, pin numbers, and locations, so carefully check the basing before you plug that IC into the socket.

USE A LOW WATTAGE SOLDERING IRON! 25 to 40 watts is a good range. Excess head could "kill" the IC.

KEEP COMPONENT LEADS SHORT! Excess lead length could cause spurious or parasitic oscillations or no operation at all.

If you are using a power supply, (other than a battery), it is a good idea to "bypass" the power leads. That is, connect a .05 or .1 mfd capacitor from the power input to ground at or near the input terminal of the IC.


TO-116


TO-91


TO-99 (8 PIN)
TO-100 (10 PIN)

# POWER SUPPLIES

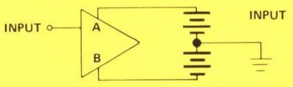
For projects using 1 or 2 IC's — batteries are usually the best supply. On larger projects, an a-c supply is better.

The power supply requirements for the various logic functions have been standardized and are, in general, as follows:

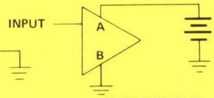
| | |
|---|---|
| RTL | 3V ± 10% (2.6 to 3.3V) and 3.6 ± 10% (3.24 to 3.96V) |
| mW RTL | 3V ± 10% (2.6 to 3.3V) and 3.6 ± 10% (3.24 to 3.96V) |
| DTL | 4V ± 10% (3.6 to 4.4V) |
| MDTL | 5V ± 10% (4.5 - 5.5V) |
| VTL | ± 4V to ±10V (8 - 20V) |
| ECL | 5.2V ±20% (4.16 - 6.24V) |
| TTL | 5V ±10% (4.5 - 5.5V) |
| HTL | 18V |

Obviously batteries in some of these odd voltage ranges are not available, however, experimentation has shown that on some lines the manufacturers are being much too conservative. For example in the HEP-580 series, many of the devices were found to work well from 1.5 to 12 volts! *Very few* did not — but after all, they are only rated from 2.6 to 4 volts (approximately). This makes it possible to use many of these IC's over a wide voltage range. Usually an IC rated at 3.2 volts minimum works well on 3 volts and one rated at 5.5 volts maximum, works at 6 volts.

IC's can be connected in one of two ways, using one or two supplies. The dual or split supply is most common in linear circuits. (See follow example:)



SPLIT SUPPLY

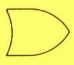


SINGLE SUPPLY

There are some applications where the split or dual supply is advantageous but generally it involves more complicated circuitry.

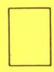
The novice in IC's is likely to be a novice in the area of computer logic also. The logic symbols are to digital IC's what schematic symbols are to resistors, capacitors, etc.

Some of the more common types are shown below:


OR GATE


AND GATE

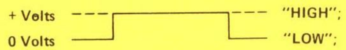

AMPLIFIER


FLIP-FLOP

These symbols have recently been standardized by the government. Prior to that time, each manufacturer had his own set of symbols.

Most computers work on the binary principle. Binary stands for "two" — two states or conditions, which are either ON or OFF, (HIGH or LOW).

Consider the condition where we have zero or near zero volts at the input to a gate, flip-flop, amplifier, etc; it is an OFF condition. If this voltage goes positive, let's say, to 1 or 2 volts it is now in an ON condition. There are two types of logic: Positive and negative. See below:




| POSITIVE LOGIC | NEGATIVE LOGIC |
|---|---|
| "ON", "1", "A"; | "OFF", "O", "$\overline{A}$" |
| "OFF", "O" "$\overline{A}$" | "ON", "1", "A" |

The common function in digital IC's are:

GATES – control the passage of signals.

BUFFERS (AMPLIFIERS) (DRIVERS) amplify power of signals to be able to drive more units.

INVERTERS – reverses the logic from + to – or – to +

EXPANDERS – affords additional inputs to a gate, example: allows 3-input gate to be converted to a 7-input gate.

ADDERS – provides the SUM and CARRY operations on two input signals.

SHIFT REGISTERS – provide bistable storage.

