Infrared Sources for Diffuse Infrared Communication Links

by

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1. Introduction

- What are the most suitable transmitters for a diffuse infrared communication link?
- What are the typical performance characteristics available today?
- Who are the present and future manufacturers of such devices?
- What are the areas in which diffuse infrared communication applications are now pushing the component designs?
- How should these devices evolve to better suit our design needs in the long-term future?

2. Available and Practical Near Infrared Transmitting Sources

- Semiconductor Laser Diodes
- Semiconductor Light Emitting Diode's (LED's)

2.1 Semiconductor Laser Diodes

- **Advantages**
    - multiwatt radiant flux levels
    - sub-nanosecond switching times
    - excellent power conversion efficiencies
    - highly divergent output beams
    - narrow spectral bandwidths
    - multi-lasing cavities on a common substrate
- **Disadvantages**
    - very expensive
    - public's perception of laser hazards
    - requires elaborate heat sinking designs
    - elaborate drive requirements

2.2 Semiconductor LED's

- **Advantages**
    - inexpensive
    - highly divergent output beams
- **Disadvantages**
    - subwatt radiant flux levels
    - sub-microsecond switching times
    - low power conversion efficiencies
    - wide spectral bandwidths

2.3 LED and Laser Diode Comparison

- **Duty Cycle less than 1%**

	LED	Laser Diode
	DN304	SDL-2280-C
Optical Output Power:	300 mW	3000 mW
Electrical Input Power:	3.8 W	10.0 W
Rise/Fall Times:	10 ns	0.5 ns
Cost:	$0.70	$2500.00
Efficiency:	**8 %**	**30 %**
Power Cost:	**$2.33 / W**	**$833 / W**

- **Duty Cycle greater than 50%**

	LED	Laser Diode
	DN304	SDL-2480-C
Optical Output Power:	45 mW	3000 mW
Electrical Input Power:	0.27 W	10.7 W
Rise/Fall Times:	10 ns	0.5 ns
Cost:	$0.70	$2500.00
Efficiency:	**16.7%**	**28%**
Power Cost:	**$15.56 / W**	**$833 / W**

2.4 Conclusion

- **Laser diode performance offer the greatest design benefits.**
- **However, because of over riding cost considerations, LED's are by default the source of choice today for diffuse infrared communication links.**

3. LED Manufacturers and Typical Performance Parameters

- **Today's Suppliers**
    - Siemens

- Stanley
- Hamamatsu
- Hitachi

- **Typical LED's Operating Parameters**

Manufacturer	Siemens	Siemens	Siemens	Stanley	Hamamatsu	Hitachi	Hitachi
Part Number	SFH 475	SFH 45V1	SFH 45V2	DN 304	L3989	HE8404SG	HE8812SG
Forward Current (mA)	100	50	100	50	50	50	50
Operating Temperature (C)	25	25	25	25	25	25	25
Forward Voltage (V)	1.4	2.7	1.5	1.55	1.45	1.6	1.5
Reverse Current (uA) (max)	1	1	1	100	20	100	100
Junction Capacitance (pF)	120	*	*	65	100	30	30
Radiant Intensity (mW/sr)	6.3	50	26	30	*	*	*
Radiant Flux (mW)	10	19	11	15	8	14	14
Center Wavelength (nm)	830	830	830	850	830	820	870
Spectral Half Bandwidth (nm)	60	30	36	40	40	30	30
Half-Intensity Angle (deg)	17	11	9	35	80	57	57
Response Time (ns)	100	50	20	10	10	10	10
DC Efficiency	7.1%	14.1%	7.3%	19.3%	11.0%	17.5%	18.7%
Pulse Efficiency (Peak Current -mA)	3.6% (1500)	4.7% (1500)	5.5% (1500)	7.9% (1000)	10.0% (900)	9.3% (250)	9.1% (250)

- **Possible New Suppliers**
  - Hewlett Packard is studying the market and have made no decisions.

4. Immediate LED Design Changes

- **Surface Mountable Packages**
  - simplify handling and assembly
  - less costly to fabricate multi-LED designs
  - require less real estate on PCB's
  - easier to heat sink

- **Heat Sinkable Packages**
  - higher device reliability
  - longer operational lifetimes between failures
  - higher radiant flux levels for existing dye designs
  - larger duty cycles
  - higher data throughput

- **Faster Optical Switching Times**
  - higher data throughput
  - wider market appeal and opportunities
  - conserves power
  - better decision certainty in receivers
  - higher SNR by trading pulse width for pulse amplitude
  - required LED rise and fall times for:
    - 1 MHz 158 ns
    - 4 MHz 40 ns
    - 10 MHz 16 ns

    - assumed rise time is equal to pulse width
    - biphase encoding - 50 % duty cycle
    - receiver contributes 75% of rise and fall time to total system

- **Higher Radiant Flux Levels**
  - allows for greater coverage area
  - increase SNR

- **All designs changes must be accomplished while keeping the cost below ten dollars per watt.**

5. Future Laser Diode Requirements for Diffuse IR Communication Links

- **Reduce power cost by a factor of 50**
- **Change public's perception on laser hazards**
  (CD Player and CD ROM Drive Manufacturers are good examples)

6. Future LED Requirements for Diffuse IR Communication Links

- **Still Higher Radiant Flux Levels**
  - allows for greater coverage area
  - increase SNR
- **Increase Power Conversion Efficiencies**
  - longer operational lifetimes between recharging of battery powered units
  - higher data throughput
- **Still Higher Frequency Response**
  - faster transitions will improve:
    - data throughput
    - conserves power
    - decision certainty of receiver demodulator
    - SNR by trading pulse width for pulse amplitude
- **Wavelength Requirements**
  - spectrally matched LED's and photodiodes
    - GaAlAs LED's match well with Si PIN Photodiodes at 850 nm
  - longer wavelengths
    - reduces broadband interference from:

        - sunlight
        - incandescent lighting
        - fluorescent lighting
    - narrower spectral bandwidth
        - 60 nm to 40 nm is common
        - allows filtering to reduce in-band interference
    - minimize line center shifts due to dye self-heating
        - typical 0.5 nm per degree Kelvin
        - better heat sinking designs

- **Package Requirements - Simplifying Handling and Assembly**

    - Multiple dice on common substrate within single package
        - minimizes required PC board area
        - uniform relative positioning of dices
        - shortest possible interconnect lengths

    - Design Issues
        - single redirection well or individual wells
        - beam shaping optics
        - parallel or series drive circuitry
        - heat sinking
        - close proximity of external drive circuitry

- **Inexpensive - wider market opportunities**

- **Uniform Beam Intensity - uniform transmission coverage**