Anderson Loop Equations

Dual-differential subtractor:

$$v_{out} = A_1 v_g - A_2 v_{ref}$$

Current regulator:

When current regulation feedback is obtained from v_{ref}

$$i = v_{ref} / R_{ref}$$

Overall circuit:

$$v_{out} = i[A_1(R + \Delta R) - A_2 R_{ref}]$$

(Note that wire resistance is irrelevant when v_g and v_{ref} are observed with insignificant energy transfer.)

When $A_1 = A_2 = 1$ and $R_{ref} = R$ then

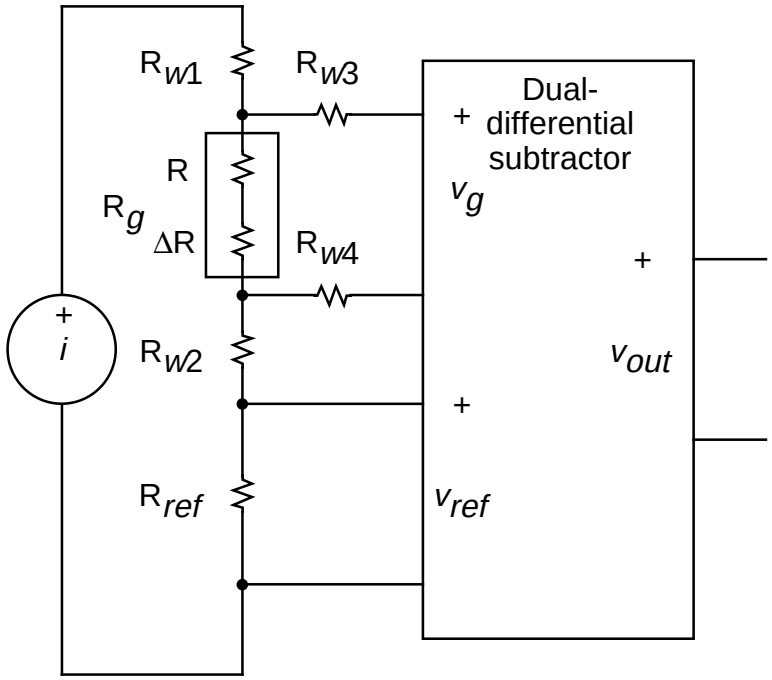
$$\Delta R = R - R_{ref}$$
$$v_{out} = i\Delta R$$
$$v_{out} = (v_{ref} / R_{ref})\, \Delta R$$
$$\Delta R = (v_{out} / v_{ref})\, R_{ref}$$

For ratiometric observations

$$\Delta R/R = (R_{ref} / R)\, (v_{out} / v_{ref})$$

When $R_{ref} = R$

$$\Delta R/R = (v_{out} / v_{ref})$$



For an electrical resistance strain gage:

$$\Delta R/R = (GF)\, \Delta l/l$$

where GF is the gage factor and $\Delta l/l$ is the definition of mechanical strain.

$$\text{strain} = \Delta l/l = \Delta R / (R\, GF)$$

From an electrical measurement using Anderson loop signal conditioning

$$\mu\text{strain} = v_{out}\, 10^6 / (v_{ref}\, GF)$$

If v_{out} is amplified by A

$$\mu\text{strain} = v_{out}\, 10^6 / (v_{ref}\, A\, GF)$$

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TWO GAGES IN INDEPENDENT ANDERSON LOOPS

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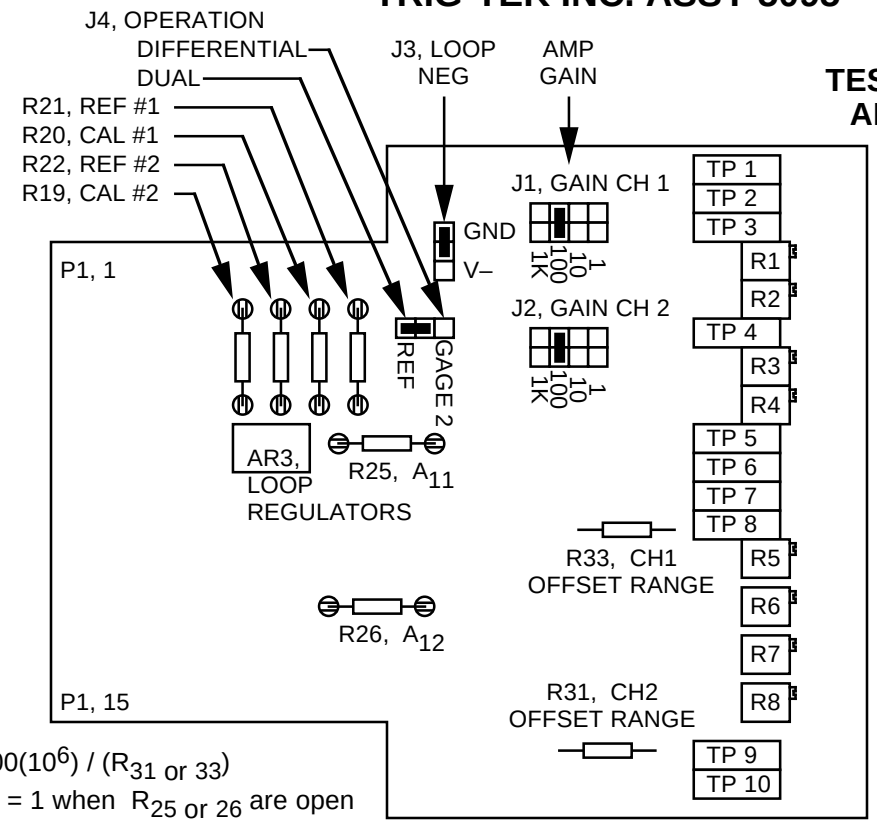


TEST POINTS AND ADJUSTMENTS

- TP 1 — CH1 REF CAL
- TP 2 — CH2 REF CAL
- TP 3 — REF
- R1 — CH1 IN NULL
- R2 — CH1 OUT NULL
- TP 4 — CH1 INPUT SHORT
- R3 — CH2 IN NULL
- R4 — CH2 OUT NULL
- TP 5 — CH2 INPUT SHORT
- TP 6 — CH1 OUTPUT
- TP 7 — GROUND
- TP 8 — CH2 OUTPUT
- R5 — CH1 BALANCE
- R6 — CH2 BALANCE
- R7 — CH1 EXC CURR SET
- R8 — CH2 EXC CURR SET
- TP 9 — CH1 EXC CURR ZERO
- TP 10 — CH2 EXC CURR ZERO