FLIP-FLOPS – Provides division or COUNT. One Flip-Flop divides by 2, provides 1 change in state output for 2 changes in state input.

From the standpoint of the hobbyist, only 3 functions are of interest; the Gate, the Amplifier, and the Flip-Flop.

## GATES

This function comes in a wide variety of configurations. There are 2, 3, 4, or more inputs and 4 categories as follows:

AND: when all inputs go to "1" output will go to "1"

NAND: output will be "1" except when all inputs go to "1"

OR: when any input goes to "1" output will be "1"

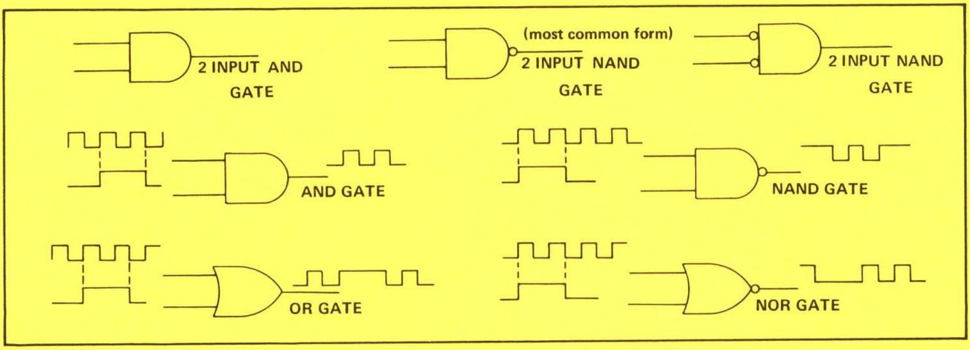
NOR: output will be "1" except when any input goes to "1"

*NAND* and *NOR* differ from *AND* and *OR* in that inversion has taken place. Refer to the following illustrations. (Note the small o at the input or output of some of the examples. This o indicates that inversion has taken place).

Gates can be connected to operate in a wide variety of applications other than those for which they were designed. Some applications are:

Free – running (astable) multivibrator; bistable (flip-flop); "One Shot" multivibrator; amplifier, dc and ac; audio mixers.

Occasionally the time arises when the hobbyist-experimenter needs something in the way of gates other than what he has or what is available. For example, you need a 3-input gate and you have a 4-input gate; simply ground one input. Ground two inputs to obtain a 2-input gate. If you have a dual 2-input gate, such as the HEP-580, and you need a 4-input gate, tie pins 6 and 7 together and this becomes the output; inputs are then on pins 1, 2, 3, and 5.

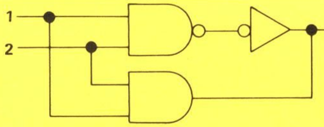



## AMPLIFIER

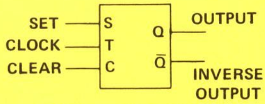
In ditigal work it is referred to as a Buffer. Its original use is to increase "fan-in" or "fan-out" capability. That is, the number of other units than can be connected in parallel to the input (fan-in) or output (fan-out). By adding proper external biasing it is possible to connect this unit to LINEAR (audio-RF) usage.

## FLIP-FLOP

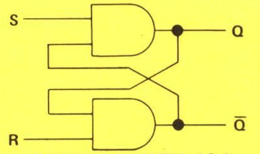
There are a number of types of flip-flops available. As mentioned previously, a flip-flop (multivibrator) can be "made up" by cross connecting two gates. The R-S Flip-Flop is one example. The J-K Flip-Flop is similar but has the added function known as "clock input" shown as "T" on the logic block.




