Low

LM158

| December 1994  LM158LM258LM358LM2904  Low Power Dual Operational Amplifiers  General Description  Advantages  Y Two internally compensated op amps in a single  The LM158 series consists of two independent high gain  package  internally frequency compensated operational amplifiers  which were designed specifically to operate from a single  Y Eliminates need for dual supplies  power supply over a wide range of voltages Operation from  Y Allows directly sensing near GND and VOUT also goes  split power supplies is also possible and the low power sup  to GND  ply current drain is independent of the magnitude of the  Y Compatible with all forms of logic  power supply voltage  Y Power drain suitable for battery operation  Application areas include transducer amplifiers dc gain  Y Pin-out same as LM1558LM1458 dual operational  blocks and all the conventional op amp circuits which now  amplifier  can be more easily implemented in single power supply sys  Features  tems For example the LM158 series can be directly operat  ed off of the standard a5V power supply voltage which is  Y Internally frequency compensated for unity gain  used in digital systems and will easily provide the required  Y Large dc voltage gain 100 dB  interface electronics without requiring the additional g15V  Y Wide bandwidth (unity gain) 1 MHz  power supplies  (temperature compensated)  Unique Characteristics  Y Wide power supply range  Single supply 3V to 32V  Y In the linear mode the input common-mode voltage  or dual supplies g15V to g16V  range includes ground and the output voltage can also  Y Very low supply current drain (500 mA)essentially in  swing to ground even though operated from only a sin  dependent of supply voltage  gle power supply voltage  Y Low input offset voltage 2 mV  Y The unity gain cross frequency is temperature  Y Input common-mode voltage range includes ground  compensated  Y Differential input voltage range equal to the power sup  Y The input bias current is also temperature  ply voltage  compensated  Y Large output voltage swing 0V to Va b 15V  Connection Diagrams (Top Views)  DIPSO Package  Metal Can Package  TLH7787 –1  Order Number LM158AH LM158AH883  TLH7787 –2  Order Number LM158J LM158J883  LM158H LM158H883 LM258H or LM358H  LM158AJ or LM158AJ883  See NS Package Number H08C  See NS Package Number J08A  Order Number LM358M LM358AM or LM2904M  See NS Package Number M08A  Order Number LM358AN LM358N or LM2904N  See NS Package Number N08E  LM158 is available per SMD 5962-8771001  LM158A is available per SMD 5962-8771002 |
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Power Dual Operational Amplifiers

