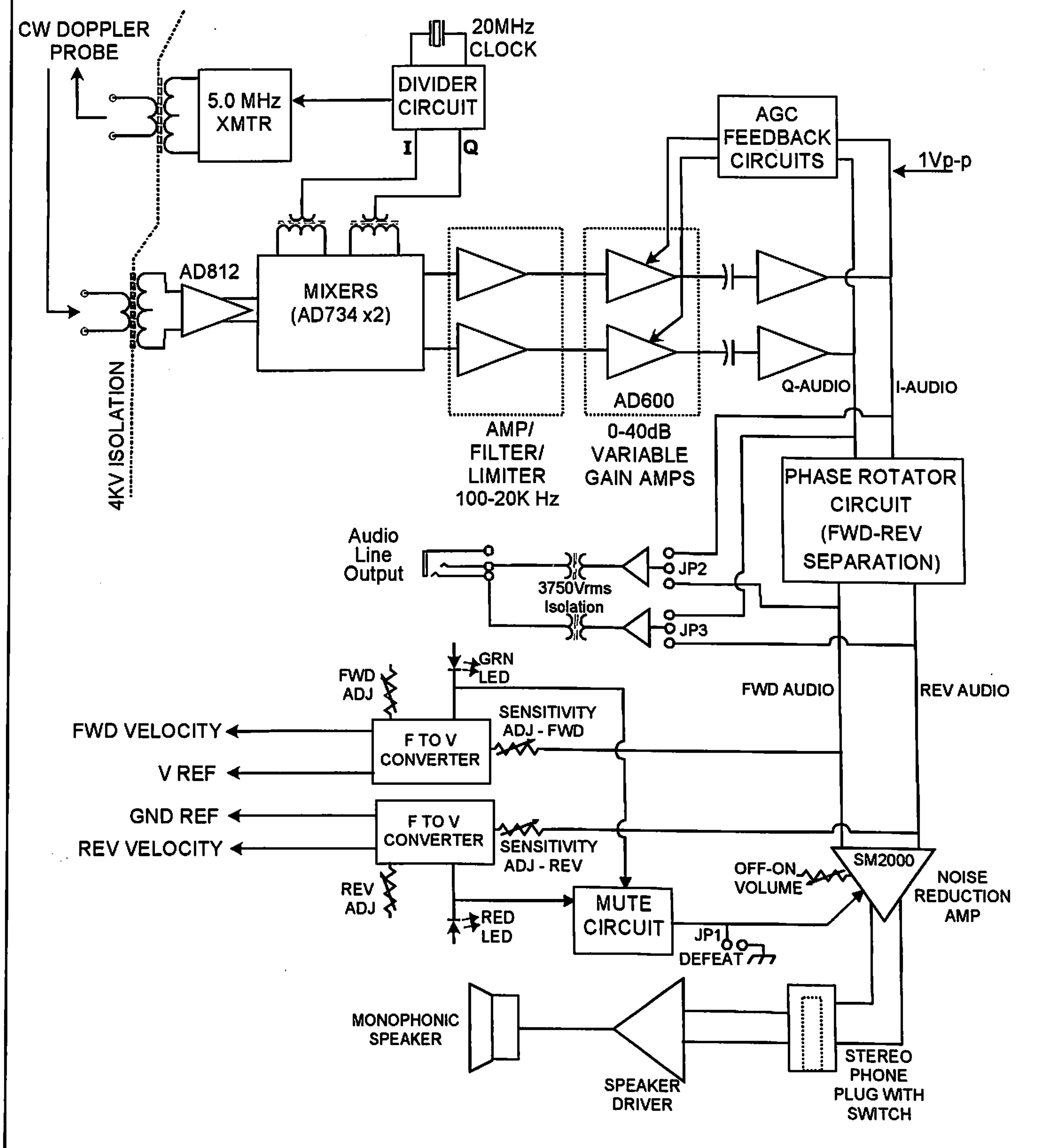


TOLERANCES: (UNLESS OTHERWISE NOTED) ALL .XXX DECIMAL: ^..005 ALL .XX DECIMAL: ^..03 ALL FRACTIONAL: ^.1/16 ALL ANGULAR: ^..5°	**Carolina Medical** VascuDOP™	MEDICAL DESIGN **James S. Campbell, EE, MD.** 3705 Sapona Trail, Pfafftown, NC 27040
MATERIAL:	DR. BY: JC,MD.	TITLE VascuDOP VELOCITY METER FUNCTIONAL BLOCK DIAGRAM
FINISH:	CHKD BY:	A — DATE 18 Dec 1998 — DRAWING NO.
	APPD.	SCALE — ECS — SHEET

VascuDOP Electrical and Mechanical Specifications

ULTRASOUND OUTPUT
- 5.00 MHz continuous wave
- 50 Ohms, nominal
- output power fixed to meet FDA guidelines for diagnostic ultrasound, not adjustable.

AUTOMATIC GAIN CONTROL (AGC)
- 40 dB (10,000x) AGC provided at mixer outputs
- AGC attack and release time 100 ms and 2 sec, nominal, respectively

THUMP (HIGH PASS) FILTER
- 9-pole Butterworth fixed at 100 Hz
- limits low frequency response to chart recorder and audio outputs

AUDIO OUTPUT CHARACTERISTICS
- 100 to 20,000 Hz bandwidth at earphone jacks, stereophonic
- 100 to 20,000 Hz +/- 1 dB, 1 Vrms, nom., at audio line output (Rload >600 ohms)
- 130 to 15,000 Hz +/- 3 dB, 1 Watt, max, output via concealed front panel speaker

CHART RECORDER OUTPUT (via AR-42 Recorder in VascuMAP environment)
- thermal strip recorder with 40 mm of waveform display
- tracing speeds: 1, 2, 5, 10, 25, and 50 cm/sec.
- waveform envelope bandwidth: 0 to 25 Hz.
- zero-velocity baseline fixed at 15 mm position of 40 mm waveform display area
- tracing polarity invertable
- full-scale recorder gain settings available:
  - 5, 10, 20, 30, 50, 100, 200, and 300 cm/sec
  - (corresponds to 333, 665, 1330, 2000, 3325, 6650, 13,300 and 20,000 Hz Doppler shift)

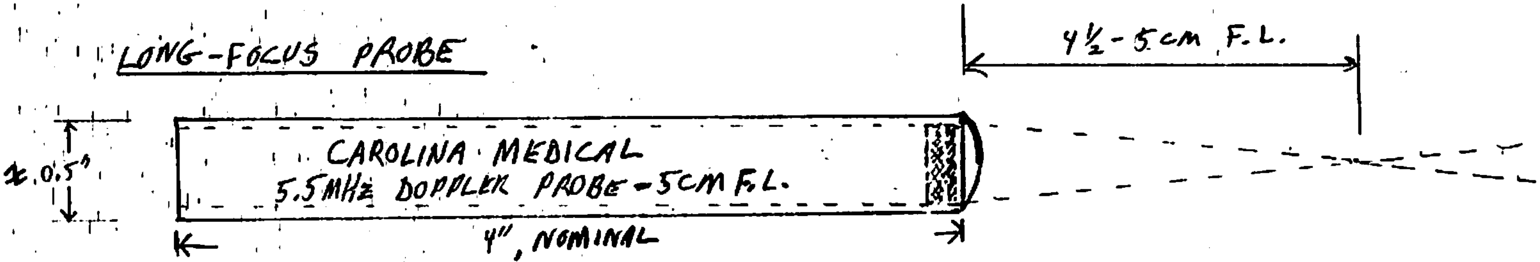
CONTROLS AND CONNECTIONS
- off-on-volume control
- FWD (green) and REV (red) LEDs indicate velocities detected
- stereo 1/8" earphone jack
- Doppler probe connector
- Isolated stereo audio line out (optional)

DOPPLER PROBES
- pencil probe with 2.0 cm focal length - standard
- High Gain probe with 2.5 cm focal length (optional)

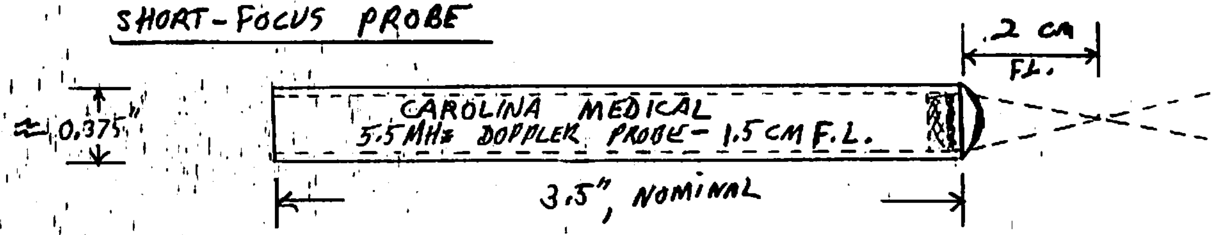
ELECTRICAL SAFETY SPECIFICATIONS (measured via UL-544)
- probe connector to protective ground isolation: 2500Vrms
- probe connector to power mains isolation: 5000 Vrms
- probe connector leakage current (all leads connected): under 50 microamps @ 60 Hz.
- Audio line output isolation from Doppler board: 3750 Vrms

MECHANICAL SPECIFICATIONS
- Case size: 16.5"W x 14.5"D x 5.25"H
- Weight: TBD
- Operating temperature: +10 to +38 Degrees, C, when calibrated at 23C.
- Operating and storage humidity: 20% to 90% RH, noncondensing
- Shock and vibration: Withstands normal shipping stresses and clinical hospital use
- Case materials: Aluminum and high-density plastic, rated UL94 V-0

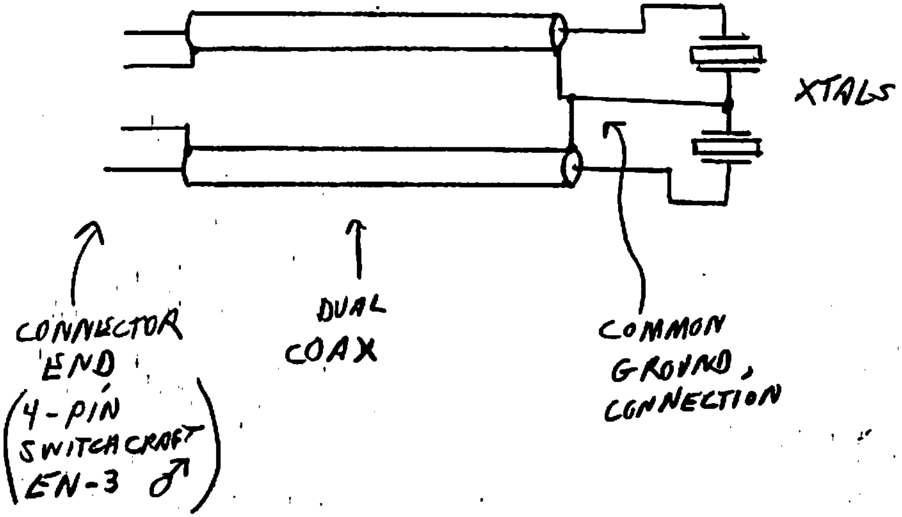
LONG-FOCUS PROBE



SHORT-FOCUS PROBE



WIRING CONNECTION:



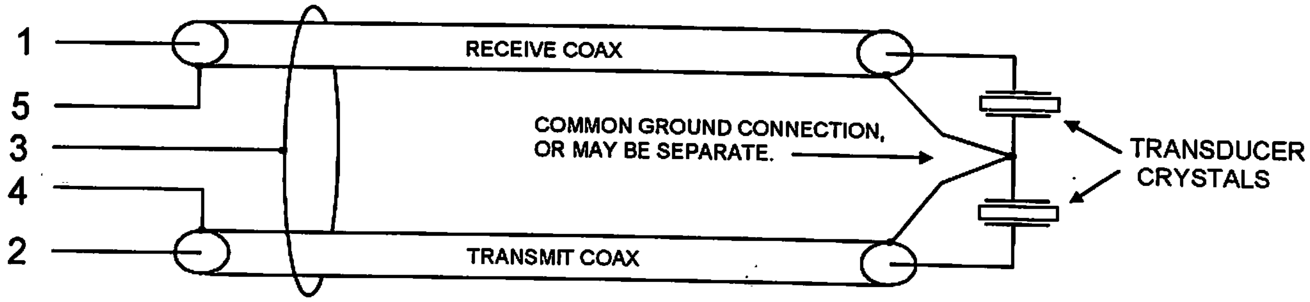
VASCU DOP

STANDARD PROBES

(PROPOSED DESIGN)

JC, MO // 9/3/95

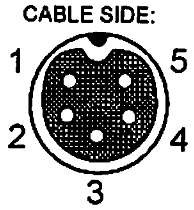
ELECTRICAL CONNECTION:



CABLE CONNECTOR:

SWITCHCRAFT EN-3
5-CONDUCTOR MALE

CABLE SIDE:



1 - RECEIVE SIGNAL
2 - TRANSMIT SIGNAL
3 - SHIELD (IF PRESENT)
4 - TRANSMIT COMMON
5 - RECEIVE COMMON

MECHANICAL SPECIFICATIONS:

Cable: 6 ft. long flexible dual coaxial with overall shield, strain relieved at probe.

Probe housing: nonconductive, washable with alcohol and common disinfectants.

ELECTRICAL SPECIFICATIONS: (in anechoic water bath)

Center Frequency:	5.0 MHz
Element Impedance:	50 Ohm, nominal
Insertion Loss:	-15 dB, maximum
Cross coupling (50 ohm):	-40 dB, minimum
Electrical Safety:	Vbk > 500Vrms for 1 minute leakage: < 10 microamps @ 120 Vrms, 50-60 Hz.

QUALIFIED SOURCES:

1) Blatek, Inc. P/N AT13322 - 5 Mhz, 30 mm focus CW/PW Probe
2) Etalon, Inc P/N CD-10-5-6-22-DZCEN31.5, 22 mm Focus CW Probe

TOLERANCES:
(UNLESS OTHERWISE NOTED)
ALL .XXX DECIMAL: ^.005
ALL .XX DECIMAL: ^.03
ALL FRACTIONAL: ^.1/16
ALL ANGULAR: ^.5°

MATERIAL:

FINISH:

MEDesign

DR. BY: JC, MD.

CHKD BY:

APPD.

James Stewart Campbell, MD.
3705 Sapona Trail, Pfafftown, NC 27040

TITLE: VascuDOP CW Doppler Probes
Basic Specifications

A

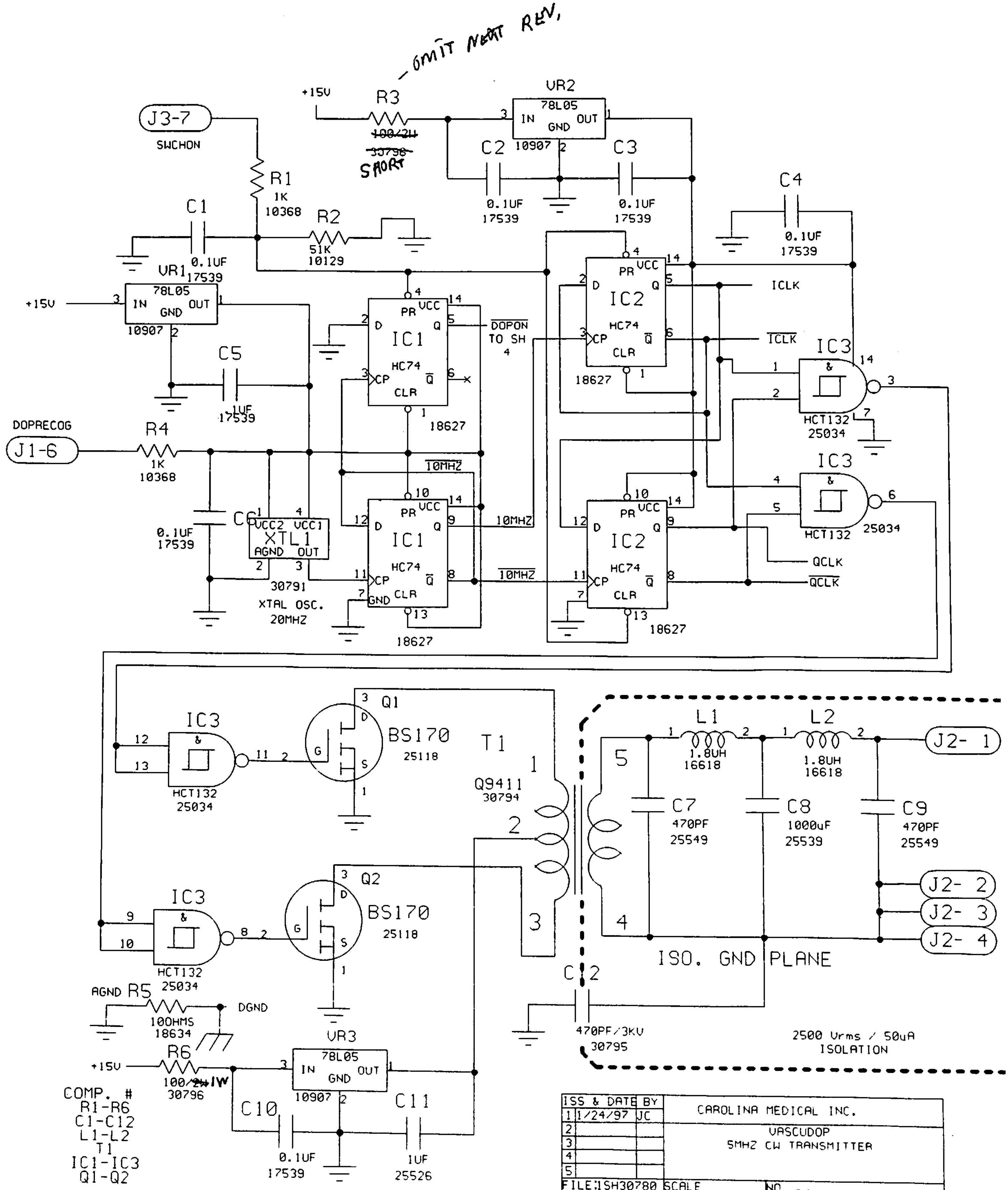
DATE: 2/2/00

DRAWING NO.

