

5003
NANOVOLT
PREAMPLIFIER

This handbook is supplied for use with instrument serial No.....

The Company maintains a policy of constant product improvement, as the components available and state of the art advance. This may lead to detail alterations in specification etc. Thus handbooks should be used for the instruments with which they are supplied.

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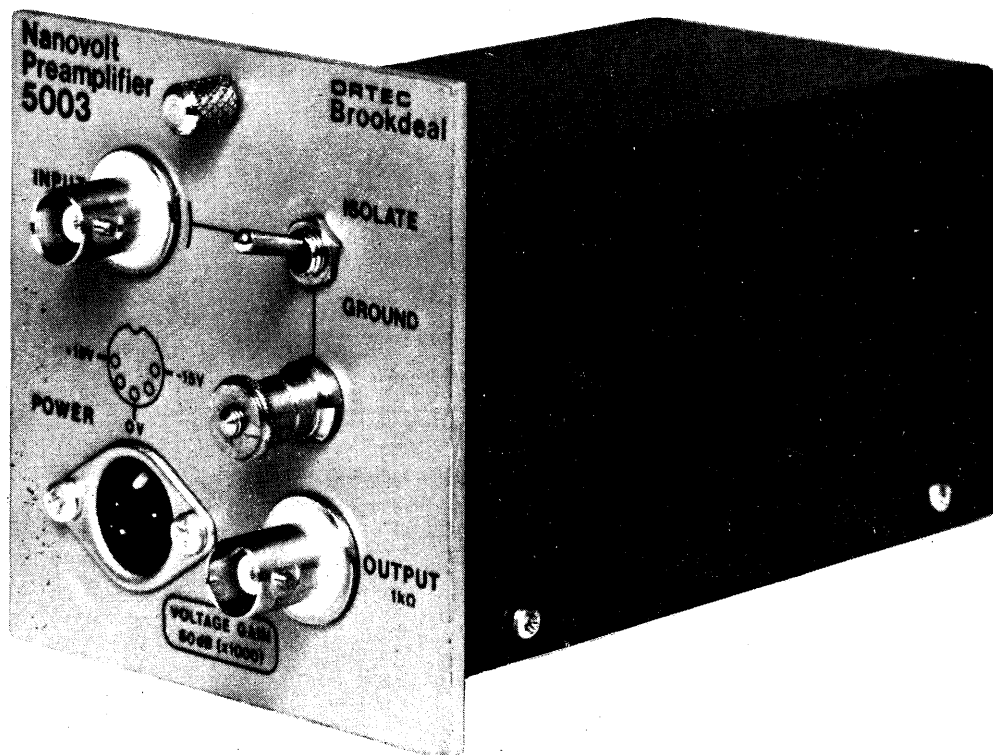
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1 introduction

The 5003 Nanovolt Preamplifier is a high-impedance voltage preamplifier which uses the lowest noise fets available. Special circuitry has been developed to take full advantage of the very low noise contributed by these fets so that the noise generated by the 5003 is no more than that given by a 250Ω resistor placed at the input. It is ideal for use with high impedance cryogenic sources, capacitance transducers and IR detectors, such as Ge, Si, PbS and PbSe.

The 5003 incorporates a special input stage which can be floated to give the ground loop immunity normally associated with differential inputs without the usual accompanying noise penalty of the additional input devices required in differential circuits.

