Overview

The EM650 integrated DFB laser module was designed for OEM laser spectroscopic applications. The module integrates Gooch&Housego's high-reliability DFB laser modules with an ultra-low-noise laser current source and an ultra-high performance temperature controller in a highly-filtered and EMI shielded package. Both the current source and temperature controller are tunable, providing both coarse and fine tuning of the laser line position. This application note describes operational details and the use of the tuning inputs in detail.

The user should read and fully understand the datasheet for the EM650, **including notes and warnings**, before attempting to use the device. The latest version of the datasheet is always available on G&H's website. The EM650 was designed for OEM use and care should be taken to properly supply power and tuning signals to the device. The user should be competent in the use of lasers, fiber-optics, and electronic hardware as the device size precludes the same level of protections offered in turnkey systems. If the application is for laboratory use, G&H also recommends that the device be ordered with the PM or SM900 option that protects the bare optical fiber with a loose 900 µm furcation tube.

Tuning a DFB Laser

When driven by a low-noise current source G&H's C-band DFBs exhibit a laser linewidth on the order of a few hundred kilohertz. The position of this line may be tuned by varying the drive current, also known as "chirping." The line position may also be varied by changing the temperature of the laser chip. The variation with temperature occurs at the well-known and repeatable rate of -12.5 GHz/°C. However, the rate at which each DFB laser chip chirps varies on a device-by-device basis, generally falling in the range of 400-800 MHz/mA at rated operating power. Chirp is also a somewhat nonlinear function of drive current. Because the temperature tuning rate is high and there is essentially no variation in output power when changing the temperature over small ranges, it is recommended that coarse tuning be accomplished using temperature with smaller adjustments made by changing the laser drive current.

Currently Gooch and Housego offers no guaranteed range over which the output frequency may be tuned, but a range of ±50 GHz from the rated operating frequency at a 25 C baseplate temperature is typical. If you require a larger range of tuning, please inquire with our sales department as special screening is available on a sliding cost scale.

EM650 Operational Details

The EM650 is conductively cooled through the module baseplate. The baseplate must be bolted or clamped to a heatsink using a thermal interface material like a heatsink "grease" or preferably Panasonic PGS series pyrolitic graphite sheeting, available in the US from Digi-Key Corp. The module baseplate must be maintained within the operational temperature range listed on the device datasheet. Please note that the module baseplate is generally warmer than the ambient temperature. The extent of the disparity will depend on the thermal interface material used and the thermal resistance of the user's heatsink under load.

The EM650 is an analog component designed to operate from a user-supplied DC power supply properly sequenced with the tuning signals, if such signals are to be applied. Care must be taken to use appropriately sized power supply wiring to ensure that at least the minimum voltage be present at the device terminals under a 3A load. 12 gauge speaker wire is generally sufficient for short connections. The user should be sure to connect supply wiring to all supply pins, ie connect the positive output of the supply to both pins 1 and 2 and the supply ground to pins 3, 4, and 5 at the EM650. Failure to use all of the supply pins will increase the effective wiring resistance and may cause the internal voltage to drop below the specified minimum, which will cause circuit malfunction and/or damage to the laser itself.

The power adjust and temperature adjust inputs should also be driven with low-impedance current limited sources. These signals should be current limited and sequenced in accordance with the device datasheet. Limiting the PA input current with a series resistor should be avoided as noise may be introduced into the laser current source, which will broaden the laser linewidth.

Temperature Control Circuit and Tuning

The temperature control circuit for the EM650 operates in the linear mode. Since the controller is not repeatedly switched on and off as in a pulsewidth modulation (PWM) circuit, the stability of the laser line position is maintained within several MHz over an interval of 100 seconds or more. This is illustrated through a series of videos depicting optical heterodyne measurements for the EM650 and other devices available on the Gooch & Housego's website. In addition, the linear-mode TEC control circuitry does not impart noise into the laser diode current source as large currents are not rapidly switched on and off through the TEC. The low noise and stability offered by linear operation is traded against the substantially increased efficiency offered PWM TEC controllers.

The EM650 may be operated with or without a signal present at the temperature adjust (TA) input. If tuning is not required, the TA input should be kept unconnected or high-impedance. **The TA input must never be shorted to ground or Vcc, which will cause circuit malfunction and may rapidly destroy the DFB laser.**

The TA input is connected internally to a 2.5 V voltage reference via a 1 kΩ resistance. In addition, this input is protected with diodes that clamp the applied voltage to ~0.5 V above Vcc and ~0.5 V below ground. This configuration requires that one of four methods be employed to safely drive the TA input.

Method 1: Gooch & Housego recommends that this method be tried first as it offers the lowest risk to hardware damage. For applications that tolerate slow tuning to a specific frequency, a 2 kΩ resistor may be placed between the TA input of the EM650 and the driving circuit. This will limit current to a safe level and power supply sequencing with the signal will not be required provide that the drive voltages do not exceed the supply rails. However, the laser will likely require many tens of seconds to settle in frequency, as the 2 kΩ resistor forms a low-pass filter with a long time constant when combined with internal filter capacitances at this input.