SCALE

ECS

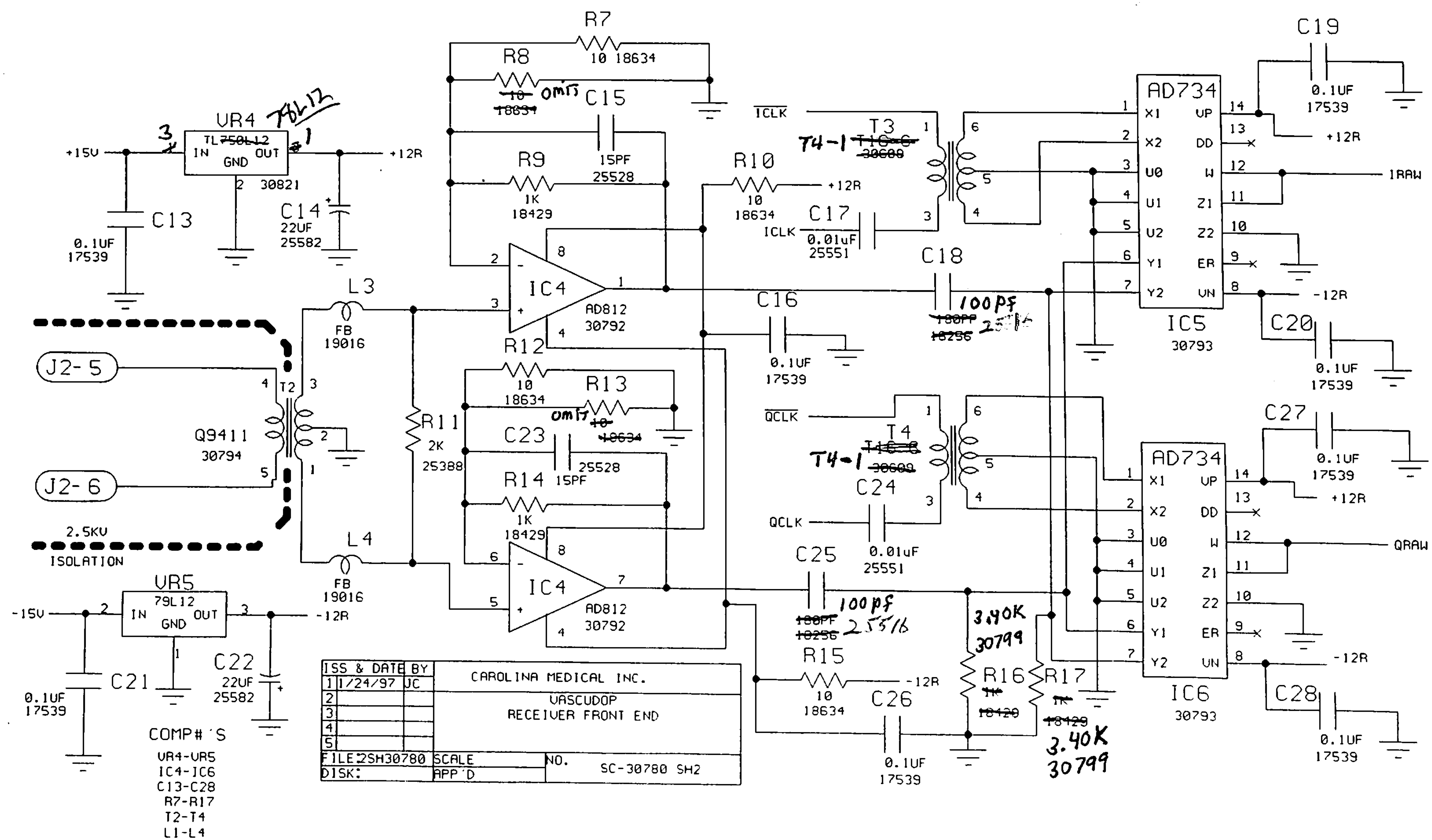
SHEET 1 of 1



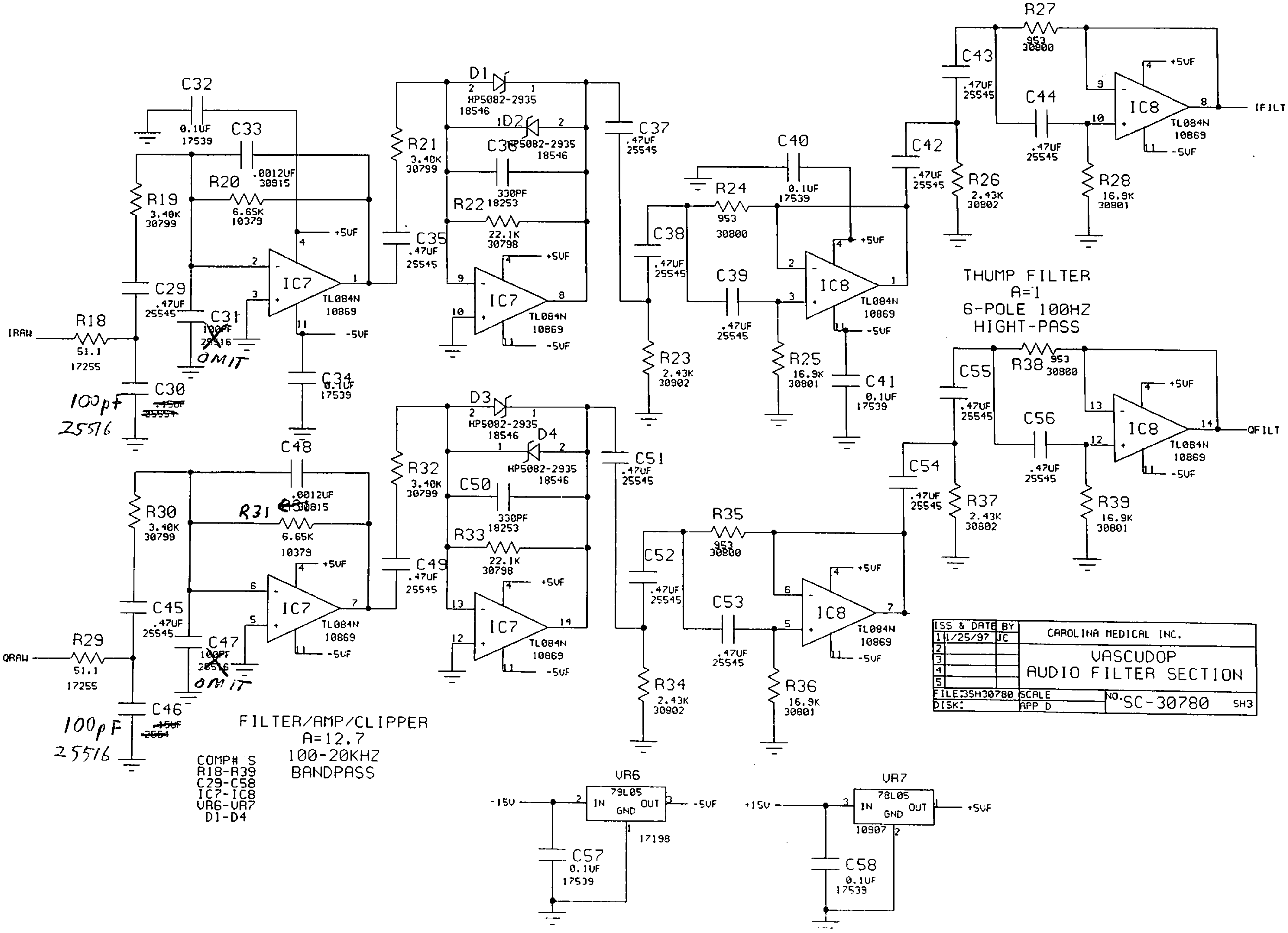
ISS & DATE	BY	CAROLINA MEDICAL INC.
1 1/24/97	JC	VASCUDOP
2		5MHZ CW TRANSMITTER
3		
4		
5		
FILE:ISH30780	SCALE	NO. SC-30780 SH1
DISK:	APP D	

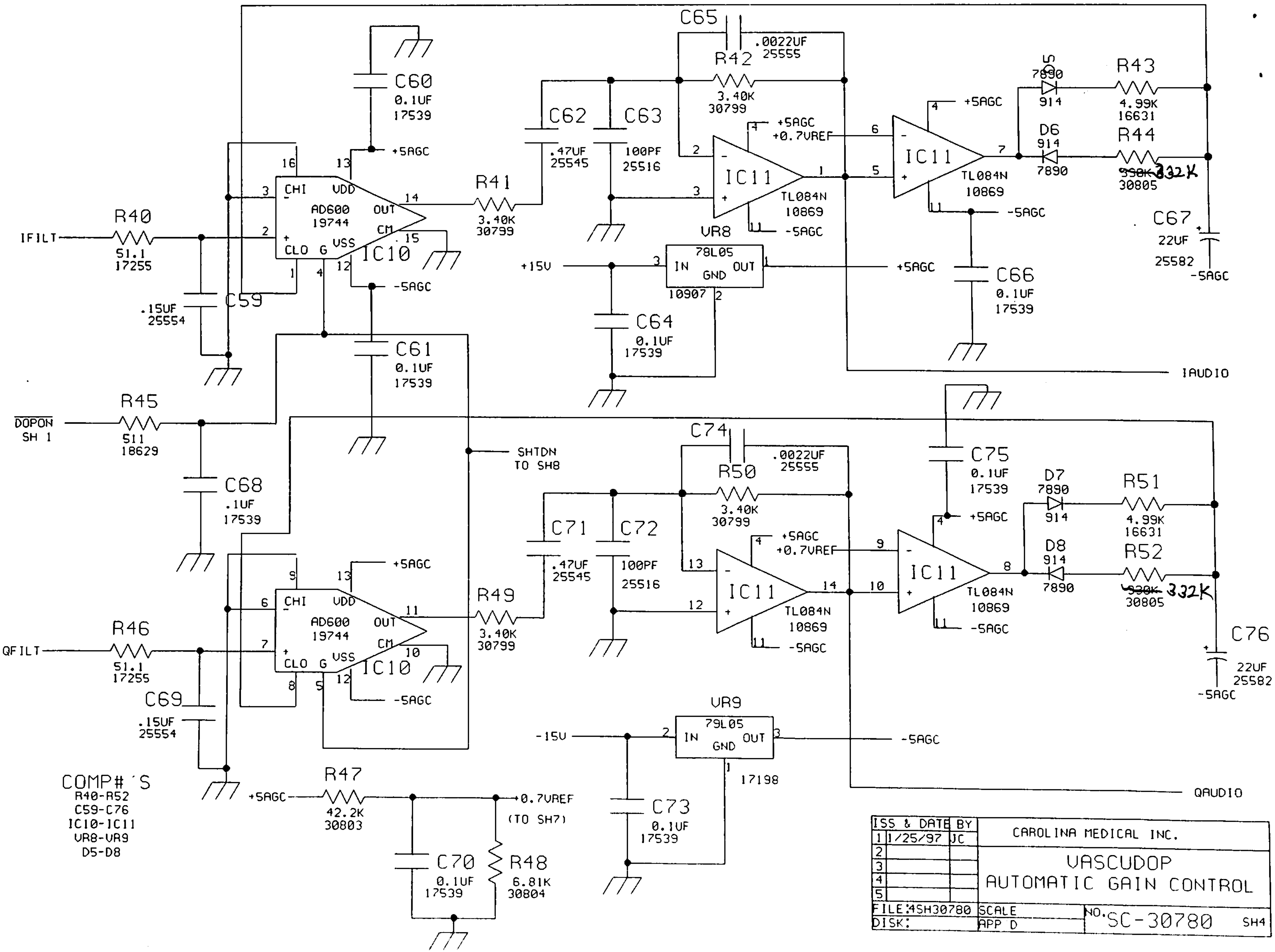
FINAL
SAVE!