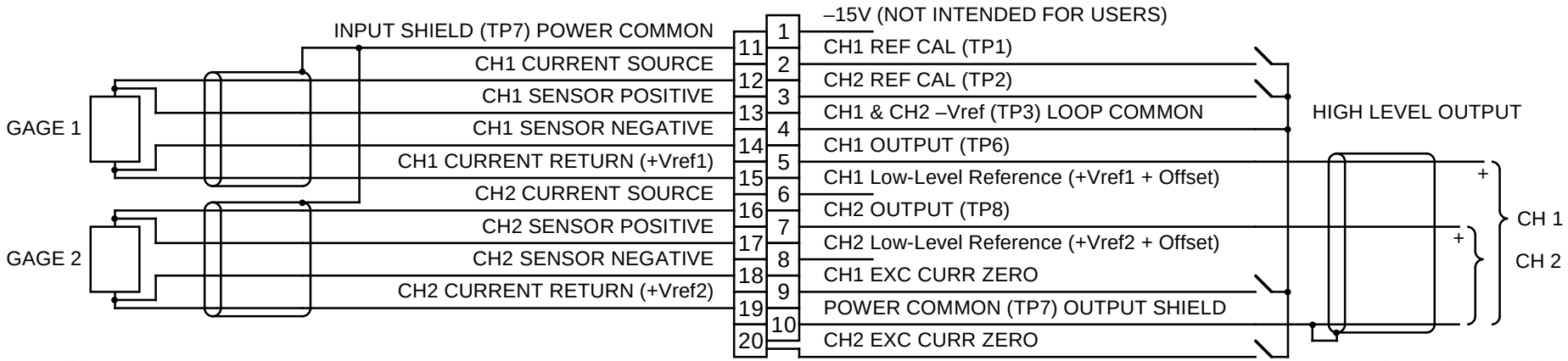
Balance Authority ($\mu V/V_{ref}$ nominal) = $\pm 100(10^6)$ / ($R_{31 \text{ or } 33}$)

Subtractor Gain = 1 + 50,000 / ($R_{25 \text{ or } 26}$) = 1 when $R_{25 \text{ or } 26}$ are open

$\Delta R_{cal} / R_g = R_{ref} / R_{cal}$

$\mu strain_{cal} = R_{ref}\ 10^6 / GF(R_{cal})$

BACKPLANE TERMINALS



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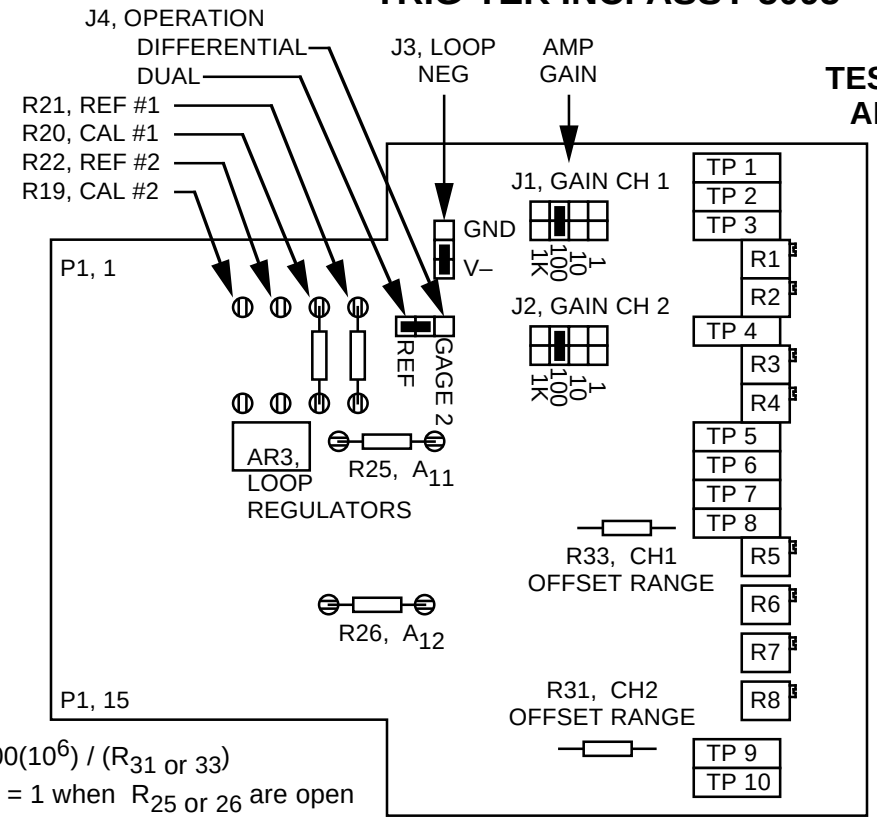
TWO INDEPENDENT GAGES IN ONE ANDERSON LOOP



TEST POINTS AND ADJUSTMENTS

- CH1 REF CAL
- CH2 REF CAL **NOT USED**
- REF
- CH1 IN NULL
- CH1 OUT NULL
- CH1 INPUT SHORT
- CH2 IN NULL
- CH2 OUT NULL
- CH2 INPUT SHORT
- CH1 OUTPUT
- GROUND
- CH2 OUTPUT
- CH1 BALANCE
- CH2 BALANCE
- CH1 EXC CURR SET, CH2 EXC CURR SET } Both influence EXC CURR
- CH1 EXC CURR ZERO, CH2 EXC CURR ZERO } Either does the ZERO