Method 2: For applications that require maximum temperature tuning speed. In this case, the TA source impedance must be kept low to avoid a reduction in bandwidth. The simplest method for doing this while also preventing the destruction of the input protection diodes is to drive the input with a source having a current limit of no more than a few milliamps. In the event that the TA input voltage exceeds Vcc by more than a few hundred millivolts, which can easily be the case at startup or shutdown if the sources are not properly sequenced, the protection diodes will themselves be protected by the current limiting action of the source.

Method 3: When fast temperature tuning is required but a current limited tuning signal is not available. In this case it is an absolute requirement that the TA drive signal and the EM650 power supply be sequenced. **If the user fails to sequence the supplies as described, the device will immediately suffer non-warrantable damage or destruction.** To properly sequence the supplies, Vcc (5 V) must first be established at the device before any TA signal is applied. **The tuning signal should not be applied simultaneously with Vcc as slight differences in timing can cause damage to the protection diodes**. This requires the use of a tri-state signal to drive the TA input or in the simplest and most dangerous case, that the TA cable or signal be connected and disconnected manually while Vcc is applied. If the user has chosen to make and break the connection manually, they should be aware that one error will render the device unusable.

Method 4: If the device must be tuned to a setpoint other than the delivered standard ITU grid frequency. Perhaps the most stable method of tuning the EM650 is to use a resistor to pull the TA pin low. Pulling the pin toward ground using a fixed resistor or potentiometer provides a very stable means of setting the output frequency. In principle the TA input may also be pulled high with a resistance, but Vcc is typically not as stable relative to the reference voltage as the local ground. As shown in Figure 1, pulling the input down will result in a decrease in the output frequency (red shift). Thus, this method is only appropriate if the ordered frequency is to the blue side of the desired frequency. **As previously mentioned, the user must take care not to pull the input all the way to ground (or Vcc), as circuit malfunction and thermal runaway will likely occur.**

Figure 1 shows the power and frequency tuning achieved using the temperature adjust input for a 63 mW 1571 nm device mounted on a 25 C water cooled heatsink with Vpa open (full power). This chart should be considered as an example, not a specification. Greater tuning range may be possible; however some devices may exhibit a mode hop. Typical mode hop free tuning range is greater than ±50Ghz. Since the available TEC temperature tuning range is dependent on the baseplate temperature and heat load, care should be taken to avoid thermal runaway when making large temperature adjustments.

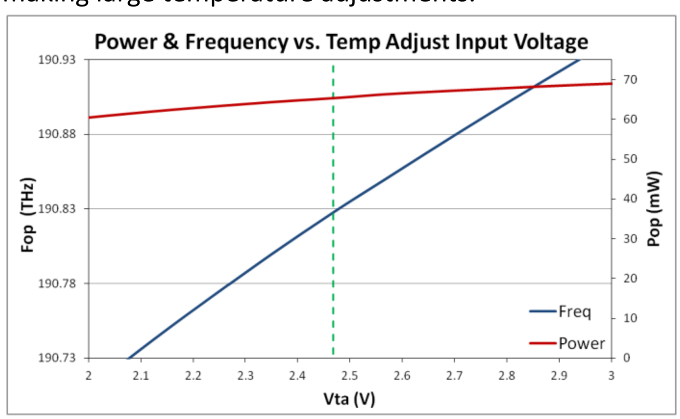

Figure 1: Variation in output frequency and power as a function of temperature adjust input voltage for a 63mW 1571nm EM650. Typical mode hop free tuning range is ±50Ghz from the default operating point. The dashed green line represents the Vta open circuit voltage.

Laser Current Source and Tuning

The laser current source in the EM650 was designed for ultra-low noise in order to minimize the laser linewidth. The current source was also designed to be adjustable to take advantage of the slower variation in line position available through changing the drive current rather than temperature. In the EM650, the laser drive current can be increased or decreased from the rated operating point using the Power Adjust (PA) input.

As delivered, the open circuit PA voltage will be approximately 2.05V at rated operating power, e.g. at 80 mW for an 80 mW unit. An example laser chip operating current for at this output power is 330 mA. To first order one may therefore say that 2 Vpa corresponds to 330 mA and the slope of the current adjustment provided is then 165 mA/V. Such a simple estimate is less accurate when using power instead of current due to the non-zero threshold current for laser operation. Obviously, as each laser exhibits a different threshold and operating current, the slope of the power adjust input varies from device to device.

The internal 2 V reference for this circuit is connected to the PA pin through a 1 kΩ resistor. If fine tuning of the output power/frequency is not required, this input should be left unconnected or high-impedance.