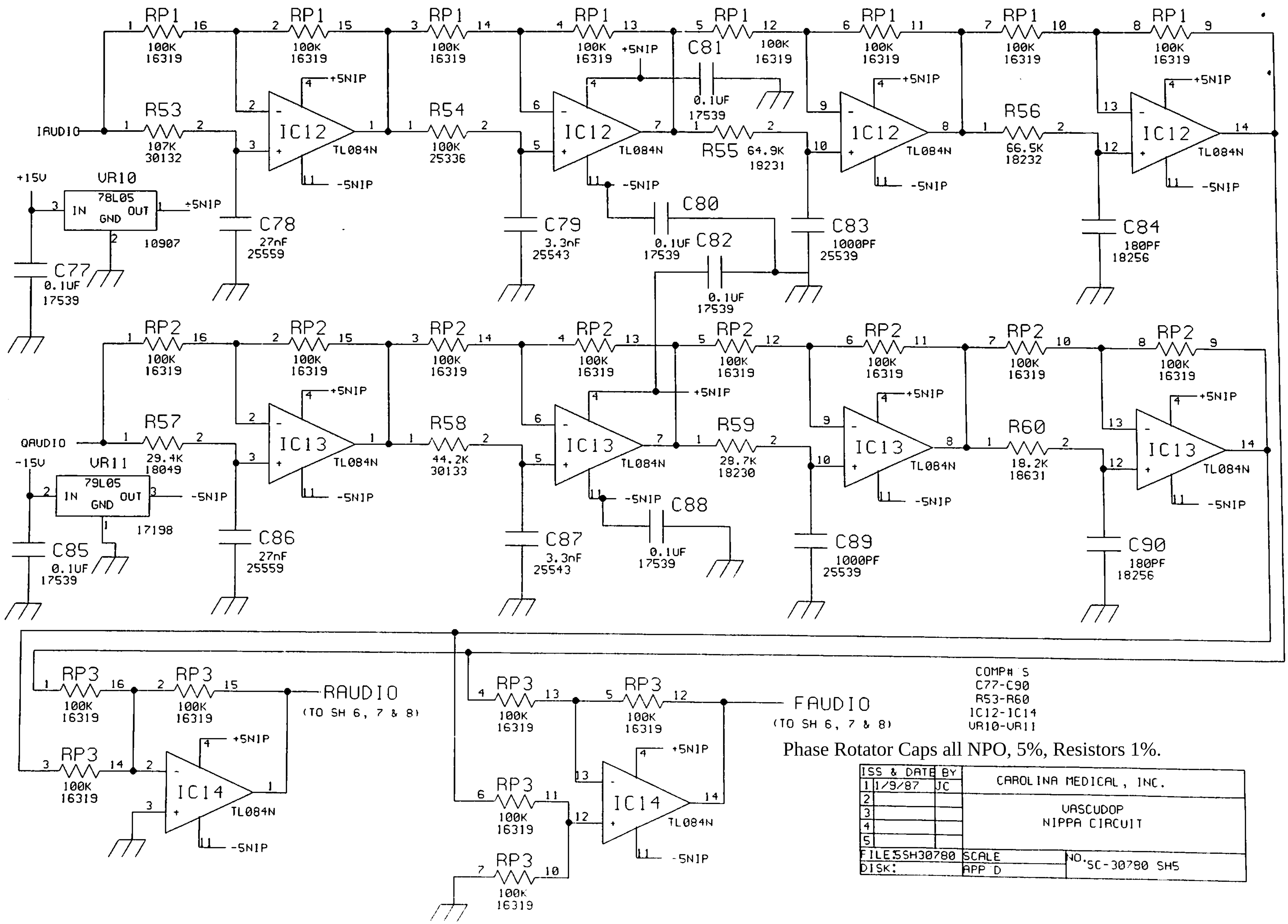
30780-6, PLT
- CORRECTION COPY

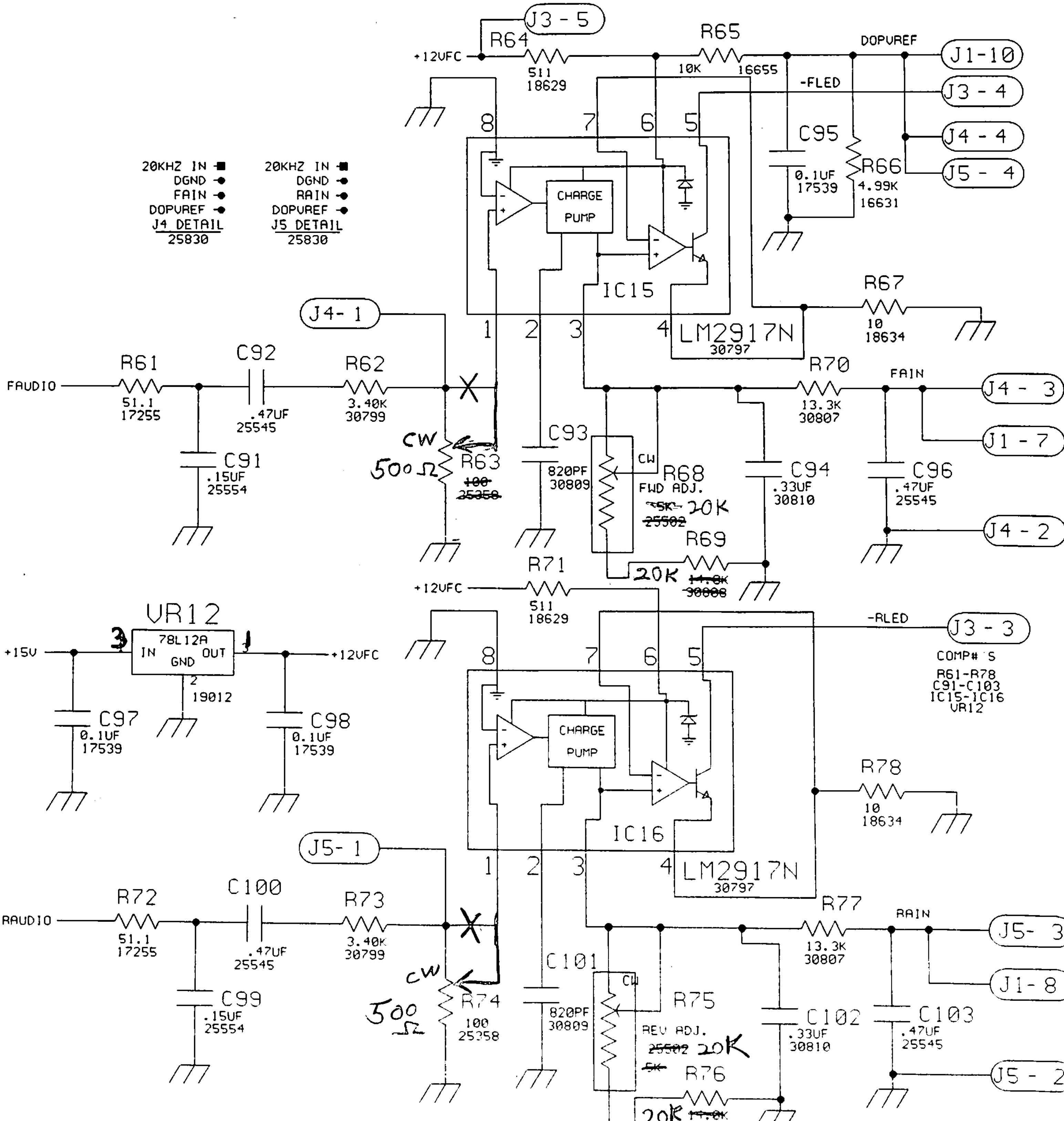


R7
10 18634
R8
10
18634
OMIT
C15
15PF
25528
R9
1K
18429
R10
10
18634
+12R
C17
0.01uF
25551
ICLK
T3
T4-1
T16-6
30609
AD734
X1
X2
U0
U1
U2
Y1
Y2
UP
DD
W
Z1
Z2
ER
UN
C19
0.1UF
17539
+12R
IRAW
-12R
IC5
30793
C20
0.1UF
17539
VR4
79L12
TL750L12
IN
GND
OUT
30821
+15V
+12R
C13
0.1UF
17539
C14
22UF
25582
IC4
AD812
30792
C16
0.1UF
17539
C18
100PF
180PF
18256
25516
L3
FB
19016
J2- 5
J2- 6
T2
Q9411
30794
R11
2K
25388
2.5KV
ISOLATION
R12
10
18634
R13
OMIT
10
18634
C23
15PF
25528
R14
1K
18429
QCLK
T4
C24
0.01uF
25551
C27
0.1UF
17539
QRAW
IC6
30793
C28
0.1UF
17539
L4
FB
19016
VR5
79L12
-15V
-12R
C21
0.1UF
17539
C22
22UF
25582
C25
100PF
180PF
18256
25516
R15
10
18634
-12R
C26
0.1UF
17539
R16
1K
18429
3.40K
30799
R17
1K
18429
3.40K
30799
COMP#'S
VR4-VR5
IC4-IC6
C13-C28
R7-R17
T2-T4
L1-L4
ISS & DATE BY
1 1/24/97 JC
2
3
4
5
CAROLINA MEDICAL INC.
VASCUDOP
RECEIVER FRONT END
FILE:2SH30780
DISK:
SCALE
APP'D
NO.
SC-30780 SH2

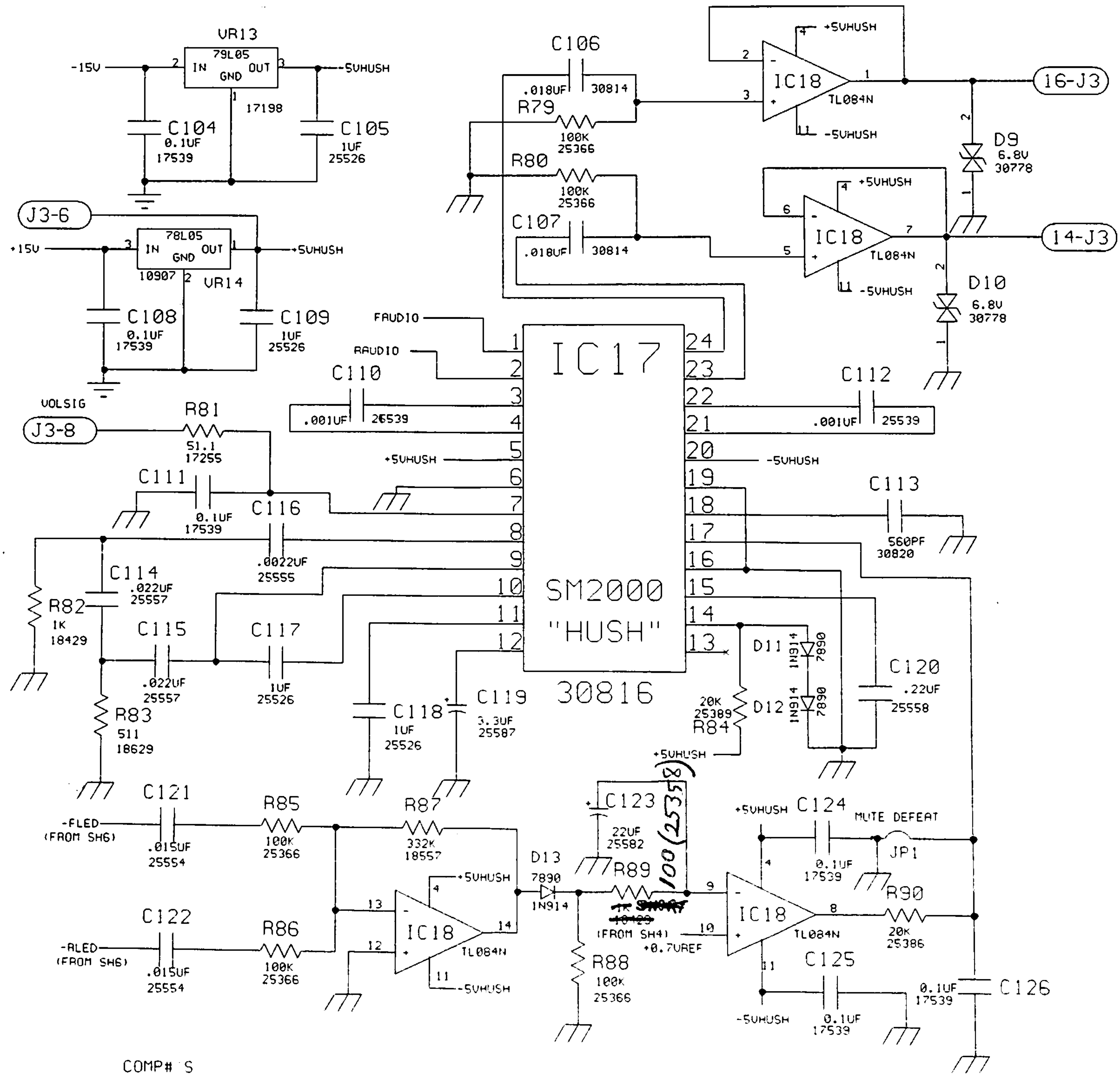

IRAW
QRAW
IFILT
QFILT
R18 51.1 17255
R19 3.40K 30799
R20 6.65K 10379
C29 .47UF 25545
C30 100pf 25516
C31 100PF 25516 OMIT
C32 0.1UF 17539
C33 .0012UF 30815
C34 0.1UF 17539
C35 .47UF 25545
IC7 TL084N 10869
R21 3.40K 30799
R22 22.1K 30798
C36 330PF 18253
D1 HP5082-2935 18546
D2 HP5082-2935 18546
C37 .47UF 25545
R23 2.43K 30802
C38 .47UF 25545
R24 953 30800
C39 .47UF 25545
C40 0.1UF 17539
R25 16.9K 30801
C41 0.1UF 17539
IC8 TL084N 10869
C42 .47UF 25545
R26 2.43K 30802
C43 .47UF 25545
R27 953 30800
C44 .47UF 25545
R28 16.9K 30801
THUMP FILTER
A=1
6-POLE 100HZ
HIGHT-PASS
R29 51.1 17255
R30 3.40K 30799
R31 6.65K 10379
C45 .47UF 25545
C46 100pF 25516
C47 100PF 25516 OMIT
C48 .0012UF 30815
C49 .47UF 25545
R32 3.40K 30799
R33 22.1K 30798
C50 330PF 18253
D3 HP5082-2935 18546
D4 HP5082-2935 18546
C51 .47UF 25545
C52 .47UF 25545
R34 2.43K 30802
R35 953 30800
C53 .47UF 25545
R36 16.9K 30801
C54 .47UF 25545
R37 2.43K 30802
C55 .47UF 25545
R38 953 30800
C56 .47UF 25545
R39 16.9K 30801
+5VF
-5VF
FILTER/AMP/CLIPPER
A=12.7
100-20KHZ
BANDPASS
COMP#'S
R18-R39
C29-C58
IC7-IC8
VR6-VR7
D1-D4
VR6 79L05 17198
-15V IN GND OUT -5VF
C57 0.1UF 17539
VR7 78L05 10907
+15V IN GND OUT +5VF
C58 0.1UF 17539
ISS & DATE BY
1 1/25/97 JC
CAROLINA MEDICAL INC.
VASCUDOP
AUDIO FILTER SECTION
FILE:3SH30780 SCALE
DISK: APP D
NO. SC-30780 SH3


C65
.0022UF
25555
R42
3.40K
30799
C60
0.1UF
17539
+5AGC
C62
.47UF
25545
C63
100PF
25516
+5AGC
+0.7VREF
IC11
TL084N
10869
R43
4.99K
16631
D5
7890
914
D6
914
7890
R44
330K 332K
30805
C67
22UF
25582
-5AGC
R40
51.1
17255
IFILT
CHI
VDD
AD600
19744
OUT
CM
CLO
G
VSS
IC10
R41
3.40K
30799
VR8
78L05
IN
GND
OUT
10907
+15V
+5AGC
-5AGC
C59
.15UF
25554
C61
0.1UF
17539
C64
0.1UF
17539
C66
0.1UF
17539
IAUDIO
R45
511
18629
DOPON
SH 1
C68
.1UF
17539
SHTDN
TO SH8
C74
.0022UF
25555
R50
3.40K
30799
C75
0.1UF
17539
D7
7890
914
R51
4.99K
16631
D8
914
7890
R52
330K 332K
30805
C71
.47UF
25545
C72
100PF
25516
R49
3.40K
30799
C76
22UF
25582
R46
51.1
17255
QFILT
C69
.15UF
25554
VR9
79L05
17198
-15V
C73
0.1UF
17539
QAUDIO
COMP#'S
R40-R52
C59-C76
IC10-IC11
VR8-VR9
D5-D8
R47
42.2K
30803
+0.7VREF
(TO SH7)
C70
0.1UF
17539
R48
6.81K
30804
ISS & DATE BY
1 1/25/97 JC
2
3
4
5
CAROLINA MEDICAL INC.
VASCUDOP
AUTOMATIC GAIN CONTROL
FILE:4SH30780
DISK:
SCALE
APP D
NO. SC-30780
SH4


RP1
100K
16319
R53
107K
30132
IAUDIO
IC12
TL084N
+5NIP
-5NIP
R54
100K
25336
R55
64.9K
18231
R56
66.5K
18232
+15V
VR10
78L05
IN
GND
OUT
10907
C77
0.1UF
17539
C78
27nF
25559
C79
3.3nF
25543
C80
0.1UF
17539
C81
0.1UF
17539
C82
0.1UF
17539
C83
1000PF
25539
C84
180PF
18256
RP2
100K
16319
QAUDIO
R57
29.4K
18049
IC13
TL084N
R58
44.2K
30133
R59
28.7K
18230
R60
18.2K
18631
-15V
VR11
79L05
17198
C85
0.1UF
17539
C86
27nF
25559
C87
3.3nF
25543
C88
0.1UF
17539
C89
1000PF
25539
C90
180PF
18256
RP3
100K
16319
IC14
TL084N
RAUDIO
(TO SH 6, 7 & 8)
FAUDIO
(TO SH 6, 7 & 8)
COMP#'S
C77-C90
R53-R60
IC12-IC14
VR10-VR11
Phase Rotator Caps all NPO, 5%, Resistors 1%.
ISS & DATE
BY
1 1/9/87 JC
2
3
4
5
CAROLINA MEDICAL, INC.
VASCUDOP
NIPPA CIRCUIT
FILE:SSH30780
DISK:
SCALE
APP D
NO. SC-30780 SH5

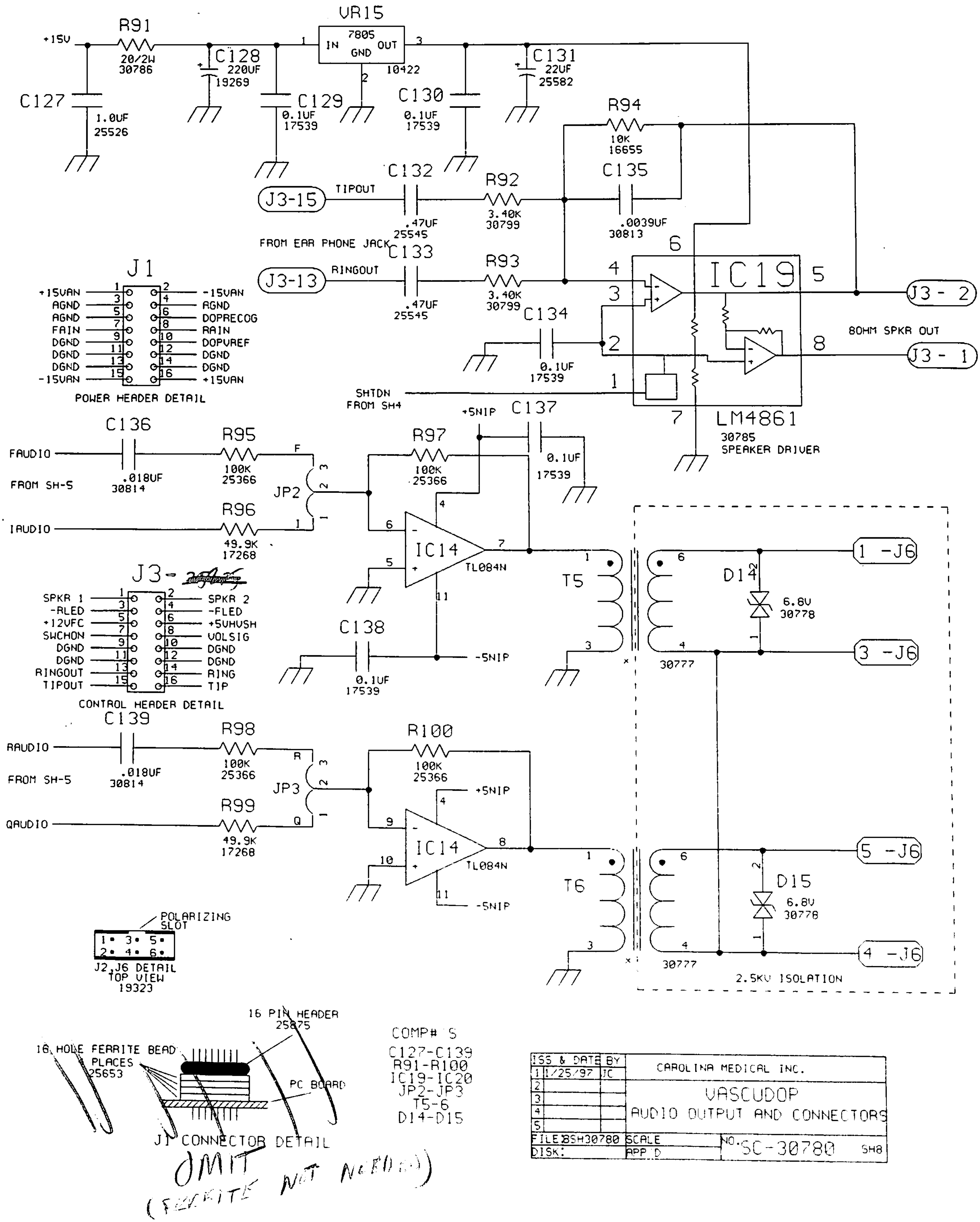


ISS	& DATE	BY	CAROLINA MEDICAL INC.
1	1/25/97	JC	VASCUDOP
2			FREQ-TO-VOLTAGE CONV.
3			
4			
5			
FILE:	SSH30780	SCALE	NO. SC-30780 SH6
DISK:		APP D	