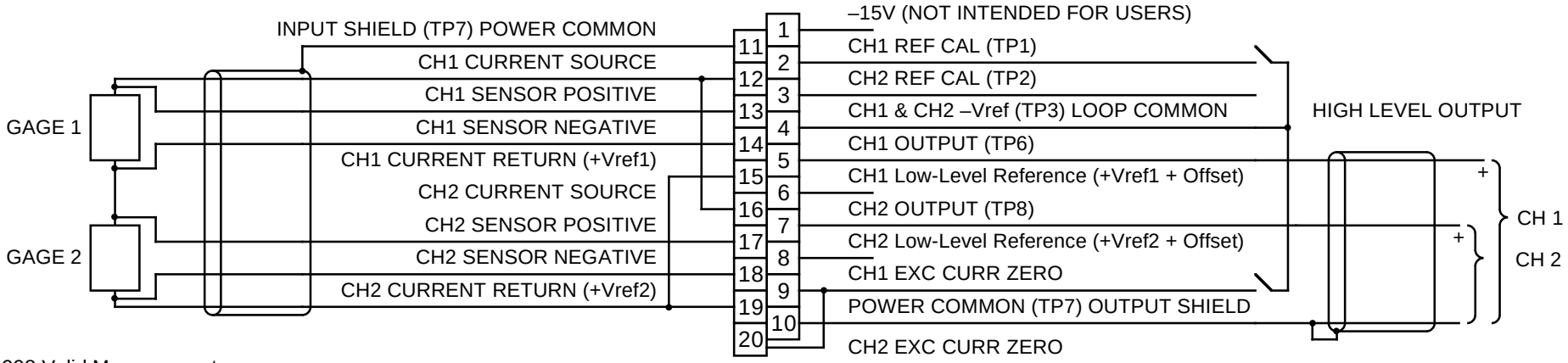
Balance Authority ($\mu V/V_{ref}$ nominal) = $\pm 100(10^6) / (R_{31 \text{ or } 33})$

Subtractor Gain = $1 + 50{,}000 / (R_{25 \text{ or } 26}) = 1$ when $R_{25 \text{ or } 26}$ are open

$\Delta R_{cal} / R_g = R_{ref} / R_{cal}$

$\mu strain_{cal} = R_{ref}\ 10^6 / GF(R_{cal})$

BACKPLANE TERMINALS



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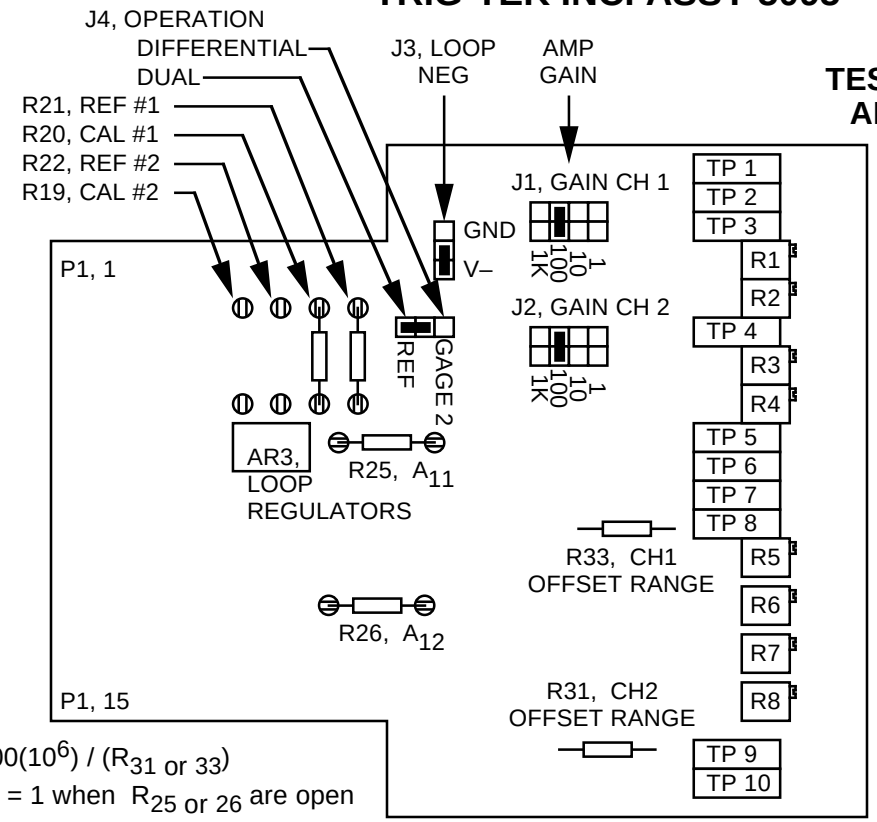
TWO INDEPENDENT GAGES SHARING A SENSE LINE IN ONE ANDERSON LOOP



TEST POINTS AND ADJUSTMENTS

- CH1 REF CAL
- CH2 REF CAL **NOT USED**
- REF
- CH1 IN NULL
- CH1 OUT NULL
- CH1 INPUT SHORT
- CH2 IN NULL
- CH2 OUT NULL
- CH2 INPUT SHORT
- CH1 OUTPUT
- GROUND
- CH2 OUTPUT
- CH1 BALANCE
- CH2 BALANCE
- CH1 EXC CURR SET, CH2 EXC CURR SET } Both influence EXC CURR
- CH1 EXC CURR ZERO, CH2 EXC CURR ZERO } Either does the ZERO

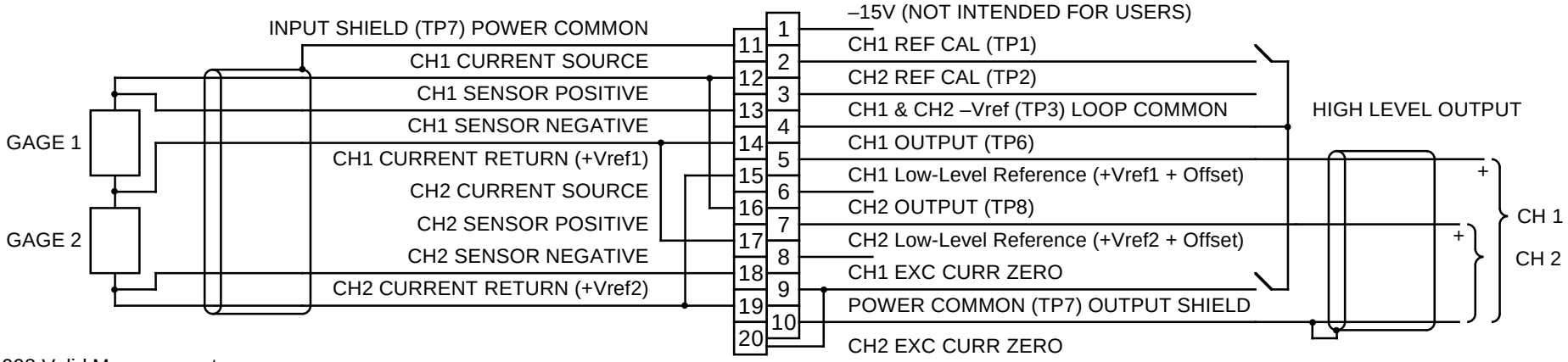
Balance Authority ($\mu V/V_{ref}$ nominal) = $\pm 100(10^6) / (R_{31 \text{ or } 33})$