TYPICAL BUFFER WITH GATED INPUT



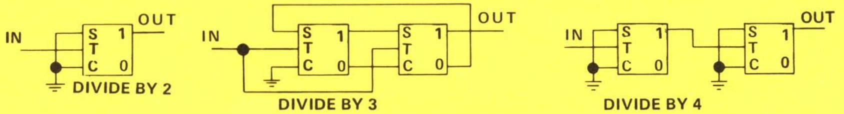

TYPICAL J-K FLIP-FLOP

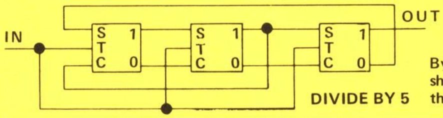



GATES CONNECTED AS A BISTABLE FLIP-FLOP

Fundamentally, flip-flops divide by two. By proper connection, division by 3,4,5 etc. can be obtained, using a few IC's as follows:

## LOGIC DIAGRAMS

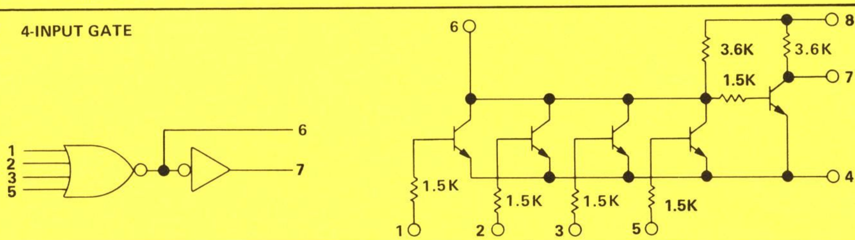


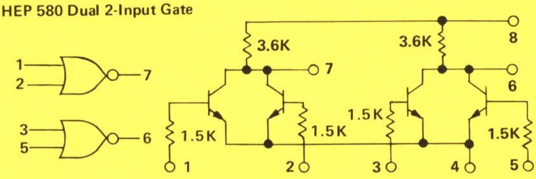

By connecting J-K Flip-Flops (HEP 583) as shown it is possible to "DIVIDE BY" something other than 2.

Schematic and logic diagrams of the HEP IC's that are contained in the HEK-1 Experimenters Kit and are used in the projects of this brochure are shown in the following illustrations:

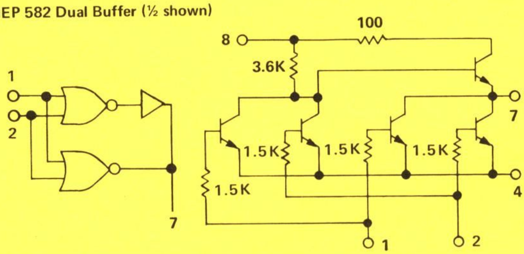
HEP 581 4-INPUT GATE

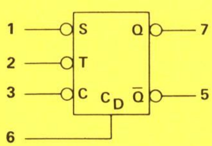



HEP 580 Dual 2-Input Gate

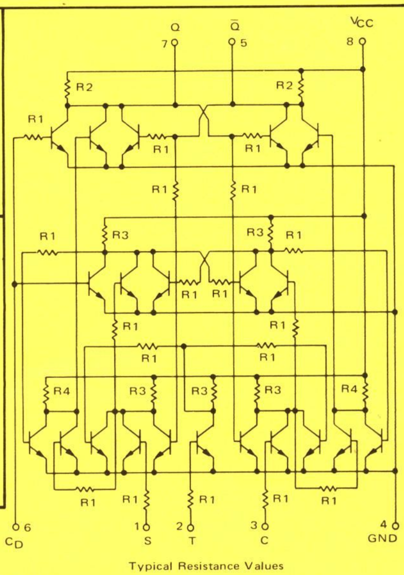



HEP 582 Dual Buffer (½ shown)



