High-sensitivity Quality Monitor for Optical Fiber Communication

HQM995(v1.2) January 20,2011

Summary

This HQM application note document describes the installation and operational procedure of the HQM.

Introduction

Since HQM is a very sensitive optical-electrical transducer, carefulness must be taken so that the high performances can be achieved.

Power Supplies

HQM requires two power supplies: +5V and –5V, none of which is allowed to share with a power supply for digital circuits. The analog voltage regulator is recommended. The switching power supply is not recommended.

The tolerance of the voltage is +/- 5% or less and the symmetric of +5V and –5V is required. It is permissible that several HQMs share one pair of +5V, -5V power supplies as long as the power supplies can provide enough current.

Each HQM should have 10uF decoupling capacitors for +5V and –5V, the tantalum capacitors are recommended. The decoupling capacitors should be close to the corresponding power supply pins as possible. The recommended analog regulator is LP29 series or LM29 series of National Semiconductor.

Background Light

HQM can detect very weak optical power down to –80 dBm, or 10^{-11} watts. If a HQM is at a quite strong light environment, the background lights would enter it through various paths, one of the possible paths is the gap of the optical connector and the receptacle. It can be verified by using a flash to illuminate the optical connector to see if the output voltage of HQM decreases.

If the background lights are stable, it can be compensated as the dark voltage. If the background lights are various, it would need an open space optical sensor to detect the background lights to adapt the dark voltage compensation voltage according to the background lights, it is complicated and not accurate. Therefore the best solution is to put HQM in a complete dark environment. Any light sources such as LED must be far from HQM.

Dark Voltage Adjustment

The definition of dark voltage is the output voltage of HQM without input optical power. The required dark voltage is 3.0V. The tolerance of the dark voltage depends on the system accuracy, usually the tolerance would be 3 V +/- 1mV.

Pin 11 of HQM is for the dark voltage compensation. The basic principle of the dark voltage compensation is to apply a DC voltage, Vadj on the pin, adjust the voltage until the output voltage on pin 6, Vout to be 3.0V+/-1mV when no input optical power and the HQM is in a complete dark environment.

Vout and Vadj have opposite directions, that means when Vadj increases, Vout decreases.

Since HQM has very high sensitivity, the range of Vadj is about +1 mV to –1 mV. If the increment or decrement of Vadj is 50 nV, Vout has the resolution of 0.1 mV.

Fig. 1 is a dark voltage adjustment circuit recommended.

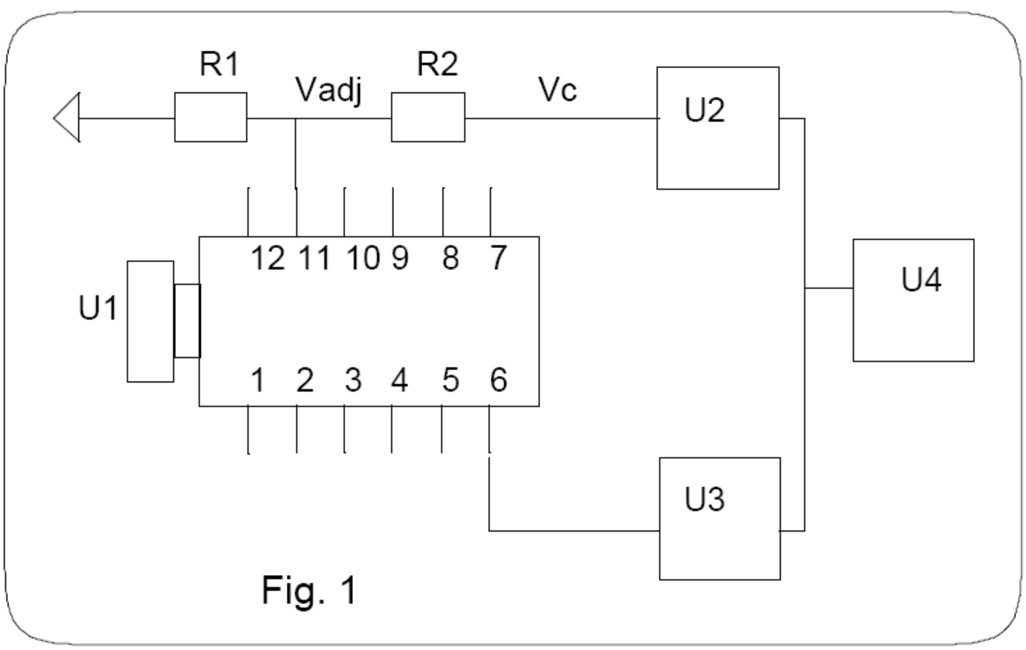

Fig. 1

Fig. 1

In Fig. 1 U1 is HQM, U2 is a bi directional voltage output DAC (digital to analog converter) which generates the dark voltage compensation control voltage Vc. U3 is a ADC(analog to digital converter) which converts the output voltage of the HQM to digital signals and sends the digital signals to the micro controller U4.R1 and R2 are two resistors which form a voltage divider to improve the resolution of Vadj. The ratio of R1/R2 will affect both of adjustment range and the resolution Vadj.

Suppose R1 is 1K ohms, R2 is 1M ohms and the output range of U2 is from +1 to –1, the adjustment range of Vadj is from –1 mV to +1mV. If the resolution of Vaj is 50 nV, the resolution of Vc is 50 uV, the resolution ot U2 should be 16 bits.