Subtractor Gain = $1 + 50{,}000 / (R_{25 \text{ or } 26}) = 1$ when $R_{25 \text{ or } 26}$ are open

$\Delta R_{cal} / R_g = R_{ref} / R_{cal}$

$\mu strain_{cal} = R_g \, 10^6 / [GF(R_{cal} + R_g)]$

BACKPLANE TERMINALS



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TWO DIFFERENTIAL GAGES IN ONE ANDERSON LOOP

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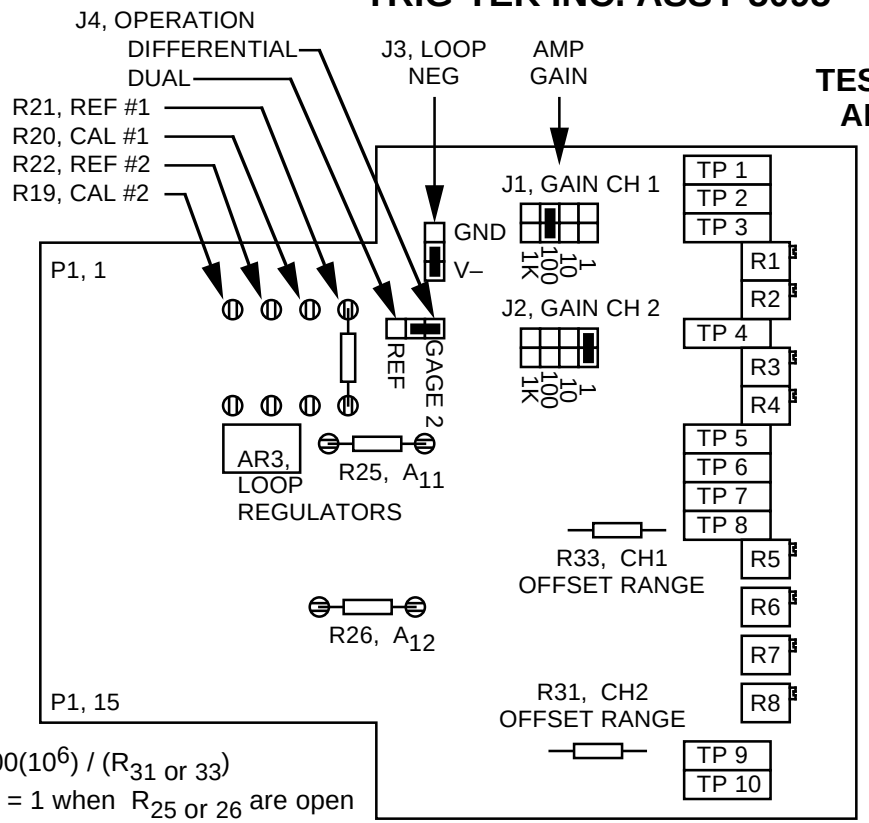


TEST POINTS AND ADJUSTMENTS

- CH1 REF CAL
- CH2 REF CAL **NOT USED**
- REF
- CH1 IN NULL
- CH1 OUT NULL
- CH1 INPUT SHORT
- CH2 IN NULL
- CH2 OUT NULL
- CH2 INPUT SHORT
- CH1 OUTPUT
- GROUND
- CH2 OUTPUT
- CH1 BALANCE, CH2 BALANCE — Both influence BALANCE
- CH1 EXC CURR SET, CH2 EXC CURR SET — Both influence EXC CURR
- CH1 EXC CURR ZERO, CH2 EXC CURR ZERO — Either does the ZERO

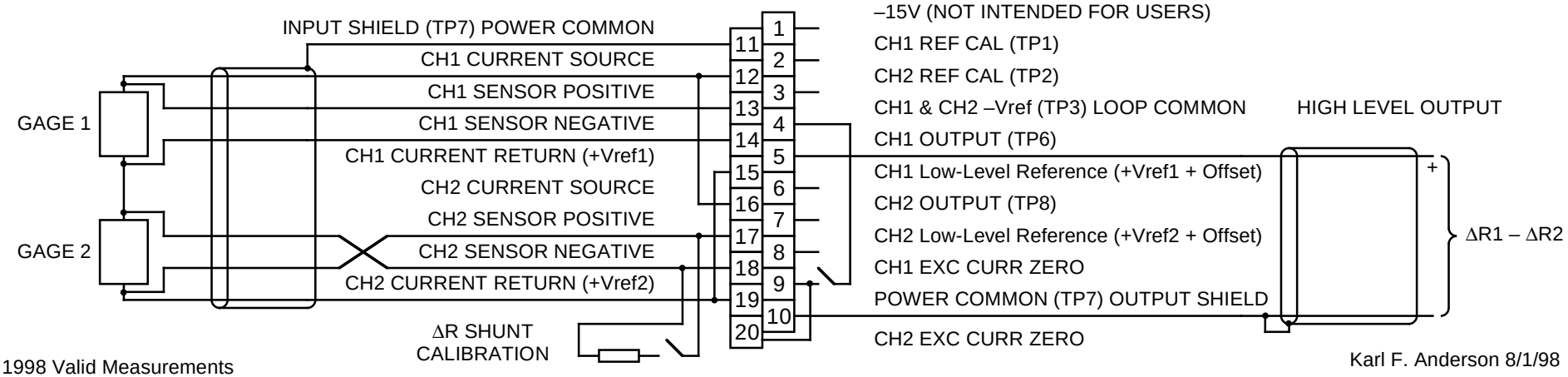
Balance Authority ($\mu V/V_{ref}$ nominal) = $\pm 100(10^6) / (R_{31 \text{ or } 33})$

Subtractor Gain = $1 + 50{,}000 / (R_{25 \text{ or } 26}) = 1$ when $R_{25 \text{ or } 26}$ are open