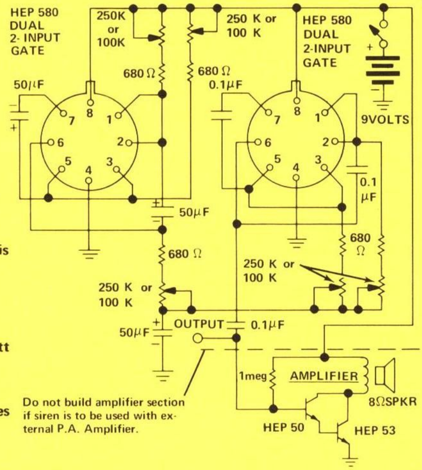

HEP 583 J-K Flip-Flop




Typical Resistance Values

R1 = 1.5k
R2 = 3.6k
R3 = 4.5k
R4 = 7.2k

# CKT. 1. ELECTRONIC SIREN




**USES:**
Burglar and intrusion alarms, automotive thefts and tamper alarms, toy sirens for bicycles.

**FEATURES:**
By slight changes in pot. setting — a wide variety of siren sounds can be obtained.

**PARTS LIST:**
**Siren**
- 2 HEP 580 Dual 2-Input Gates
- 5 680 Ω Resistors ¼ or ½ watt 10%
- 5 250 K or 100 K Potentiometers (trimmers)
- 2 50 µF Capacitors Electrolytic 10 Volts (or higher)
- 3 0.1 µF Capacitors, Disc Ceramic
- 1 ON-OFF Switch
- 9 Volt Battery (transistor radio)

**Output Jack (if external amp is used)**
- 2 HEP 454 IC Sockets
- Vector Board and Terminals

**AMPLIFIER**
- 1 1 meg Resistor ¼ or ½ watt 10%
- 1 HEP 50 NPN Transistor
- 1 HEP 53 NPN Transistor
- 1 8 Ω Speaker 1½ to 2½ inches diameter
- 2 Transistor Sockets

# LINEAR IC'S

Linear IC's must be of particular interest to the TV-radio repair technician. Broadly speaking they are all amplifiers, the specific difference being in the power output, impedances, etc. For example, the HEP 592 is a complete stereo pre-amp, the only thing required externally being the potentiometers. The HEP 590 can operate as an RF or IF stage. Experimentation with linear IC's is very straight forward and many circuits have been published that lend themselves very well to the HEP 590, 591, 592 and 593 devices.

## IC CROSS REFERENCE FOR HOBBYIST EXPERIMENTERS

| Type to be Replaced | See Note | HEP Replacement | Type to be Replaced | See Note | HEP Replacement | Type to be Replaced | See Note | HEP Replacement |
|---|---|---|---|---|---|---|---|---|
| CA3002 | | 590 | MC811F | 2 | 581 | SW303T | | 553 |
| CA3003 | | 590 | MC814G | | 584 | SW304F | 2 | 554 |
| CA3004 | | 590 | MC814F | 2 | 584 | SW304T | | 554 |
| CA3013 | | 591 | MC817P | 1 | 570 | SW306F | 2 | 556 |
| CA3014 | | 591 | MC824P | 1 | 570 | SW306T | | 556 |
| MC303G | | 553 | MC876P | 1 | 572 | SW308F | 2 | 558 |
| MC303F | 2 | 553 | MC881G | 1 | 582 | SW308T | | 558 |
| MC304G | | 554 | MC882G | 1 | 583 | SW353F | 2 | 553 |
| MC304F | 2 | 554 | MC890P | 1 | 572 | SW353T | | 553 |
| MC306G | | 556 | MC899P | 1 | 571 | SW354F | 2 | 554 |
| MC306F | 2 | 556 | MC910G | 1 | 580 | SW354T | | 554 |
| MC308G | | 558 | MC910F | 1, 2 | 580 | SW356F | 2 | 556 |
| MC308F | 2 | 558 | MC911G | 1 | 581 | SW356T | | 556 |
| MC353G | | 553 | MC911F | 1, 2 | 581 | SW358F | 2 | 558 |
| MC353F | 2 | 553 | MC914G | 1 | 584 | SW358T | | 558 |
| MC354F | | 554 | MC914F | 2 | 584 | U3F991129X | 2 | 581 |
| MC354F | 2 | 554 | MC981G | 1 | 582 | U3F991421X | 2 | 584 |
| MC356G | | 556 | MC982G | 1 | 583 | U3F991422X | 2 | 584 |
| MC356F | 2 | 556 | MC1302G | | 592 | U5B991021X | | 580 |
| MC358G | | 558 | MC1302P | 2 | 592 | U5B991029X | | 580 |
| MC358F | 2 | 558 | MC1303P | 2,3 | 592 | U5B991129X | | 581 |
| MC710G | | 580 | MC1314G | | 591 | U5B991421X | | 584 |
| MC710F | 2 | 580 | MC1550G | | 590 | U5B991422X | | 584 |
| MC711G | | 581 | MC1554G | | 593 | U5B991429X | | 584 |
| MC711F | 2 | 581 | PA713 | | 590 | U5B992329X | 4 | 572 |
| MC714G | | 584 | PA7601 | | 590 | U5B992329X | 3 | 583 |
| MC714F | 2 | 584 | PL990029 | 4 | 571 | U5F991121X | 2 | 581 |
| MC717P | 3 | 570 | PL991021 | 1 | 580 | U5B770339X | | 590 |
| MC724P | | 570 | PL991029 | | 580 | U5D990029X | 4 | 571 |
| MC776P | 3 | 572 | PL991129 | | 581 | U5D990029X | 3 | 582 |
| MC781G | | 582 | PL991429 | | 584 | WM1146T | | 590 |
| MC782G | | 583 | PL992329 | 4 | 572 | µL900 | 4 | 571 |
| MC790P | | 572 | PL992329 | 3 | 583 | µL911 | 3 | 581 |
| MC799P | | 571 | SN17810L | 1 | 580 | µL914 | (4) | 584 (570) |
| MC810G | | 580 | SN17910L | 1 | 580 | µL923 | 4 | 572 |
| MC810F | 2 | 580 | SN17811L | 1 | 581 | | | |
| MC811G | | 581 | SW303F | 2 | 553 | | | |