LM258

LM358

LM2904

C1995 National Semiconductor Corporation RRD-B30M115Printed in U S ATLH7787

| Units  mV  mA  mA  nA  nA  V  15  150 C  85 C  Max  250  12  50  2  7  b  Distributors for availability and specifications  LM2904  C  C  C  C  C  LM2904  40 C to  a  Va  250V  65 C to  a  See AN-450 ‘‘Surface Mounting Methods and Their Effect on Product  260  300  260  215  220        Typ  05  45  1  5  2  Reliability’’ for other methods of soldering surface mount devices  b  Min  b  0  LM358A  LM358  15  125 C  150 C  85 C  Max  250  12  70 C  50  2  7  b  LM258A  LM258  Va  260 C  300 C  260 C  215 C  220 C  25 C to  a  LM358  250V  55 C to  a  65 C to  a  0 C to  a            Typ  05  45  1  5  2  LM158  LM158A  Min  b  b  b  0  15  Vapor Phase (60 seconds)  Operating Temperature Range  Metal Can  Max  150  LM258  12  30  Storage Temperature Range  Soldering (10 seconds)  2  5  b  10 seconds)  10 seconds)  Infrared (15 seconds)  ESD Tolerance (Note 10)  Va  Small Outline Package  Dual-In-Line Package  DIP  please contact the National Semiconductor Sales Office  Soldering Information  LM158  Typ  05  45  1  3  2  Lead Temperature  Lead Temperature  Min  0  (Soldering  (Soldering  LM158  LM358  LM258  15  Max  100  12  30  2  3  b  LM358A  Va  Typ  05  45  1  5  2  Min  0  15  unless otherwise stated  Max  12  50  10  2  2  b  LM158A  Va  26V  Typ  05  20  Continuous  1  1  2  LM2904  530 mW  830 mW  03V to a  50 mA  26V  26V  Min  0  25 C  b  50V  LM358A  Aerospace specified devices are required  25 C  26V)  LM358  e  TA  a  Over Full Temperature Range  32V  e  Continuous  e  25 C  0V  e  LM258A  Conditions  Ratings  26V) TA  LM258  on All Op Amps  530 mW  830 mW  550 mW  03V to a  50 mA  Electrical Characteristics Va  30V (LM2904 Va  32V  32V  e  (Note 7)  (Note 6)  e  25 C  ) VCM  ) TA  LM158  LM158A  e  b  e  IIN(b  ) or IIN(b  Va  (Note 5) TA  30V  0V  Absolute Maximum  5V  (LM2904  Small Outline Package (M)  %  ) b  03V)  25 C  e  Output Short-Circuit to GND  Power Dissipation (Note 1)  e  e  e  (One Amplifier) (Note 2)  RL e  IIN(a  IIN(a  VCM  Differential Input Voltage  Va  Va  Va  e  b  15V and TA  Input Common-Mode  k  Input Offset Current  Va  Input Offset Voltage  Input Current (VIN  Input Bias Current  Supply Voltage  Parameter  Molded DIP  Supply Current  Input Voltage  Voltage Range  Metal Can  (Note 3)  If Military  (Note 9)  s  Va |
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| C  Units  C  mV  mV  mA  mA  mA  mA  dB  dB  dB  nA  nA      mV  pA  V  Max  200  500  10  60  LM2904  120  Typ  100  100  50  20  40  70  45  10  40  40  7  b  Min  12  10  20  25  50  50  Max  150  500  60  9  LM358  120  Typ  100  100  50  20  40  85  10  40  40  7  b  Min  12  10  20  25  65  65  Max  100  300  60  7  LM258  120  Typ  100  100  50  20  40  85  40  40  10  7  LM158  b  Min  12  10  20  50  70  65  Max  200  300  75  60  20  5  unless otherwise stated  LM358A  120  Typ  100  100  50  20  40  85  40  40  10  7  b  Min  12  10  20  25  65  65  Max  100  200  30  60  15  4  Note 4  LM158A  120  Typ  100  100  50  20  40  85  40  40  10  7  50V  b  Min  12  10  20  50  70  65  a  e  25 C  Electrical Characteristics (Continued) Va  200 mV  (Input Referred) (Note 8)  1V  e  0V  15V  1 kHz to 20 kHz TA  25 C  25 C  Conditions  e  25 C  (Note 2)  e  5V  25 C  (For VO  b  VINa  e  5V to 30V  e  e  0V to Va  e  )  )  e  O  TA  TA  V  IIN(b  ) or IIN(b  e  TA  Va  1V  0V  0V  1V  1V  15V  15V  15V  15V  15V  to 26V) TA  25 C  25 C  25 C  2 kX  2V  2V  (LM2904  0X  0X  (Note 5)      to 11V)  ) b  e  e  e  e  e  e  e  e  e  e  e  e  e  e  e  e  e  e  e  VINa  VINa  RL t  VINb  VINb  VINb  IIN(a  IIN(a  VCM  RS  RS  f e  VO  VO  Va  Va  Va  Va  Va  Va  TA  TA  TA  Sink  Source  Short Circuit to Ground  Amplifier-to-Amplifier  Large Signal Voltage  Input Offset Current  Input Offset Current  Input Offset Voltage  Input Offset Voltage  Input Bias Current  Parameter  Common-Mode  Output Current  Rejection Ratio  Rejection Ratio  Power Supply  Coupling  Drift  Drift  Gain |
