MOTOROLA HEP® Semiconductors

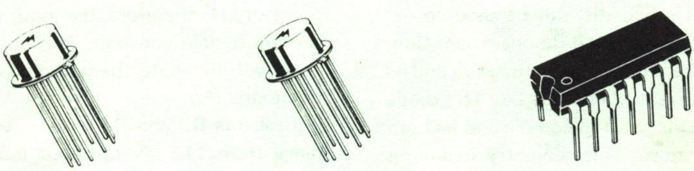
- 3 Prime Quality ICs
- 10 Amateur Radio Projects
- VHF Techniques

10 PROJECTS

Build These and Other Useful Projects Using:

- Two HEP 590 RF-IF Linear IC'S, a Versatile, Common-Emitter, Common-Base Cascode Circuit for Communications Applications.
- One HEP 570 A Quad 2-Input Positive Logic NOR Gate.

RADIO AMATEUR'S IC PROJECTS



The IC has invaded the VHF spectrum.

The VHF bands are becoming more and more popular for amateur radio communications. Solid state devices are also invading these areas as technology is gained. One of these devices is the versatile HEP 590. The HEP 590 is a high gain IC with extremely low internal feedback and a wide agc range. The circuit is a common-emitter, common-base pair (cascode connection) with an agc transistor and associated biasing circuitry. The amplifier is built on a single die and is comparable to a single transistor, yet it offers performance advantages unobtainable with a single device.

VHF work is sometimes difficult and does not always follow "a rule of thumb" pattern. The ability to build successfully in the VHF area will be a challenge, but is not difficult once the technique of handling the shorter wavelengths is achieved.

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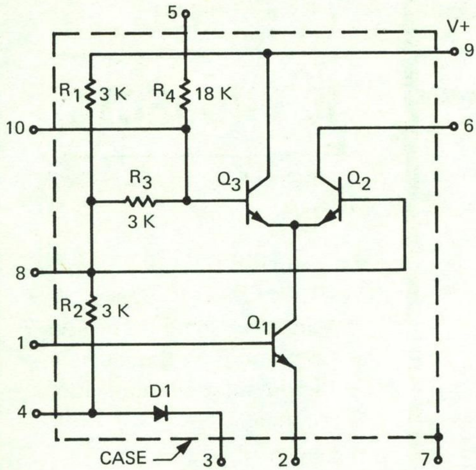
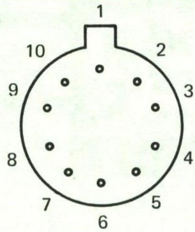
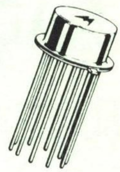
HEP 590 – HIGH FREQUENCY RF-IF AMPLIFIER





BOTTOM VIEW

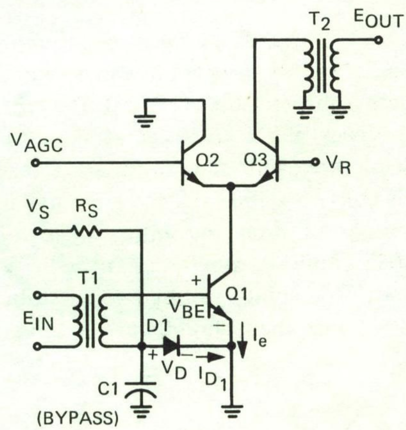


CASE 71

The following description of the HEP 590 circuitry is given so that a deeper insight of it's operation and capabilities may be realized.

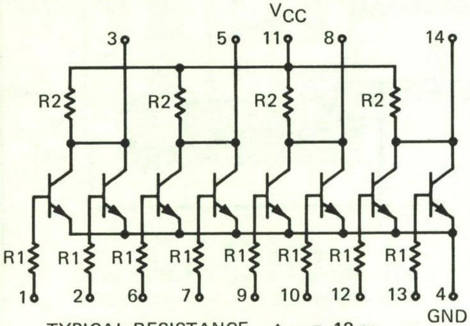
A simplified schematic will be used to explain the HEP 590 ac and dc operation. Considering dc operation first, the voltage Vs and Rs establish the current Id in diode D1. This diode and Q1 are on the same silicon die and laid out close to each other. This geometry maintains the current of Q1 to within 5% of D1. Gain stability is achieved throughout temperature changes. This biasing technique demonstrates matching characteristics that are difficult to accomplish with descrete components but easily accomplished with I/C's. The emitter current of Q1 will be shared by Q2 and/or Q3, depending on the relationship of Vagc and Vr. When Vagc is 114 Mv greater than Vr, Q3 is turned off and all of the collector current of Q2 is transferred to Q1. Since Q3 is off, the ac gain will be at it's minimum point. If on the other hand, Vagc is less than Vr by 114 Mv, all of the collector current present in Q1 will flow through Q3. This condition is the optimum operating point for maximum gain. When ac is applied to the base of Q1 the output is taken from the collector of Q3. Thus, the combination of Q1-Q3 acts as a common-emitter common-base pair. This pair reduces the internal feedback 2 orders of magnitude when compared to a single transistor. This feedback is unmeasurable up to frequencies of 300 MHz. The ability to vary the gain of this circuit can also be a performance advantage when compared to a single transistor. The agc voltage will have little affect on the operating point of Q1; therefore, the input impedance of Q1 will remain constant. This constant impedance will eliminate the detuning of any tuned input circuitry.

