BURR-BROWN®

4213/883B SERIES

MODEL NUMBERS:
4213WM/883B 4213VM/883B
4213WM 4213VM
4213UM/883B
4213UM

REVISION D
JANUARY, 1989

Military MULTIPLIER - DIVIDER

FEATURES

- HI REL MANUFACTURE
- ACCURATE
  ±1/2% TOTAL ERROR (W grade)
  ±1% TOTAL ERROR (V and U grades)
- 4-QUADRANT MULTIPLICATION
  2-QUADRANT DIVISION
- NO EXTERNAL COMPONENTS NECESSARY
- DIFFERENTIAL INPUT
- MIL-STD-883B SCREENING
- -55°C TO +125°C SPECIFICATIONS

DESCRIPTION

The 4213/883B Series is a high performance, precision multiplier/divider with a total full scale error of ±1/2% or ±1%. It is intended for transducer and analog computation applications; it will also square, square root, and perform trigonometric computations. It has differential inputs and is ideal for instrumentation applications. The operating range is −55°C to +125°C. The 4213/883B is a monolithic bipolar IC. It is assembled into a hermetic TO-100 (10-lead can).

These devices are manufactured on a separate Hi-Rel manufacturing line with impeccable clean room conditions which assures "built-in" quality and provides for a long product life.

The 4213/883B Series is available in three electrical performance grades. The W grade features premium accuracy (±1/2% total error, ±50mV feedthrough, and ±25mV offset error). The V grade features ±1% total error, ±100mV feedthrough, and ±30mV offset error. The U grade has excellent performance from -25°C to +85°C and is also specified from -55°C to +125°C. U grade applications include test equipment, shipboard, ground support, and industrial applications where operation is normally between -25°C and +85°C and full temperature operation must be assured.

Two product assurance levels are available: standard, and /883B. The /883B suffixed devices feature Hi-Rel manufacture, 100% screening per MIL-STD-883 method 5004 class B, and a 5% PDA. Quality assurance further processes /883B devices, performing group A and B inspections on each inspection lot and group C and D inspections as required by MIL-STD-883.

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PDS-458D

DETAILED SPECIFICATION
MICROCIRCUITS, LINEAR
MULTIPLIER
MONOLITHIC, SILICON

1. SCOPE

1.1 Scope. This specification covers the detail requirements for a precision, integrated circuit multiplier.

1.2 Part Number. The complete part number is as shown below.

4213	V	M	/883B
Basic. model number	Grade (see 1.2.1)	Metal package	Hi-Rel product designator (see 1.2.2)

1.2.1 Device type. The device is a single, four-quadrant, analog multiplier; it will also function as a single, two-quadrant, analog divider, a squarer, a square rooter, etc. (see paragraph 8.3). Three electrical performance grades are provided. The W grade features premium accuracy of ±1/2% total error, ±50mV feedthrough and ±25mV offset error. The V grade features ±1% total error, ±100mV feedthrough and ±30mV offset error. The U grade features excellent performance from -25°C to +85°C and guarantees performance from -55°C to +125°C.

Electrical specifications are shown in Table I. Electrical tests are shown in Tables II and III.

1.2.2 Device Class. The device class is similar to the hybrid class (class B) product assurance level, as defined in MIL-M-38510. The Hi-Rel product designator portion of the part number distinguishes the product assurance level as follows:

Hi-Rel product designator	Requirements
/883B	Standard model, plus 100% MIL-STD-883 hybrid class screening, with 5% PDA, plus quality conformance inspection (QCI) consisting of Groups A and B performed on each inspection lot, plus Groups C and D performed as required by MIL-STD-883.
(none)	Standard model, including 100% electrical testing.

1.2.3 Case outline. The case outline is A-2 (10-lead can, TO-100) as defined in MIL-M-38510, Appendix C. The case is metal and is conductive.

1.2.4 Absolute maximum ratings.

Supply voltage range	±20VDC
Input voltage range (X, Y, and Z inputs)	±20VDC 1/
Differential input voltage (X, Y, and Z inputs)	±40VDC 1/
Storage temperature range	-65°C to +150°C
Output short-circuit duration	Unlimited 2/
Lead temperature (soldering, 60sec)	300°C
Junction temperature	T_J = 175°C

1/ The absolute maximum input voltage is equal to the supply voltage.

2/ Short circuit may be to ground only. Rating applies to +125°C case temperature or +75°C ambient temperature at ±15VDC supply voltage.

1.2.5 Recommended operating conditions.

Supply voltage range	±8.5VDC to ±20VDC
Ambient temperature range	-55°C to +125°C
Input voltage range ($\pm V_{CC}$ = 15VDC)	±10VDC

1.2.6 Power and thermal characteristics.

Package	Case outline	Maximum allowable power dissipation	Maximum θ J-C	Maximum θ J-A
10-lead can (TO-100)	A-2	225mW at T_A = 125°C	70°C/W	220°C/W

2. APPLICABLE DOCUMENTS

2.1 The following documents form a part of this specification to the extent specified herein.

SPECIFICATION

MILITARY

MIL-M-38510 - Microcircuits, general specification for.