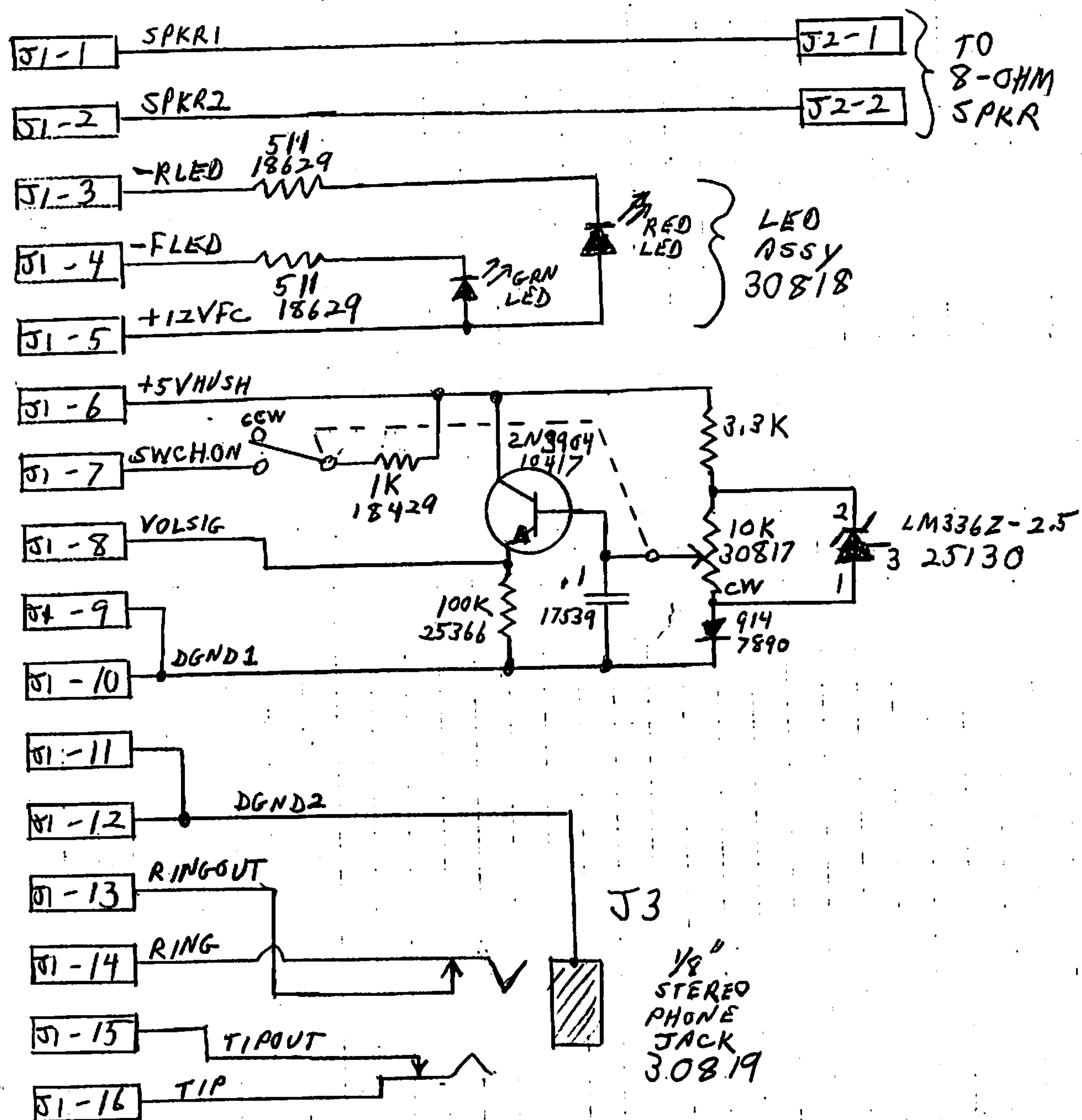


COMP#'S
R79-R90
C104-C126
IC17-IC18
D9-D13
JP1
VR13-VR14

ISS & DATE	BY	
1 6/6/97	JC	CAROLINA MEDICAL INC.
2		VASCUDOP
3		NOISE REDUCTION SECTION
4		AND AUTOMATIC MUTE
5		
FILE:7SH30780	SCALE	NO. SC-30780 SH7
DISK:	APP D	



+15V
R91
20/2W
30786
VR15
7805
IN
GND
OUT
10422
C128
220UF
19269
C129
0.1UF
17539
C127
1.0UF
25526
C130
0.1UF
17539
C131
22UF
25582
R94
10K
16655
C132
TIPOUT
J3-15
.47UF
25545
R92
3.40K
30799
C135
.0039UF
30813
FROM EAR PHONE JACK
C133
RINGOUT
J3-13
.47UF
25545
R93
3.40K
30799
C134
0.1UF
17539
IC19
LM4861
30785
SPEAKER DRIVER
J3- 2
80HM SPKR OUT
J3- 1
SHTDN
FROM SH4
J1
+15VAN
-15VAN
AGND
AGND
DOPRECOG
FAIN
RAIN
DGND
DOPVREF
DGND
DGND
DGND
DGND
-15VAN
+15VAN
POWER HEADER DETAIL
C136
FAUDIO
.018UF
30814
FROM SH-5
R95
100K
25366
JP2
R96
IAUDIO
49.9K
17268
R97
100K
25366
+5NIP
C137
0.1UF
17539
IC14
TL084N
T5
-5NIP
C138
0.1UF
17539
D14
6.8V
30778
30777
1 -J6
3 -J6
J3-
SPKR 1
SPKR 2
-RLED
-FLED
+12VFC
+5VHVSH
SWCHON
VOLSIG
DGND
DGND
DGND
DGND
RINGOUT
RING
TIPOUT
TIP
CONTROL HEADER DETAIL
C139
RAUDIO
.018UF
30814
FROM SH-5
R98
100K
25366
JP3
R99
QAUDIO
49.9K
17268
R100
100K
25366
+5NIP
IC14
TL084N
-5NIP
T6
D15
6.8V
30778
30777
5 -J6
4 -J6
2.5KV ISOLATION
POLARIZING SLOT
J2,J6 DETAIL
TOP VIEW
19323
16 PIN HEADER
25875
16 HOLE FERRITE BEAD
PLACES
25653
PC BOARD
J1 CONNECTOR DETAIL
OMIT
(FERRITE NOT NEEDED)
COMP# 'S
C127-C139
R91-R100
IC19-IC20
JP2-JP3
T5-6
D14-D15
ISS & DATE BY
1 1/25/97 JC
CAROLINA MEDICAL INC.
VASCUDOP
AUDIO OUTPUT AND CONNECTORS
FILE: BSH30780
SCALE
DISK:
APP D
NO. SC-30780
SH8



SC-30781

VASCUDOP

CONTROL DAUGHTER BOARD

P1 OF 1

JC, MD // 4/2/97

PROOF COPY

VascuDOP Calibration and Maintenance Manual

Basic Description of the VascuDOP Continuous Wave Doppler

The VascuDOP is a full-functioned 5 MHz CW Doppler for calibrated axial blood flow velocity measurement and medical diagnostic purposes. It consists of a 7.5" by 4.25" three-layer circuit board which contains a 5 MHz sinusoidal waveform transmitter with transformer-isolated Doppler probe connections, a low-noise receiver-mixer with I and Q audio outputs driving matched 100 Hz low-pass "thump" filters and dual 40dB automatic gain amplifiers, a precision Nippa circuit to develop forward and reverse flow signals from I and Q audio, and dual frequency-to-voltage converters to perform zero-crossing envelope detection on the FWD and REV signals. Isolated high-fidelity audio line outputs of the FWD/REV or I/Q signals are provided for off-board spectral analysis by personal computer, and volume-adjustable audio with custom noise reduction and automatic mute drives a 1-watt speaker or stereo headphones. A small daughterboard (PC-30781) provides on-off-volume adjustment, FWD/REV signal indicator LEDs, and speaker and earphone connections. This daughterboard is connected by a 16-conductor ribbon cable, and may be located several feet from the main circuit board. Power requirements for the VascuDOP are +/-15 volts DC supplied by an off-board linear power supply. Circuit adjustments and jumpers consist of two F-to-V sensitivity trimmers, two F-to-V calibration trimmers (with associated 4-pin service connectors), two audio output selector jumpers (FWD-I and REV-Q), and a Mute Defeat jumper/switch connector to disable the automatic mute function if desired.

Mechanical Mounting Considerations:

The VascuDOP board has five 0.157" round mounting holes, one on each corner and the other in the center of the board. These holes are ringed by insulation clearance and may be used with conductive mounting screws or other mounts. Size 6 machine screws are recommended for mounting.

The front-end portion of the VascuDOP board, and especially the mixer section, should be mechanically separated and shielded from any magnetic fields, transformers, and power circuitry to avoid coupling these noise sources into the very sensitive circuitry.

The leads to the Doppler probe and the isolated audio line output must be designed with voltage breakdown to adjacent chassis metal or circuitry as a specification to preserve the 4 KV isolation of the probe connector. The Doppler probe connection cables should be low triboelectric type to prevent lead "rustle" if the unit is moved during operation. It may be necessary to encircle the Probe Connector (J2) tightly with a small tie-wrap to prevent connector noise.

The 16-lead ribbon cables for power and control circuits do not need to be isolated from ground except for special applications. They should be well separated from any power cables, however.

Detailed Circuit Description:

Ground Plane Layout:

There are three separate ground planes on the VascuDOP board - AGND, DGND, and IGND. AGND and DGND are connected by 10-ohm resistor (R5) to prevent potential differences if the board is unplugged. AGND supplies the transmitter (IC1,2,3), receiver(IC4), I&Q mixers (IC5,6), and audio filter sections (IC7,8). Three signals (IFILT, QFILT, !DOPON) then are passed to the

DGND section through low-pass filters. DGND supplies the remainder of the circuitry consisting of the AGC amplifiers, F-to-V converters, Nippa circuit, and audio drivers. The third plane (IGND), an isolated ground region for the Doppler Probe connections and transmitter output filter, is AC-coupled to AGND via C12, a 470pf/3KV capacitor. AGND and DGND are pinned out separately at the Power Header (J1). The cable attached to the Power Header should pass through a low-pass filter (3 turns through a ferrite bead is recommended) before AGND and DGND are combined at the off-board power supply. The Ground Plane layer of the VascuDOP board is the middle of the three layers.

Power Supplies and Regulation:
The VascuDOP, like any high-gain Doppler circuit, is sensitive to conducted noise on the power supplies or ground. Switching power supplies should be avoided to reduce "hash" noise unless adequate shielding and extra ferrite suppression in the power cable can be provided. Low-ripple regulated +15 and -15 DC voltages are preferred to reduce hash noise and power frequency hum. The positive supply should be rated for 0.55 amps, and the negative supply for 0.15 amps. Power supply voltages are not critical (pos. or neg. 14-18V), as all voltage regulation is done locally on the VascuDOP board.

Even with linear power supplies, the 16-lead power cable should be run three (3) turns through a large (1") high-loss ferrite bead. The bead should be at the VascuDOP end of the cable. This prevents high frequency feedback from the digital ground sections getting to the sensitive analog ground circuitry. The ferrite bead also attenuates any conducted noise in the power supply leads or in the F-to-V output connections.

The Power Supply Header:
The 16-pin, 0.1" DIP header (J1) uses 12 pins to connect the power and grounds to the VascuDOP. Four additional signal lines are included in J1. These are FWD and REV analog voltage waveforms (FAIN & RAIN) from the F-to-V converters (IC15,16) and an analog reference voltage, DOPVREF, (approx. +2.5V) for off-board A-to-D conversion of FAIN and RAIN. Also present is a +5V logic high signal to indicate the VascuDOP is plugged in and powered (DOPRECOG). Note that the Power Header (J1) has been designed so that plugging in the connector the wrong way around will not damage the VascuDOP (but the analog outputs will not operate correctly). See SH8 of the schematics for pinout details.

Pin #	Name	Function
1	+15VAN	+15 Volt supply pin (1 of 2)
2	-15VAN	-15 Volt supply pin (1 of 2)
3	AGND	Analog ground return
4	AGND	Analog ground return
5	AGND	Analog ground return
6	DOPRECOG	Logic High (+5V) from VascuDOP to motherboard
7	FAIN	Forward flow analog waveform signal (0-2.5V)
8	RAIN	Reverse flow analog waveform signal (0-2.5V)
9	DGND	Digital Ground for A-D converter reference
10	DOPVREF	approx. 2.5V reference for A-D conversion of FAIN & RAIN
11	DGND	Digital Ground return
12	DGND	Digital Ground return
13	DGND	Digital Ground return
14	DGND	Digital Ground return
15	-15VAN	-15 Volt supply pin (2 of 2)

16	+15VAN	+15 Volt supply pin (2 of 2)

The Transmitter Section:
Transmitter frequency is controlled by a 20MHz crystal oscillator (XTL1) for stability. The 20MHz signal is divided by two in IC1b to provide 10MHz and !10MHz signals that are used to clock the two "D" registers in IC2 to produce the 5 MHz ICLK and QCLK (and their inverse signals) for the receiver section, with Q lagging I by 90 degrees. IC3 then develops the signals ICLK AND QCLK and !ICLK AND !QCLK which drive the transmitter output driver transistors (Q1,2) that are connected in a transformer-coupled Class D configuration. The staggered outputs of IC3 assure that the output driver transistors are not ON at the same time. The isolated output of the 4:1 step-down transmitter transformer (T1) is passively filtered by a 5 MHz two-section L-C "pi" filter. RF output from this filter into a 50 Ohm load is 5 Vpp, nominal. The RF filter and Doppler probe connector (J2) is located on an isolated ground plane (IGND) which is AC-coupled to analog ground via C12, a 470 pF, high-voltage capacitor which removes common-mode noise from the Doppler Probe and cable. C12 SHOULD NEVER BE REPLACED BY A LOW-VOLTAGE CAP OR ONE OF GREATER CAPACITANCE.

The transmitter is turned OFF when the SWCHON signal (J3, pin7) goes LOW. This logic low level presets IC2a and clears IC2b, shutting off both output transistors. If the control daughterboard is not connected to J3, the transmitter will be off because R2 pulls SWCHON low. Note that IC1a acts as an inverter for SWCHON to produce !DOPON. This inverted signal is used to shut down IC10 (the AGC amplifier) and IC19 (the audio speaker amplifier) thus shutting all audio outputs off and reducing current consumption.

The Receiver-Mixer Front End:
The signal generated by the receiving crystal in the Doppler probe is fed directly from J2 into the unbalanced side of transformer T2. T2 provides patient isolation and is connected in 1:4 step-up, grounded center-tap secondary configuration to provide differential voltage gain while attenuating common-mode noise. Ferrite beads (L3,4) reduce any high-frequency interference to the high-impedance inputs of the low-noise amplifiers in IC4. Load matching of the Doppler crystal impedance occurs at R11. The RF amplifiers in IC4 each provide a voltage gain of 100, and their outputs are 180 degrees out of phase to drive the inputs of two mixers (IC5,6) in push-pull fashion. Any DC component of the RF amp outputs is removed by C18 and C25 before driving the mixers.

The two mixer IC's (IC5,6) multiply the RF input at their "y" terminals (see SC-30780 sh2) by the square-wave I or Q voltage signals from IC2 which drive the mixer "x" inputs via the 1:1 grounded center-tap secondary transformers (T3,4) to attenuate any common-mode noise on the I and Q signals. Conversion gain to produce the raw I and Q audio signals is approximately one (0 dB).

To allow high-level mixing, the RF amplifiers (IC4) and the two mixers (IC5,6) are powered by +/- 12Volt regulators (VR4,5), with power to IC4 de-coupled from the mixers by R10-C16 and R15-C26 to prevent oscillation. This configuration allows up to +/- 20 Volt differential RF output from IC4 and +/- 10V outputs from the mixers without clipping or distortion.

Audio Filter Section:

The mixer outputs (IRAW and QRAW) are processed identically in two separate channels. Close-tolerance components are used throughout to assure equal processing of both channels. For the following circuit explanation, component designators are written with the I-channel designator before the Q-designator - e.g. (CI,Q).

The "raw" unfiltered audio from the mixers is first low-pass filtered to remove any RF (R18-C30, R29-C46). Then it goes through a Butterworth 3-pole 100Hz high-pass filter (IC7a,IC7b). Next it is processed in a 100-20kHz band-pass filter (IC7c,IC7d) where Shottky diodes (D1&D2,D3&D4) clip any non-physiologic high-amplitude signals (over +/-0.3V) such as those produced by probe movement. These signals need to be limited to prevent long recovery times in the automatic gain control (AGC) stages which follow. Blood flow signals are not affected by this clipping, as they are of much smaller amplitude. Finally, the conditioned I and Q audio is passed through a 6-pole 100Hz low-pass "thump" filter (IC8ac,IC8bd) to block the undesired low-frequency signal from vessel wall motion. The signals are then fed to the AGC Amplifiers as IFILT and QFILT.

Automatic Gain Control (AGC) Circuit:
The AGC circuit is based on the AD600 dual voltage-controlled amplifier (IC10a,IC10b). These amplifiers provide 0 to 40 dB of gain and are equipped with individual feedback loops that monitor the audio outputs to maintain a peak output voltage of 0.7Vp. Note that this stage and all following circuit stages are supplied by Digital Ground (DGND). The three signals coming from the AGND area (IFILT, QFILT, and !DOPON) are low pass filtered (to DGND) to prevent oscillation when the AGC amps are providing maximum gain.

AGC operation is as follows: The output from the AGC amp (IC10a or IC10b) is buffered and bandpass filtered (100-20K Hz) in IC11a and IC11d to produce the signals IAUDIO and QAUDIO. These audio signals are compared against a common 0.7Vdc reference in IC11b and IC11c. The comparator output charges and discharges a storage capacitor (C67, C76) with a fast attack rate and a slow decay rate. Voltage stored on these storage capacitors is fed back directly to the respective AGC amplifier. A low feedback voltage increases the gain of the amplifier, and vice versa. In this manner, the amplitudes of IAUDIO and QAUDIO are kept as equal as possible. This is important for the optimum operation of the Nippa circuit which follows, and for stable audio line output levels.

Forward-Reverse Flow Signal Separation Circuit:
The VascuDOP uses a proprietary phase rotator/comparator (Nippa) circuit to convert the I and Q audio signals into their forward and reverse flow components, which are the clinically important signals. IC12 processes IAUDIO and IC13 processes QAUDIO, then these signals are added in IC14a to create the reverse flow signal (RAUDIO) and subtracted in IC14d to create the forward flow signal (FAUDIO). The Nippa circuit has a voltage gain of about 2. Greater than 40dB of forward-reverse signal separation is accomplished by having tight-tolerance components in the Nippa circuit and high-quality pre-processing of the I and Q audio inputs to the circuit. The FAUDIO and RAUDIO signals are used to drive the frequency-to-voltage (F-to-V) converters IC15 and IC16, the earphone and speaker amplifiers, and the isolated audio line outputs (if selected by JP2 and JP3).

