Optical Communications.
or, Talking over a Beam of Light.

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Why Do It?

It's a Technical Challenge.
Learn about Optics and Electronics.
Experiment with various Analog and Digital Modes.
Combine with Hiking, "Summits-on-the Air" (SOTA).
Contribute to our Knowledge.
Make Contacts in ARRL VHF Contests.

* A.R.R.L. Rules: "Above 300 GHz, contacts are permitted for contest credit only between licensed amateurs using mono-chromatic signal sources (for example, LASER or LED) and employing at least one stage of electronic detection on receive. LASER usage is restricted to ANSI Z136 Class I, II, IIa, and IIIa (i.e., output power is less than 5mW)."

* Down-Load the KA7OEI Optical (Lightbeam) through-the-air communications page. http://modulatedlight.org/optical—comms/optical_index.html

Clint Turner's 100+ Page Treatise provides hours of fascinating reading, with detailed explanations and construction details. KA7OEI and K7RJ have a world-record optical contact of 173-miles!

* Optical Sources.

* LASERS. *	L.E.D. s.
Coherent (one Frequency).	Non-Coherent.
Very Collimated.	Not well Collimated (need Lenses).
Difficult to Modulate Linearly-May be turned off or on (PWM or FM).	Easily Modulated by varying Current (High-Quality Voice or Video).
Low Efficiency (a few per-cent).	High Efficiency (20-50 per-cent).
Inexpensive.	Very Inexpensive.
Safety-May cause Injury!	Safe at High-Power Levels (1-5W).

* Optical Detectors.

Use inexpensive Photo-Diode. For example the BPW-34 ($1) has a peak response at 850 nm (upper infrared), and is nearly as good at 630 nm (red), but really down at 460 nm (blue).

— (OVER). —

* Optical Detectors (cont'd).

Note that the Human Eye responds from ~760nm (deep red) to ~380nm (violet), with a Peak around 560nm (yellow-green). Some electronic Detectors are fragile (photo-tubes), insensitive (photo-transistors, solar cells), slow (photo-resistors), or expensive (avalanche photo-diode). Most circuits use a Junction Field-Effect Transistor input stage – the simplest is by K3PGP, and improved by VK7MJ and KA7OEI.

* PROBLEMS TO SOLVE:
* Finding Line-of-Sight Paths.
* Operating in Day-Light.

* A FEW TERMS:

Coherent: Tending to remain united (phase or frequency of waves).
Collimate: To make parallel (the individual rays in a beam).
Diffraction: Bending from a straight line, occurring when waves pass around an object in their path.
Scintillation: Sparkling or twinkling as light from a star.
Spherical Aberration: Deviation of refracted or reflected light rays from a single focus, resulting in the formation of a blurred image.