STANDARD

MILITARY

MIL-STD-883 - Test methods and procedures for microcircuits.

3. REQUIREMENTS

3.1 General. Burr-Brown uses production and test facilities and a quality and reliability assurance program adequate to assure successful compliance with this specification.

3.1.1 Detail specifications. The individual item requirements are specified herein. In the event of conflicting requirements, the order of precedence will be the purchase order, this specification, and then the reference documents.

3.2 Design, construction, and physical dimensions.

3.2.1 Package, metals, and other materials. The package is in accordance with paragraph 3.5.1 of MIL-M-38510, except that organic and polymeric materials are used for die attach. The exterior metal surfaces are corrosion resistant. The other materials are nonnutrient to fungus as specified in MIL-M-38510.

3.2.2 Design documentation. The design documentation is in accordance with MIL-M-38510.

3.2.3 Internal conductors and internal lead wires. The internal conductors and internal lead wires are in accordance with MIL-M-38510.

3.2.4 Lead material and finish. The lead material is kovar type (type A). The lead finish is gold plate with nickel underplating. The lead material and finish is in accordance with MIL-M-38510 and is solderable per MIL-STD-883, method 2003.

3.2.5 Glassivation. The dice utilized are glassivated.

3.2.6 Die thickness. The die thickness is in accordance with MIL-M-38510.

3.2.7 Physical dimensions. The physical dimensions are in accordance with paragraph 1.2.3 herein.

3.2.8 Circuit diagram and terminal connections. The circuit diagram and terminal connections are shown in Figure 1.

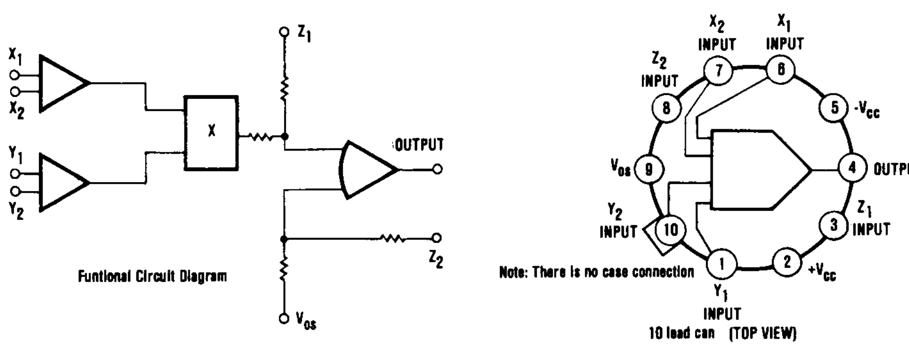


FIGURE 1. Functional Circuit Diagram and Terminal Connections.

3.3 Electrical performance characteristics. The electrical performance characteristics are as specified in Table I and apply over the full operating ambient temperature range of -55°C to +125°C, unless otherwise specified.

TABLE I. Electrical Performance Characteristics.

All characteristics T_A = -55°C to +125°C, $\pm V_{CC}$ = 15VDC, unless otherwise noted.