Frequency-to-Voltage Converter Circuits:
The VascuDOP board has two F-to-V circuits based on LM2917N IC devices. These circuits monitor FAUDIO (IC15) and RAUDIO (IC16) to provide independent simultaneous zero-crossing F-to-V conversion of both audio signals. The two frequency envelope outputs (FAIN and RAIN) are ported to the power supply header (J1) for off-board A-to-D conversion, if desired. These spans of these outputs are trimmer-adjustable so that a 20KHz signal has the value of 2.50 V, the value of DOPVREF (Approx. 2.5V), or 3.00V (which corresponds to 1.0V = 1.0 meter/sec). Note that a DC

input signal (0 Hz) has an output of 0.00V with respect to DGND (there are no zero adjustments). To provide maximum signal-to-noise differentiation, adjustment trimmers are provided to set the input sensitivity of both Forward and Reverse channels. See the section on VascuDOP Calibration for step-by-step instructions on these adjustments.

Operation of the two F-to-V converters is identical. The channel for the FWD signal will be described here. See SC-30780-SH6 for corresponding part designators in the REV channel. The FAUDIO signal is first low-pass filtered at 20kHz by R61 and C91, Then high-pass filtered at 100 Hz by C92 and the sum of R62+R63 to remove any DC offset. R63 also forms an adjustable voltage divider to prevent noise from toggling the ground-referenced Schmitt trigger input of IC15. Every zero-crossing of an audio signal of sufficient amplitude transfers a charge stored on C93 to the output capacitor C94. This charge is then drained off to DGND through R68+R69, producing a voltage dependent on the toggle frequency of the input (FAUDIO). The value of this voltage is adjustable by changing the resistance of R68. R70 and C96 then low-pass filter this output voltage at 25 Hz to smooth the waveform signal (FAIN). FAIN thus has an output bandwidth from DC to 25 Hz, more than adequate to accurately follow the velocity changes in mammalian arteries and veins. Output impedance is 13 Kohm, thus these outputs should only drive loads of over 1.3 megohm to provide better than 1% accuracy. Most A-to-D converters have a much greater input impedance than this, so accuracy should be much better than 1%. 16-bit A-to-D conversion is recommended for adequate resolution at low flow velocity measurement.

An on-chip 7.5V zener diode regulates the voltage at pin 6 of IC15. R64 limits the current into pin 6 to about 9 mA. This stable 7.5V level at pin 6 is divided by R65 and R66 to generate the approx. 2.5V reference signal DOPVREF. Note that this reference voltage, like FAIN and RAIN, has an output impedance of over 10Kohm and thus should only drive loads of over 1 megohm to provide better than 1% accuracy.

The F-to-V converters also provide drive for the FWD and REV LEDs on the control daughterboard. This is done by connecting the dedicated auxiliary output amplifier in each F-to-V IC as an emitter follower driving a 10 ohm load (R67, R78). The open collector of the output transistor draws current through its respective LED, depending on the F-to-V output voltage (FAIN or RAIN). Maximum LED current is limited by series resistors located on the control daughterboard. Power for the LEDs comes from VR12 through J3, pin5. This circuit allows the LED's brightness to be modulated by the frequency of the detected audio signal.

Noise Reduction Section:

The VascuDOP incorporates a specialized stereo audio processor IC, the SM2000 "HUSH" device (IC17), to provide the clearest audio possible with the least amount of background noise. The SM2000 operates on +/-5V locally-regulated supplies and provides Dolby-type noise reduction, voltage-controlled volume adjustment, and automatic mute of the earphone and speaker audio. The mute function silences the audio output when no Doppler signal is present at the inputs of the F-to-V Converters. Mute can be defeated by placing a shorting jumper on JP1, or a panel-mounted SPST switch may be connected to JP1 to allow operator selection of mute function.

Internal operation of the SM2000 is beyond the scope of this section, however, the basic connections and external circuitry will be discussed.

Audio inputs to IC17 are pins 1 (FAUDIO) & 2 (RAUDIO). The processed audio outputs are pins 23 (REV) & 24 (FWD). These output signals are high-pass filtered at 90 Hz to remove any DC offset, then they are buffered by IC18a and IC18b before driving the stereo earphone jack on the control daughterboard via J3 pins 14 &16. These outputs are protected against transient overvoltage by D9 and D10. Earphone output is isolated from the power mains only by the internal isolation of the +/-15V power supply.

The noise reduction "threshold" is set by the voltage at pin 14. This is approx. +1.2V to allow for the intrinsically higher noise levels of medical Doppler circuits. High-frequency "hiss" is attenuated in IC17 unless an audio signal becomes greater than this threshold, at which time the audio output bandwidth is quickly opened up to let the full signal through to the listener. When the audio input decreases, the bandwidth is again reduced. This takes 1-2 seconds, and the bandwidth reduction is audible using stereo earphones.

Audio volume attenuation in IC17 is controlled by a 0-2.5Vdc voltage at VOLSIG (J3, pin8). This signal is low-pass filtered to prevent any RF signal feedthrough at pin 7 of IC17. 2.5 Volts at pin 7 gives 70dB attenuation (very low audio volume), while a zero volt input produces no attenuation (max. audio volume). Thus VOLUME IS INVERSELY PROPORTIONAL TO VOLTAGE. Volume output decreases about 1 dB with each 22mV increase in control voltage.

The audio output of IC17 is muted (shut off) by a +5V signal at pin 17. Pulling the voltage at pin 17 to zero or below turns the audio output ON. To provide an automatic mute function, the VascuDOP monitors the AC component of the -FLED and -RLED lines coming from the control daughterboard. These lines remain high when there is not enough Doppler audio to toggle the inputs of the F-to-V converters (IC15&16), thus their AC component is zero. As the F-to-V converters detect a significant audio signal, however, they begin to pull -FLED and -RLED low in a pulsating fashion, creating an AC component that is amplified by IC18d, rectified by D13, and stored as a DC voltage on C123 which is discharged slowly to ground through R88 and R89. The voltage on C123 is compared against the common 0.7Vdc reference in IC18c. When the voltage on C123 is GREATER than 0.7V, the mute line is pulled LOW, turning the audio output ON. The mute line can also be forced low (keeping the audio ON) by placing a shorting jumper (or switch) across JP1, thus grounding pin 17 of IC17.

Audio Output Stages:
The stereo earphone outputs are driven by two of the op amps in IC18, a TL084 device, feeding J3 pins 16 (FWD audio) and 14 (REV audio). Return for these stereo signals is via ground at J3 pins 11 & 12 if phones are plugged in. The earphone jack on the control daughterboard has switches on both channels to direct the audio back to J3, pins 13 & 15 if the earphones are NOT plugged in. These two signals (TIPOUT AND RINGOUT) are mixed together through 100 Hz high-pass filters before driving the inverting input of IC19, a 1 Watt SMT audio power amplifier which is designed to drive a single 8 Ohm speaker in a "bridge tied load" (double-ended, ungrounded) configuration. Speaker connection is via J3, pins 1 & 2. Speaker polarity is not important in this monophonic application. Note that the speaker driver (IC19) operates off a single +5V supply, and has its own 7805 regulator (VR15). The +15 Volt supply to this regulator is first dropped through R91 and ripple is attenuated by C128 (220uF).

The audio speaker driver (IC19) is shut down by a logic high level (+5V) on the SHTDN line to pin 1 of the IC (SHTDN also mutes the AGC amplifiers in IC10). This signal is the inverse of logic signal SWCHON (J3, pin7).

Transformer-isolated stereo audio output is available from the VascuDOP. This output is jumper-selectable to provide either I and Q audio or FWD and REV audio, depending on which format is required for off-board computation of the Doppler spectral display. The inputs to the inverting driver op amps (IC14 b,c) are configured so that output amplitude is approximately 0.5Vrms into a 600 Ohm line from either source. JP2 selects FWD or I audio at J6 pins1-3, and JP3 selects REV or Q at J6 pins 4-5. J6 pins 3 and 4 are tied together as a common return to allow connection using standard 3-conductor audio jacks, with audio polarity correctly preserved. These audio outputs are protected against transients by D14 and D15.

Note that the isolated audio line outputs are NOT processed through the SM2000, as these outputs are fixed-amplitude and full-bandwidth for FFT processing of the detected flow signals. The stereo audio line output is usually fed to the audio input of a personal computer for spectral analysis and storage as a 16-bit stereo *.WAV file.

The Control Connector Interface:

Manual operator control of the VascuDOP is performed via the 16-pin Control Connector. A small daughterboard (PC-30781) has been designed to interface with this connector and supply all connections and controls. It is attached using a 16-conductor ribbon cable, and can be located several feet from the VascuDOP board, depending on external sources of noise. The Control Connector can be driven with other devices than PC-30781. Explanation of the operation of each pin of the Control Connector follows:

Pin #	Name	Function
1	SPKR1	8 Ohm/1W speaker output terminal 1
2	SPKR2	8 Ohm/1W speaker output terminal 2
3	-RLED	Return lead from RED LED, needed for MUTE operation
4	-FLED	Return lead from GRN LED, needed for MUTE operation
5	+12VFC	+12 Volt supply to daughterboard, 10mA, max.
6	+5VHUSH	+5 Volt supply to daughterboard, 10mA, max.
7	SWCHON	+5V logic signal to this pin turns Doppler ON, 0V=OFF
8	VOLSIG	0 to2.5V analog signal, inversely controls audio volume output
9	DGND	Digital Ground connection for volume control circuit
10	DGND	Digital Ground connection for volume control circuit
11	DGND	Digital Ground connection for phone jack
12	DGND	Digital Ground connection for phone jack
13	RINGOUT	REV audio return if phones not plugged in
14	RING	REV audio to earphone jack
15	TIPOUT	FWD audio return if phones not plugged in
16	TIP	FWD audio to earphone jack

VascuDOP Board Assembly Notes:

WARNING: STATIC SENSITIVE COMPONENTS - Strict STATIC PRECAUTIONS must be followed during assembly, handling, testing, shipping, and installation of the VascuDOP Board.

Assembly of the VascuDOP is straightforward. The board has been designed for hand or semi-automated assembly using standard rosin flux solder and a suitable soldering iron and/or via wave solder technique. It is suggested that the I.C.s, DIP resistors, diodes and two ferrite beads be installed and soldered first, as they lie flat on the board. The one SMT device (IC19), may be cemented to the board before soldering. Then the remainder of the components can be added.

Add a drop of silicone sealant (CME# 6112) between the two ferrite beads to cement them to the board after soldering so they can not move or rattle. Also use the silicone sealant to cement the two inductors (L1 & L2) together so that they cannot move or vibrate.

Glue the two small finned heat sinks to the tops of IC5 and IC6 using less than a drop of cyanoacrylate "superglue" (CME#   ). Be sure to spread the glue thinly over the entire top of the IC before pressing the heat sink into place.

Note that most of the resistors are installed in an upright "hairpin" configuration using 0.1" lead spacing. No insulation is required on the long resistor leg. Be sure the resistors are not bent over or twisted accidentally during assembly or test.

Observe correct orientation when installing J2 and J6. See The device assembly drawing for details.

Initial Test and Burn-In of the VascuDOP Board:

Equipment Needed:
Test Stand to support the board
+/-15V Linear Power Supply with connector to match J1 - Power.
Test Plug TE-yyyyy (50 Ohm transmitter load with receiver input shorted)
PC-30781 Control Daughterboard with cable to mate with J3 - Control.
20Mz Bandwidth Oscilloscope with calibrated amplitude and time-base.
Two Ammeters - 300 mA range
8-Ohm speaker with leads
Shorting Jumper for 0.1" cntr square male pins

Visually inspect board and components for proper insertion and orientation. Check for solder bridging especially around the ICs and connectors.

Mount the VascuDOP Board on a suitable test stand

Connect a 50 Ohm, 0.25 Watt non-inductive resistor across J2, pins 1 to 2. Place a short across J2, pins 5 to 6. Use TE-xxxxx (a specially wired plug for this purpose) or equivalent.

Connect a known good PC-30781 Control Daughterboard to J3, observing proper plug orientation. Turn the volume control fully counterclockwise (CCW) - the OFF position.

Connect an 8 Ohm speaker to the speaker connection on the PC-30781 daughterboard.

Connect the +/-15V linear regulated power supply to J1, with the power supply ground connected to both AGND and DGND of the VascuDOP. The cable should have three turns through a large ferrite bead as described in the Power Supply section. Ammeters connected in series with both power leads are advised to prevent possible component damage.

Turn on the power supply and observe current draw with the Doppler turned OFF at the Control Daughterboard. The current in either supply line should not exceed 200 mA when OFF. If either current is greater than this, shut off the power quickly and reject the board.

Place a shorting jumper on JP1, the Mute Defeat jumper (this may be done with the power ON).

Turn the Volume Control clockwise (CW) slowly until it is fully CW. A white-noise "hiss" should be audible from the speaker. If there is no "hiss", or if there is other noise present (squeal, hum, popping, etc.) the board is rejected.

Turn the volume control on PC-30781 down, but NOT OFF. With a calibrated oscilloscope, observe the output waveform across the 50 Ohm load resistor of TE-xxxxx, There should be a sinusoidal 5.00 MHz, 6Vp-p signal present. If this signal is not present, or if it is not symmetric or of the wrong frequency (such as 2.5 MHz) the board is rejected.

Place the board and testing setup in a fireproof burn-in area. Continue to run the board with the Volume Control switch on the attached PC-30781 board turned ON for 12 hours, minimum.

After burn-in, recheck the board for correct transmitter output waveform, and proper audio output "hiss" with JP1 shorted. If either are not correct, the board is rejected.

Aligning the VascuDOP Board

The only adjustments needed on the VascuDOP are setting the sensitivity and span of the two Frequency-to-Voltage converters (four adjustments, total). The Sensitivity of each channel is set first, then the Spans are calibrated. These adjustments have no affect on the isolated audio line outputs from the board.

Sensitivity Adjustment

Initial F-to-V Sensitivity is adjusted by trimmers R63 and R74 with a dummy or active probe attached. Later this may need final adjustment with the board powered by and operating in the final application of use.

Equipment Needed:
Test Stand to support the board
+/-15V Linear Power Supply with connector to match J1 - Power.
Test Plug TE-yyyyy or active Doppler Probe connected to J2 - Probe.
PC-30781 Control Daughterboard with cable to mate with J3 - Control.

Observe the LEDs on the attached PC-30781 daughterboard and listen to the output hiss with the Mute function active (JP1 open), the sensitivity trimmers are adjusted to the point where the receiver noise level does not flicker the FWD/REV LEDs or trip the mute ON.

Slowly turn R63 while observing the FWD (green) LED in subdued lighting until the LED flashes infrequently or not at all (the ultimate endpoint depends on the circuit application). Repeat the same procedure on R74 while observing the REV (red) LED.

Notes on sensitivity endpoint adjustment:
The Sensitivity of each channel can be set at maximum by allowing the receiver noise to flicker the LEDs frequently. This gives better velocity measurement accuracy for weak Doppler signals. Such high sensitivity triggers the Mute function often, however. If this sensitivity is required by the user specification, place a jumper on JP1 to keep the audio turned on (less annoying to the listener). For general clinical Doppler use, the sensitivity can be turned down so that the Mute is triggered infrequently (some triggering may be unavoidable due to occasional external noise signals "leaking" in to the Doppler probe.
CAUTION: Setting the Sensitivity too high turns the LEDs on and gives false velocity readings by counting noise as velocity signal.

Span Adjustment
There are three separate alignments possible for the Span Adjustment in each channel: (A) 20KHz = DOPVREF Out, (B) 20KHz = 2.50V Out, or (C) 20KHz = 3.00V Out. Other span adjustments are possible, as the output voltage range is 2 to over 3 volts for a frequency input of 20KHz. In each case, Span is set by injecting a known audio frequency into the F-V circuits (IC15, IC16) and adjusting R68 or R75 for the desired output calibration. The choice of Span alignment (A ,B, or C) depends on the system in which the VascuDOP is to be used.

Two service headers (J4, J5) are provided to simplify alignment connections. The alignment procedure follows. The FWD channel alignment will be described in detail. Span alignment of the REV channel is identical, except that R75 and J5 are used.

Equipment Needed:
Test Stand to support the board
+/-15V Linear Power Supply with connector to match J1 - Power
Digital voltmeter with over 2 megOhm input impedance
Audio Signal Generator with 20 kHz sine wave signal
Frequency counter accurate to 0.1% at 20 kHz.

<u>Alignment of the F-to-V Converter Spans - Choose Desired Calibration:</u>

(A) 1.00Meters/sec = DOPVREF/3 (20KHz = DOPVREF): Use this calibration when using DOPVREF as the reference for A-D Conversion.

Apply power to a tested VascuDOP board using TE-zzzzz or equivalent. The control daughterboard and load resistor (TE-xxxxx) are not required for this procedure.

For convenience, test cable TE-qqqqqq may be used in the following connections.

Check the voltage from J4, pin 2 (DGND) to J4, pin 4 (DOPVREF). It should be 2.5V, nominal. If not, the board is rejected.

Using J4, pin2 as a ground point, apply a nominal 1Vpp, 20 kHz+/-100Hz signal to J4, pin1.

Connect the voltmeter from Pin3 (FAIN) to Pin4 (DOPVREF).

Adjust R68 to NULL the voltage from Pin3 to Pin 4.

Remove the signal generator/frequency counter and SHORT pin 1 to pin 2.

Use the voltmeter to measure Pin3 (FAIN) to Pin2 (DGND). The reading should be 5.0 milliVolts (0.005V) OR LESS. If it is greater, the board is rejected.