$\Delta R_{cal} / R_g = R_g / (R_{cal} + R_g)$

$\mu strain_{cal} = R_g \, 10^6 / [GF(R_{cal} + R_g)]$

BACKPLANE TERMINALS



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TWO DIFFERENTIAL GAGES SHARING A SENSE LINE IN ONE ANDERSON LOOP

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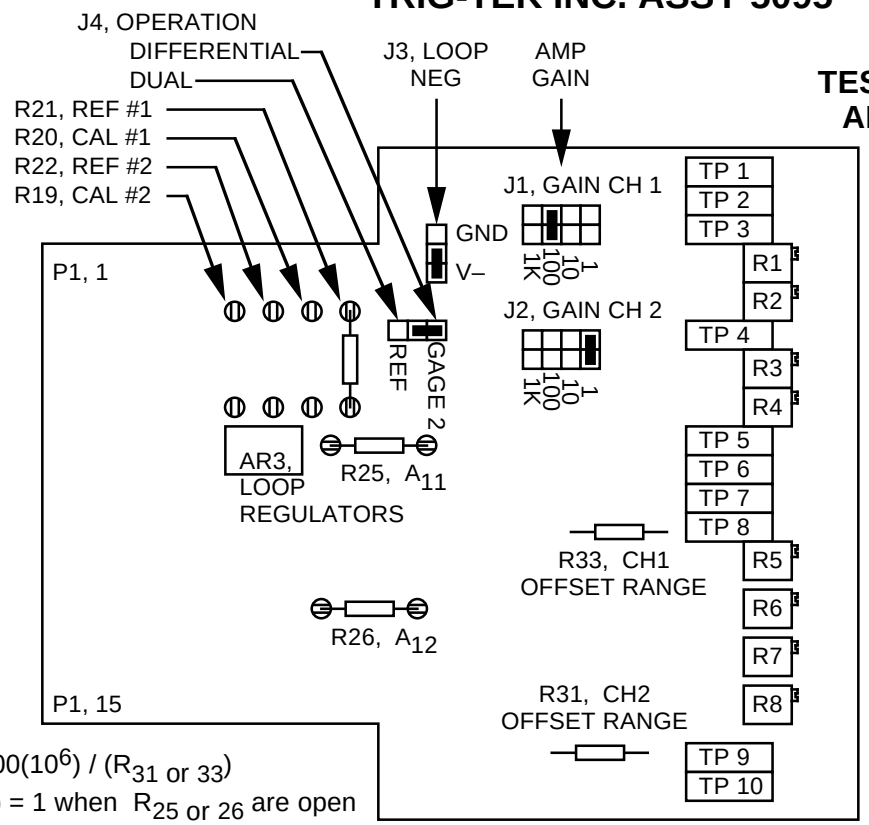


TEST POINTS AND ADJUSTMENTS

- CH1 REF CAL
- CH2 REF CAL **NOT USED**
- REF
- CH1 IN NULL
- CH1 OUT NULL
- CH1 INPUT SHORT
- CH2 IN NULL
- CH2 OUT NULL
- CH2 INPUT SHORT
- CH1 OUTPUT
- GROUND
- CH2 OUTPUT
- CH1 BALANCE, CH2 BALANCE — Both influence BALANCE
- CH1 EXC CURR SET, CH2 EXC CURR SET — Both influence EXC CURR
- CH1 EXC CURR ZERO, CH2 EXC CURR ZERO — Either does the ZERO

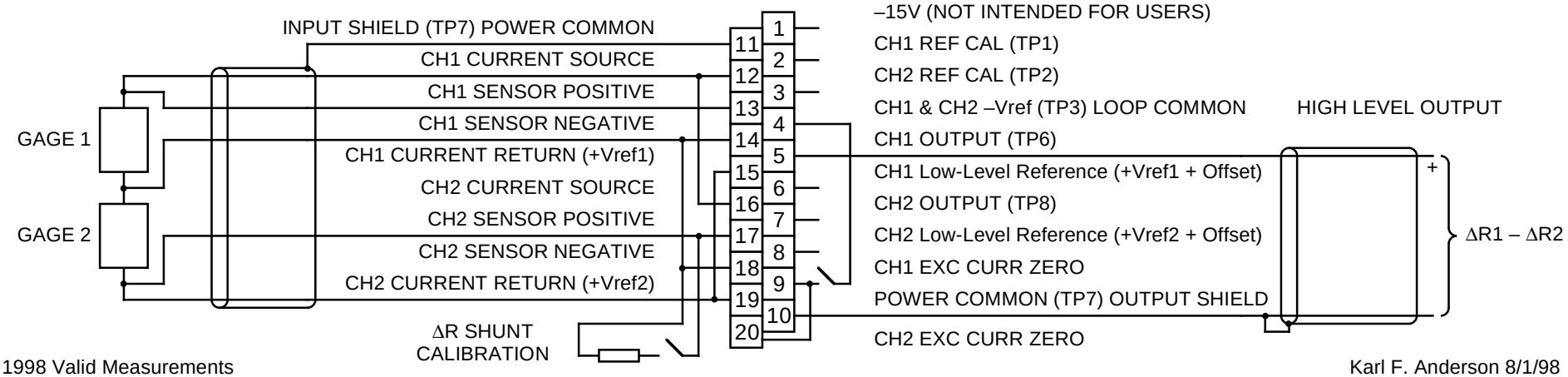
Balance Authority ($\mu V/V_{ref}$ nominal) = $\pm 100(10^6) / (R_{31 \text{ or } 33})$

Subtractor Gain = $1 + 50{,}000 / (R_{25 \text{ or } 26}) = 1$ when $R_{25 \text{ or } 26}$ are open