CHARACTERISTICS	SYMBOL	CONDITIONS	LIMITS 4212WM/883B 4213WM MIN	TYP	MAX	4213VM/883B 4213VM MIN	TYP	MAX	4213UM/883B 4213UM MIN	TYP	MAX	UNITS
ACCURACY												
Total Error	E_T	Each quadrant T_A = +25°C			1/2			1			1	+% of FSR
		-25°C to +85°C									2	+% of FSR
		T_A = -55°C			3			3			4	±% of FSR
		T_A = +125°C			4			4			8	±% of FSR
Feedthrough												
X Input	FT_X	V_X = 20V, p-p T_A = +25°C		30	50		30	100			100	±mV, p-p
		V_Y = 0, f = 50Hz -55°C to +125°C			100			200			200	±mV, p-p
Y Input	FT_Y	V_X = 0, f = 50Hz T_A = +25°C		25	40		25	80			80	±mV, p-p
		V_Y = 20V, p-p -55°C to +125°C			80			180			180	±mV, p-p
Nonlinearity												
X Input	LIN_X	V_X = 20V, p-p, V_Y = ±10V T_A = +25°C		0.08			*			*		±% of FSR
Y Input	LIN_Y	V_Y = 20V, p-p, V_X = ±10V T_A = +25°C		0.01			*			*		±% of FSR
INPUT												
Input Resistance	R_{IN}	X, Y, Z inputs, pin 9 open	3.5	10		*	*		*	*		MΩ
Input Bias Current	I_{IB}	X, Y, Z inputs T_A = +25°C		1.4	2.5		*	*		*	*	μA
		-55°C to +125°C			6			*			*	μA
Input Voltage Range	V_{IN}	Rated Operation	±10			*			*			V
Common-mode Rejection	CMR	+10V, -6V	60			*			*			dB
DYNAMIC CHARACTERISTICS												
Small Signal Bandwidth ±3dB	BW_{3dB}	X and Y inputs T_A = +25°C	450	550		*	*		*	*		kHz
Bandwidth ±1 flatness	$BW_{1\%}$	X and Y inputs T_A = +25°C	70			*			*			kHz
Full Power Bandwidth	BW_{FP}	T_A = +25°C	130			*			*			kHz
Slew Rate	SR	X and Y inputs T_A = +25°C	20			*			*			V/μsec
OUTPUT												
Output Voltage	V_{OM}	R_L = 2kΩ, C_L = 1000pF	10			*			*			±V
Output Resistance	R_O	Closed loop		1.5	10		*	*		*	*	Ω
Output Noise	N	T_A = +25°C 1Hz to 10kHz			200			*			*	μV, rms
		1Hz to 10MHz			1000			*			*	μV, rms
Output Offset Error 1/	V_{OO}	T_A = +25°C			25			30			50	±mV
		-25°C to +85°C									100	±mV
		-55°C to +125°C			100			100			200	±mV
Output Offset Error	$\Delta V_{OO}/\Delta T$	-25°C to +85°C									1.7	±mV/°C
Temperature Sensitivity		-55°C to +125°C			1.0			1.0			2.0	±mV/°C
Short Circuit Current	I_{OS}	T_A = +25°C	5		20	*		*	*		*	mA
		-55°C to +125°C	5		30	*		*	*		*	mA
POWER SUPPLY												
Power Supply Range			8.5	15	20	*	*	*	*	*	*	±V
Power Dissipation, Quiescent		T_A = +25°C		150	180		*	*		*	*	mW
		-55°C to +125°C			225			*			*	mW
TEMPERATURE RANGE (AMBIENT)												
Operating			-55		+125	*		*	*		*	°C
Storage			-65		+150	*		*	*		*	°C

*Specifications same as 4213WM

NOTE:

1/ Externally adjustable to zero

3.3.1 Additional electrical performance characteristics. Electrical performance curves are shown in paragraph 7.

3.3.2 Transfer functions. The transfer functions for multiplier and divider connections are shown in Figure 2.

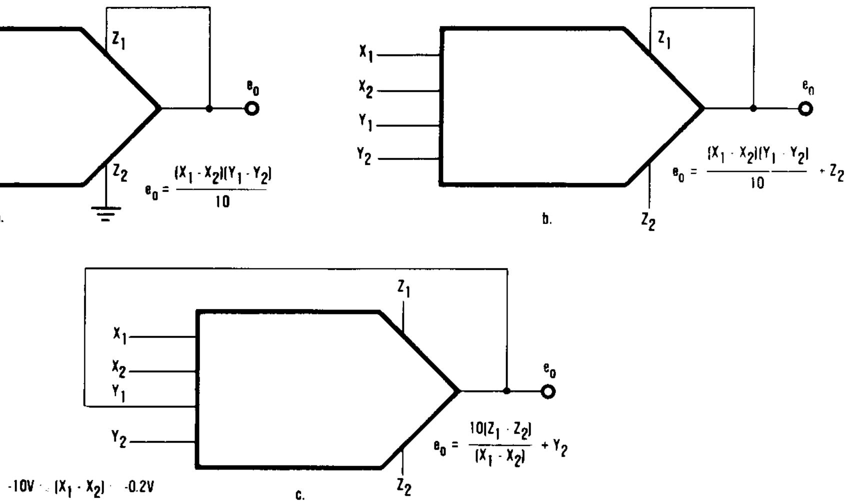


FIGURE 2. Transfer Functions.

3.3.3 Output offset error null. The multiplier is capable of being nulled to zero offset error using the circuit in Figure 3.

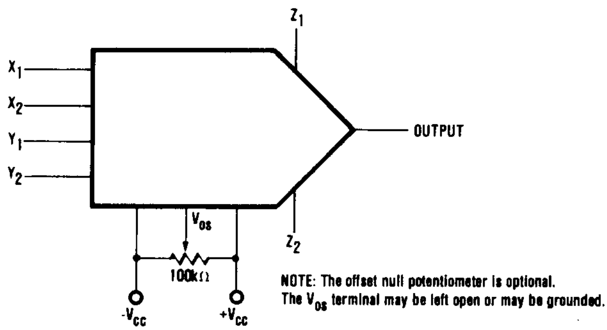


FIGURE 3. Offset Null Circuit.

3.4 Electrical tests. Electrical tests requirements are specified in Table II, which constitute the minimum electrical tests for screening, qualification, and quality conformance, are shown in Table II.