Remove all connections to J4. The alignment of the FWD channel is complete.

Alignment of the REV Channel F-to-V Converter:
Using the same equipment and procedure "A" above, check and adjust the REV channel using J5 for connections and R75 for the adjustment.

(B) 1.00Meters/sec= 0.8333V (20KHz = 2.50V): Use this calibration when using an external 2.50V reference for A-D Conversion.

Apply power to a tested VascuDOP board. The control daughterboard and load resistor are not required for this procedure.

For convenience, test cable TE-qqqqqq may be used in the following connections.

Using J4, pin2 as a ground point, apply a nominal 1Vpp, 20 kHz+/-100Hz signal to J4, pin1.

Connect the voltmeter from Pin3 (FAIN) to Pin2 (DGND).

Adjust R68 to adjust the voltage on pin3 to 2.500V +/-.005V.

Remove the signal generator/frequency counter and SHORT pin 1 to pin 2.

Use the voltmeter to measure Pin3 (FAIN) to Pin2 (DGND). The reading should be 5.0 milliVolts (0.005V) OR LESS. If it is greater, the board is rejected.

Remove all connections to J4. The alignment of the FWD channel is complete.

Alignment of the REV Channel F-to-V Converter:
Using the same equipment and procedure "B" above, check and adjust the REV channel using J5 for connections and R75 for the adjustment.

(C) 1.00 Meter/sec = 1.00V (20Khz = 3.00V): Use this calibration when using an external voltmeter or voltage-calibrated recorder as the tracing display device.

Apply power to a tested VascuDOP board. The control daughterboard and load resistor are not required for this procedure.

For convenience, test cable TE-qqqqqq may be used in the following connections.

Using J4, pin2 as a ground point, apply a nominal 1Vpp, 20 kHz+/-100Hz signal to J4, pin1.

Connect the voltmeter from Pin3 (FAIN) to Pin2 (DGND).

Adjust R68 to adjust the voltage on pin3 to 3.000V +/-.005V.

Remove the signal generator/frequency counter and SHORT pin 1 to pin 2.

Use the voltmeter to measure Pin3 (FAIN) to Pin2 (DGND). The reading should be 5.0 milliVolts (0.005V) OR LESS. If it is greater, the board is rejected.

Remove all connections to J4. The alignment of the FWD channel is complete.

Alignment of the REV Channel F-to-V Converter:
Using the same equipment and procedure "C" above, check and adjust the REV channel using J5 for connections and R75 for the adjustment.

Final Installation and Alignment of the VascuDOP Board:

WARNING: STATIC SENSITIVE COMPONENTS - Strict STATIC PRECAUTIONS must be followed during handling, testing, shipping, and installation of the VascuDOP Board.

After initial test and alignment of the VascuDOP board as described above, the board is ready for mounting and final alignment in the end application. Safety testing may then be performed.

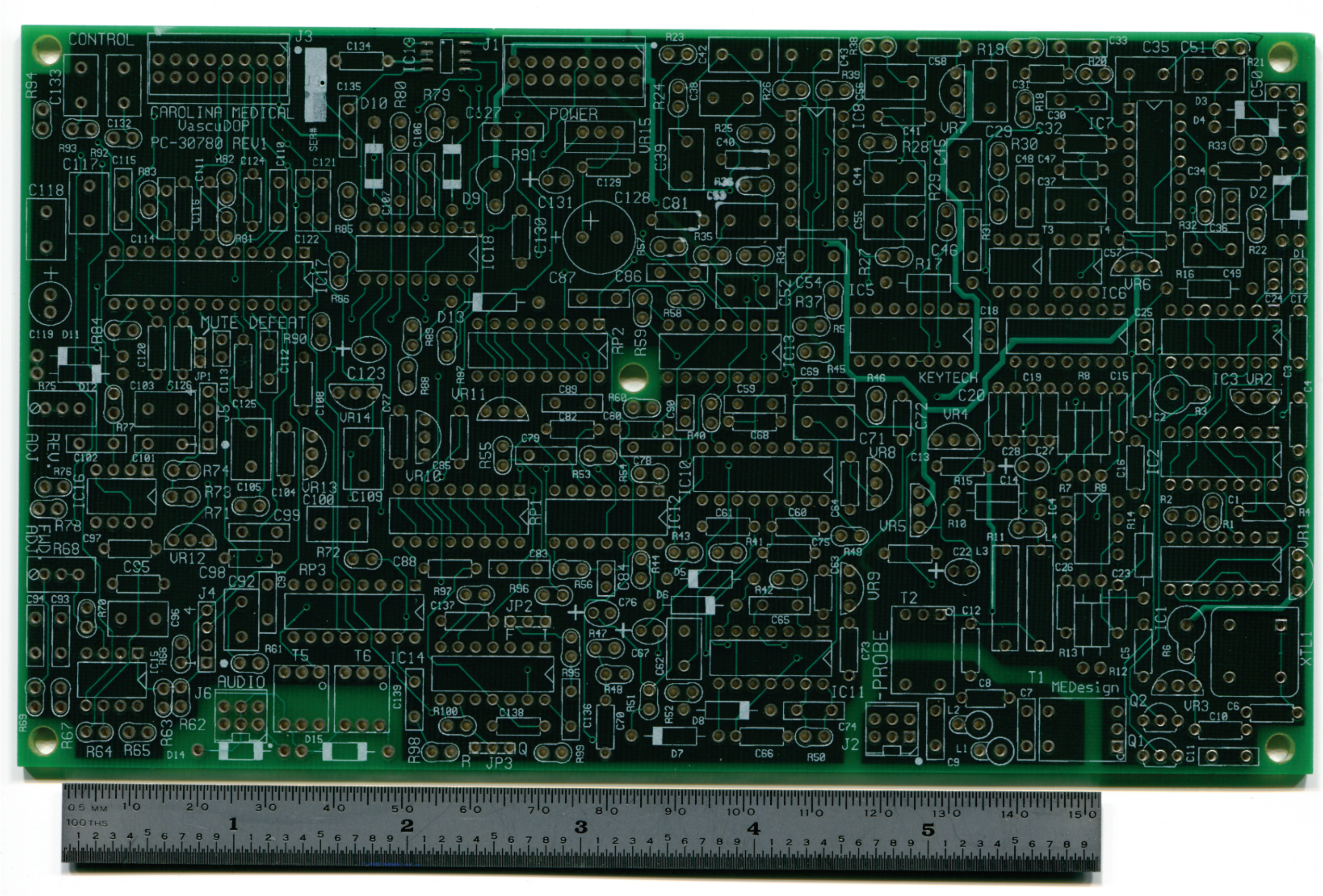
Mount the board firmly using at least 4 of the 5 mounting locations. Route all cables away from power and noise sources and attach in place as required by the application.

Place jumpers on JP2 and JP3 to give FWD/REV or I/Q audio line output as required by the application.

With the VascuDOP powered by the host device and connected to a control board (PC30781 or equivalent) mounted in the host device, attach a Doppler probe as specified for the device. Turn on all other circuitry in the system to create a realistic noise environment for that system. Then adjust Sensitivity Trimmers R63 and R74 for the desired noise sensitivity as required by the end-user specification.

If the Span Adjustment has not been previously set at the factory as required for the end specification, align the Spans as described in the section on Board Alignment. Otherwise, do not adjust these trimmers if already calibrated.

After complete installation of the VascuDOP Board and closure of the host unit, the Doppler Probe connection and Audio Line output may be tested for voltage breakdown and current leakage as required for the application. A special Doppler probe connector with all 5 pins connected together should be used when testing breakdown and leakage to the power mains. Likewise, an audio connector with all 3 leads connected together should be used to test that port. See the VascuDOP board specification for the voltage breakdown and leakage ratings intrinsic to the board. Additional protection against breakdown and excessive leakage may be added as needed by proper specification of the power supply of the host unit. Further protection against breakdown and leakage may be gained by specification and testing of the Doppler probe to be used. Breakdown specifications up to 7.5 KV and leakage less than 10 uA at 250Vac may be obtained with these three layers of protection.



VascuDOP$_{TM}$ 3-Layer Printed Circuit Board, Rev 1. Aug 1998

No cuts or jumpers required on assembly!

VascuDOP PCB's

INVOICE

FLEX FOUR, INC.
1200 ABBOTT DR.
ELGIN, IL 60123
(847) 741-9910 FAX (847) 741-9810

INVOICE NUMBER: 2703

INVOICE DATE: 8/10/98

PAGE: 1

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PFAFFTOWN, NC 27040
USA

Ship To:
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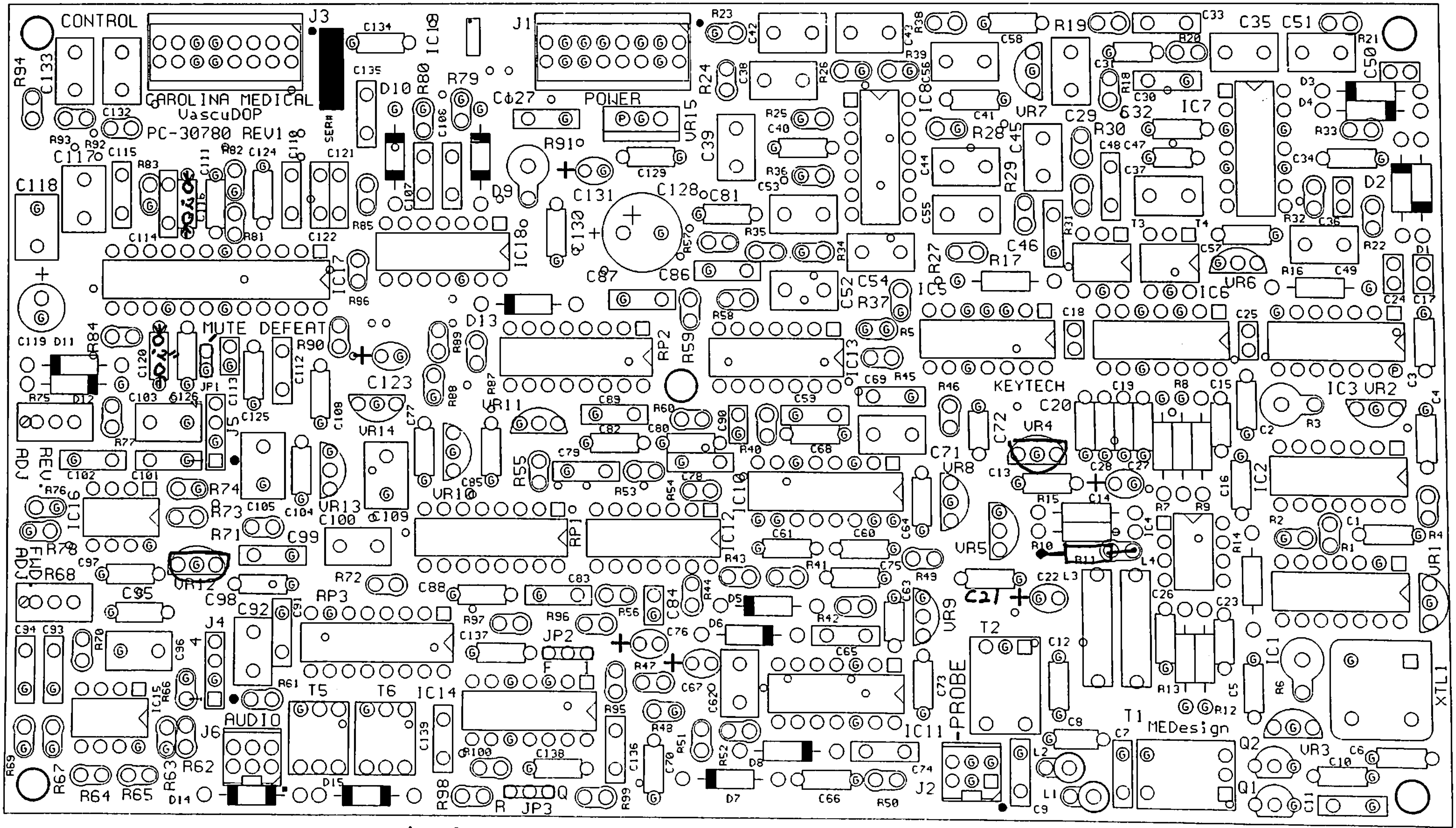
3705 SAPONA TRAIL
PFAFFTOWN, NC 27040
USA

CUSTOMER ID	CUSTOMER PO	PAYMENT TERMS
2124	001	Net 30 Days

SALES REP ID	SHIPPING METHOD	SHIP DATE	DUE DATE
900	Courier	8/10/98	9/9/98

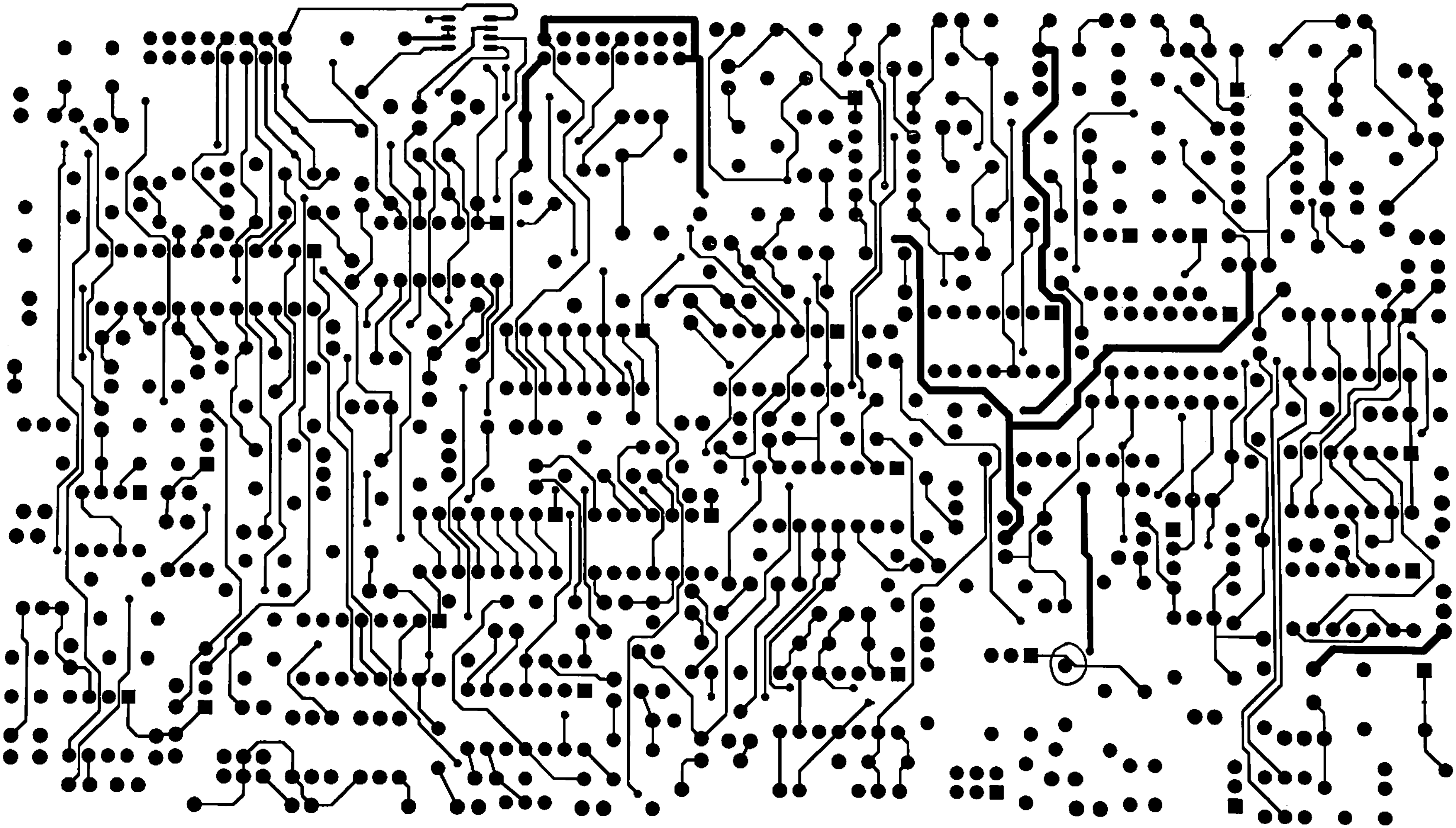
QUANTITY	ITEM NUMBER	DESCRIPTION	UNIT PRICE	EXTENSION
→ 6.00	PCB	DOPPCB	34.52	207.12
1.00	OTHER	TOOLING & PHOTOPLOTTING	400.00	400.00
1.00	ELEC	ELECTRICAL TEST	350.00	350.00



ALL THRU-HOLE DESIGN with 1 SMT - IC19
RESISTORS MOUNTED VERTICALLY ON 0.1" CNTRS

ISSUE	DATE	INIT	CAROLINA MEDICAL INC.
1	3/1/98	JC	VASCUDOP
2			SILKSCREEN
3			
4			
5			
DISK:			APP.
FILE:			SCALE

DRW. PC30780.ZIP



1) RUN PIN 7 of IC 19 (SMT) TO GND.

2) ROUTE TRACE FROM T2 AWAY FROM PIN OF C12.

ISSUE	DATE	INIT
1	3/1/98	JC
2		
3		
4		
5		

CAROLINA MEDICAL INC.

