Radio Shack®

# Service Manual

22-305

## RF Frequency Counter

Cat. No.: 22-305

# Contents

# Specifications

## GENERAL SPECIFICATIONS

Gate Time ..... 64 mS (fast)
..... 640 mS (slow)
Display ..... 8-digit liquid crystal
Display Update Rate ..... 128 mS
..... 1.28 S (slow)
Display Resolution ..... 1 KHz (fast)
..... 100 Hz (slow)
Accuracy ..... 1 ppm ± 1 least significant digit
Operating Temperature ..... -18°C (-64°F) to +35C (+95°F) - Test to Specification
Power Requirements ..... 4 x AA Alkaline Batteries (Radio Shack Cat. No. 23-552) or
4 x AA NiCad Batteries (Radio Shack Cat. No. 23-125) and/or
9 VDC Adapter (Radio Shack Cat.No. 273-1455)
Low Power Detect ..... 4.1V ± 0.15V
Backlight On Time ..... 10 ± 5 S

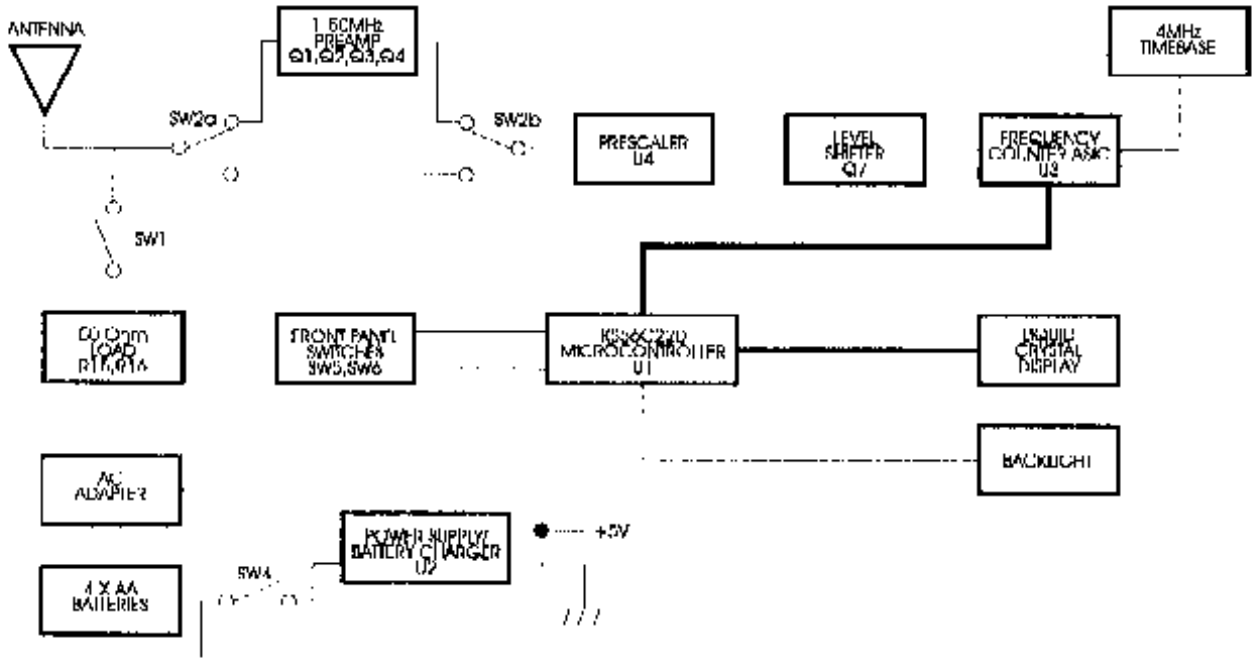
## INPUT CHARACTERISTICS

Range ..... 1 MHz to 1.3 Ghz
Sensitivity ..... 150 mV minimum 1 MHz to 1.3 GHz
Dynamic Range ..... 10 mV to 1 RMS
Coupling ..... AC
Input Impedance ..... 50 Ω or Hi-Z
Absolute Maximum Input Level ..... 1.4 Vp-p
(The counter may be damaged if this is exceeded)