TABLE II. Electrical Test Requirements.
(The individual tests within the subgroups appear in Table III)

MODELS / MIL-STD-883 TEST REQUIREMENTS (HYBRID CLASS)	4213WM/883B 4213WM	4213VM/883B 4213VM	4213UM/883B 4213UM
	Subgroups (see Table III)		
Interim electrical parameters (Pre burn-in) (Method 5004)	1	1	1
Final electrical test parameters (method 5004)	1, 2, 3, 4, 5, 6	1, 2, 3, 4, 5, 6	1, 2, 2U, 3, 3U, 4, 4U, 5, 5U, 6, 6U
Group A test requirements (method 5005) [1]	1, 2, 3, 4, 4A, 5, 6	1, 2, 3, 4, 5, 6	1, 2, 2U, 3, 3U, 4, 4U, 5, 5U, 6, 6U
Group C end point electrical parameters (method 5005) [1]	1	1	1
Additional electrical subgroups performed prior to Group C inspections [1]	1C,2C,3C,5C,6C,7C	1C,2C,3C,5C,6C,7C	1C, 2C, 3C, 5C, 6C, 7C

*PDA applies to subgroup 1 (see 4.3.d)
[1] Applies to "/883B" version only

TABLE III. Group A Inspection.

SUBGROUP	PARAMETER SYMBOL	CONDITIONS $\pm V_{CC}$ = 15VDC, pin 9 open unless otherwise specified	4213 V GRADE MIN	4213 V GRADE MAX	4213 W GRADE MIN	4213 W GRADE MAX	4213 U GRADE MIN	4213 U GRADE MAX	UNITS
1 T_A = +25°C	V_{OO}			±30		±25		±50	mV
	I_{IB}	X_1 Input		2.5		2.5		2.5	μA
	P_D			180		180		180	mW
1C T_A = +25°C	CMR	X = Y = +10V to -6V	60						dB
	R_{IN}		3.5						MΩ
	R_O			10					Ω
	I_O		5	20					mA
2 T_A = +125°C	V_{OO}			±100		±100			mV
2U T_A = +85°C	V_{OO}							±100	mV
2C T_A = +125°C	I_{IB}	X_1 Input		6					μA
	$\frac{\Delta V_{OO}}{\Delta T}$	$\frac{\Delta V_{OO}}{\Delta T} = \frac{V_{OO}(+125°C) - V_{OO}(+25°C)}{100°C}$		±1					mV/°C
	P_D			225					mW
	CMR	X = Y = +10V to -6V	60						dB
3 T_A = -55°C	V_{OO}			±100		±100			mV
3U T_A = -25°C	V_{OO}							±100	mV
3C T_A = -55°C	I_{IB}	X_1 Input		6					μA
	$\frac{\Delta V_{OO}}{\Delta T}$	$\frac{\Delta V_{OO}}{\Delta T} = \frac{V_{OO}(-55°C) - V_{OO}(+25°C)}{80°C}$		±1					mV/°C
	P_D			225					mW
	CMR	X = Y = +10V to -6V	60						dB
4 T_A = +25°C	E_T	Each quadrant		±1		±1/2		±1	%
	FT_X	X = 20V, p-p; Y = 0; f = 50Hz		100		50		100	mV, p-p
	FT_Y	X = 0; Y = 20V, p-p; f = 50Hz		80		40		80	mV, p-p
4A T_A = +25°C	V_{OM}	R_L = 2kΩ, C_L = 1000pF		±10					V
5 T_A = +125°C	E_T	Each quadrant		±4		±4			%
5U T_A = +85°C	E_T	Each quadrant						±2	%
5C T_A = +125°C	V_{OM}	R_L = 2kΩ, C_L = 1000pF		±10					V
	FT_X	X = 20V, p-p; Y = 0; f = 50Hz		200					mV, p-p
	FT_Y	X = 0; Y = 20V, p-p; f = 50Hz		180					mV, p-p
6 T_A = -55°C	E_T	Each quadrant		±3		±3			%
6U T_A = -25°C	E_T	Each quadrant						±2	%
6C T_A = -55°C	V_{OM}	R_L = 2kΩ, C_L = 1000pF		±10					V
	FT_X	X = 20V, p-p; Y = 0; f = 50Hz		200					mV, p-p
	FT_Y	X = 0; Y = 20V, p-p; f = 50Hz		180					mV, p-p
7C T_A = +25°C	$BW_{1\%}$	X = 20V, p-p; Y = 10V	70						kHz
	$BW_{1\%}$	X = 10V; Y = 20V, p-p	70						kHz
	SR	X = +20V-step; Y = 10V; R_L = 2kΩ	20						V/μsec
	SR	X = 10V; Y = +20V-step; R_L = 2kΩ	20						V/μsec
	BW_{3dB}	X = 1V, rms; Y = 10V	450						kHz
	BW_{3dB}	X = 10V; Y = 1V, rms	450						kHz
	BW_{FP}	R_L = 20kΩ, V_o = ±10V	130						kHz
	N	f_B = 1Hz to 10kHz		200					μV, rms
	N	f_B = 1Hz to 10MHz		1000					μV, rms