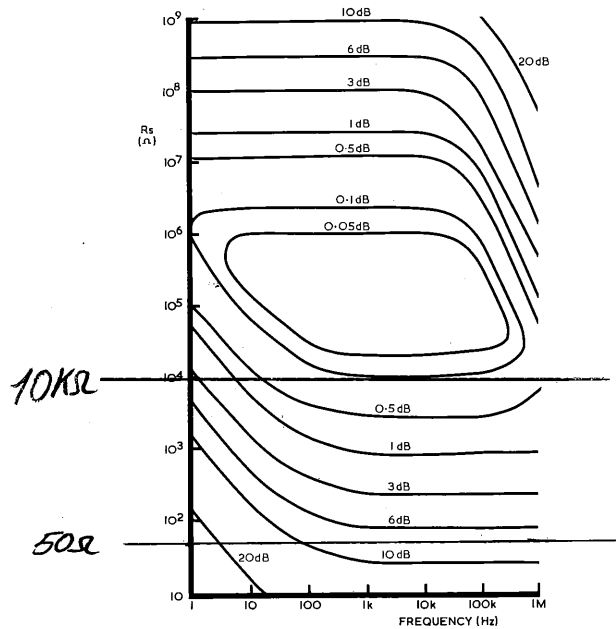


option 11

2 specifications

- 2.1 frequency range (-3dB) 0.5Hz to 1MHz
→ mod 10 version 0.1Hz to 1MHz
- 2.2 voltage gain 60dB (x1000) fixed
accuracy ±2%
stability ±0.3%/°C
- 2.3 noise
- 2.3.1 noise voltage shorted input
at 10Hz 5nV rms/√Hz
at 1kHz 2nV rms/√Hz
- 2.3.2 noise current open circuit input
(at 1kHz), 14fA rms/√Hz

the noise figure contours are shown below



- 2.4 INPUT unsymmetrical differential
- 2.5 INPUT impedance 100M Ω in parallel with 15pF
mod 11 version 1G Ω in parallel with 10pF
- 2.6 common mode rejection 80dB
- 2.7 maximum common mode input voltage 300mV p-p

2.8	maximum differential input voltage	20mV p-p
2.9	non-linearity	0.1%
2.10	OUTPUT level impedance slew rate	20V p-p up to 100kHz 1k Ω 20V/ μ s
2.11	safe overload levels inputs	\pm 400V dc or 240V ac at 50Hz
2.12	power requirements voltage current	\pm 15V, 0V dc 35mA
2.13	physical details height width depth weight	81mm 77mm 130mm 0.4kg (1lb)

Unless otherwise stated, specifications refer to 1kHz and 20°C.

3 operating instructions

facilities

operating instructions

3.1 installation

The 5003 is designed for use as a preamplifier with the 9500 series of lock-in amplifiers or as a stand-alone amplifier when the power is derived from one of the 9590 series of powerbins.

Remove the appropriate blanking plate (see handbook) from the lock-in amplifier or powerbin. Insert the body of the preamplifier into the space left by the blanking plate, pushing the bottom edge of the preamplifier connector panel into the slot in the lower extrusion. Push the top edge of the panel against the top extrusion and tighten *more* the fixing screw.

The preamplifier may also be mounted remotely next to the signal source if required. In this case, extension cables (model 5029) are available in order to connect signal and power to the lock-in or powerbin.

3.2 POWER

The 5003 operates from dc supplies of $\pm 15V$ and $0V$. The POWER socket is DIN type.

*intentional
modification*

When the preamplifier is to be mounted in either the lock-in amplifier or the powerbin, connect the 230mm (9") 5-pin DIN-connector terminated power cable to the preamplifier and mainframe. If the preamplifier is to be used remotely, connect the 3m (10') power cable, which is supplied as part of the 5029 accessory.

NB The current consumption of the 5003 is 35mA and in early *mini* models of the lock-in amplifier model 9501, a small modification is required so that it can supply this current to the preamp. On the 9501 signal channel board, change R34 and R35 from 100Ω to 10Ω . On the 9501 power supply board, change R10 from $10k\Omega$ to $12k\Omega$.

Switch on the powerbin or lock-in amplifier as appropriate.

3.3 INPUT

The input circuit is an unsymmetrical differential configuration. When the GROUND/ISOLATE switch is set to the GROUND position, the outer of the BNC input socket is grounded and the input may be used in the conventional single-ended mode. However, the input stage can be floated by setting the switch to ISOLATE. This gives the ground loop immunity normally associated with differential inputs without the accompanying noise penalty of the additional input devices required in differential circuits. The maximum common-mode input voltage is 300mV p-p.

Input noise is 2nV rms/ $\sqrt{\text{Hz}}$ at 1kHz, which makes the 5003 very suitable for high impedance cryogenic sources and certain IR detectors.

3.4 OUTPUT

Maximum OUTPUT is + and - 10V at 200 μ A p-p from 1k Ω .