Resistors R3 and R4 serve to widen the agc range from 114 Mv to about 0.86 volts. This range makes the agc line less susceptible to external noise.



HEP 590 SIMPLIFIED SCHEMATIC

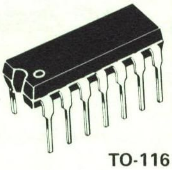
HEP 570 – RTL QUAD 2-INPUT GATE



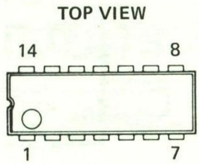
TYPICAL RESISTANCE VALUES
R1 = 450 Ω
R2 = 640 Ω

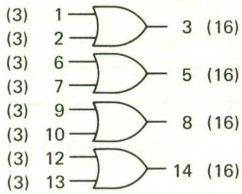
t_{pd} = 12 ns
P_D = 100 mW (INPUT HIGH)
30 mW (INPUTS LOW)

Quad 2-input positive logic NOR gates in a single package. Each may be used independently, paralled for increasing the number of inputs (subject to loading rules), or cross-coupled to form bistable elements.



TO-116





$3 = \overline{1 + 2}$

NUMBER IN PARENTHESIS INDICATES LOADING FACTOR

The successful fabrication of VHF equipment will depend upon the mechanical as well as electrical design of the circuit. As construction is tried at VHF, one discovers that short lengths of interconnecting wire can become tuned circuits, capacitors become tuned tank coils, and resistors become capacitive. These affects may be reduced by the proper mechanical design and layout. An old discarded T-V tuner should be examined for VHF wiring techniques. Wiring is short and the lack of unnecessary lead length is apparent. This point-to-point wiring is true not only of the input-output circuitry, but also of the bypass circuits.

At VHF, a decoupling device easy to use is the ferrite bead. The bead requires no connections and is simply slipped over the interconnecting wiring. This bead performs as a choke at RF while passing dc currents. Several beads may be used to increase the RF decoupling.

Small values of capacitors (a few pf) may be used to tune out the lead inductances of the input and output circuits. These capacitors should be of a high quality silver-mica or ceramic type. For bypassing, the ceramic standoff or feed-through type as used in the T-V tuners, is an excellent capacitor. At first look it would appear to be a standoff or feed-through, actually it is a ceramic tube with a ring around it's center. The ring is one side of the capacitor and is soldered directly to the chassis. The other side of the capacitor is the center hole of the tube. Do not use excessive heat when soldering leads to the center hole of the capacitor. Excessive heat will vaporize the silver flash from the inside of the ceramic tube. This vaporization will prevent the solder's electrical bond with the ceramic material and the capacitor will be destroyed. This capacitor, because of its low inductance, is also excellent for coupling.

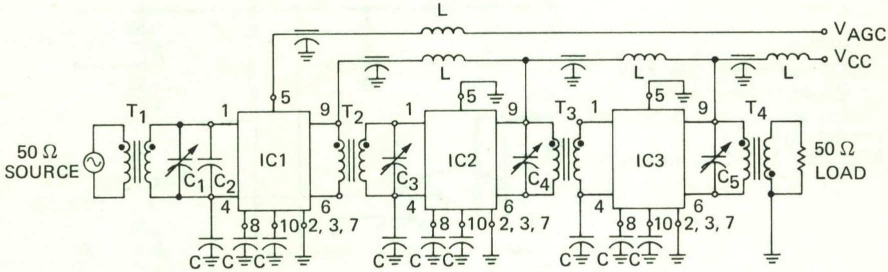
At VHF, resistors will become capacitive. Quarter watt resistors will display lower values of capacitance than higher wattage units.