## TIMEBASE

Frequency ..... 4 MHz
Initial Accuracy ..... ±1 ppm

# Block Diagram



# Theory of Operation

## GENERAL DESCRIPTION

This instrument is a digital frequency counter used to make frequency measurement of radio frequency (RF) signals. The unit has a specified range of 1 Megahertz (MHz) to 1300 MHz (1.3 GHz). The 22-305 is a microcontroller based instrument capable of measuring and displaying the frequency of RF signals with different resolutions and display update rates. See User's Manual for details of operation.

## CIRCUIT DESCRIPTION

### Power Supply

Power for the counter circuit is provided by either a 9 Volt DC wall adapter or by 4 NiCad or Alkaline AA batteries. The 9 VDC from the wall adapter is regulated by U2 to provide +5 VDC for the rest of the circuit. R17 provides charge current for NiCad batteries when SW4 is in the NiCad position. D5 provides a 0.3 Volt Drop when NiCad batteries are used to power the unit. D6 and D11 provided a 1 volt drop when Alkaline batteries are used to power the circuit.

### Low Power Detect

U5 is a low voltage detector with an open drain output. R25 will pull pin 31 of the microcontroller high when the input to U5 is above approximately 4.1V. U5 will pull its output low when the input voltage is below approximately 4.1V.

### RF Input Circuit

SW1, R15 and R16 provide a user selectable 1/2 W 50 Ω load. D12 and D13 provide protection from large input voltages by clipping inputs to 5.7 Volts and -0.7 Volts respectively. SW2 selects whether the input signal will be passed through the low frequency amplifier or directly to the prescaler. Q1, Q2, Q3, Q4, and associated components provide amplification for 1 to 50 Mhz signals to decrease the jitter caused by slow rise/fall times input into the prescaler, U4.

### Prescaler

The prescaler IC, U4, divides by 64 the frequency into pin 1. Q7 and associated components shift the output of the prescaler from ECL voltage levels to CMOS voltage levels for input to the frequency counter ASIC, U3.

### Frequency Counter ASIC

U3 is an application specific integrated circuit (ASIC) that performs frequency counting functions on the signals input to pin 22 (FIN). The ASIC has two basic modes of operation, fast and slow gate speeds. The state (high/low) of the HI/LO pin (16) determines the current gate speed (fast/slow). At the start of each gate period, the ASIC clears its internal counters and begins gating the input frequency into the counter string. At the end of the gate period, the ASIC signals the microcontroller that the counters have been updated and can be read for display. The microcontroller is responsible for sending commands to the ASIC for various control functions of the gate period and also reads back the counter data after the end of the period. The microcontroller must also strobe some of the ASIC commands.

The various modes of the ASIC are controlled as follows:

Time Base Control (pin 16):

| | |
|---|---|
| 0 | Select 640 mS time base (Slow gate speed) |
| 1 | Select 64 mS time base (Fast gate speed) |

ASIC Control:

| Pins 6 5 4 3 | Function | Strobed |
|---|---|---|
| 0 0 0 0 | Read Digit 0 | No |
| 0 0 0 1 | Read Digit 1 | No |
| 0 0 1 0 | Read Digit 2 | No |
| 0 0 1 1 | Read Digit 3 | No |
| 0 1 0 0 | Read Digit 4 | No |
| 0 1 0 1 | Read Digit 5 | No |
| 0 1 1 0 | Read Digit 6 | No |
| 0 1 1 1 | Read Digit 7 | No |
| 1 0 0 0 | Clear Counters/Reset ASIC | Yes |
| 1 0 0 1 | Enable Count | Yes |
| 1 0 1 0 | Read Busy State | No |
| 1 0 1 1 | Latch Count Data | Yes |
| 1 1 1 0 | Read Overflow Bit | No |

## Microcontroller

The microcontroller is a 4-bit Samsung KS56C220. The microcontroller reads the condition of the backlight and gate speed keys, SW5 and SW6, and controls the states of the backlight and the gate speed of the frequency counter ASIC accordingly. The microcontroller resets the ASIC, waits for the gate time to be complete, then reads the digits of the frequency from the ASIC, one digit at a time. The microcontroller then restarts the gate cycle again. The microcontroller drives the liquid crystall display (LCD) used to show the frequency. The microcontroller updates the display after each gate and blinks the decimal point to indicate that a gate period has ended. When the microcontroller detects that its pin 31 is at a low level, it turns on the rightmost decimal point in the display to indicate that the unit's power is insufficient to give accurate readings.