For operation in single-ended mode, set the GROUND/ISOLATE switch to GROUND. Connect the signal source to the INPUT socket by means of a coax cable and BNC connector. To use the "differential" mode, set the switch to ISOLATE. The signal voltages should be connected to the INPUT socket and the signal ground to the screw *with* terminal on the 5003 panel. A rear panel screwdriver adjust *control* is provided in order to trim the signal low voltage to approximately ground potential when the switch is set to ISOLATE. The "signal low" voltage is limited to $\pm 600\text{mV}$.

Ensure that the input voltage does not exceed the safe overload level of $\pm 400\text{V}$ dc or 240V rms ac (at 50Hz).

The 5003 noise matches sources from 250 Ω to 100M Ω (at 1kHz) and replaces the input transformer in many applications. From cryogenic sources, the optimum impedance matching range is 1k Ω to 20M Ω .

When the 5003 is used as a preamplifier with a 9500 series lock-in amplifier, the 5003 OUTPUT should be connected to the signal input of the lock-in via a 230mm (9") BNC terminated coax cable. If the preamplifier is used remote from the lock-in, connection may be made using the 3m (10') signal cable of the 5029 extender kit.

When the 5003 is used as a preamplifier with other equipment, the OUTPUT interfaces easily with other equipment which has an input impedance $\geq 100\text{k}\Omega$.

4 circuit description

The 5003 consists of a low-noise preamplifier situated on board I, followed by a differential output stage on board II.

The signal input is coupled through C1, C2 and C3 to the parallel input fets Q5 and Q6, which have independent trims RV1 and RV2 for bias current. The input impedance is given by the parallel connection of (R1 + R2) and (R6 + R7).

Bipolar transistors Q1 - Q4 provide input protection and the base of Q4 is capacitor coupled to the sources of the input devices in order to reduce the effective capacitance across the input socket.

A GROUND/ISOLATE switch enables the "low" terminal of the input socket to be connected either to the amplifier ground or to an alternative "signal low" point on the base of Q9. The supply rail for the input stage is established from this point through ZD1, which is current-sourced from Q13. RV3, mounted on the rear chassis plate, is used to trim the "signal low" voltage to approximately ground potential when SW1 is in the ISOLATE position. D1 and D2 limit the total variation in "signal low" voltage to $\pm 600\text{mV}$ from ground potential.

The low-noise preamplifier is completed by Q7 and Q8 and has a gain $(R10 + R5)/R5$, the final output appearing at the emitter of follower Q10, current-sourced from fet Q12. A second output, which follows the "signal low" voltage, appears at the emitter of Q9, current-sourced from fet Q11.

The output stage is based on the high-performance operational amplifier Q101 - Q108, which is connected as a differential stage with feedback resistor R108. RV102 provides a trim for the stage gain which is nominally 30.

RV101 is used as a trim to null the effect of common-mode voltages appearing at the outputs of Q9 and Q10 in the preamplifier, whilst RV103 provides adjustment for the voltage offset of the dc coupled output.

5 parts list

5.1 low-noise preamplifier board

circuit ref	component value	tol %	volts wkg	power rtg.W	type	grade
R1,2	100M	5		$\frac{1}{8}$		
R3	1k	1		$\frac{1}{2}$		
R4	33	5		"		
R5	10	1		"		
R6,7	100M	5		$\frac{1}{8}$		
R8	56k	"		$\frac{1}{2}$		
R9	33	"		"		
R10	330	1		"		
R11	1k	5		"		
R12	560	1		"		
R13	56k	5		"		
R14	15k	"		"		
R15	100	"		"		
R16,17	560	"		"		
R18	68	"		"		
R19	100	"		"		
R20	3k3	"		"		
R21	560	1		"		
RV1,2	22k				90VC	
C1	0 μ 22		400		TFM	
C2,3	0 μ 22		100		PMT2R	
C4	0 μ 1		"		"	
C5,6	100 μ		16		Printilyt	
C7	1000 μ		"		"	
C8	1000p				S/M radial	
D1,2					1N4148	
ZD1	12V					*
Q1-4					BC184LC	A
Q5,6						FM10
Q7					BC184LC	A
Q8					BC214LC	AX
Q9,10					BC184LC	A
Q11,12					BF244A	
Q13,14					BC214LC	AX