Note 1: Temperature range is narrower.

Note 2: Case Difference

Note 3: Milliwatt vs Medium power may require slight circuit value variations to optomize performance.

Note 4: Plastic replaces 2 metal units (Case Difference)

## CKT. 2.

# SIGNAL INJECTOR

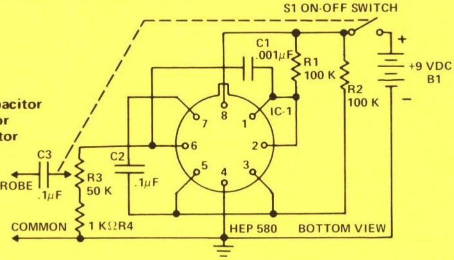
### AUDIO SIGNAL PROBE FOR SIGNAL INJECTION IN TESTING AM RECEIVERS OR AUDIO AMPLIFIERS

**SPECIFICATIONS:**
Output voltage variable 1 to 7 V peak-to-peak, 1300 cps tone. Battery drain at 9. Voc =5.5MA.

**PARTS LIST:**
1 IC-1 = HEP-580
1. HEP 454, IC socket
2. 100 K Ω ½ watt resistors ($R_1$ & $R_2$)
3. $R_3$ = 50 K Ω potentiometer s/switch linear taper (output control)
4. $C_1$ = .001 μF 25 V capacitor
5. $C_2$ = .1 μF 25 V capacitor
6. $C_3$ = .1 μF 600 V capacitor
7. $B_1$ = 9 V battery
8. $R_4$ = 1 K Ω ½ watt resistor

Misc = wire solder etc.

NOTE: Frequency of tone may be raised or lowered by lowering or raising the value of $C_1$.



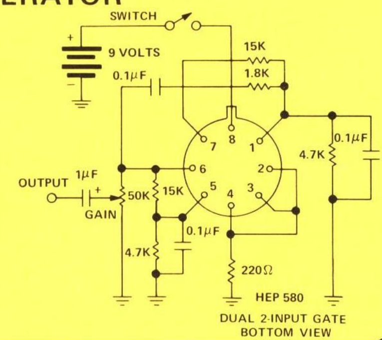

## CKT. 3.

# AUDIO SIGNAL GENERATOR

**USES:**
General Audio Testing

**FEATURES:**
Output Adjustable From 0 Volts to Approximately 2 Volts PK-PK. Sine Wave Output Fixed Frequency Approximately 1000 CPS.