## Backlight

The display has a user controllable backlight. The microcontroller reads the state of SW5 and if the key is pressed for less than 2 seconds turns on the backlight with Q6 for 10 seconds. If the user presses the backlight key for more than 2 seconds the micro turns on and keeps on the backlight until the unit is turned off.

## Calibration Procedure

The 4 Mhz timebase of the frequency counter determines the calibration of the frequency counter. The frequency counter can be calibrated using two different methods:

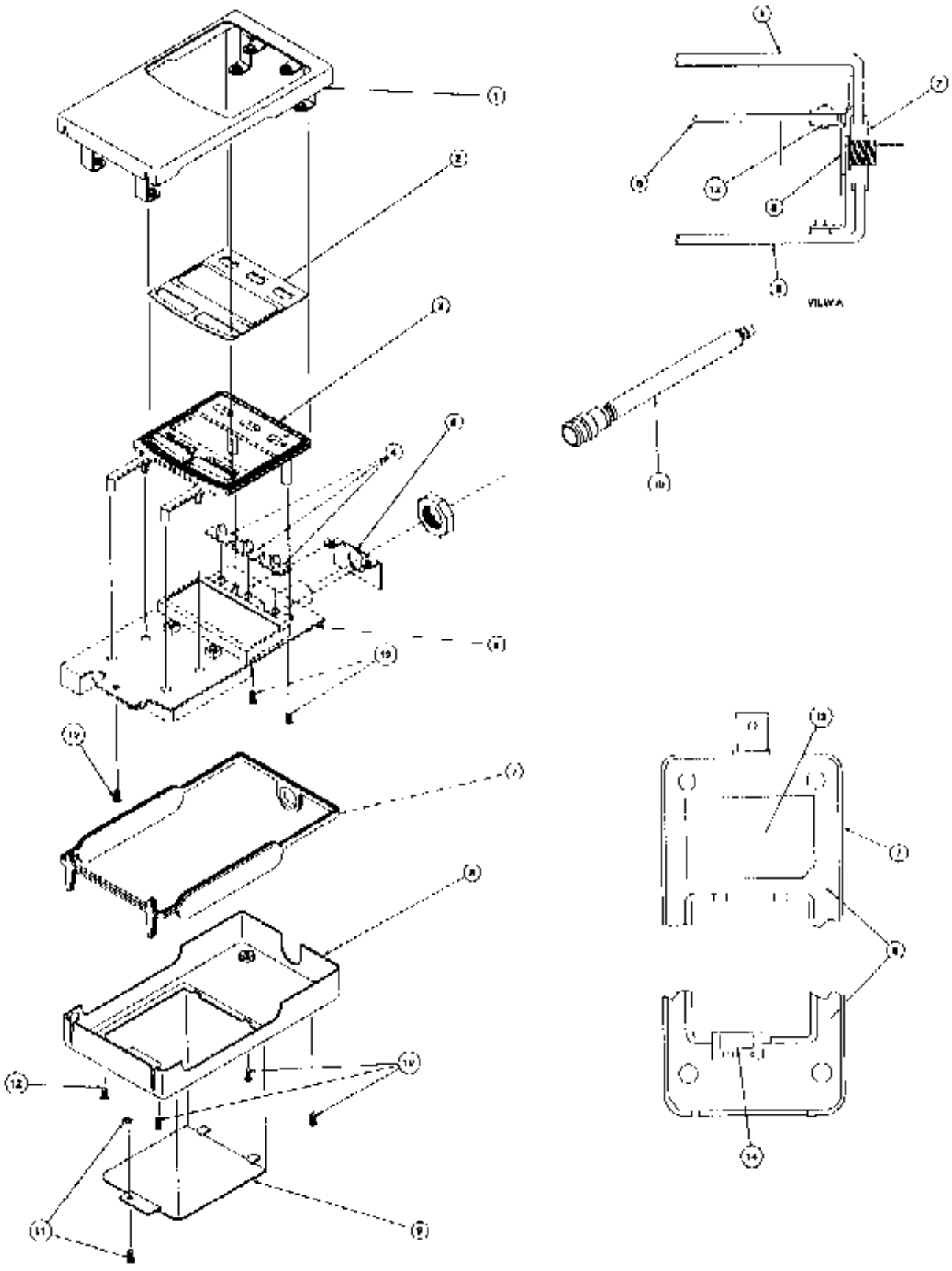
1. Use a high frequency signal generator such as a Fluke 6082A Synthesized RF Signal Generator to input a 150 mV signal into jack, J1 at 1000 MHz (1 GHz). The signal should be unmodulated. Set the frequency counter for Slow gate speed for maximum resolution on the display. Slowly adjust trimmer capacitor C16 until the display indicates a frequency between 999.9989 MHz and 1000.0011 MHz.