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| Units  mV  output current is approximately 40 mA independent of the magnitude of  15V (at 25 C) but either or both  which applies for the device soldered in a printed  It is due to the collector-base junction of the input PNP transistors becoming forward biased and thereby acting as input diode  temperature  voltage level (or to ground for a large  03V (at 25 C)  where  mV  mA  mA  This typically can be detected as this type of capacitance increases at higher frequencies  simultaneous shorts on all amplifiers  V  V  V  V  use external resistors  2  Max  100  b  LM358A  Va  again returns to a value greater than b  LM2904  This current is essentially constant independent of the state of the output so no loading change exists on the input lines  Typ  the LM358  24  20  5  8  Min  The dissipation is the total of both amplifiers  15  22  23  10  5  0  b  85 C  The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 03V (at 25 C) The upper end of the common-mode voltage range is V  a  2  Destructive dissipation can result from  This transistor action can cause the output voltages of the op amps to go to the Va  Max  20  b  a  Va  s  LM358  TA  W  Typ  s  28  20  5  8  C  25 C  junction temperature and a thermal resistance of 120  which was negative  Min  b  15  26  27  10  5  0  all temperature specifications are limited to  5V to 26V  2  Max  20  LM258  b  Va  the maximum  junction temperature  from  This is not destructive and normal output states will re-establish when the input voltage  continuous short-circuits can exceed the power dissipation ratings and cause eventual destruction  Typ  28  20  LM158  5  8  a  V  For LM2904  Min  When considering short cirucits to ground  25  27  26  10  5  0  insure that coupling is not originating via stray capacitance between these external parts  2  Max  20  b  150 C maximum  unless otherwise stated  15V) at 25 C  Va  LM358A    Typ  LM258A  28  20  5  8  125 C maximum  85 C  military specifications and to RETS158X for LM158 military specifications  LM158A can be derated based on a a  b  Min  15  26  27  10  a  With the LM258  5  0  and over the full input common-mode range (0V to Va  s  the amplifier to saturate or to reduce the power which is dissipated in the integrated circuit  TA    2  parasitic transistor action on the IC chip  Max  s  20  LM2904 must be derated based on a a  b  40 C  This input current will only exist when the voltage at any of the input leads is driven negative  Va  can cause excessive heating and eventual destruction  LM158A  26V for LM2904) independent of the magnitude of Va  Note 4  b  LM158A  and the LM2904 specifications are limited to  Typ  28  20  15  5  50V  Min  for the LM158  25  26  27  10  10  due to the PNP input stage  0  a  10 kX  e  LM258A and LM158  2 kX  Electrical Characteristics (Continued) Va  125 C  RL e  RL e    0V  0V  there is also lateral NPN  LM358A  a  Conditions  overdrive) for the time duration that an input is driven negative  10 kX  26V)  26V)  e  e  s  (Note 7)  in series with 100 pF  2V  2V  TA  The direction of the input current is out of the IC  VINb  VINa  5V to 30V  1V to 11V)  operating in a still air ambient The LM258  the LM358  s  e  e  e  e  RL e  15V  55 C  VO  VO  1V  1V  15V  30V  Due to proximity of external components  70 C  Va  Va  30 V  At values of supply voltage in excess of a  15V  15V  These specifications are limited to b    2 kX  a  a  from  5V  (LM2904  (LM2904  the output to Va  For operating at high temperatures  a  32V without damage (a  a  a  Refer to RETS158AX for LM158A  e  e  s  e  e  e  e  e  e  e  with Va  In addition to this diode action  VINa  RL t  VINb  TA  Human body model 15 kX  (VO  Va  Va  Va  Va  Va  Va  s  specifications are limited to 0 C  0X  Sink  Source  VOL  VOH  Short circuits from  e  Input Common-Mode  Large Signal Voltage  RS  Parameter  14V  inputs can go to a  Output Current  Voltage Range  to allow  j  circuit board  VO  Note 10  possible  Voltage  Output  Note 4  clamps  Note 6  Note 5  Note 9  Note 3  Note 2  Note 8  Note 7  Note 1  Swing  Gain  Va |
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4