**PARTS LIST:**
1 HEP 580 Dual 2-Input Gate
3 0.1 μF Capacitors Disc Ceramic
1 1 μF Capacitor Electrolytic 10 Volts (or higher)
2 15 K Resistors ¼ or ½ watt 10%
1 220 Ω Resistors ¼ or ½ watt 10%
1 1.8 K Resistors ¼ or ½ watt 10%
1 ON-OFF Switch (may be part of Gain Adjust).
1 50 K Potentiometer (audio taper)
1 9 Volt Transistor Radio Battery
Output Jacks (as desired)
Vector Board and Terminals
1 HEP 454 IC Socket




## CKT. 4.

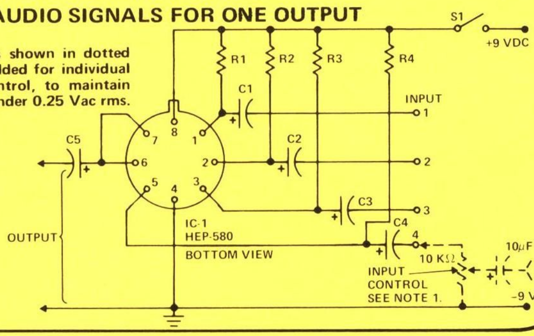
# 4 CHANNEL PREAMP MIXER

### MIX 4 LOW LEVEL AUDIO SIGNALS FOR ONE OUTPUT

**SPECIFICATIONS:**
At 0.25 V pk-to-pk input, output is constant 4.5 V pk-to-pk 20 Hz to 1.MHz ± 1 1db. (input voltage must not exceed 0.25 V pk-to-pk over the frequency range specified) Current drain @ 9 Vdc = 3.0 MA.

NOTE 1. Parts shown in dotted lines may be added for individual input level control, to maintain input voltage under 0.25 Vac rms.

**PARTS REQUIRED:**
1 HEP 580 IC
1 HEP 454 IC socket
$R_1$ $R_2$ $R_3$ $R_4$ 330 K Ω resistors ½ watt
$C_1$, $C_2$, $C_3$, $C_4$, $C_5$, 10 μFD 10 V electroyletics
S1= Spst switch
9 V Power source or battery




## CKT. 5.

# SQUARING AMP

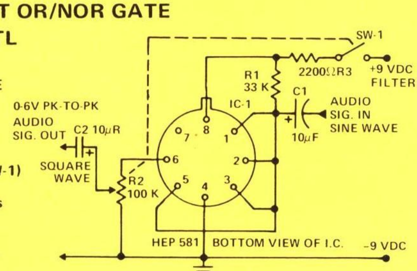
### (SINE TO SQUARE WAVE CONVERTER) USING HEP 581 4 INPUT OR/NOR GATE MW MRTL

**SPECIFICATIONS:**
2.0 to 10.0 Vac sine wave input produces symetrical square wave output 2. Vac peak-to-peak maximum. DC to 1 MHz current drain 3.5 MA at 9 Vdc.

**SUGGESTED APPLICATION:**
Teit Hi-Fi amplifier frequency response in conjunction with oscilliscope.

NOTE: Pin 4 connected to CASE

**PARTS REQUIRED:**
IC1 1 Hep 581
$R_1$ 33 K resistor
$R_2$ 100 K pot with switch (SW-1)
$R_3$ - 2200 Ω
$C_1$ & $C_2$ 10 μF electroylotics at 10 Vdc
1 HEP 454 IC socket
9 V battery or power supply



# CKT. 6. HEP WIDE BAND PREAMPLIFIER

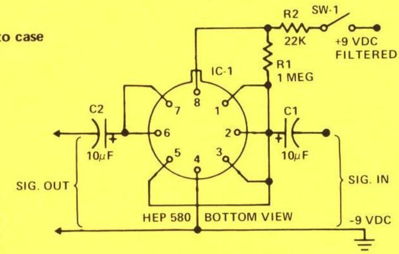
## USING HEP 580 DUAL 2 INPUT NOR GATE

**SPECIFICATIONS:**
With 9.0 Vdc supply and .01 Vac P-P input. Output is appx. 1 volt = 10 Hz to 1 MHz. Current drain = .2 ma. Gain factor over specified bandwidth = 100.