2. Use another frequency counter with high resolution such as an HP 5385A to measure the frequency of the 4 MHz timebase. Set up the additional frequency counter for maximum resolution at 4MHz. Connect pin 41 of the frequency counter ASIC to the input of the other counter with a high impedance probe and adjust trimmer capacitor C16 until the other counter indicates a frequency between 3.999996 MHz and 4.000004 MHz.

# Troubleshooting

| Symptom | Cause and Remedy |
|---|---|
| No Operation | • Check output of 9VDC Wall Adapter<br>• Check AA battery voltage<br>• Check voltages at U1, pins 1 and 3<br>• Check for + 5VDC power on all ICs<br>• Check for oscillation on U1, pin 37<br>• Check voltage on U1, pin 34<br>• Check SW3 |
| Liquid Crystal Display Inoperative | • Check for oscillation on U1, pin 37<br>• Check U1, pins 1 to 18 and 49 to 64<br>• Check U1, pins 21, 22, 23, and 24 |
| Display Backlight Inoperative | • Check Q6 and associated components |
| Display Backlight Always On | • Check U5 and R25 |
| Display Unstable when unit operated in the 50 W Mode | • Check Resistance of R15 and R18 |
| Display Incorrect at Known Frequency | • Unit not in calibration. Calibrate unit according to calibration procedure page 7. |
| Display Unstable When Unit Operated in the 1-50MHz Mode | • Check Q1, Q2, Q3, Q4, and associated components |
| Display Always Shows 0.0000 or 0.000 in 1-50MHz and 50Mhz to 1.3Ghz Ranges | • Check power on U3 pins 7, 14, 21, 28, 39, and 43<br>• Check U4, pin 4 |
| Display Unstable In All Modes | • Check U4, pins 1 and 4 |
| Display Shows 1/2 or 1/4 of Correct Frequency | • Check U4, pins 3 and 6 |
| Display Always Shows "TEST" | • Check U1, pin 30 |
| NiCad Batteries Do Not Charge | • Defective R17 |

# Exploded View



## Parts List

| Ref. No. | Description | RS Part No. | Mfr's Part No. |
|---|---|---|---|
| 1 | Cover Assembly, Front | | 601960050A |
| | Cover, Front | | 601260290A |
| | Bracket, Top | | 411160130A |
| | Bracket, Bottom | | 411160140A |
| 2 | Lens, Cosmetic | | 715160160A |
| 3 | Bezel, Front | | 601260290A |
| 4 | Key Topper, Slide | | 659060260A |
| 5 | Bracket, Connecting | | 411160120A |
| 6 | Board, Assembly | | A379001 (REF) |
| 7 | Grommet, Cover | | 481160030A |
| 8 | Cover, Bottom | | 601360340A |
| 9 | Door, Battery | | 602160190A |
| 10 | Antenna | | 112060070A |
| 11 | Screw, M 2.6 x 5mm Long w/Retaining Ring | | HCBC2605SB |
| 12 | Screw, M 2.6 x 5mm Long | | HMB02605SB |
| 13 | Label, Rating | | 738061960A |
| 14 | Battery Type Label | | NPN |