VASCUDOP

COMPONENT TRACE LAYER

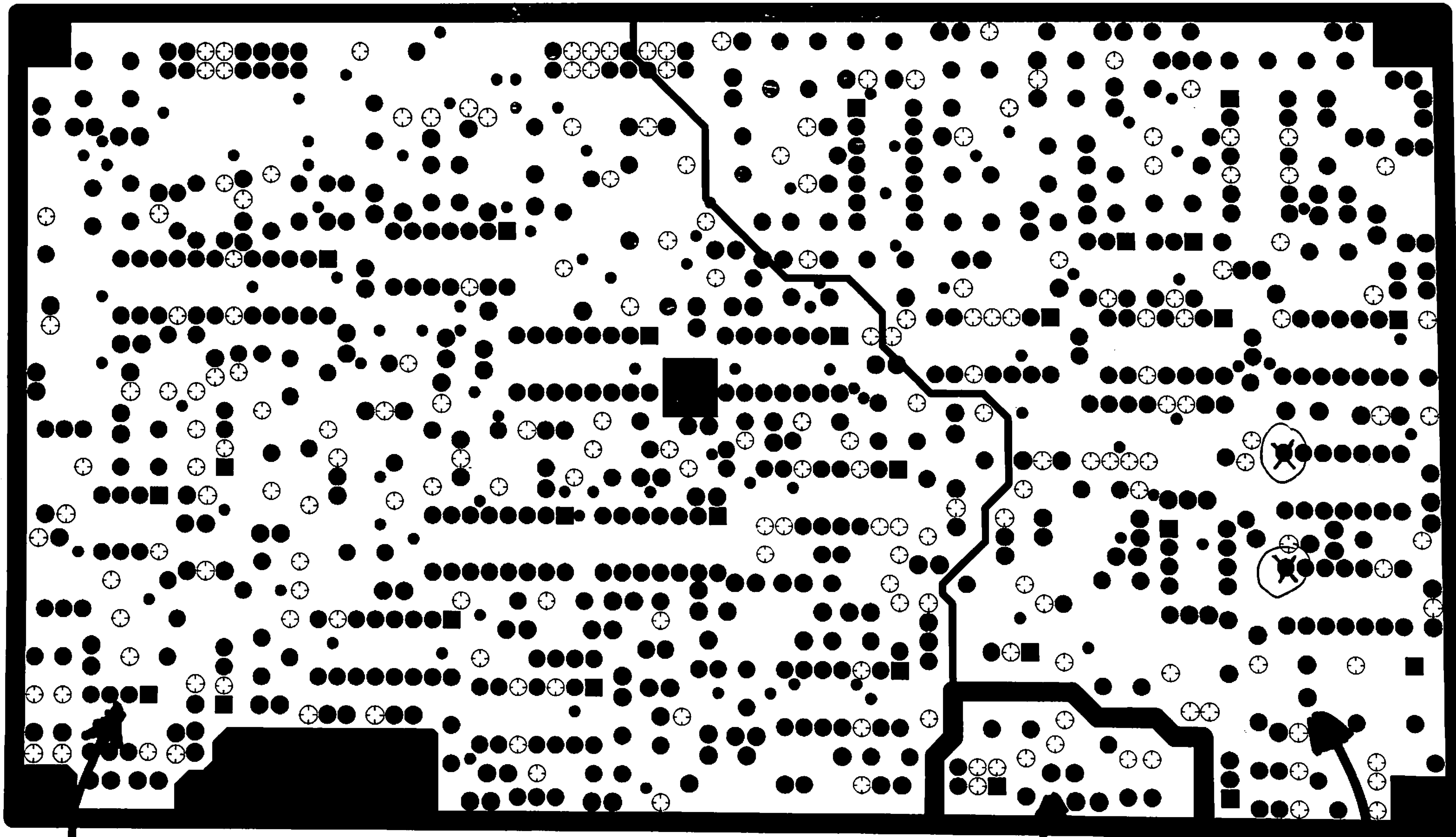
DISK:

FILE:

APP.

SCALE

DRW. PC30780.ZIP



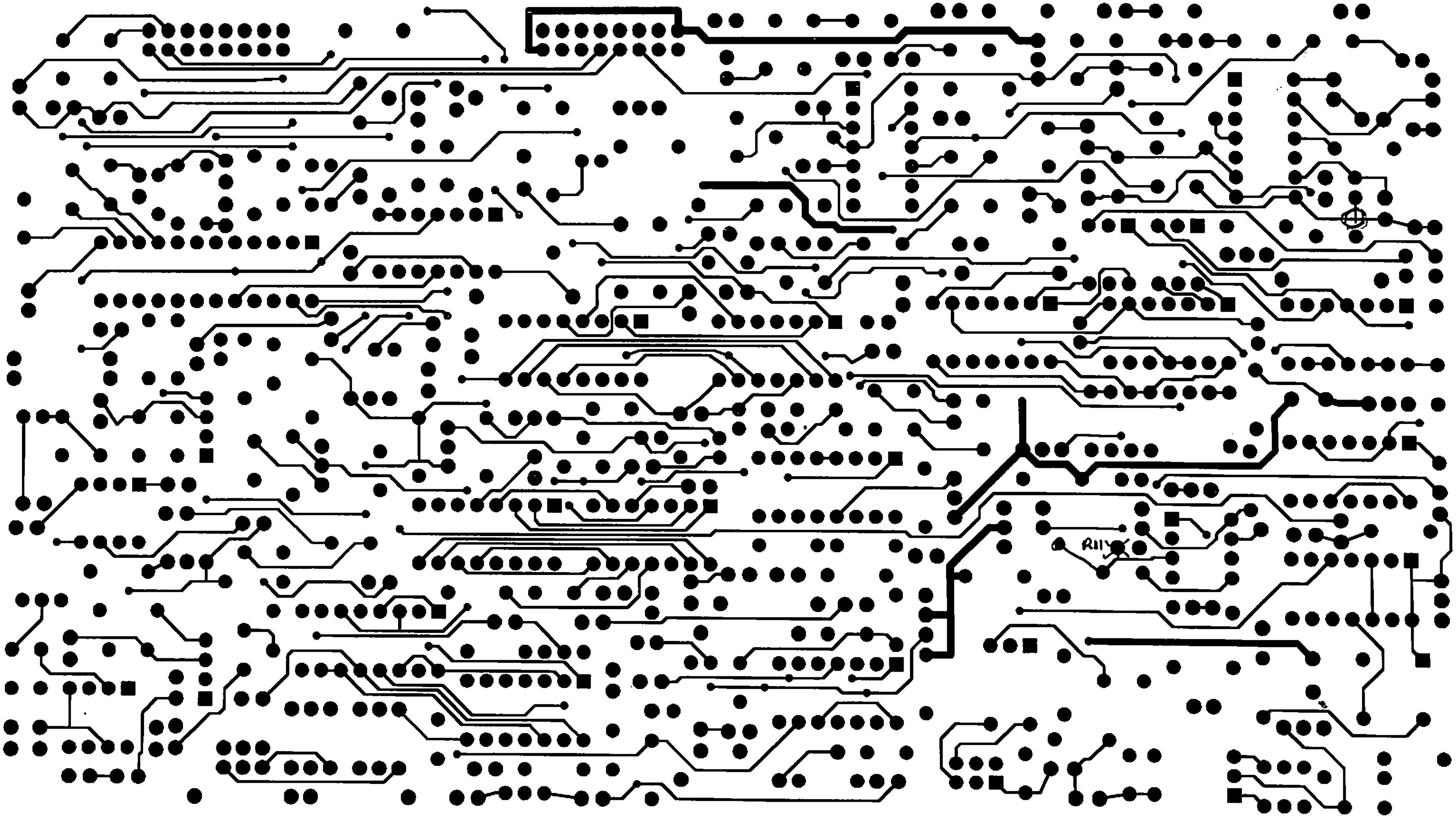
X = CONNECT TO GND PLANE.

DGND

IGND

AGND

ISSUE	DATE	INIT	CAROLINA MEDICAL INC.
1	3/1/98	JC	VASCUDOP
2			
3			INTERNAL LAYER
4			GND PLANE
5			
DISK:		APP.	DRW. PC30780.ZIP
FILE:		SCALE	



ISSUE	DATE	INIT
1	3/1/98	JC
2		
3		
4		
5		

CAROLINA MEDICAL INC.

VASCUDOP

SOLDER SIDE
TRACE LAYER

DISK:

FILE:

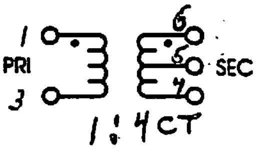
APP.

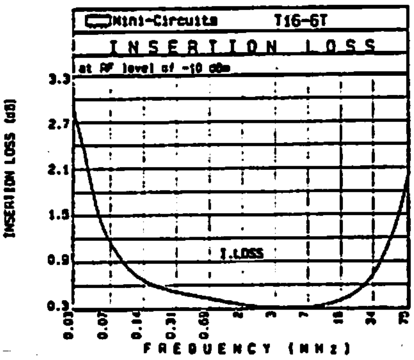
SCALE

DRW. PC30780.ZIP

ELECTRICAL SPECIFICATIONS:

Ohms Ratio: 16
Frequency of use: 0.03 - 75 MHz
RF Power Rating: 250 mW, Max.
DC Current Rating: 30 mA, Max.
Insertion Loss (50 Ohm): See Diagram and chart





T16-6T

.03 TO 75 MHz

FREQ. (MHz)	I. LOSS (dB)	INPUT R. LOSS (dB)
0.030	2.98	1.55
0.050	1.66	3.37
0.060	1.33	4.30
0.100	0.78	7.70
0.201	0.56	12.89
20.000	0.49	11.81
30.000	0.70	8.64
38.744	0.90	6.92
72.335	1.93	3.49
75.000	2.03	3.32

MECHANICAL:

Package: 6-pin DIP on 0.3" centers
Plastic case

Style X65

SOURCES:

1) Mini-Circuits, Inc, Brooklyn, NY Part Number **T16 - 6T - X65**

TOLERANCES: (UNLESS OTHERWISE NOTED) ALL .XXX DECIMAL: ^..005 ALL .XX DECIMAL: ^..03 ALL FRACTIONAL: ^.1/16 ALL ANGULAR: ^.5°	PROPRIETARY INFORMATION Copyright by CAROLINA MEDICAL, inc. King, NC, USA 27021 This drawing remains the property of Carolina Medical.	**Carolina Medical**
MATERIAL:	DR. BY: JC, MD. Medical Design	TITLE Transformer, RF 1:4CT
FINISH:	CHKD BY:	A · DATE 7/8/96 · DRAWING NO. MS-30609
	APPD.	SCALE · ECS · SHEET 1 of 1

MATERIALS
Cord and panel connector shells, contact locking disk, and cable clamp assembly: Thermoplastic polymer glass fiber, flame retardant

Coupling ring: Nylon and UL recognized

Rear boot and connector shell interior: Thermoplastic rubber

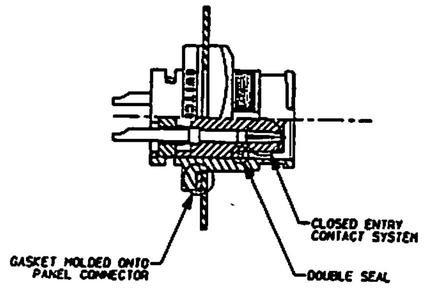
Contacts: Copper base alloy gold-plated over nickel underplate

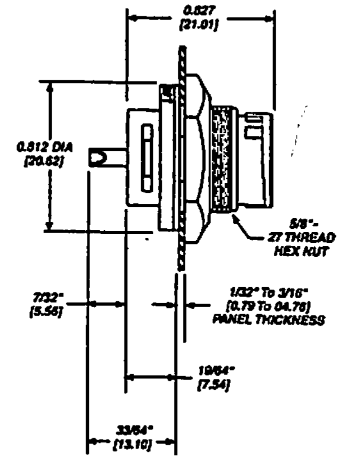
SPECIFICATIONS

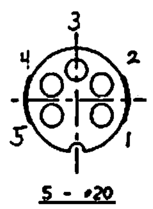
MECHANICAL
Shock: Mil-Std 202 Method 213B, condition K
Vibration: Mil-Std 202 Method 201
Life: 600 insertion/withdrawal cycles (minimum)

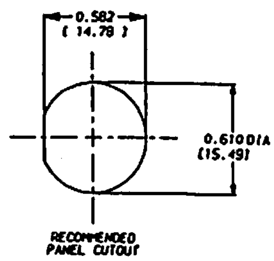
ELECTRICAL
Voltage Rating (sea level): Tested at 600 VRMS
Insulation Resistance: 100 Megohms (minimum) at 77°F
Contact Resistance: 3.0 Millohms (maximum)
Current Rating: 7.5 Amps (#20 contact)
13.0 Amps (#16 contact)

ENVIRONMENTAL
Temperature Limits: -40°C to +65°C (non-operating)
Moisture Resistance: Mil-Std 202 Method 106F
Insulation Resistance: Mil-Std 202 Method 302, condition B
Thermal Shock: Mil-Std 202 Method 107G
Salt Spray: Mil-Std 202 Method 101D, condition B
Water Tightness Test: U.S. Coast Guard CFR 46 Part 110.20









SOURCES:

1) Switchcraft, Inc., Chicago, IL, Part Number **EN3- P- 5 - F**

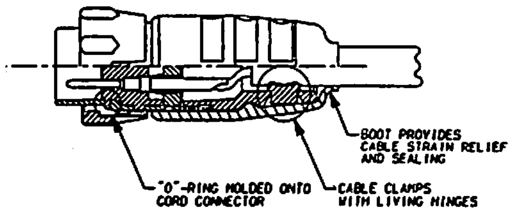
TOLERANCES: (UNLESS OTHERWISE NOTED) ALL .XXX DECIMAL: ^..005 ALL .XX DECIMAL: ^..03 ALL FRACTIONAL: ^.1/16 ALL ANGULAR: ^..5°	PROPRIETARY INFORMATION Copyright by CAROLINA MEDICAL, inc. King, NC, USA 27021 This drawing remains the property of Carolina Medical.	**Carolina Medical**
MATERIAL:	DR. BY: JC, MD. MEDICAL DESIGN	TITLE Connector, 5-Pin Female Panel Mount
FINISH:	CHKD BY:	**A** DATE 7/8/96 DRAWING NO. **MS-30686**
	APPD.	SCALE ECS SHEET 1 of 1

MATERIALS
Cord and panel connector shells, contact locking disk, and cable clamp assembly: Thermoplastic polymer glass fiber, flame retardant

Coupling ring: Nylon and UL recognized

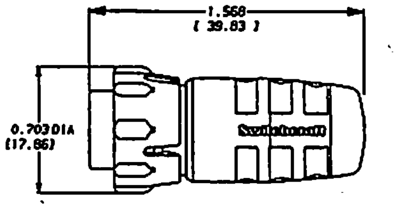
Rear boot and connector shell interior: Thermoplastic rubber

Contacts: Copper base alloy gold-plated over nickel underplate



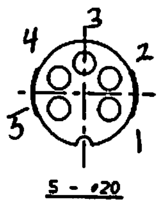
SPECIFICATIONS

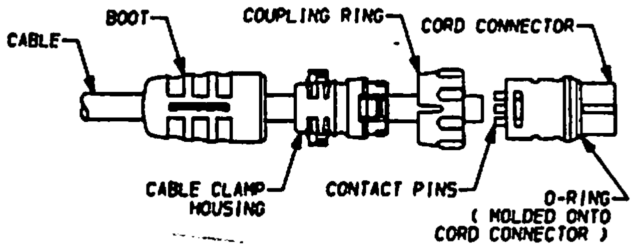
MECHANICAL
Shock: Mil-Std 202 Method 213B, condition K
Vibration: Mil-Std 202 Method 201
Life: 600 insertion/withdrawal cycles (minimum)



ELECTRICAL
Voltage Rating (sea level): Tested at 600 VRMS
Insulation Resistance: 100 Megohms (minimum) at 77°F
Contact Resistance: 3.0 Milliohms (maximum)
Current Rating: 7.5 Amps (#20 contact)
13.0 Amps (#16 contact)

ENVIRONMENTAL
Temperature Limits: -40°C to +65°C (non-operating)
Moisture Resistance: Mil-Std 202 Method 106F
Insulation Resistance: Mil-Std 202 Method 302, condition B
Thermal Shock: Mil-Std 202 Method 107G
Salt Spray: Mil-Std 202 Method 101D, condition B
Water Tightness Test: U.S. Coast Guard CFR 46 Part 110.20





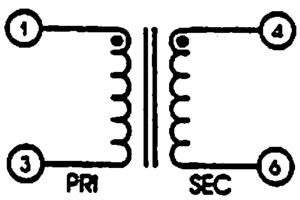
SOURCES:

1) Switchcraft, Inc., Chicago, IL, Part Number **EN3- C- 5 - M**

TOLERANCES: (UNLESS OTHERWISE NOTED) ALL .XXX DECIMAL: ^..005 ALL .XX DECIMAL: ^..03 ALL FRACTIONAL: ^.1/16 ALL ANGULAR: ^..5°	PROPRIETARY INFORMATION Copyright by CAROLINA MEDICAL, inc. King, NC, USA 27021 This drawing remains the property of Carolina Medical.	**Carolina Medical** [redacted]
MATERIAL:	DR. BY: JC, MD. MEDICAL DESIGN	TITLE Connector, Cable 5-Pin Male
FINISH:	CHKD BY:	A — DATE 7/8/96 — DRAWING NO. MS-30687
	APPD.	SCALE — ECS — SHEET 1 of 1

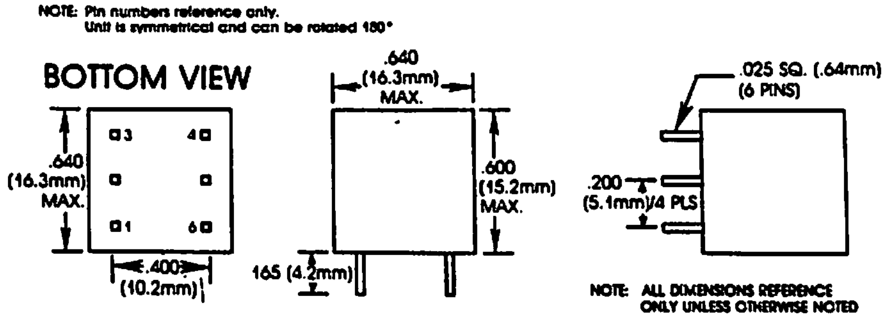
ELECTRICAL SPECIFICATIONS:

Turns Ratio:	1:1 +/-2%
Impedance:	600 Ohm Primary and Secondary, Nom.
Freq Response:	200-4000 Hz +/- 0.25 dB
Coil Resistance:	75 Ohm, Max.
Max DC Current :	0 mA, Unbalanced
Insertion Loss:	1.5 dB, Max.
Dielectric Strength:	3750 Vrms for 1 min, Min.
Insulation Resistance:	>100 MegOhm @500 Vdc



MECHANICAL:

Note: Shape not important except for maximum outline shown.