3.5 Marking. Marking is in accordance with MIL-STD-883. The following marking is placed on each microcircuit as a minimum.

a. Part number (see paragraph 1.2)
b. Inspection lot identification code[1/]
c. Manufacturer's identification (BURR-BROWN® BB)
d. Manufacturer's designating symbol (CEBS)
e. Country of origin
f. Electrostatic sensitivity identifier
g. Compliance indicator "C"

3.6 Workmanship. These microcircuits are manufactured, processed, and tested in a careful and workmanlike manner. Workmanship is in accordance with good engineering practices, workmanship instructions, inspection and test procedures, and training, prepared in fulfillment of Burr-Brown's product assurance program.

3.6.1 Rework provisions. Rework provisions, for the /883B Hi-Rel product designation, are in accordance with MIL-M-38510.

3.7 Traceability. Traceability is in accordance with MIL-M-38510. Each microcircuit is traceable to the production lot and to the component vendor's component lot. Reworked or repaired microcircuits maintain traceability.

3.8 Product and process change. Burr-Brown will not implement any major change to the design, materials, construction, configuration, or manufacturing process which may affect the performance, quality, reliability or interchangeability of the microcircuit without full or partial requalification.

3.9 Screening. Screening for the /883B Hi-Rel product designation, is in accordance with MIL-STD-883, method 5004, class B, except as modified in paragraph 4.3 herein.

For the standard model, Hi-Rel product designation (none), routine manufacturing processing includes Burr-Brown internal visual inspection, and stabilization bake, fine leak, gross leak, constant acceleration (condition D) and external visual inspection per MIL-STD-883, method 2009.

For the /883B Hi-Rel product designation, all microcircuits will have passed the screening requirements prior to qualification or quality conformance inspection.

3.10 Qualification. Qualification is not required. See paragraph 4.2 herein.

3.11 Quality conformance inspection. Quality conformance inspection, for the /883B Hi-Rel product designation, is in accordance with MIL-STD-883, except as modified in paragraph 4.4 herein. The microcircuit inspection lot will have passed quality conformance inspection prior to microcircuit delivery.

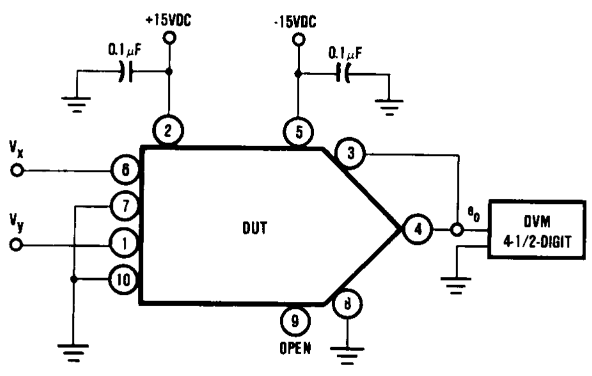


FIGURE 4. Test Circuit for Total Error.

1/ A 4-digit date code, indicating year and week of seal and a 4- or 5-digit lot identifier are marked on each unit.

PROCEDURE:

1. Set $V_x = V_y = +10.000$VDC ± 1mV, measure $E_o = E_{o1}$.
2. Set $V_x = V_y = -10.000$VDC ± 1mV, measure $E_o = E_{o2}$.
3. Set $V_x = +10.000$VDC ± 1mV and $V_y = -10.000$VDC ± 1mV, measure $E_o = E_{o3}$.
4. Set $V_x = -10.000$VDC ± 1mV and $V_y = +10.000$VDC ± 1mV, measure $E_o = E_{o4}$.
5. Calculate $V_{o1} = |E_{o1} - 10|$, $V_{o2} = |E_{o2} - 10|$, $V_{o3} = |E_{o3} + 10|$ and $V_{o4}. = |E_{o4} + 10|$.
6. V_{ox} is the largest of V_{o1}, V_{o2}, V_{o3} or V_{o4}.

$$E_T(\%) = \frac{V_{ox}}{10} \times 100$$

4. PRODUCT ASSURANCE PROVISIONS

4.1 Sampling and inspection. Sampling and inspection procedures are in accoradance with MIL-M-38510 and MIL-STD-883, method 5005, except as modified herein.

4.2 Qualification. Qualification is not required unless specified by contract or purchase order. When so required, qualification will be in accordance with the inspection routine of MIL-M-38510, paragraph 4.4.2.1. The inspections to be performed are those specified herein for groups A, B, C, and D inspections (see paragraphs 4.4.1, 4.4.2, 4.4.3, and 4.4.4).

Burr-Brown has performed and successfully completed qualification inspection as described above. The qualification report is available from Burr-Brown.