| Typical Performance Characteristics  Input Voltage Range Input Current Supply Current  Open Loop Frequency  Common-Mode  Voltage Gain Response  Rejection Ratio  Voltage Follower Pulse  Voltage Follower Pulse  Large Signal Frequency  Response  Response (Small Signal)  Response  Output Characteristics  Output Characteristics  Current Sourcing  Current Sinking  Current Limiting  TLH7787 –4 |
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| Typical Performance Characteristics (Continued) (LM2902 only)  Input Current Voltage Gain  TLH7787 –5  Application Hints  Capacitive loads which are applied directly to the output of  The LM158 series are op amps which operate with only a  the amplifier reduce the loop stability margin Values of 50  single power supply voltage have true-differential inputs  pF can be accomodated using the worst-case non-inverting  and remain in the linear mode with an input common-mode  unity gain connection Large closed loop gains or resistive  voltage of 0 VDC These amplifiers operate over a wide  isolation should be used if larger load capacitance must be  range of power supply voltage with little change in perform  driven by the amplifier  ance characteristics At 25C amplifier operation is possible  down to a minimum supply voltage of 23 VDC  The bias network of the LM158 establishes a drain current  which is independent of the magnitude of the power supply  Precautions should be taken to insure that the power supply  voltage over the range of 3 VDC to 30 VDC  for the integrated circuit never becomes reversed in polarity  or that the unit is not inadvertently installed backwards in a  Output short circuits either to ground or to the positive pow  test socket as an unlimited current surge through the result  er supply should be of short time duration Units can be  ing forward diode within the IC could cause fusing of the  destroyed not as a result of the short circuit current causing  internal conductors and result in a destroyed unit  metal fusing but rather due to the large increase in IC chip  Large differential input voltages can be easily accomodated  dissipation which will cause eventual failure due to exces  and as input differential voltage protection diodes are not  sive function temperatures Putting direct short-circuits on  needed no large input currents result from large differential  more than one amplifier at a time will increase the total IC  input voltages The differential input voltage may be larger  power dissipation to destructive levels if not properly pro  than Va without damaging the device Protection should be  tected with external dissipation limiting resistors in series  with the output leads of the amplifiers The larger value of  provided to prevent the input voltages from going negative  more than b03 VDC (at 25C) An input clamp diode with a  output source current which is available at 25C provides a  resistor to the IC input terminal can be used  larger output current capability at elevated temperatures  (see typical performance characteristics) than a standard IC  To reduce the power supply current drain the amplifiers  op amp  have a class A output stage for small signal levels which  converts to class B in a large signal mode This allows the  The circuits presented in the section on typical applications  amplifiers to both source and sink large output currents  emphasize operation on only a single power supply voltage  Therefore both NPN and PNP external current boost tran  If complementary power supplies are available all of the  sistors can be used to extend the power capability of the  standard op amp circuits can be used In general introduc  ing a pseudo-ground (a bias voltage reference of Va2) will  basic amplifiers The output voltage needs to raise approxi  mately 1 diode drop above ground to bias the on-chip verti  allow operation above and below this value in single power  cal PNP transistor for output current sinking applications  supply systems Many application circuits are shown which  take advantage of the wide input common-mode voltage  For ac applications where the load is capacitively coupled  range which includes ground In most cases input biasing is  to the output of the amplifier a resistor should be used from  not required and input voltages which range to ground can  the output of the amplifier to ground to increase the class A  easily be accommodated  bias current and prevent crossover distortion Where the  load is directly coupled as in dc applications there is no  crossover distortion |
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| Typical Single-Supply Applications (Va e 50 VDC)  Non-Inverting DC Gain (0V Input e 0V Output)  R not needed due to  temperature independent IIN  TLH7787 –6  TLH7787 –7  DC Summing Amplifier  (VIN’S t 0 VDC and VO t 0 VDC)  Power Amplifier  VO e 0 VDC for VIN e 0 VDC  AV e 10  TLH7787 –8  TLH7787 –9  Where VO e V1 a V2 a V3 a V4  (V1 a V2) t (V3 a V4) to keep VO l 0 VDC  ‘‘BI-QUAD’’ RC Active Bandpass Filter  fO e 1 kHz  Q e 50  AV e 100 (40 dB)  TLH7787 –10 |
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| Typical Single-Supply Applications (Va e 50 VDC) (Continued)  Fixed Current Sources  Lamp Driver  TLH7787 –12  Current Monitor  R1  R2 J I1TLH7787 –11  I2 e    LED Driver  VO e 1V (IL)  1A  (Increase R1 for IL small)  TLH7787 –13  VL s Va b2V  Driving TTL  TLH7787 –14  Pulse Generator  TLH7787 –15  Voltage Follower  VO e VIN  TLH7787 –17  TLH7787 –16 |
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| Typical Single-Supply Applications (Va e 50 VDC) (Continued)  Squarewave Oscillator  Pulse Generator  TLH7787 –18  TLH7787 –19  Low Drift Peak Detector  HIGH ZIN  LOW ZOUT  TLH7787 –20  High Compliance Current Sink  Comparator with Hysteresis  TLH7787 –22  IO e 1 ampvolt VIN  (Increase RE for IO small)  TLH7787 –21 |
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| Typical Single-Supply Applications (Va e 50 VDC) (Continued)  Voltage Controlled Oscillator (VCO)  TLH7787 –23  WIDE CONTROL VOLTAGE RANGE 0 VDC s VC s 2 (Va b15V DC)  AC Coupled Inverting Amplifier  AV e Rf  R1 (As shown AV e 10)  TLH7787 –24  Ground Referencing a Differential Input Signal  VO e VR  TLH7787 –25 |
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| Typical Single-Supply Applications (Va e 50 VDC) (Continued)  AC Coupled Non-Inverting Amplifier  AV e 1 a R2  R1  AV e 11 (As Shown)  TLH7787 –26  DC Coupled Low-Pass RC Active Filter  fO e 1 kHz  Q e 1  AV e 2  TLH7787 –27  Bandpass Active Filter  fO e 1 kHz  Q e 25  TLH7787 –28 |
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| Typical Single-Supply Applications (Va e 50 VDC) (Continued)  High Input Z DC Differential Amplifier  R2 e R4  TLH7787 –29 For R1  (CMRR depends on this  resistor ratio match)  R3  VO e 1 a R4  R3 (V2 b V1)  As Shown VO e 2 (V2 b V1)  Photo Voltaic-Cell Amplifier  Bridge Current Amplifier  For e kk 1 and Rf ll R  TLH7787 –30  VO j VREF e2 JRfR  TLH7787 –33  High Input Z Adjustable-Gain  DC Instrumentation Amplifier  TLH7787 –31  If R1 e R5 R3 e R4 e R6 e R7 (CMRR depends on match)  VO e 1 a 2R1  R2 (V2 b V1)  As shown VO e 101 (V2 b V1) |
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12