**PARTS REQUIRED FOR WIDE BAND AMP.**
IC-1 = HEP 580
$C_1$ $C_2$ = 10 MFD 10 volt electroylics
$R_1$ = 1 meg ¼ or ½ watt resistor
$R_2$ 22 K Ω ¼ or ½ watt. HEP 454 IC socket
9 V Battery or power source
Misc wire, solder etc.
SW-1 ON-OFF Switch

NOTE: Pin 4 connected to case

**SUGGESTED APPLICATIONS**
Oscilliscope preamp
Microphone preamp
Phonograph preamp
Hearing Aid preamp
etc.
May also be used as a stereo (2 channel) Pre-amp or a 2 or 4 channel mixer. Please refer to the IC Chip schematic for input and output connections.

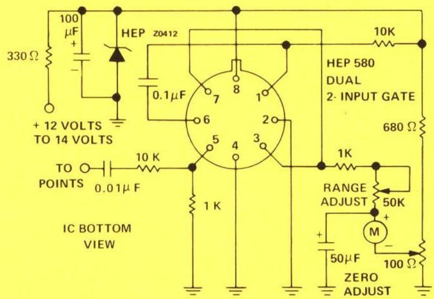



# CKT. 7. PRECISION TACHOMETER

**USES:**
Tachometer can be used on automobile, boat, motorcycle, etc.

**FEATURES**
Very flexible circuit — range and number of cylinders — compensated for by 1 adjustment.

**PARTS LIST:**
1 HEP 580 Dual z-Input Gate
1 HEP Z0412 Zener Diode (9.1V)
1 330 Ω ½ watt 10% Resistor
2 10 K ¼ or ½ watt 10% Resistor
1 680 Ω ¼ or ½ watt 10% Resistor
2 1 K ½ or ¼ watt 10% Resistor
1 100 μF Capacitor Electroylic 15 Volts (or higher)
1 50 μF Capacitor Electroylic 10 Volts (or higher)
1 0.01 μF Capacitor Disc Ceramic
1 0.1 μF Capacitor Disc Ceramic
1 100 Ω Potentiometer (trimmer)
1 50K Potentiometer Linear (range adjust)
1 50 μA meter
Vector Board and Terminals
1 HEP 454 IC Socket




**OPERATION FOR CALIBRATION**
Connect lines to ground, 12 Volts, and points with engine turned off but ignition switch "on". Zero meter with Zero Adjust. To set range — check auto speed using a tach from a service station or garage.

(Range maximum can be whatever you desire. And calibrate the rest of the scale accordingly.) As as arbitrary adjustment, most automobiles idle at about 600 RPM — with engine idling — adjust Range pot until needle is in approximately the 600 RPM position.

# CKT. 8. XTAL CONTROLLED FREQUENCY SOURCE

## SQUARE WAVE

**SPECIFICATIONS:**
Accurate frequency source of 100 or 50 kHz square wave signals for test purposes or markers for communications receivers. Operates from 5 to 15 Vdc at 9.0 Vdc current. Drain is 5.5 MA. Voltage output at "A" or "B" is 1.0 volts peak-to-peak at 9 Vdc power source.

**PARTS LIST:**
1 HEP 580 Dual 2 input GATE
1 HEP 583 J-K flip-flop
$R_1$ & $R_2$ 100 K Ω resistors ½ watt
$X_1$ 100 kHz crystal
$C_1$ .001 μF cap
$C_2$ & $C_3$ .1 μF cap
2 HEP 454 IC sockets
1 XTAL socket
$R_3$ 1 K Ω resistor ½ watt
Misc: Solder wire etc.
9 V Battery or power supply
S1 Spst switch