Single-strand copper wire or strap is the best material to employ as a conductor at VHF. Stranded wire will exhibit more RF loss than a solid lead. At higher frequencies, RF current will concentrate at the surface of the wire. This condition is referred to as "skin effect." A round wire will provide the best balance of current concentration; but the self inductance of any wire must be considered in tuned circuits.

At VHF, "hot spots" along the chassis or cabinet may be detected. This condition is created by the RF current paths. Chassis themselves may turn into a self resonant cavity. These hot spots may necessitate the relocation of bypass points.

45 MHz STAGGER TUNED AMPLIFIER

FEATURES:
- AGC control of gain
- 70 dB of power gain
- Low input and output impedances (50 ohm)



PARTS LIST:

L	1 μH CHOKE
C	0.005 μF
C_1	9-35 pF
C_2	160 pF
C_3	9-35 pF
C_4	2-8 pF
C_5	5-18 pF

T_1: 2 TURNS–7 TURNS #26 WIRE ON T12-10 CORE

T_2: 28 TURNS–9 TURNS #30 WIRE ON T20-10 CORE

IC1, 2, 3, HEP 590

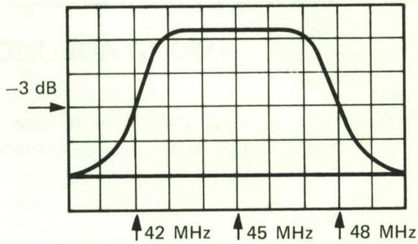
T_3: 19 TURNS–8 TURNS #34 WIRE ON 57-2651-6 CORE

T_4: 19 TURNS–2 TURNS #32 WIRE ON T20–2 CORE

MICROMETAL CORES OR EQUIVALANT

TUNING

As pointed out earlier, one very important characteristic of the HEP 590 is the ease with which it is tuned. The first prototype circuit was tuned as follows: each stage was disconnected from the other stages and loading applied to each stage to simulate the actual circuitry in cascade. Each stage was then tuned to the desired center frequency with the correct bandwidth. Once each stage was tuned, the circuits were connected in cascade and final fine tuning adjustments made. With the experience gained in tuning the first prototype, the second prototype was tuned by merely sweeping the amplifier with a Jerrold 890 sweep generator and tuning while observing the output on an oscilloscope. A photograph of the sweep is shown below. The final results were: Center frequency – 45 MHz, Bandwidth – 6 MHz, and Power Gain – 70.0 dB.



AGC CHARACTERISTICS

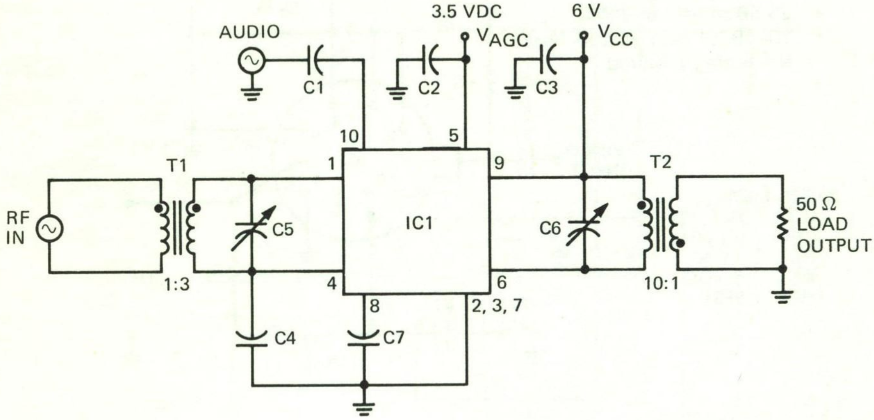
The choice of the stage or stages to be agc'd is more or less arbitrary. Various agc combinations of the three stages were tried to study their effectiveness. With the agc applied only to the first stage, 64 dB of agc control was obtained with a maximum deviation from flatness in the passband of 0.7 dB. With the agc applied to all three stages, 90 dB of agc control was obtained, with a maximum deviation from flatness in the passband of 1 dB. These two conditions represent the minimum and maximum extremes. When the combinations of the three stages taken two at a time were tried, they all fell within the above range. Thus for the design specification, it was sufficient to agc only the first stage. The variation of bandwidth and center frequency were measured and the results are shown in the table. This data indicates a maximum of 5% bandwidth deviation occurring at the low gain (maximum agc) condition, with full agc occurring over a 2.5 volt range. With an input of 50 μvolts rms, the output signal into 50 ohms is 156 mvolts with a noise level of 6.8 mvolts.