| Typical Single-Supply Applications (Va e 50 VDC) (Continued)  Using Symmetrical Amplifiers to  Reduce Input Current (General Concept)  TLH7787 –32  Schematic Diagram (Each Amplifier)  TLH7787 –3 |
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| Physical Dimensions inches (millimeters)  Metal Can Package (H)  Order Number LM158AH LM158AH883 LM158H  LM158H883 LM258H or LM358H  NS Package Number H08C |
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| Physical Dimensions inches (millimeters) (Continued)  Cerdip Package (J)  Order Number LM158J LM158J883 LM158AJ or LM158AJ883  NS Package Number J08A  SO Package (M)  Order Number LM358M LM358AM or LM2904M  NS Package Number M08A |
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LM2904 LM358LM258LM158

Power Dual Operational Amplifiers

| Physical Dimensions inches (millimeters) (Continued)  Molded Dip Package (N)  Order Number LM358AN LM358N or LM2904N  NS Package Number N08E  LIFE SUPPORT POLICY  NATIONAL’S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION As used herein  1 Life support devices or systems are devices or 2 A critical component is any component of a life systems which (a) are intended for surgical implant support device or system whose failure to perform can into the body or (b) support or sustain life and whose be reasonably expected to cause the failure of the life failure to perform when properly used in accordance support device or system or to affect its safety or with instructions for use provided in the labeling can effectiveness  be reasonably expected to result in a significant injury  to the user  National Semiconductor National Semiconductor National Semiconductor National Semiconductor Corporation Europe Hong Kong Ltd Japan Ltd 1111 West Bardin Road Fax (a49) 0-180-530 85 86 13th Floor Straight Block Tel 81-043-299-2309 Arlington TX 76017 Email cnjwgetevm2nsccom Ocean Centre 5 Canton Rd Fax 81-043-299-2408 Tel 1(800) 272-9959 Deutsch Tel (a49) 0-180-530 85 85 Tsimshatsui Kowloon  Fax 1(800) 737-7018 English Tel (a49) 0-180-532 78 32 Hong Kong  Franais Tel (a49) 0-180-532 93 58 Tel (852) 2737-1600  Italiano Tel (a49) 0-180-534 16 80 Fax (852) 2736-9960 |
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