$\Delta R_{cal} / R_g = R_g / (R_{cal} + R_g)$

$\mu strain_{cal} = R_g \, 10^6 / [GF(R_{cal} + R_g)]$

BACKPLANE TERMINALS



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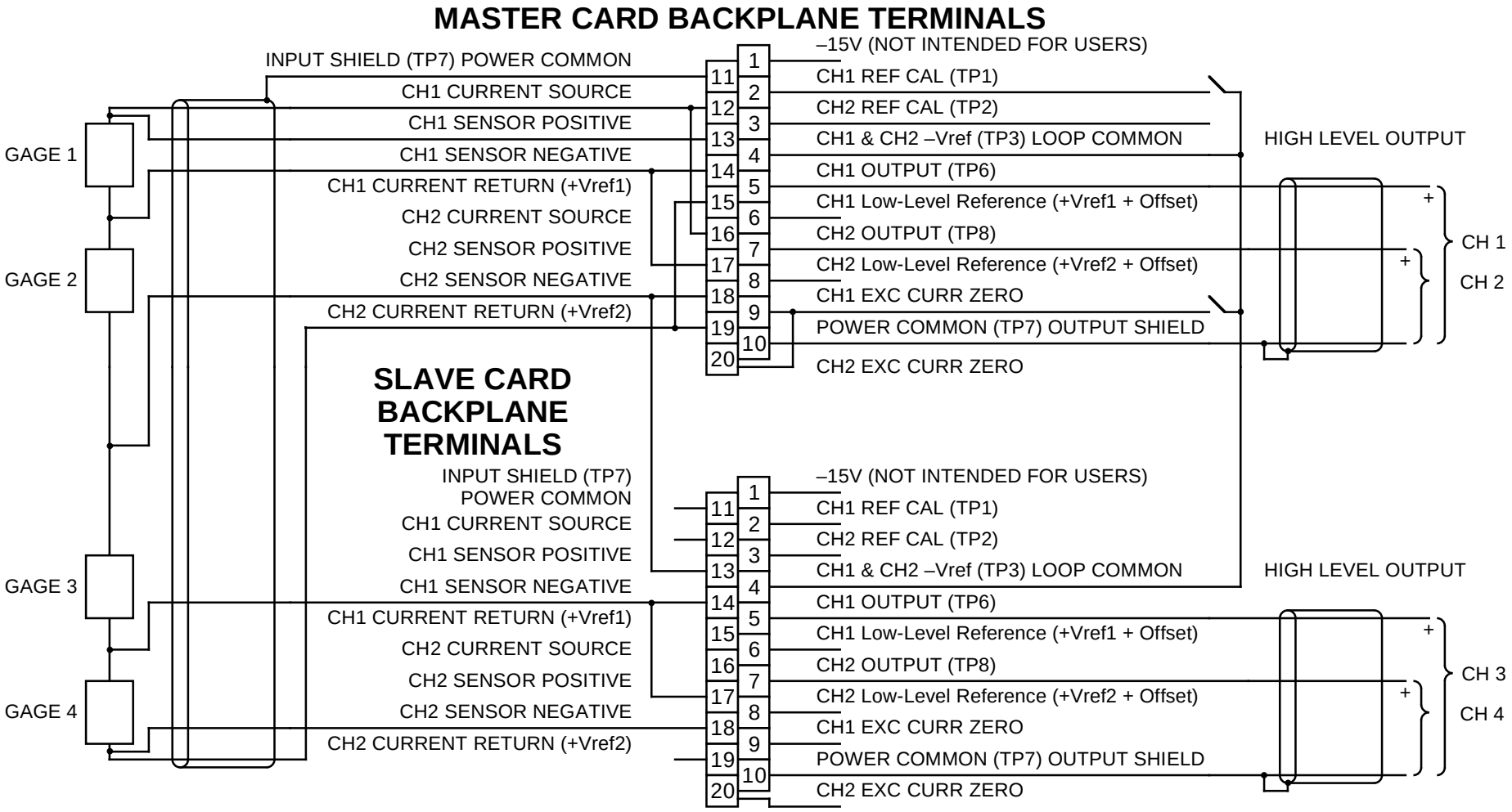
7-WIRE CONNECTION OF FOUR KELVIN-SENSED GAGES IN A SINGLE ANDERSON LOOP



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MASTER CARD FOR AN ANDERSON LOOP WITH KELVIN SENSING

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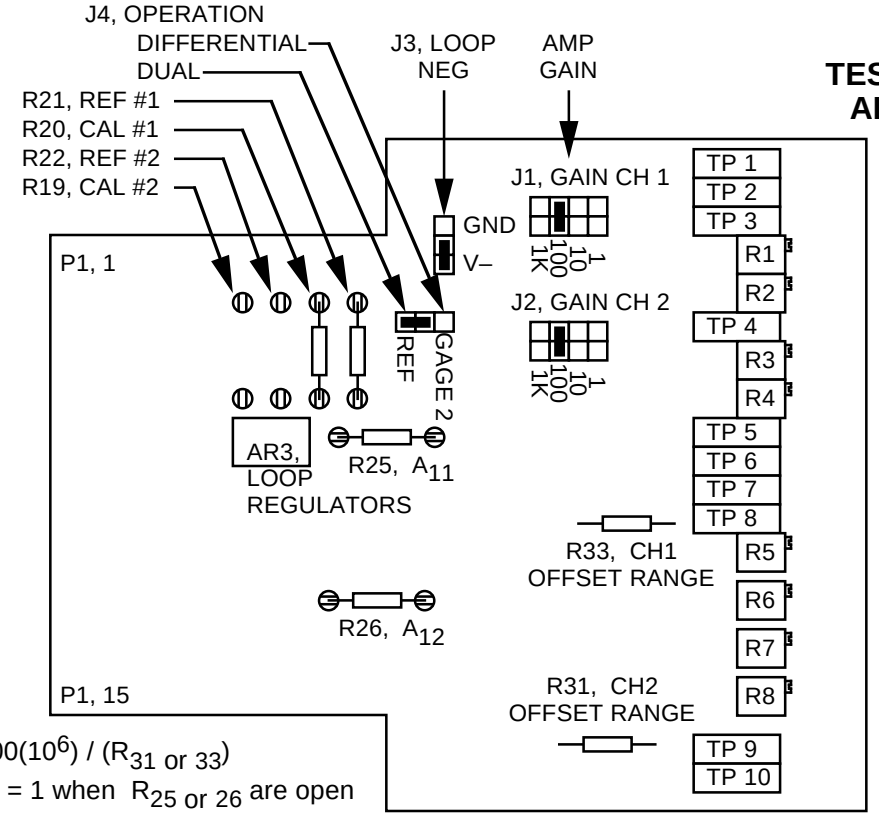


TEST POINTS AND ADJUSTMENTS

- CH1 REF CAL
- CH2 REF CAL **NOT USED**
- REF
- CH1 IN NULL
- CH1 OUT NULL
- CH1 INPUT SHORT
- CH2 IN NULL
- CH2 OUT NULL
- CH2 INPUT SHORT
- CH1 OUTPUT
- GROUND
- CH2 OUTPUT
- CH1 BALANCE
- CH2 BALANCE
- CH1 EXC CURR SET, CH2 EXC CURR SET } Both influence EXC CURR
- CH1 EXC CURR ZERO, CH2 EXC CURR ZERO } Either does the ZERO