SOURCES:

1) PREM Magnetics, Inc, Part # SPT-015, or SPT-016
2) Many other Manufacturers. Use specifications above to qualify parts.

TOLERANCES:
(UNLESS OTHERWISE NOTED)
ALL .XXX DECIMAL: ^..005
ALL .XX DECIMAL: ^..03
ALL FRACTIONAL: ^.1/16
ALL ANGULAR: ^..5°

MATERIAL:

FINISH:

DR. BY: JC, MD. MEDICAL DESIGN

CHKD BY:

APPD.

Carolina Medical

[redacted]

TITLE Transformer, 600 Ohm 1:1 Audio Line Isolation

	DATE	DRAWING NO.
A	5/1/97	MS-30777

SCALE **ECS** **SHEET** 1 of 1

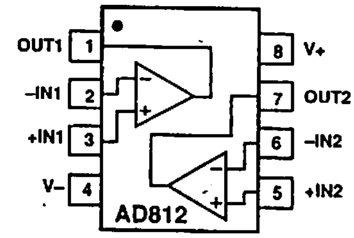
FEATURES
Two Video Amplifiers in One 8-Pin ~~SOIC~~ DIP Package
Optimized for Driving Cables in Video Systems
Excellent Video Specifications (R_L = 150 Ω):
- Gain Flatness 0.1 dB to 40 MHz
- 0.02% Differential Gain Error
- 0.02° Differential Phase Error

Low Power
- Operates on Single +3 V Supply
- 5.5 mA/Amplifier Max Power Supply Current

High Speed
- 145 MHz Unity Gain Bandwidth (3 dB)
- 1600 V/µs Slew Rate

Easy to Use
- 50 mA Output Current
- Output Swing to 1 V of Rails (150 Ω Load)

PIN CONFIGURATION
8-Pin Plastic
Mini-DIP ~~& SOIC~~



ABSOLUTE MAXIMUM RATINGS[1]

Supply Voltage . . . . ±18 V
Internal Power Dissipation[2]
  Plastic (N) . . . . 1.3 Watts
  ~~Small Outline (R) . . . . 0.9 Watts~~
Input Voltage (Common Mode) . . . . $\pm V_S$
Differential Input Voltage . . . . ±1.2 V
Output Short Circuit Duration
  . . . . Observe Power Derating Curves
Storage Temperature Range N, R . . . . –65°C to +125°C
Operating Temperature Range . . . . –40°C to +85°C
Lead Temperature Range (Soldering 10 seconds) . . . . +300°C

NOTES
[1]Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
[2]Specification is for device in free air: 8-Pin Plastic Package: θ_{JA} = 90°C/Watt; ~~8-Pin SOIC Package: θ_{JA} = 140°C/Watt.~~

MECHANICAL:

Industry-standard 8-pin plastic DIP, 0.3" row spacing with 0.1" lead spacing. (Analog Devices N-8 package).

SOURCES:

1) Analog Devices, Inc., Order # AD812AN (8-pin plastic DIP)

STILL AVAILABLE IN DIP AND SOIC 2022, ~$10ea

TOLERANCES: (UNLESS OTHERWISE NOTED) ALL .XXX DECIMAL: ^.005 ALL .XX DECIMAL: ^.03 ALL FRACTIONAL: ^.1/16 ALL ANGULAR: ^.5°	PROPRIETARY INFORMATION Copyright by CAROLINA MEDICAL, inc. King, NC, USA 27021 This drawing remains the property of Carolina Medical.	**Carolina Medical**
MATERIAL:	DR. BY: JC, MD. MEDICAL DESIGN	TITLE AD812 Dual RF Op Amp
FINISH:	CHKD BY:	A — DATE 4/27/97 — DRAWING NO. MS-30792
	APPD.	SCALE — ECS — SHEET 1 of 1

ELECTRICAL SPECS:

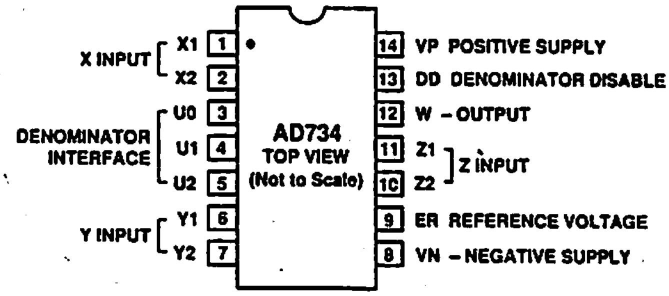
ABSOLUTE MAXIMUM RATINGS[1]

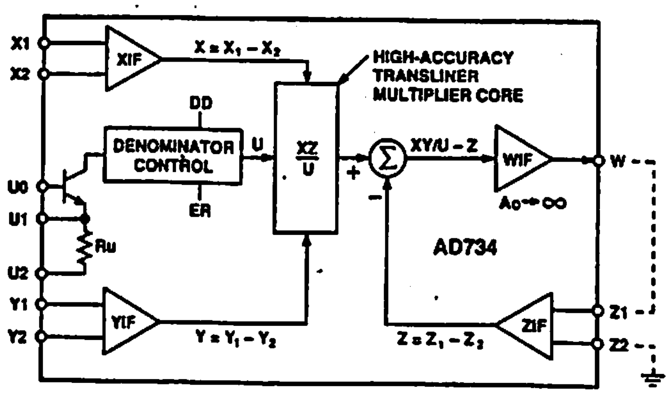
Supply Voltage . . . . ±18 V
Internal Power Dissipation[2]
  for T_J max = 175°C . . . . 500 mW
X, Y and Z Input Voltages . . . . VN to VP
Output Short Circuit Duration . . . . Indefinite
Storage Temperature Range
  Q . . . . −65°C to +150°C
Operating Temperature Range
  AD734A, B . . . . −40°C to +85°C
  AD734S . . . . −55°C to +125°C
Lead Temperature Range (soldering 60 sec) . . . . +300°C
Transistor Count 81

NOTES
[1]Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied.
[2]14-Pin Ceramic DIP: θ_{JA} = 110°C/W

AD734 CONNECTION DIAGRAM

14-Pin DIP





AD734 Block Diagram

MECHANICAL SPECS:

Industry-Standard 14-pin plastic DIP Package with 0.3" row spacing and 0.1" lead spacing.

SOURCES:

1) Analog Devices, Inc., Order # AD 734 AN (plastic DIP)
May also use AD 734 AQ (Ceramic DIP, more expensive)

PDIP VERSION STILL AVAILABLE 2022, ~$45/ea

TOLERANCES:
(UNLESS OTHERWISE NOTED)
ALL .XXX DECIMAL: ^.005
ALL .XX DECIMAL: ^.03
ALL FRACTIONAL: ^.1/16
ALL ANGULAR: ^.5°

MATERIAL:

FINISH:

DR. BY: JC, MD. MEDICAL DESIGN

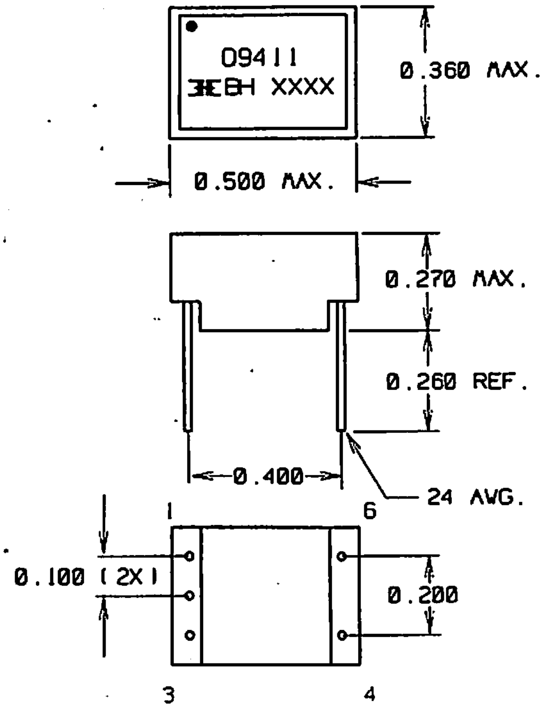
CHKD BY:

APPD.

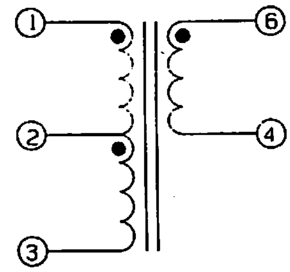
Carolina Medical

TITLE
AD 734
4- Quadrant Multiplier

A	DATE 4/26/97	DRAWING NO. MS-30793
SCALE	ECS	SHEET 1 of 1



SCHEMATIC



ELECTRICAL SPECIFICATIONS

TURNS RATIO: 4CT:1

OPEN CIRCUIT INDUCTANCE: 626.8uH NOM. (1-3) 100 KHz 100mV

PRIMARY LEAKAGE INDUCTANCE: 0.71uH NOM. (1-3 SHORT 6-4) 120 KHz 50mV

INTERWINDING CAPACITANCE: 4.0pF NOM. (1-6)

DC RESISTANCE: (1-3) 0.16 OHMS NOM
(6-4) 0.06 OHMS NOM.

HIGH VOLTAGE TEST: 2500 VAC / 1 SEC. (1-6)

SOURCES:

1) BH Electronics, Inc, Burnsville, MN, Part # Q9411

TOLERANCES:
(UNLESS OTHERWISE NOTED)
ALL .XXX DECIMAL: ^..005
ALL .XX DECIMAL: ^..03
ALL FRACTIONAL: ^.1/16
ALL ANGULAR: ^..5°

MATERIAL:

FINISH:

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DR. BY: JC, MD.

CHKD BY:

APPD.

Carolina Medical

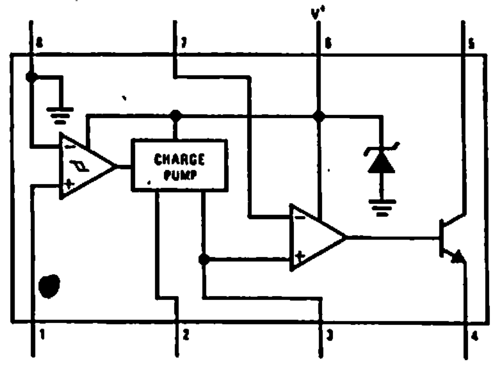
[redacted]

TITLE **RF Isolation Transformer Wideband**

A | DATE 4/26/97 | DRAWING NO. MS-30794

SCALE | ECS | SHEET 1 of 1

ELECTRICAL SPECS:



Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Supply Voltage	28V
Supply Current (Zener Options)	25 mA
Collector Voltage	28V
Differential Input Voltage	
Tachometer	28V
Op Amp/Comparator	28V
Input Voltage Range	
Tachometer ~~LM2907-8~~, LM2917-8	±28V
~~LM2907, LM2917~~	~~0.0V to +28V~~
Op Amp/Comparator	0.0V to +28V

Power Dissipation	
~~LM2907-8~~, LM2917-8	1200 mW
~~LM2907-14, LM2917-14~~	~~1580 mW~~
(See Note 1)	
Operating Temperature Range	−40°C to +85°C
Storage Temperature Range	−65°C to +150°C
Soldering Information	
Dual-In-Line Package	
Soldering (10 seconds)	260°C
~~Small Outline Package~~	
~~Vapor Phase (60 seconds)~~	~~215°C~~
~~Infrared (15 seconds)~~	~~220°C~~

See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering surface mount devices.

MECHANICAL SPECS:

Packaged in standard 8-pin, through-hole, Plastic DIP Package.

SOURCES:

1) National Semiconductor Corp, Number LM2917N-8 in DIP package.

STATUS: ACTIVE AND AVAILABLE 2022

TOLERANCES: (UNLESS OTHERWISE NOTED) ALL .XXX DECIMAL: ^..005 ALL .XX DECIMAL: ^..03 ALL FRACTIONAL: ^.1/16 ALL ANGULAR: ^..5°	PROPRIETARY INFORMATION Copyright by CAROLINA MEDICAL, inc. King, NC, USA 27021 This drawing remains the property of Carolina Medical.	**Carolina Medical** [redacted]
MATERIAL:	**DR. BY:** JC, MD. MEDICAL DESIGN	**TITLE** LM 2917N - 8 F - to - V Converter
FINISH:	**CHKD BY:**	**A** **DATE** 4/26/97 **DRAWING NO.** MS-30797
	APPD.	**SCALE** **ECS** **SHEET** 1 of 1

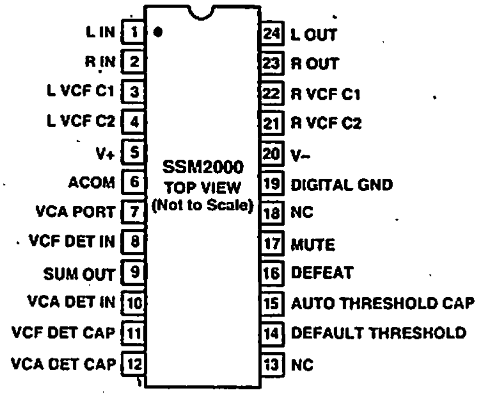
ABSOLUTE MAXIMUM RATINGS

Supply Voltage	+18 V
Audio Input Voltage	Supply Voltage(s)
Control Port Voltage (Pin 7)	Positive Supply
Default Override (Pin 14)	V+
Defeat (Pin 16)	V+
Mute Override (Pin 17)	V+
Operating Temperature Range	–40°C to +85°C
Storage Temperature Range	–65°C to +150°C
Junction Temperature (T_J)	+150°C
Lead Temperature (Soldering, 60 sec)	+300°C

ESD RATINGS

883 (Human Body) Model	2.5 kV
EIAJ Model	300 V

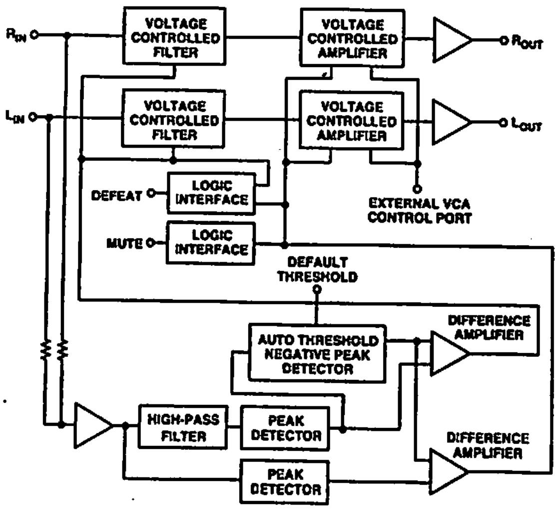
PIN CONFIGURATION
24-Lead Plastic DIP
24-Lead SOIC



NC = NO CONNECT

SIMPLIFIED THEORY OF OPERATION

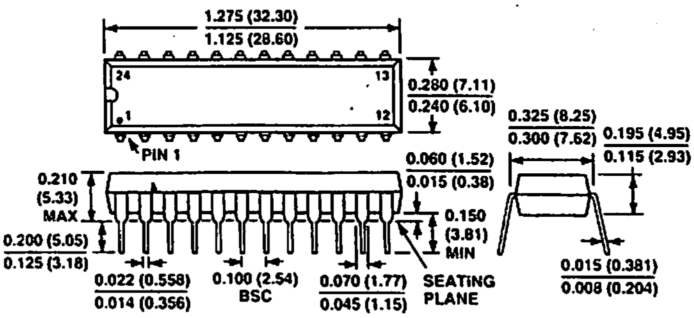
The input audio signals are processed to extract information concerning the frequency distribution and amplitude of both the desired signals and the undesired noise. Left and right audio signals are passed through voltage controlled (low-pass) filter, and then through a voltage controlled amplifiers. Both the filters and amplifiers are low distortion, and add negligible noise of their own. The VCF has a user-definable cutoff range that is usually set from 1 kHz to 35 kHz. It can be set to cover other ranges as required by the application. The VCA can be adjusted from a loss to a gain, adding to the SSM2000's versatility. In accordance with proprietary patented algorithms, control signals are derived and applied to both the VCF and VCA, resulting in up to 25 dB noise suppression with the minimum loss of desired signals.



SSM2000 System Block Diagram

OUTLINE DIMENSIONS
Dimensions shown in inches and (mm).

24-Pin Plastic DIP
(N-24)



OBSOLETE PART 2022

SOURCES:

1) Analog Devices, Inc., Order # SSM2000P (plastic DIP)

TOLERANCES: (UNLESS OTHERWISE NOTED) ALL .XXX DECIMAL: ^..005 ALL .XX DECIMAL: ^..03 ALL FRACTIONAL: ^.1/16 ALL ANGULAR: ^.5°	PROPRIETARY INFORMATION Copyright by CAROLINA MEDICAL, inc. King, NC, USA 27021 This drawing remains the property of Carolina Medical.	Carolina Medical [redacted]		
MATERIAL:	DR. BY: JC, MD.	TITLE SSM2000 "HUSH" Noise Reduction System		
FINISH:	CHKD BY:	A	DATE 4/27/97	DRAWING NO. MS-30816
	APPD.	SCALE	ECS	SHEET 1 of 1