Figure 2 depicts the variation in output power and frequency achieved using the power adjust input. For spectroscopic applications the laser would be coarse tuned to the frequency of interest using the TA input and then fine tuned over a few milliampere range via the PA input to minimize laser amplitude modulation.

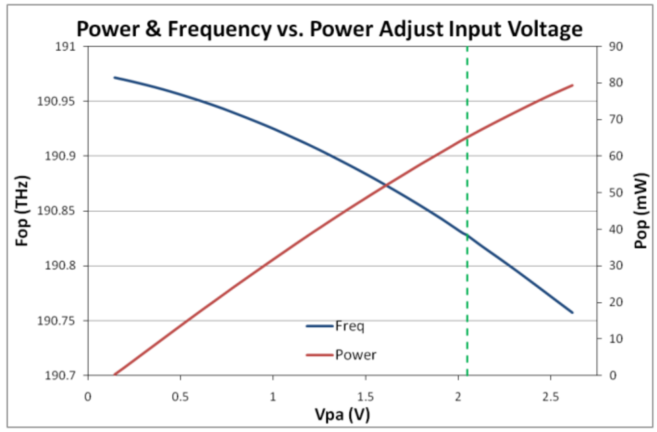

Figure 2: Variation in output power and output frequency for a 63mW rated 1571nm EM650 using the power adjust input. The dashed green line represents the Vpa open circuit voltage. Note some devices may exhibit a mode hop (frequency shift) as power increases. Typical mode hop free tuning range is ±50GHz from default operating point

The PA input also offers significantly higher frequency tuning bandwidth than the TA input. The previously mentioned heterodyne videos available on the Gooch & Housego's website show examples of tuning the output frequency in 1 GHz steps using a resistor and switch to pull either the PA or TA input toward ground. These videos offer a visual comparison of the tuning speed of the two methods. The -3 dB bandwidth of the laser current source is approximately 8 kHz.

As shown in Figure 2 it is possible to drive the laser to operate at an output power higher than rated. Large deviations from the rated power, while possible, will reduce the device lifetime and present a somewhat higher thermal load to the TEC. As a rough estimate, the device lifetime will be reduced by the increase in drive current (above the operating point) raised to the fifth power. As the power level is increased, kinks in the power curve and/or a drastic increase in RIN may be observed. **In general, Vpa should not be adjusted more than 0.2 V above the open circuit voltage (again, this is a general device dependent sugges-**

tion), or approximately 2.25V. Pulling the pin all the way to ground (not below) is permitted, but it should never be tied to Vcc or above.

Supply Dependence and Noise Immunity

For very sensitive applications, the supply and associated wiring from which the EM650 draws power is worth consideration. G&H has intentionally injected AC noise at frequencies ranging from 10 kHz up to 15 MHz at amplitudes as high as 1 V_{p-p} and have observed no effect in performance as measured through the very sensitive heterodyne technique. This performance is the result of the combination of extremely heavy broadband filtering in the device and a novel circuit topology that maintains a very high common-mode rejection (CMR) ratio. However, very low frequency variations in the supply voltage must be considered as they cannot be filtered out and tend to cause global variations within the circuitry that are outside the circuit CMR range.

Variations in the voltage supplied to the EM650 may be the result of poor regulation or regulation of the voltage at some distance from the device. It should be noted that the current drawn by the EM650 at startup, baseplate temperature extremes, or when the TA input has been used to drive the output frequency far from the baseplate temperature, will generally be higher than 1 A and will vary as a function of tuning or ambient temperature. If possible, it is recommended that a DC supply with remote sense lines be used, with the sense lines connected as closely as possible to the EM650. Through this method, the user can minimize the effect of wiring resistance under conditions such as those listed above.

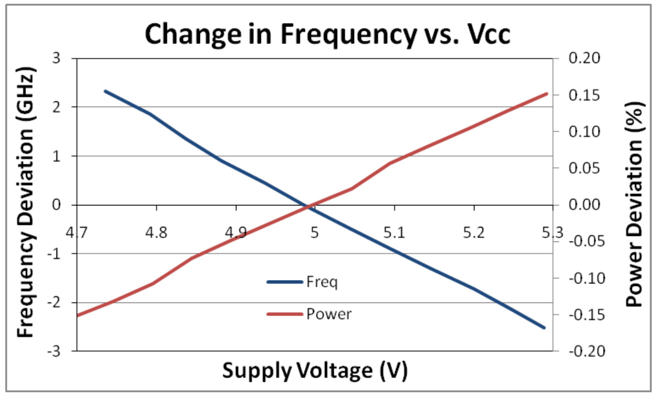

Figure 3: Frequency and power deviation as a function of supply voltage.

Figure 3 depicts the change in output frequency and power as a function of supply voltage as measured at the device terminals. While the variations are small, the EM650 is capable of substantially better performance when Vcc is held steady.