DATA SHEET FOR QP-SD-NORM PCBA

Application

The QP-SD-NORM PCBA is a companion signal processor circuit board to the PSS-QP50-6SD and is used to normalize the top minus bottom and left minus right signals generated by the PSS-QP50-6SD sum and difference amplifiers. The user should also refer to the data sheets for the QP50 quadrant diode and PSS-QP-6SD sum and difference amplifier.

The purpose of normalizing the difference signals from the QP50-6SD is to create bottom minus top and left minus right signals whose magnitudes are independent of variations in the intensity of the light beam impinging on the QP50 quadrant diode. The normalization results in light beam location signals that are dependent only on the position of the light beam and that are not compromised by the variations in the intensity of the light.

Theory of Operation

The QP-SD-NORM PCBA accomplishes the function of normalizing the light beam location signals $V_{(b-t)}$ and $V_{(l-r)}$ by comparing these signals to the sum signal of the QP5-6SD circuit board. This signal V_{sum} is the sum of the signals generated by each of the four quadrants of the photodiode.

The desired transfer function for normalization is defined by the following equations:

$$\text{Vout } 1 = V_{(b-t)\text{ normalized}} = V_k \ (V_{(b-t)} / V_{sum}) \qquad (1)$$

$$\text{Vout } 2 = V_{(l-r)\text{ normalized}} = V_k \ (V_{(l-r)} / V_{sum}) \qquad (2)$$

Where V_k is a constant reference voltage. Referring to the PSS data sheets for the QD 50 and PSS-QP50-6SD it will be seen that for 633 nm wavelength light the responsivity of the QP50 is 0.45 amps per watt. The total area illuminated for all four quadrants is A_{total}. The PSS-QP50-6SD provides a current to voltage gain of 10^4 and the output of the PSS-QP50-6SD is therefore:

$$V_{(b-t)} = (0.45)\ (E)\ (10^4)\ [(A1 + A2) - (A3 + A4)] / A_{total} \quad (3)$$

$$V_{(l-r)} = (0.45)\ (E)\ (10^4)\ [(A1 + A3) - (A2 + A4)] / A_{total} \quad (4)$$

Where A1 through A4 represent the illuminated areas of each diode Q1 through Q4 and E represents the energy of the light beam in watts.

The sum of all diode quadrants is:

$$V_{sum} = (0.45)\ (E)\ (10^4)\ (A1 + A2 + A3 + A4) / A_{total} \quad (5)$$

Note that

$$(A1 + A2 + A3 + A4) = A_{total}$$

By placing the result of equations 3, 4 and 5 into equations 1 and 2, multiplying by the reference voltage V_k and canceling the responsivity, total area, and energy terms gives:

$$Vout\ 1 = V_k\ [(A1 + A2) - (A3 + A4)] / A_{total} \quad (6)$$

$$Vout\ 2 = V_k\ [(A1 + A3) - (A2 + A4)] / A_{total} \quad (7)$$

This is the desired result since now the voltage outputs are dependent only on the illuminated areas. A necessary condition is that all the light impinging on the diode is confined to the active areas. In this case the sum of the illuminated portions of all quadrants is a constant A_{total}:

$$Vout\ 1 = V_k\ (A_{b-t}\ /\ A_{total})$$

$$Vout\ 2 = V_k\ (A_{l-r}\ /\ A_{total})$$

Implementation

The QP-SD-NORM PCBA normalizes the b-t and l-r signals of the PSS-QP50-6SD by the use of a Real Time Analog Computational Unit. For two quadrant operation this unit requires that the denominator, in this case the Vsum signal, to be greater than the numerator.

Since, during operation of the QD50-6SD, both the $V_{(b-t)}$ signal and the $V_{(l-r)}$ may go to plus or minus voltage values, the circuit is designed to add the Vsum signal to the numerator and multiply the $(V_{(b-t)})$ signal by a gain factor of 10. A gain of G is also introduced into the numerator portion of the Vsum signal. The result is shown as the following:

$$Vout\ 1 = 10V\ (V_{(b-t)}) + G\ V_{sum}\ )/\ V_{sum} = 10V\ (1G + (V_{(b-t)}\ /\ V_{sum}\ ))\ \text{and}$$

$$Vout\ 2 = 10V\ (V_{(l-r)}) + G\ V_{sum}\ )/\ V_{sum}\ , = 10V\ (1G + (V_{(l-r)}\ /\ V_{sum}\ ))$$

The value for G is determined by R5/25k. R5 has been set to 35.7K and therefore

$$G = 1.428$$

Two quadrant operation is now possible and the real time analog computational unit and associated circuitry then appears to operate with both positive and negative values for

$V_{(b-t)}$ and $V_{(l-r)}$. The denominator being a sum of positive numbers should not be negative.

There only remains the need to deal with the case where either numerator value goes to zero. In this case the output would incorrectly equal 14.28 volts. In order to correct this case R 29 and R 30 have been added to provide a means to adjust out the undesirable offset and the output correctly adjusted is:

$$\text{Vout 1} = 10\,(V_{(b-t)} / V_{sum})$$

$$\text{Vout 2} = 10\,(V_{(l-r)} / V_{sum})$$

Again note that in the foregoing analysis a necessary condition is that all the light must remain within the area defined by A_{total}. If any of the light moves outside the area of the diode array the normalization process will fail since A_{total} now becomes a variable quantity.

Specifications

Operating bandwidth: 250 kHz

Maximum voltage inputs with Vplus = 15 volts, Vminus = 15 volts

b-t	5 volts
l-r	5 volts
sum	5 volts

Operating voltage range

Vplus minimum +6 volts, maximum +15 volts

Vminus minimum -6 volts, maximum -15 volts

Current draw typical +/- 15 ma.

Offset Adjusting Procedure

Bottom minus top adjustment

1. on the QP-SD-NORM PCBA apply + and – 15 volts and ground to pins 5, 7,6 of J2 respectively
2. connect pin 2 of J2 to ground.
3. connect a calibrated voltmeter to pin 2 of J1
4. adjust R13 to zero the voltmeter reading

Left minus Right adjustment

1. on the QP-SD-NORM PCBA apply + and – 15 volts and ground to pins 5, 7,6 of J2 respectively
2. connect pin 3 of J2 to ground.
5. connect a calibrated voltmeter to pin 3 of J1
6. adjust R29 to zero the voltmeter reading

Testing the PSS QP-SD-NORM PCBA

Testing the QP-SD-NORM PCBA is accomplished by connecting a sine wave signal to the bottom minus top input while varying a DC voltage source that is connected to the sum input.

1. connect + 15 volts to J1 pin 6, -15 volts to J1 pin7, and ground to J1 pin 6.
2. set the sine wave generator output to + /– 2 volts peak to peak at a frequency of 100 Hz.
3. connect the sine wave generator to J2 pin 2.

4. set the DC power source to +0.50 volts.
5. connect the DC power source to J2 pin 4.
6. read and record the b-t output at J1 pin 2 using a calibrated volt meter.
7. set the DC power source to +1.00 volt.
8. read and record the b-t output at J1 pin 2 using a calibrated volt meter.
9. set the DC power source to +1.50 volts
10. read and record the b-t output at J1 pin 2 using a calibrated volt meter.
11. connect the sine wave generator to J2 pin 3
12. repeat steps 4 through 10.

The voltage readings for b-t steps 4 to 10 should be the same +/- 0.01 volt

The voltage readings for l-r steps 4 to 10 should be the same +/- 0.01 volt

Repeat the above test with the sine wave generator set to 1kHz, 10kHz, and 100kHz.