4.3 Screening. Screening, for the /883B Hi-Rel product designation, is in accordance with MIL-STD-883B, method 5004, class B, and is conducted on all devices. The following additional criterian apply:

a. Constant acceleration test (MIL-STD-883, method 2001) is test condition D, Y_1 axis only.

b. Interim and final test parameters are specified in Table II. The interim electrical parameters test prior to burn-in is optional at the discretion of the manufacturer.

c. Burn-in test (MIL-STD-883, method 1015) conditions:
   (1) Test condition B
   (2) Test circuit is Figure 5 herein
   (3) $T_A = +125°C$ minimum
   (4) Test duration is 160 hours minimum

d. Percent defective allowable (PDA). The PDA, for the /883B Hi-Rel product designation only, is 5 percent and includes both parametric and catastrophic failures. It is based on failures from group A, subgroup 1 test after cool-down as final electrical test in accordance with MIL-STD-883, method 5008, and with no intervening electrical measurements. If interim electrical parameter tests are performed prior to burn-in, failures resulting from preburn-in screening failures may be excluded from the PDA. If interim electrical parameter tests prior to burn-in are omitted, all screening failures shall be included in the PDA. The verified failures of group A, subgroup 1 after burn-in in that lot are used to determine the percent defective for that lot, and the lot is accepted or rejected based on the PDA.

e. External visual inspection need not include measurement of case and lead dimensions.

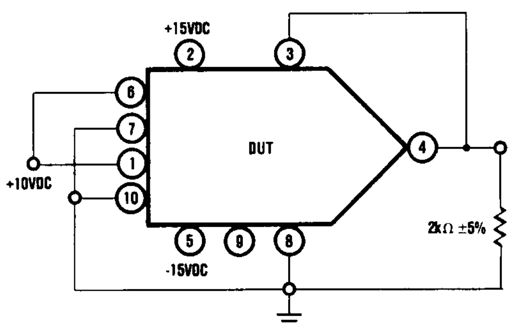


FIGURE 5. Test Circuit, Burn-in and Operating Life Test.

4.4 Quality conformance inspection. Groups A and B inspections of MIL-STD-883, method 5005, are performed on each inspection lot. Groups C and D inspections of MIL-STD-883, are performed as required by MIL-STD-883.

A report of the most recent groups C and D inspections is available from Burr-Brown.

4.4.1 Group A inspection. Group A inspection consists of the test subgroups and LTPD values shown in MIL-STD-883, method 5005, and as specified in Table II herein.

4.4.2 Group B inspection. Group B inspection consists of the test subgroups and LTPD values shown in MIL-STD-883, method 5005, class B.

4.4.3 Group C inspection. Group C inspection consists of the test subgroups and LTPD values shown in MIL-STD-883, method 5005, class B, and as follows:

a. Operating life test (MIL-STD-883, method 1005) conditions:
   (1) Test condition B
   (2) Test circuit is Figure 5 herein
   (3) T_A = 125°C minimum
   (4) Test duration is 1000 hours minimum

b. End point electrical parameters are specified in Table II herein.

c. Additional electrical subgroups are specified in Table II herein.

4.4.4 Group D inspection. Group D inspection consists of the test subgroups and LTPD values shown in MIL-STD-883, method 5005.

4.5 Methods of examination and test. Methods of examination and test are specified in the appropriate tables. Electrical test circuits are as prescribed herein or in the referenced test methods of MIL-STD-883.

4.5.1 Voltage and current. All voltage values given, except the input offset voltage (or differential voltage) are referenced to the external zero reference level of the supply voltage. Currents given are conventional current and positive when flowing into the referenced terminal.

5. PREPARATION FOR DELIVERY

5.1 Preservation-packaging and packing. Microcircuits are prepared for delivery in accordance with MIL-M-38510.

6. NOTES

6.1 Notes. The notes specified in MIL-M-38510 are applicable to this specification.

6.2 Intended use. Microcircuits conforming to this specification are intended for use in applications where the use of screened parts is desirable.

6.3 Ordering data. The contract or order should specify the following:

a. Complete part number (see paragraph 1.2)

b. Requirement for certificate of compliance, if desired.

6.4 Definitions.

Total error. Total error (E_T) is the difference between the actual output voltage and the ideal output voltage expressed as a percentage of the maximum output voltage, 10 volts. It is the sum of the individual errors and includes feedthrough and output offset voltage.

Feedthrough. Feedthrough (FT_X or FT_Y) is the output voltage when the ideal output voltage is zero (i.e., X = 0, Y = ±V or X = ±V, Y = 0).