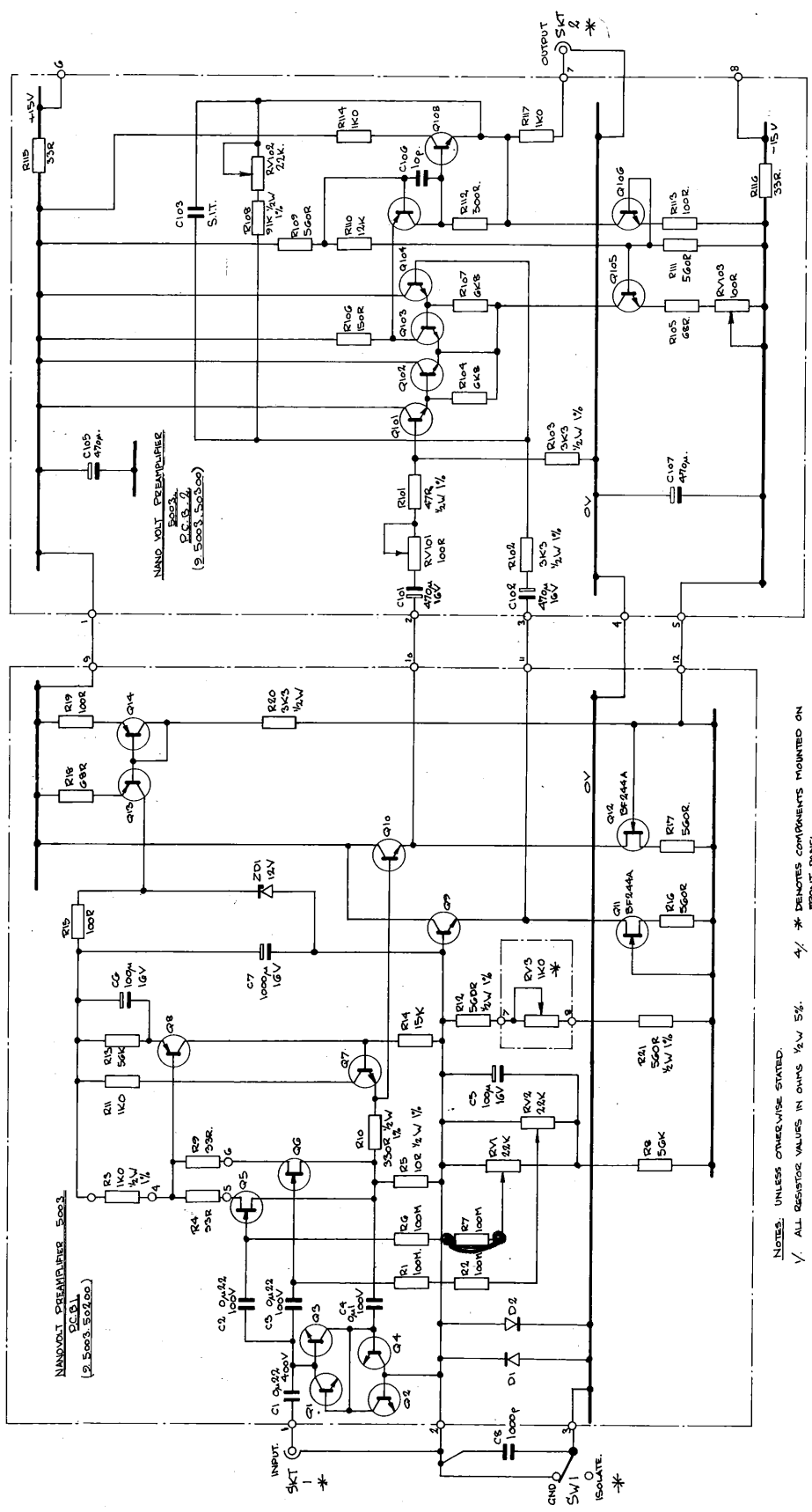
5.2 differential output board

circuit ref	component value	tol %	volts wkg	power rtg.W	type	grade
R101	47	1		1/2		
R102,3	3k3	"		"		
R104	6k8	5		"		
R105	68	"		"		
R106	150	"		"		
R107	6k8	"		"		
R108	91k	1		"		
R109	560	5		"		
R110	12k	"		"		
R111	560	"		"		
R112	300	"		"		
R113	100	"		"		
R114	1k	"		"		
R115,6	33	"		"		
R117	1k	"		"		
RV101	100				62V	
RV102	22k				90VC	
RV103	100				62V	
C101,2	470u		16		Printilyt	
C103	SIT					
C105	470u		16		Printilyt	
C106	10p				S/M radial	
C107	470u		16		Printilyt	
Q101-104					BC184LC	TM2
Q105,106					BC184LC	A
Q107					BC214LC	AX
Q108					BC184LC	A