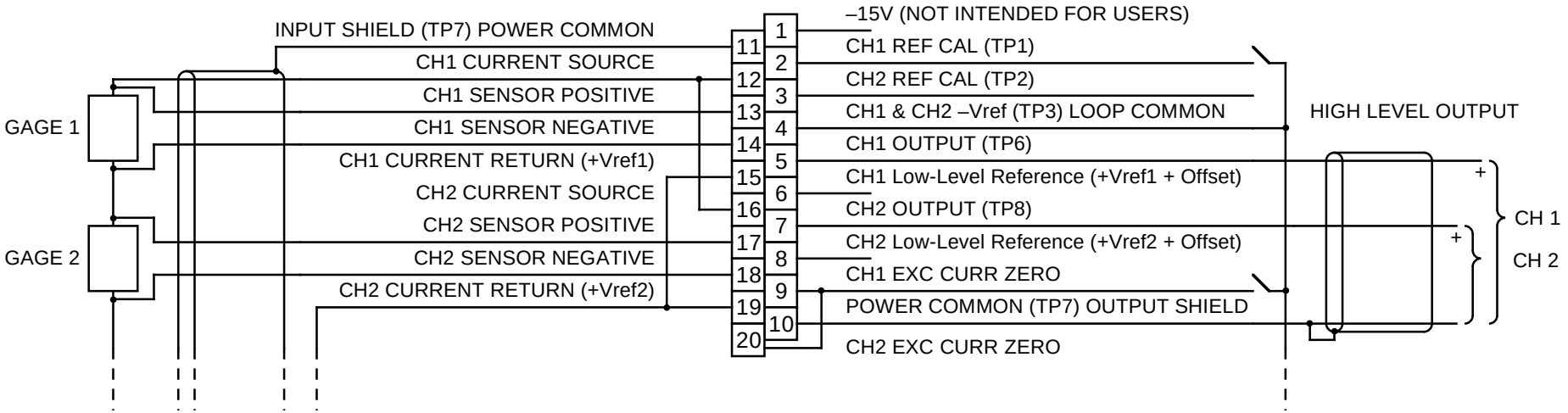
Balance Authority ($\mu V/V_{ref}$ nominal) = $\pm 100(10^6) / (R_{31 \text{ or } 33})$

Subtractor Gain = $1 + 50{,}000 / (R_{25 \text{ or } 26}) = 1$ when $R_{25 \text{ or } 26}$ are open

$\Delta R_{cal} / R_g = R_{ref} / R_{cal}$

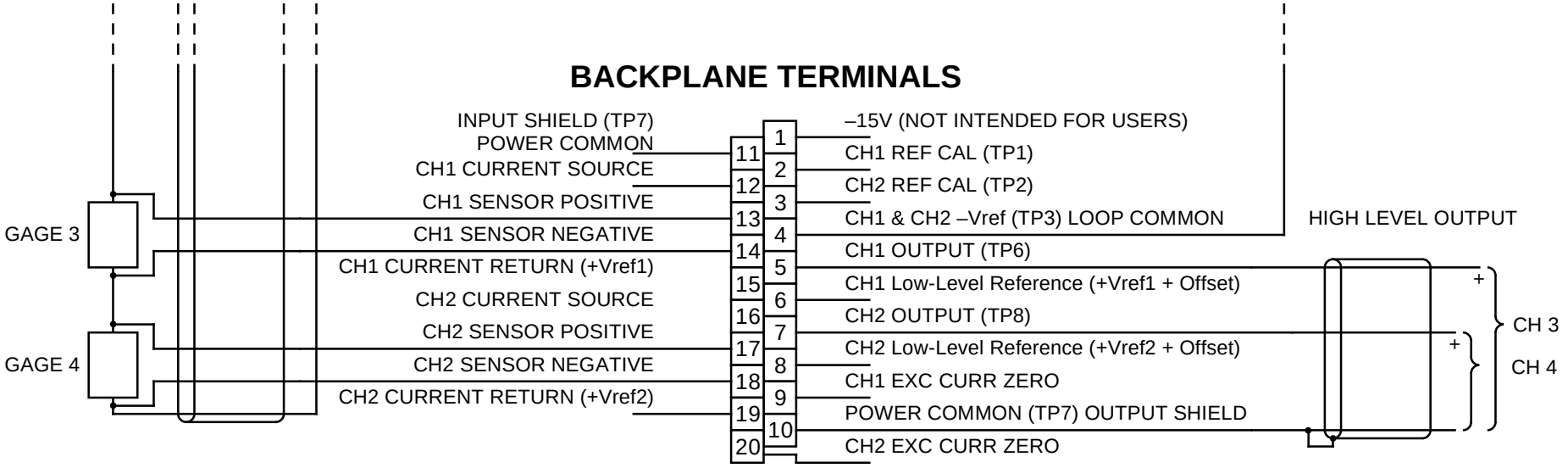
$\mu strain_{cal} = R_{ref}\, 10^6 / GF(R_{cal})$

BACKPLANE TERMINALS



SLAVE CARD FOR AN ANDERSON LOOP WITH KELVIN SENSING

BACKPLANE TERMINALS



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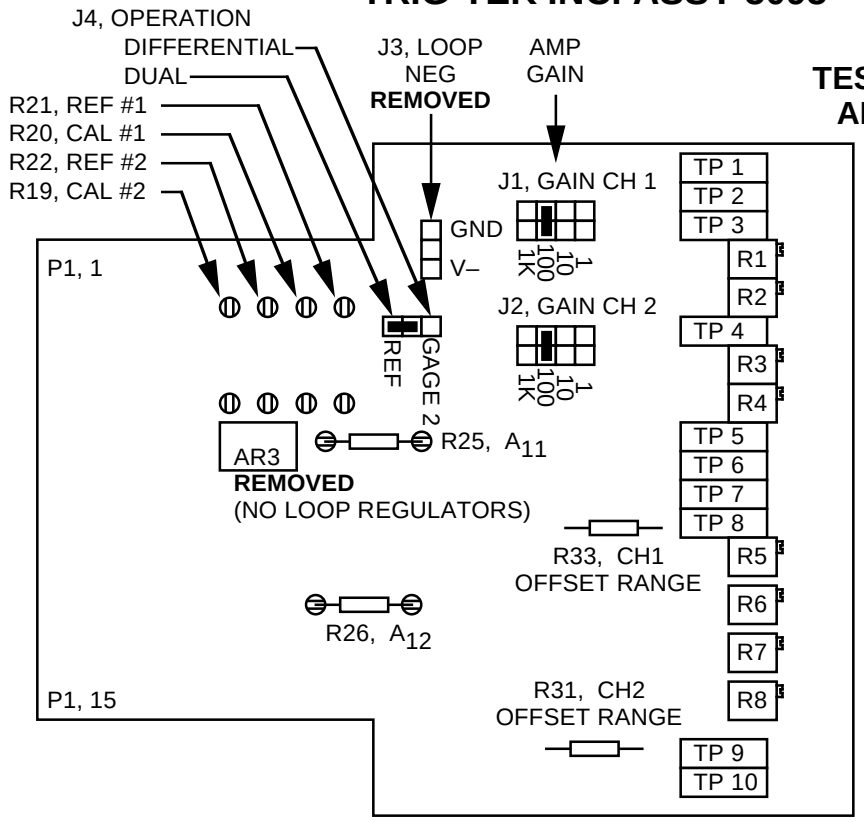