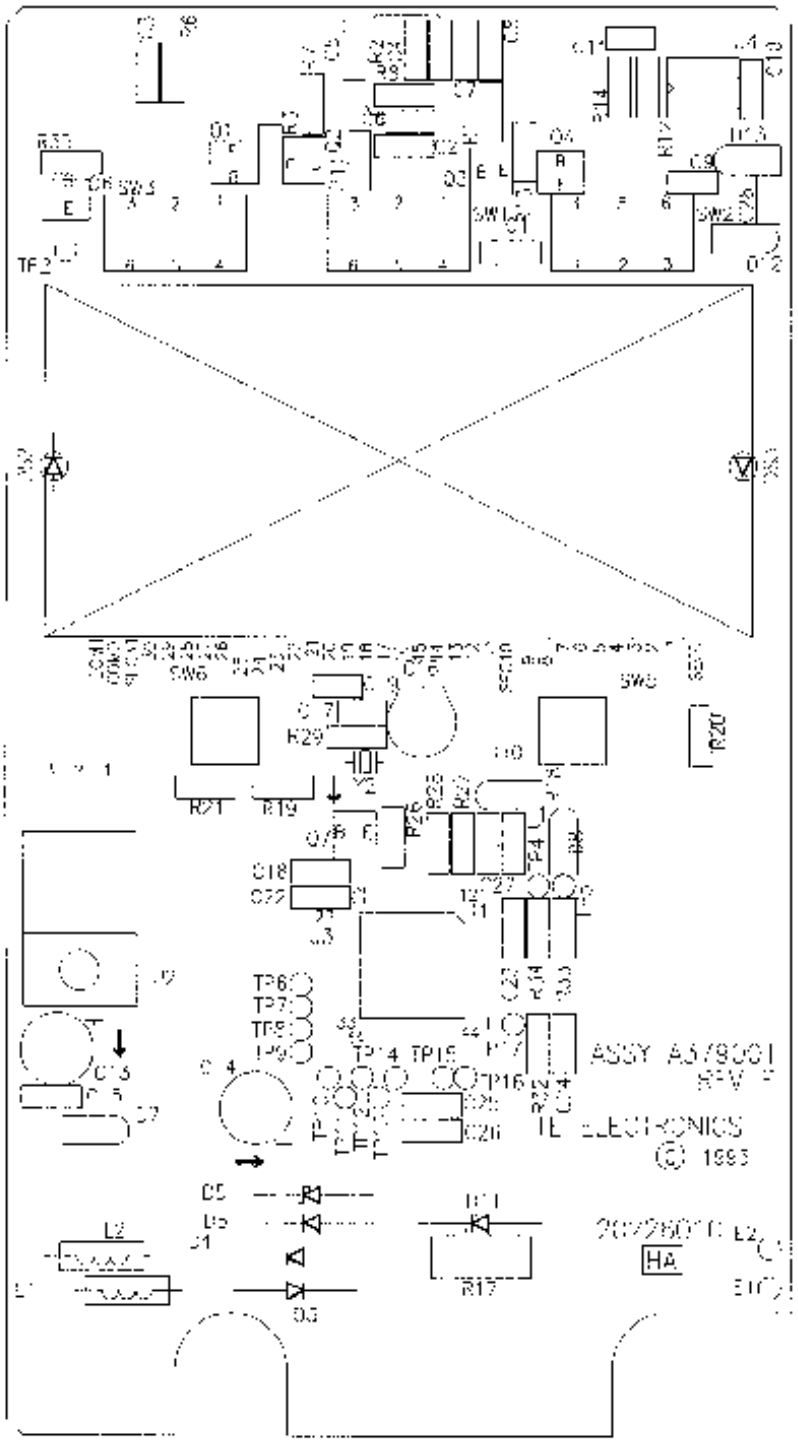
# Parts List

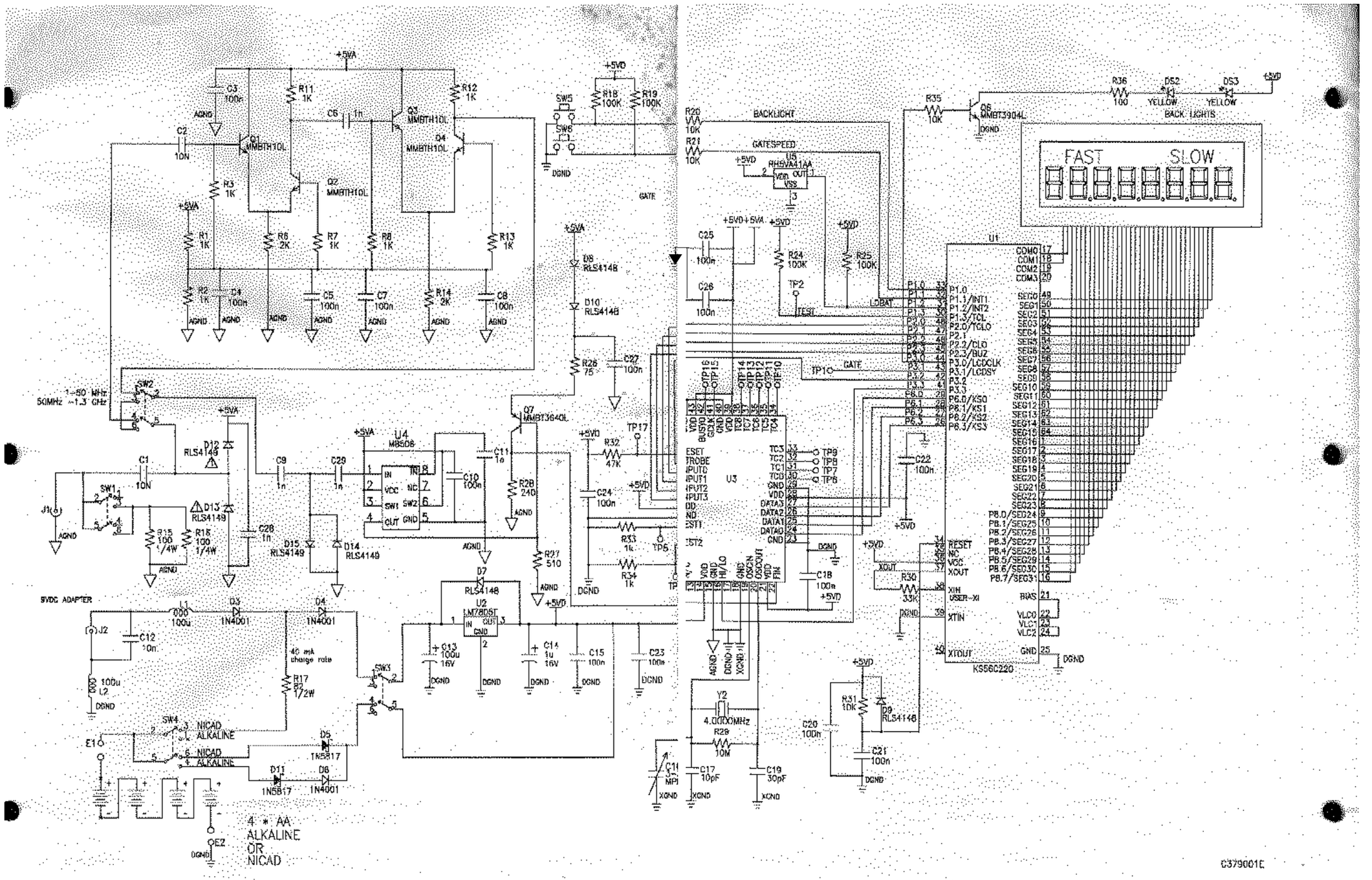
## Base Parts List

| Reference # | Description | RS Part # | MFR Part # |
|---|---|---|---|
| C14 | CAP,ELEC,1.0UF,50V,20%,2MM,BULK | | CEACK105M |
| C13 | CAP,ELEC,100UF,16V,20%,5MM,BULK | | CEACG107M* |
| C6,9,11,26,29 | CAP,CER,1000PF,50V,5%,1206,NPO-X | | CBWAK102J* |
| C1,2,12 | CAP,CER,.01UF,50V,+80/ 20%,1206 | | CJWPK103Z* |
| C3-5,7,8,10,15,18, 20, 27 | CAP,CER,.1UF,50V,+80/-20%,1206 | | CJWPK104Z* |
| C17 | CAP,CER,10PF,50V,5%,0805,NPO-X | | CBVAK100J* |
| C19 | CAP,CER,30PF,50V,5%,0805,NPO-X | | CBVAK300J* |
| R26 | RES,MG,75,1/8W,5%,1206 | | RG0EW750J* |
| R38 | RES,MG,100,1/8W,5%,1206 | | RG0EW101J* |
| R15,16 | RES,MG,100,1/4W,5%,1210 | | RG0QX101J* |