5.3 components not on pcb's

RV3	1k				80	
SW1	ground/ISOLATE switch				5.0103.00006	*

* Items marked thus should be obtained from Brookdeal Electronics Ltd. since they are either selected versions of parts available from other manufacturers or are specially made to Brookdeal designs. When ordering such parts, please quote instrument type, serial number and circuit reference.

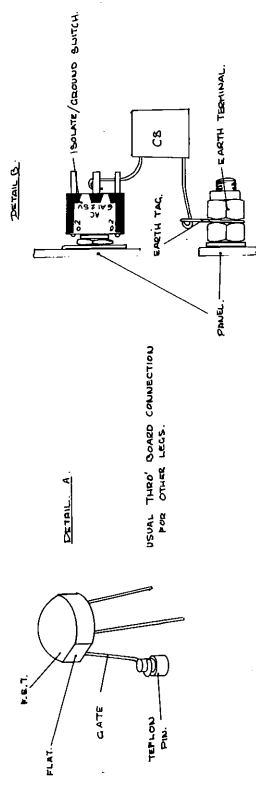


*Alimentazione
 Vin ± 15V
 Vout ± 15V*

fig 1 circuit diagram

- NOTES: UNLESS OTHERWISE STATED:
 1/ ALL RESISTOR VALUES IN OHMS 1/2W 5%
 2/ ALL CAPACITOR VALUES IN PFDAS.
 3/ ALL NPN TRANSISTORS ARE BC141C.
 4/ ALL PNP TRANSISTORS ARE BC244C.

*Lo 0V (come del ±15V)
 è collegato allo chassis
 e allo schermo del cavo di
 alimentazione
 Il DC LEVEL non è collegato*



4 LINKS CONNECTING TEPLON PINS ON OPPOSITE SIDE OF BOARD.
 NOTE: GATES OF O'S & G ARE CONNECTED TO TEPLON PINS. SEE DETAIL A.
 †/DETAIL B SHOWS WHERE CE IS CONNECTED TO INPUT DMC.

● TEPLON PINS 04, 05, 06, 08, 09, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000.

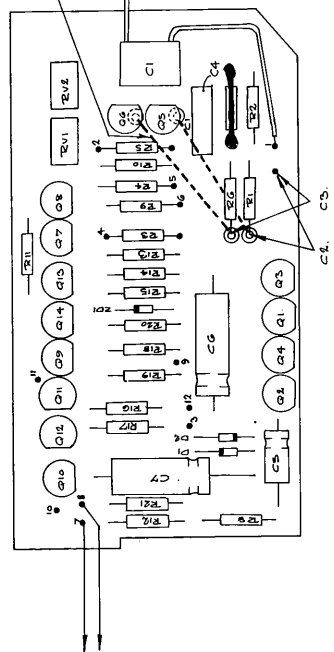


fig 2(a) low noise preamplifier
 - component layout

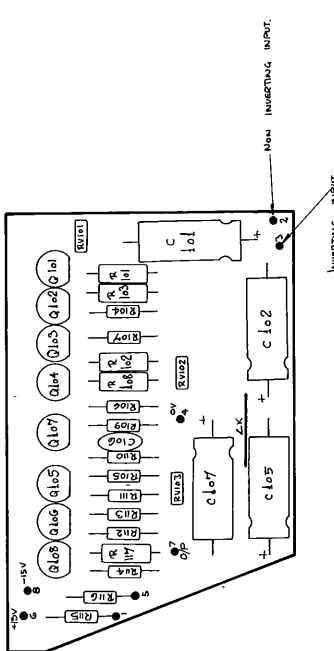


fig 2(b) differential output
 - component layout