TEST POINTS AND ADJUSTMENTS

- CH1 REF CAL **NOT USED**
- CH2 REF CAL **NOT USED**
- REF
- CH1 IN NULL
- CH1 OUT NULL
- CH1 INPUT SHORT
- CH2 IN NULL
- CH2 OUT NULL
- CH2 INPUT SHORT
- CH1 OUTPUT
- GROUND
- CH2 OUTPUT
- CH1 BALANCE
- CH2 BALANCE
- CH1 EXC CURR SET **NOT USED**
- CH2 EXC CURR SET **NOT USED**
- CH1 EXC CURR ZERO **NOT USED**
- CH2 EXC CURR ZERO **NOT USED**

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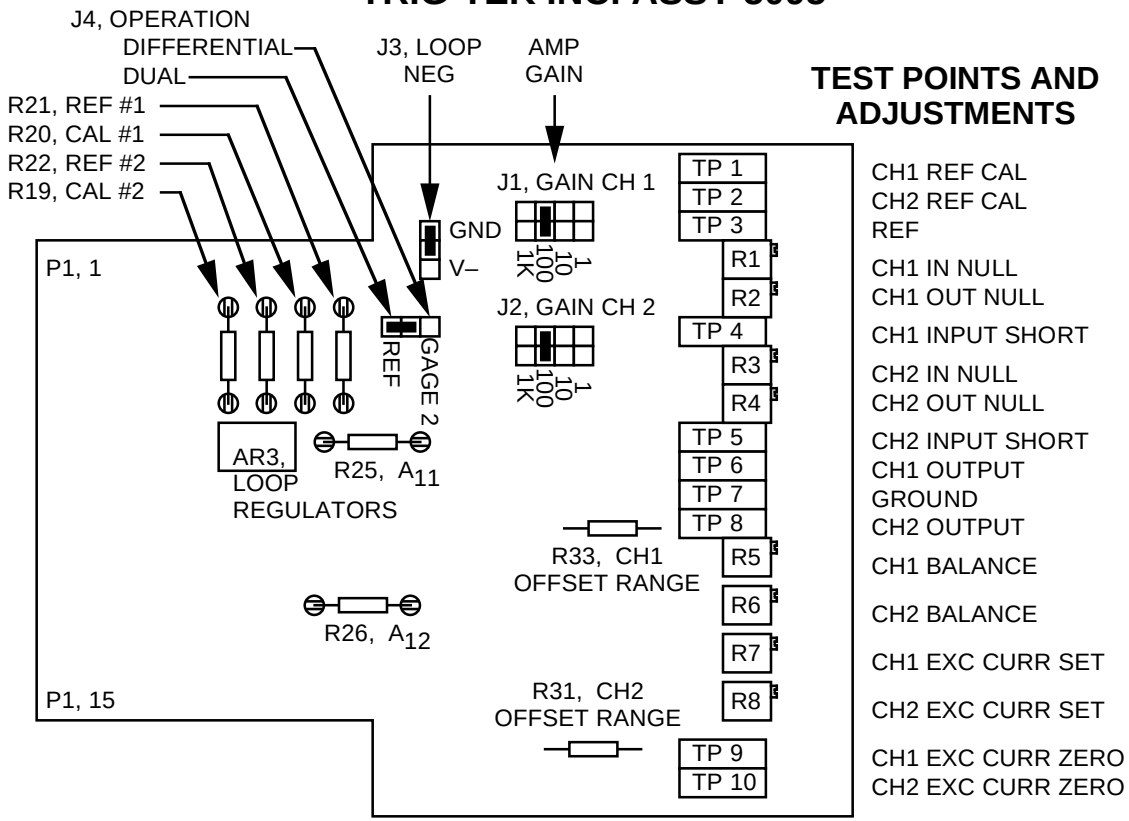

TEST POINTS AND ADJUSTMENTS

- CH1 REF CAL
- CH2 REF CAL
- REF
- CH1 IN NULL
- CH1 OUT NULL
- CH1 INPUT SHORT
- CH2 IN NULL
- CH2 OUT NULL
- CH2 INPUT SHORT
- CH1 OUTPUT
- GROUND
- CH2 OUTPUT
- CH1 BALANCE
- CH2 BALANCE
- CH1 EXC CURR SET
- CH2 EXC CURR SET
- CH1 EXC CURR ZERO
- CH2 EXC CURR ZERO

BACKPLANE TERMINALS

		1	–15V (NOT INTENDED FOR USERS)
INPUT SHIELD (TP7) POWER COMMON	11	2	CH1 REF CAL (TP1)
CH1 CURRENT SOURCE	12	3	CH2 REF CAL (TP2)
CH1 SENSOR POSITIVE	13	4	CH1 & CH2 –Vref (TP3) LOOP COMMON
CH1 SENSOR NEGATIVE	14	5	CH1 OUTPUT (TP6)
CH1 CURRENT RETURN (+Vref1)	15	6	CH1 Low-Level Reference (+Vref1 + Offset)
CH2 CURRENT SOURCE	16	7	CH2 OUTPUT (TP8)
CH2 SENSOR POSITIVE	17	8	CH2 Low-Level Reference (+Vref2 + Offset)
CH2 SENSOR NEGATIVE	18	9	CH1 EXC CURR ZERO
CH2 CURRENT RETURN (+Vref2)	19	10	POWER COMMON (TP7) OUTPUT SHIELD
	20		CH2 EXC CURR ZERO

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