The results of this design strongly indicate that the HEP 590 has tremendous potential for use in both the RF and IF stages of television, radio, radar, and communication gear where high gain, wide agc control, and low cost are of prime importance.

AGC Voltage	Power Gain dB	Center Frequency MHz	Bandwidth MHz
0.0	70.0	45.0	6.0
0.5	70.0	45.0	6.0
1.0	70.0	45.0	6.0
1.5	70.2	45.0	6.0
2.0	70.2	45.0	6.0
2.5	63.5	45.0	5.9
3.0	58.4	45.0	5.8
3.5	46.1	45.0	5.8
4.0	28.7	45.0	5.8
4.5	6.2	45.0	5.7

6 METER AM MODULATOR

FEATURES: • Up to 90% modulation with little distortion



PARTS LIST:

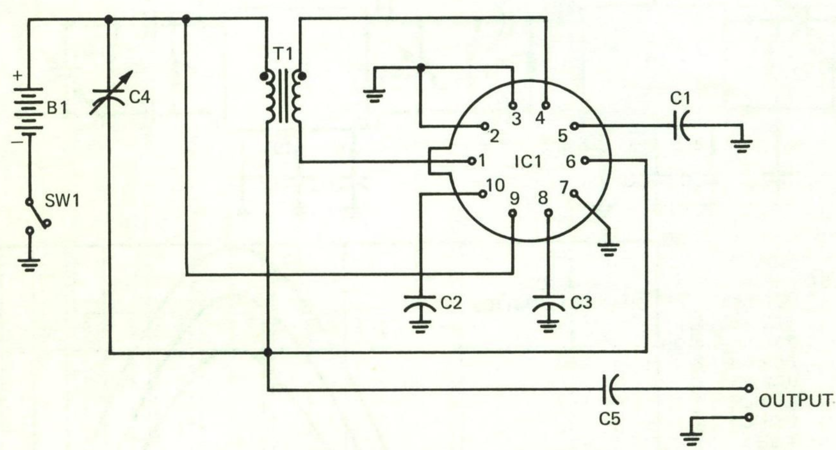
IC1	HEP 590
C1	1 μF
C2, 3	0.47 μF
C4, 7	0.1 μF
C5, 6	1.5 TO 10 pF (TUNE TO 52.25 MHz)

T_1: 6:18 TURNS #32 WIRE ON MICROMETAL T-12-2 CORE

T_2: 28:3 TURNS #36 WIRE ON MICROMETAL T-12-2 CORE

5-10 MHz VFO OR 40 METER TRANSMITTER

FEATURES: • Sine wave output over the full oscillator range



PARTS LIST:

IC1	HEP 590
C1, 2, 3,5	0.1 μF
C4	170-780 pF
B1	6-12 VDC

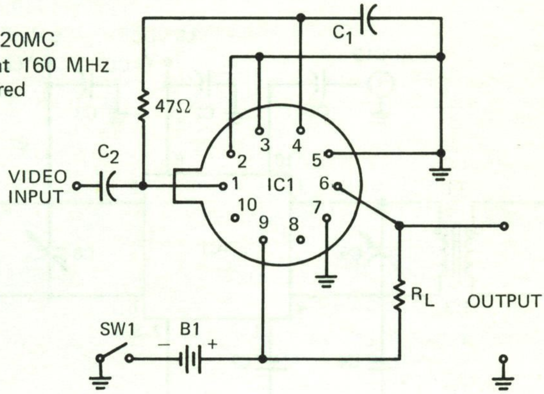
T1 21 TURNS - 7 TURNS
#36 WIRE ON MICROMETALS T-12-2 CORE
$L_P = 1.3\ \mu H$, $L_S = 0.1\ \mu H$

SW1 SPST

VIDEO AMPLIFIER

FEATURES:

- 25 dB of gain to 20MC
- 10 dB of gain at 160 MHz
- No tuning required



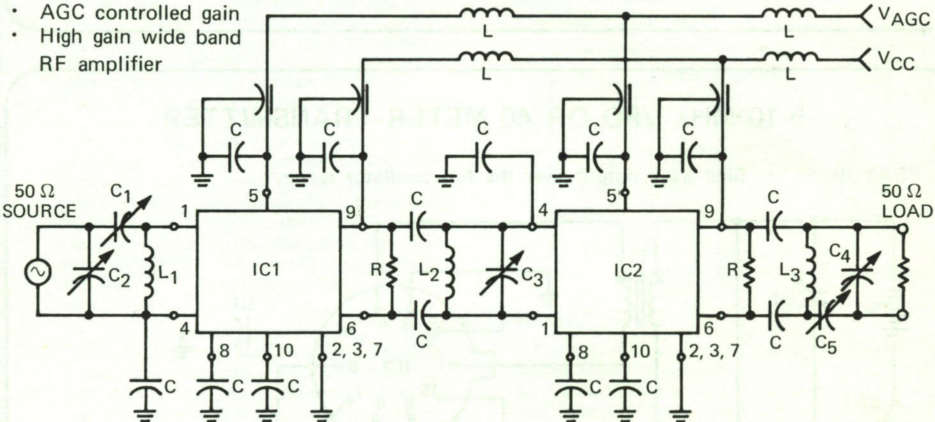
PARTS LIST:

IC1	HEP 590
C1,2	0.1 μF
RL	1.8 K
B1	6 VDC
SW1	SPST

WIDE BAND 45 MHz AMPLIFIER

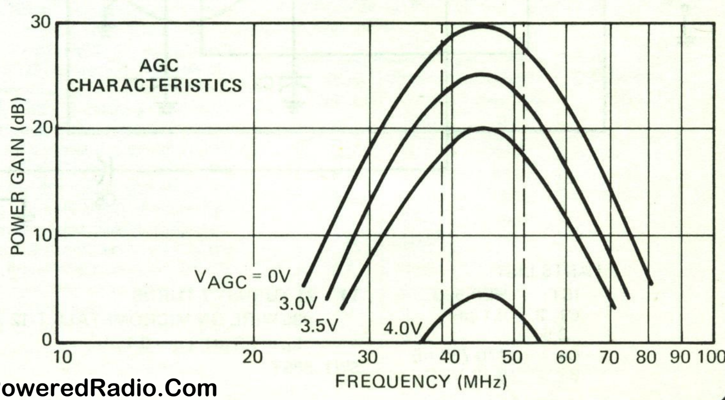
FEATURES:

- AGC controlled gain
- High gain wide band RF amplifier



PARTS LIST:

IC1,2	HEP 590
C	.002 μF
C1,2,4,5	9-35 pF
C3	2-8 pF
L1	0.42 μH
L2	0.68 μH
L3	0.55 μH
L	1 μH
R	510 Ω

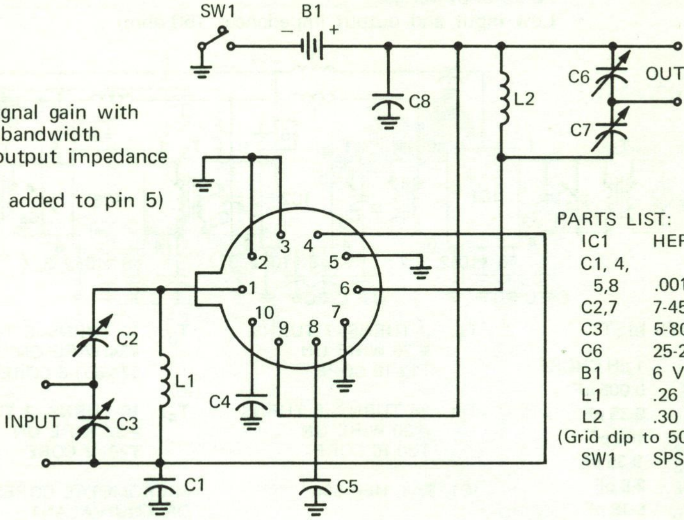


6 METER PREAMP

FEATURES:

- 30 dB of signal gain with a 0.6 MHz bandwidth
- Input and output impedance matching

(AGC may be added to pin 5)



PARTS LIST:

IC1	HEP 590
C1, 4, 5,8	.001 μF
C2,7	7-45 pF
C3	5-80 pF
C6	25-280 pF
B1	6 VDC
L1	.26 μH
L2	.30 μH