Since the output range of HQM is from +3V to –0.5V, U3 should be able to accept bi directional input analog voltage or use the voltage shift technology described in Section 6 to shift the voltage range to +3.5V to 0V. The U3 resolution depends on the system requirement. If the output voltage resolution of 1mV is required 1mV, the resolution of U3 should be 12 bits or more, If the output voltage resolution of 0.1 mV is required, the U3 resolution should be 16 bits or more.

The procedure of the dark voltage compensation adjustment is described as follows:

1) Power on the test system and warm it about two minutes
2) Under the control of U4, set U2 to output the maximum positive voltage as Vc1.
3) Delay 10 second to read the HQM voltage by U3, delay 1 second, read it again, if the two reading is the same, it is a stable output voltage named Vd1.
4) If Vd1 is not +3V+/-1mV, according the following formula, the Vc2 output from U2 for the next try can be obtain:

$$Vc2 = Vc1 + 0.1001 - 1.001 * 10^{5-2*Vd1}$$

The formula is valid for R1=1K ohms, R2=1M ohms

5) Repeat 3) and 4) until the output voltage of HQM is 3V+/-1mV Record the final Vc value and the corresponding environment temperature.

A lookup table should be created for the dark voltage compensation control voltage Vc under different environment temperatures. The table should be saved in a non volatilized memory such as hard disk, EEPROM, flash memory.

During the system normal operation, when the environment temperature changes, the U2 output voltage should be changed according to the lookup table to keep the HQM measurement accuracy.

Temperature Measurement

The temperature sensor should be equipped near HQM. If multi HQMs are used and the temperature distribution is not uniform in the locations of HQM, one temperature sensor for each HQM is recommended.

The temperature sensor may be the type of analog output or digital output, the sensitivity of the sensor should be about 1°C. The temperature sensor should is close to HQM as possible.

HQM Output Voltage Shift and Magnification

Most of ADCs operates for positive input voltage. The circuit shown in Fig.2 can shift and magnify the HQM output range of +3V/-0.5V to about +5V/0V.

In Fig. 2 U1 is an operational amplifier with low input offset voltage and low temperature drift, Vb is the bias voltage.

It is well known the U1 output voltage Vout should be

$$Vout = (1 + \frac{R1}{R2}) * Vin + \frac{R1}{R2} * Vb$$

For the recommended values of R1=200K ohms, R2=698K ohms, Vb=-2.25V, when Vin is –0.5V, Vout is

1.4 mV, when Vin is 3V, Vout is 4.504V. Therefore when the operational amplifier is inserted between HQM and the ADC, Vin is connected to HQM output, the ADC input voltage range is within +5V/0V.

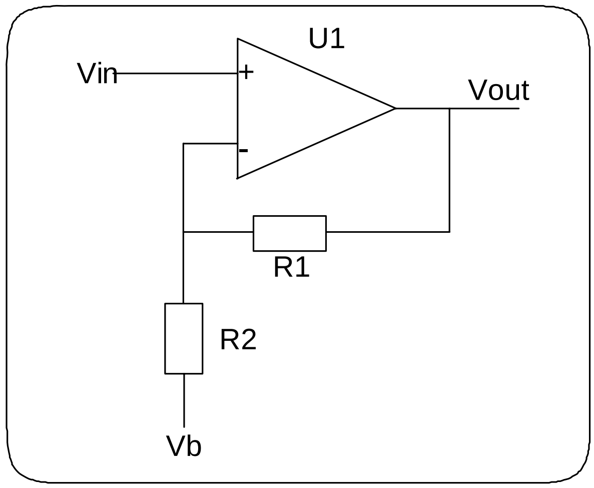

Fig. 2

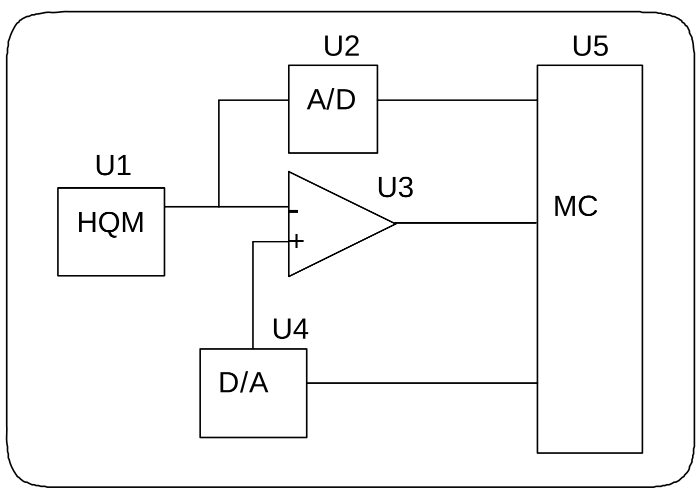

Fig.3

Hardware Warning

When HQM is used for optical fiber communication quality monitor system, the hardware warning for optical signal power degradations may be required. The unit circuit of the hardware warning is shown in Fig. 3.

When the optical fiber communication system is in the initialization, the ADC U2 reads the HQM U1 output voltage under the control of U5, the output voltage is called initial voltage, according to the initial voltage, U5 sets the degradation threshold voltage , usually 3dB lower than the initial voltage as the first degradation threshold.

The threshold voltage is applied to the positive input terminal of the voltage comparator U3 through the DAC U4 while the negative input terminal of U3 is connected to the output of HQM. When the HQM output voltage is dropped to lower than the threshold voltage, the U3 output has a transition from logic high to logic low, the transition invokes the interrupt of U5, U5 will response it and start a series of processing actions.

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