| R17 | RES,CF,82,1/2W,5%,AX,12.5MM | | RCGH1820J* |
| R28 | RES,MG,240,1/8W,5%,1206 | | RG0EW241J* |
| R27 | RES,MG,510,1/8W,5%,1206 | | RG0EW511J* |
| R1-3,7,8,11-13,33,34 | RES,MG,1K,1/8W,5%,1206 | | RG0EW102J* |
| R6,14 | RES,MG,2K,1/8W,5%,1206 | | RG0EW202J* |
| R20,21,31,35 | RES,MG,10K,1/8W,5%,1206 | | RG0EW103J* |
| R30 | RES,MG,33K,1/8W,5%,1206 | | RG0EW333J* |
| R32 | RES,MG,47K,1/8W,5%,1206 | | RG0EW473J* |
| R18,19,24,25 | RES,MG,100K,1/8W,5%,1206 | | RG0EW104J* |
| R29 | RES,MG,10M,1/8W,5%,1206 | | RG0EW106J* |
| D7-10 | DIODE,LL4148,CHIP | | SDSI56002- |
| D14,15 | DIODE,SI,RLS4140 T,CHIP | | SDSI66007 |
| D3,4,6 | DIODE,1N4002 T,AX | | SDSIT0065- |
| D5,11 | DIODE,SI,1N5817-T,AX | | SDSIT0130 |
| U2 | IC,MC7805CT,MOTOROLA | | SIMC7805C1 |