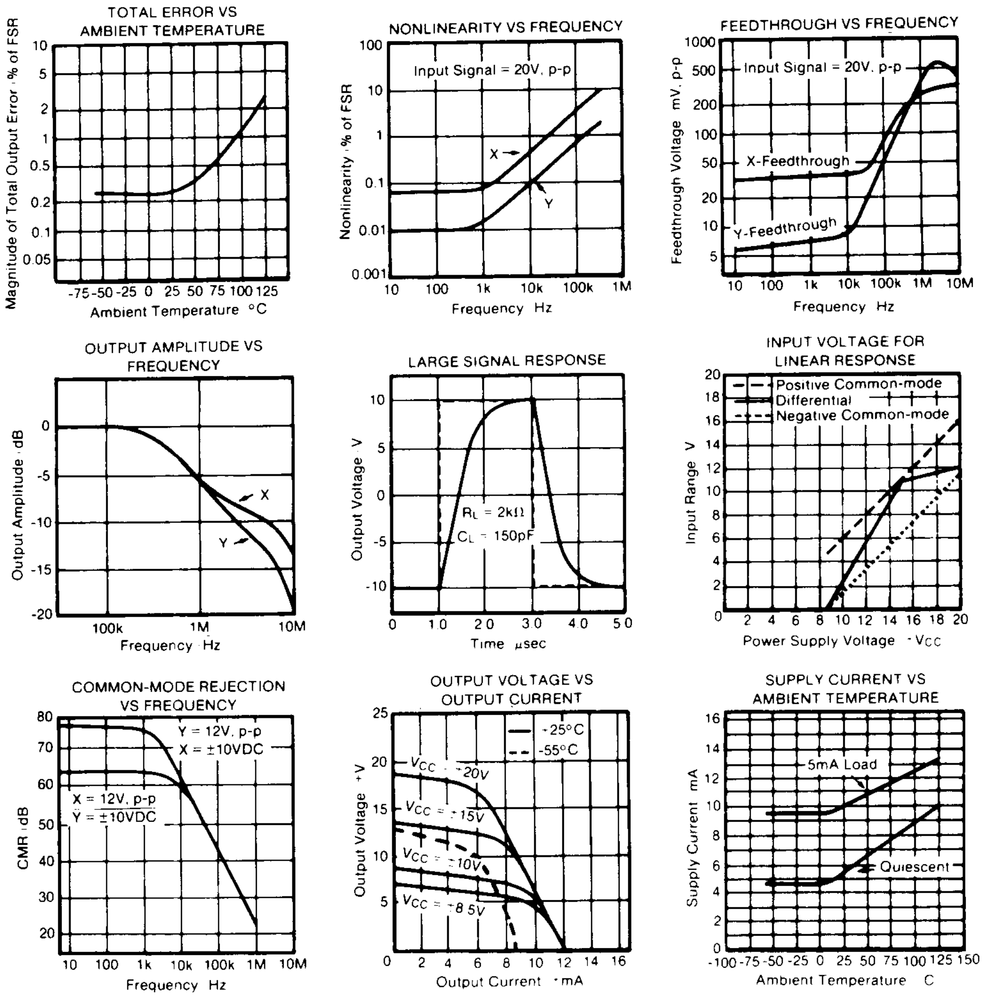
6.5 Microcircuit group assignment. These microcircuits are assigned to Technology Group D with a microcircuit group number of 49 as defined in MIL-M-38510, Appendix E.

6.6 Electrostatic sensitivity. These microcircuits may be damaged by electrostatic discharge. Electrostatic sensitive precautions should be observed at all times.

6.7 Power Supply Sequencing. Apply, and remove, both supplies together. Alternatively, apply the positive supply first. Permanent damage may occur if the minus supply is applied with an input greater than +6VDC.

7. ELECTRICAL PERFORMANCE CURVES.

(Typical at T_A = +25°C and ± V_{CC} = 15VDC unless otherwise specified.)



8. APPLICATIONS INFORMATION

8.1 Power supply decoupling. For optimum performance and to prevent frequency instability due to power supply lead inductance, each power supply should be decoupled by connecting a 1μF tantalum capacitor from each power supply pin to ground (power supply common).

8.2 Capacitive loads. Stable operation is maintained with capacitive loads up to 1000pF, except for the square root mode which is limited to 50pF. Higher capacitive loads can be driven if a 100Ω resistor is connected in series with the output for isolation.

8.3 Typical Applications.

8.3.1 Multiplication. The basic connection for four-quadrant multiplication is shown in Figures 2a and 2b. Optional offset nullling is shown in Figure 3. Feedthrough may be minimized by applying an external nulling voltage to the X and/or Y input, as appropriate. Usually, the nulling voltage is applied to X_2 or Y_2. If Z_2 input is not used, it should be grounded.

Figure 6 shows how to achieve a scale factor larger than 0.1 (i.e., a denominator less than 10). A larger scale factor is electrically advantageous in some applications, but this has the disadvantage of proportionately increasing the output offset voltage. Note, the offset may be nulled as shown in Figure 3. Also, the small signal bandwidth is reduced to about 50kHz.