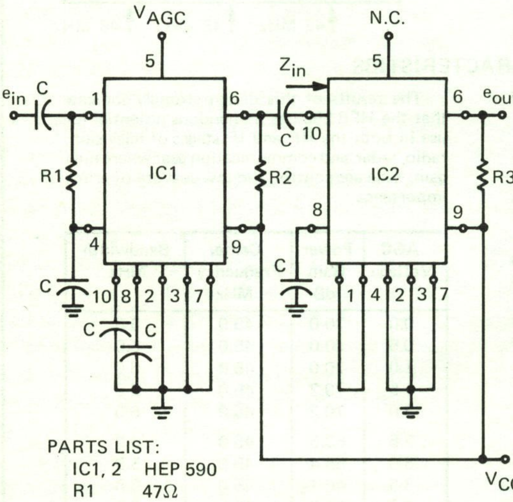
(Grid dip to 50.25 MHz)

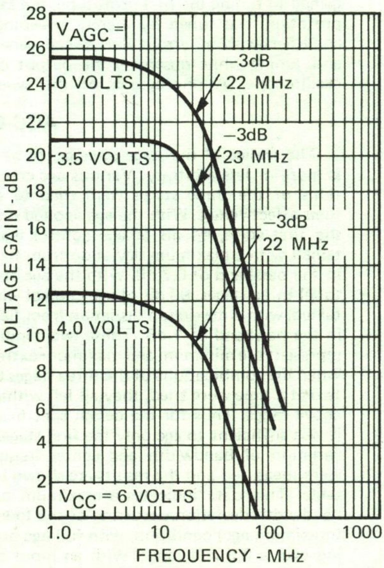
SW1	SPST

TWO STAGE VIDEO AMPLIFIER

FEATURES:

- AGC control of IC gain
- No tuned circuits required





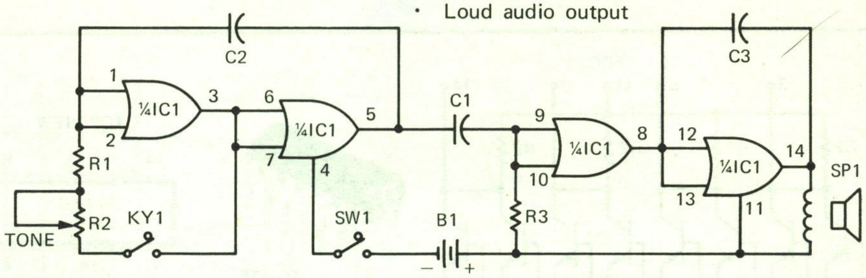
VIDEO AMPLIFIER RESPONSE WITH AGC

PARTS LIST:

IC1, 2	HEP 590
R1	47Ω
R2	1.8 K
R3	3.3 K
C	0.1 μF

CODE PRACTICE OSCILLATOR

FEATURES:
- Simple to construct
- Loud audio output

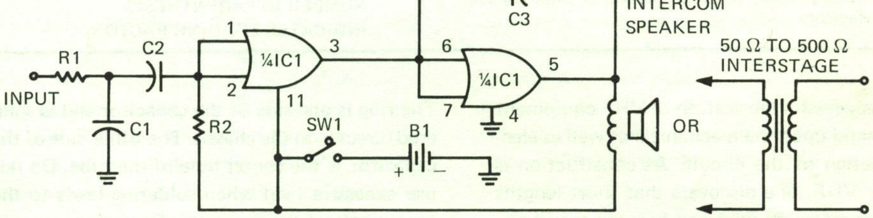


PARTS LIST:

IC1	HEP 570	R3	10 K	SW1	SPST	SP1	45 Ω
R1	3.9 K	C1, 2	.05 μF	KY1	MORSE KEY		INTERCOM
R2	10 K POT	C3	.001 μF	B1	3 VDC		4″ SPEAKER

MICROPHONE OR AUDIO AMPLIFIER

FEATURES:
- Class A high gain amplifier
- Compact size



PARTS LIST:

IC1	HEP 570	C1	.01 μF	SW1	SPST
R1	100 Ω	C2	.25 μF	B1	3 VDC
R2	220 K	C3	.001 μF		

CRYSTAL OSCILLATOR-CALIBRATOR

FEATURES:
- High harmonic square wave output
- A dual frequency calibrator may be constructed by using both halves of the IC

PARTS LIST:

IC1 HEP 570
R1, 2 56 K
C2 9-35 pF

XTAL FREQ	C1 pF
100 KHZ	1000
500 KHZ	430
1 MHZ	39