| U4 | IC,MB506,CHIP | | SIMB506 |
| Q1-4 | XSISTOR,MMDTH10,NPN,CHIP | | STMDH10--- |
| Q6 | XSISTOR,MMBT3904LT1,CHIP | | STMB3904-- |
| Q7 | XSISTOR,MMBT3640T1,CHIP | | STMD3640-- |
| U3 | IC,M60023-1007FP,CHIP | | SICR6009-- |
| U1 | IC,TCR5010(KS56C220-71),CHIP | | SICR6010-- |
| DS2,3 | LED,GREEN,LN01301C | | SL-G00045- |
| L1,2 | IND,100UH,LAL03NA,AX | | 142011510A |
| J2 | JACK,POWER DC-HEC0470-01-230 | | 196204200A |
| J1 | CONN,BNC,13-60 | | 192960010A |
| C16 | TRIMMER,(5-30PF),TZ03R300-ER | | 154010040A |
| Y2 | CRY,4.000MHZ,HC49/U,20PF | | 391060780A |
| 2.100 | LCD | | 550500090A |
| U5 | IC,RH5VA41AA,CHIP | | SIRH5VA41A |
| SW5,6 | SWITCH,KEY,SKHHAJ2410-TC | | 187010201A |
| SW1-4 | SWITCH,SLIDE,SLVB232-04-EP | | 183160300A |