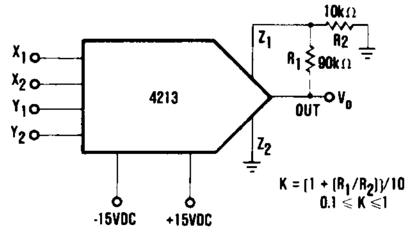


FIGURE 6. Connection for Unity Scale Factor.

8.3.2 Division. The basic connection for two-quadrant division is shown in Figure 2c. Divider error is approximately

$$\epsilon_{divider} = \frac{10\epsilon_{multiplier}}{X_1 - X_2}$$

Note, the divider error will become very large for small values of $(X_1 - X_2)$. A 10 to 1 denominator range is a practical limit.

8.3.3 Squaring. The basic connection is shown in Figure 7.

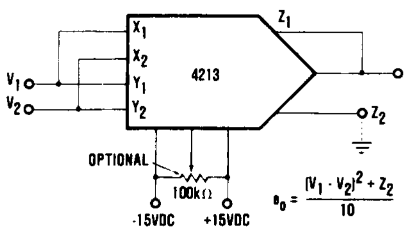


FIGURE 7. Squaring Connection.

8.3.4 Square Root. Figure 8 shows the connection for taking the square root of the voltage $V_{Z1} - V_{Z2}$. The diode prevents a latching condition which could occur if the input momentarily changed polarity. The load resistance R_L must be in the range of $10k\Omega \leq R_L \leq 1M\Omega$ to provide the current necessary to operate the diode. The output offset should be nulled for optimum performance; allow the input to be its smallest expected value and adjust R_1 for the proper output voltage. The square root mode accuracy is then approximately that of the multiply mode.

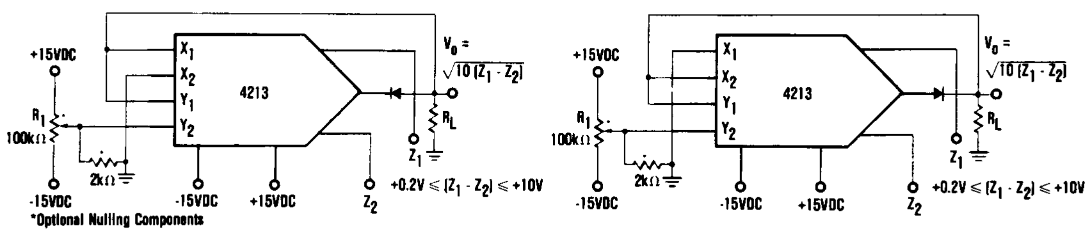


FIGURE 8. Square Root Connection.

8.3.5 Percent. The circuit of Figure 9 has a sensitivity of 1V/% and is capable of measuring 10% deviations. Wider deviation can be measured by decreasing the ratio of R_2/R_1.

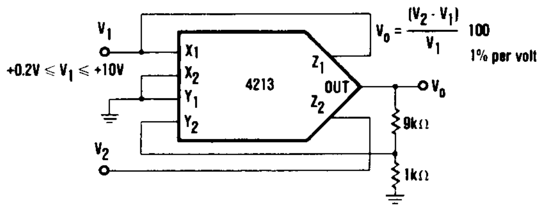


FIGURE 9. Percentage Computation.

8.3.6 Sine Function Generator. The circuit in Figure 10 uses implicit feedback to implement the following sine function approximation: $V_O = (1.5715V_1 - 0.004317V_1^3)/(1 + 0.001398V_1^2) = 10\ \text{sine}\ (9V_1)$.

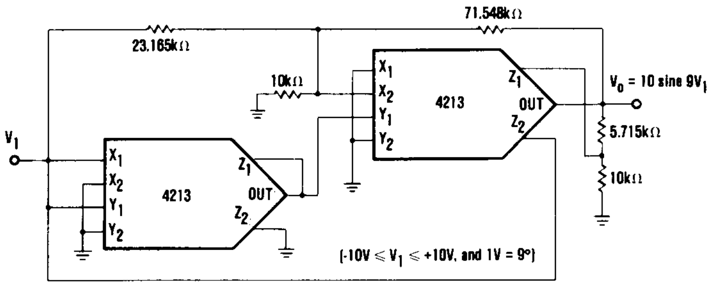


FIGURE 10. Sine Function Generator.

8.3.7 Single-phase Power Measurement. Figure 11 shows a circuit for measurement of single-phase instantaneous and real power.

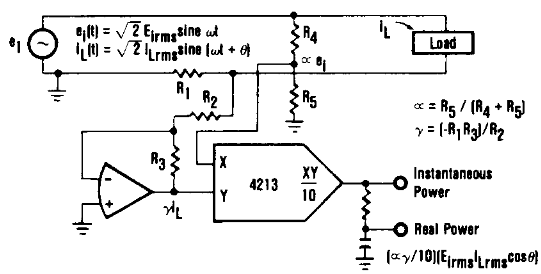


FIGURE 11. Single-Phase Instantaneous and Real Power Measurement.