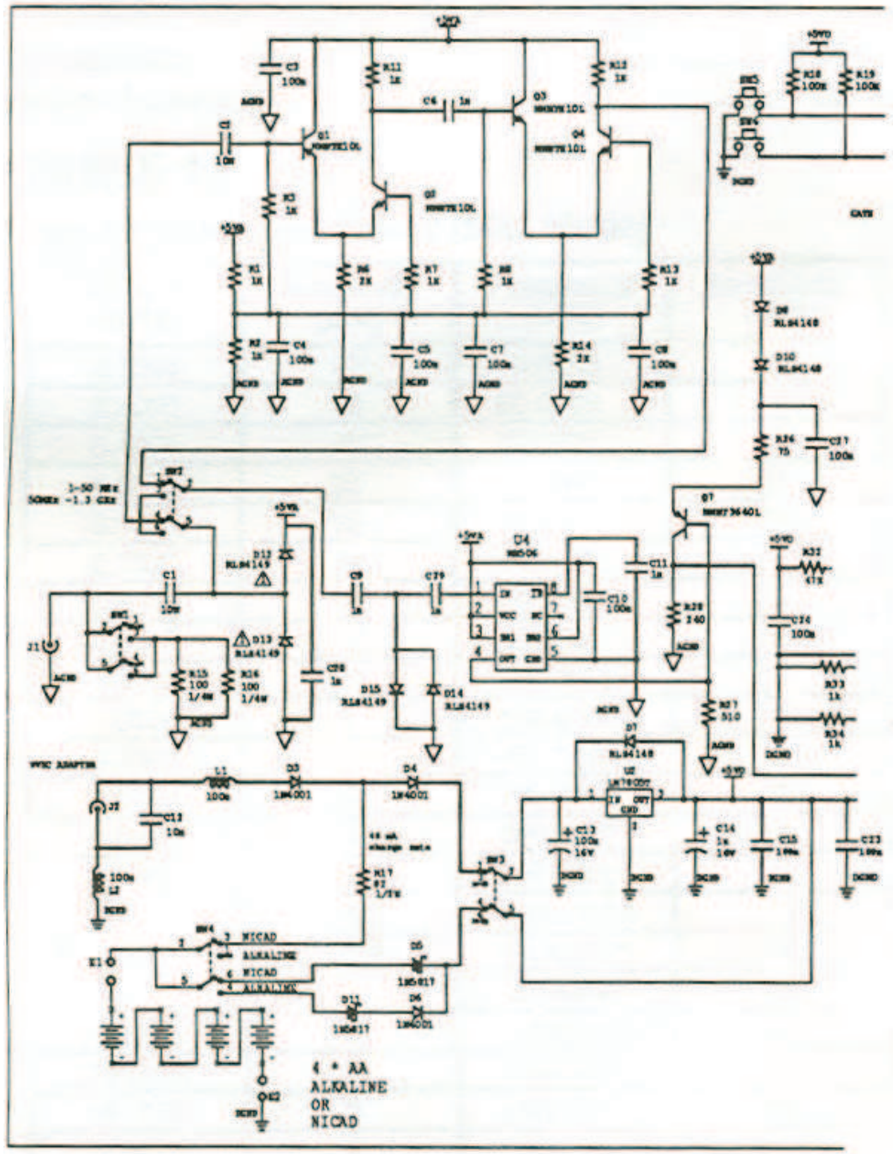
# PCB Layout and Schematic

Main PCB




+5VA
+5VD
AGND
DGND
GATE
BACKLIGHT
GATESPEED
FAST
SLOW
BACK LIGHTS
LOBAT
TEST
1~50 MHz
50MHz ~1.3 GHz
SVDC ADAPTER
4 * AA
ALKALINE
OR
NICAD
45 mA
charge rate
4.0000MHz
KS56C220
C379001E
for free by
RadioAmateur.eu

# SCHEMATIC






# SCHEMATIC