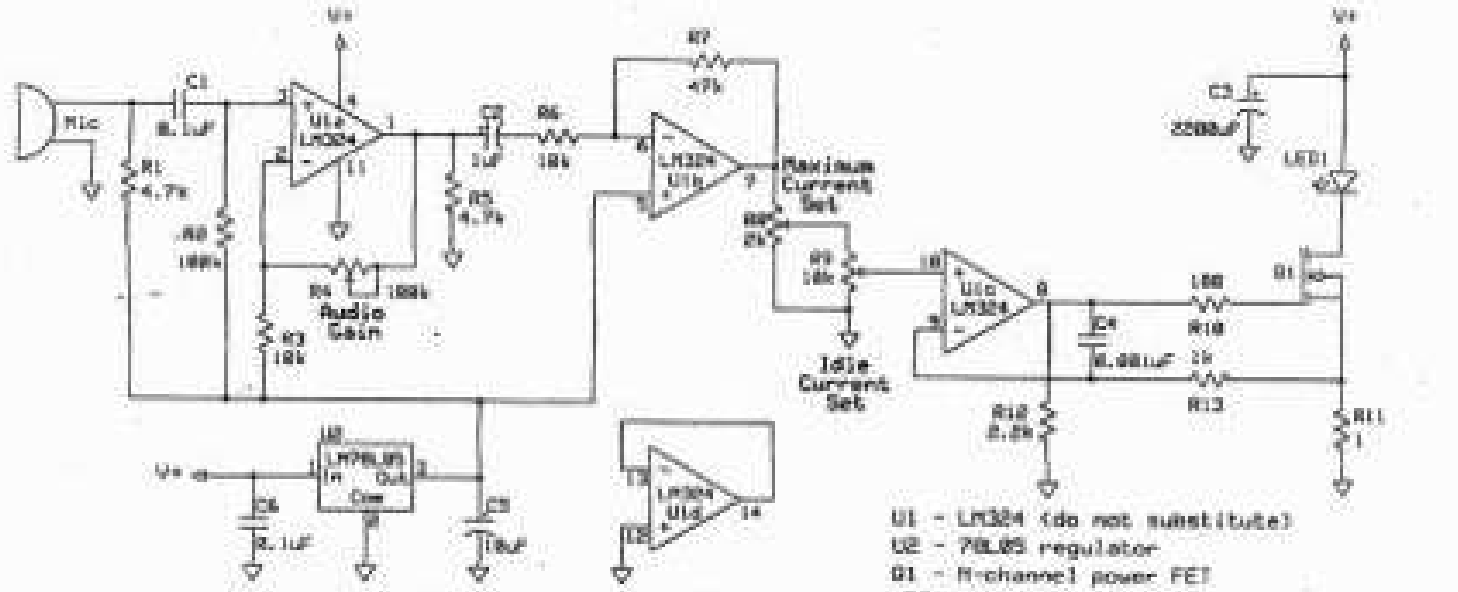
* OPTICAL UNITS:

Ångstrom: Measure of Wave-Length. 1 Å = 1×10^{-10} meters (10Å = 1nm).
Candela: Measure of Intensity per Area. 1 cd = 1 lumen/steradian.
Candle (Int): Same as Above. 1cd = 1 lumen/steradian.
Candle Power: Measure of Radiation, equal to 12.566 lumens.
Foot-candle: Measure of Intensity per Area, equal to 1 lumen/sq. ft.
Lambert: Measure of Intensity per Area, equal to 1 lumen/sq. cm.
Lumen: Measure of Radiation, equal to 0.07958 candle-power (spherical).
1 Lumen = 0.0015 watt, or 1 watt ≈ 666.7 lumens.
Lux: Measure of Intensity per Area, equal to 1 lumen/sq. meter.
nanometer: Measure of Wave-Length. 1nm = 1×10^{-9} meters (1nm = 10Å).
Radian: Angular Measure. 1 Radian = Circle circumference / 2π.
1 Radian ≈ 57.2958 degrees.
Steradian: "Solid" Angular Measurement. 1 sr = 1 sq. radian
12.57 sr covers a sphere, or 1 sr = 0.079577 spheres.
terahertz: Measure of Frequency. 1THz = $1\times10^{+12}$ Hz., or 1×10^{6} MHz.

* FREQUENCY AND WAVE-LENGTH:

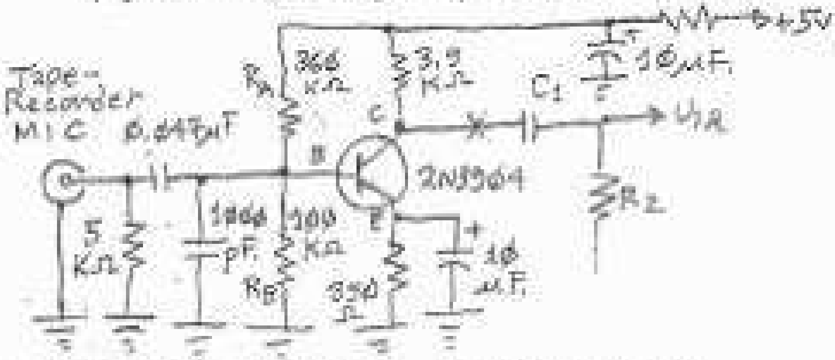
$f = \frac{c}{\lambda}$ and $\lambda = \frac{c}{f}$,
where f = Frequency in Hz, λ = Wave-Length in Meters, $c = 3\times10^{8}$ meters/sec.
If λ is in nanometers (nm), and f is in terahertz (THz), this simplifies to $f = 300{,}000 \div \lambda$, and $\lambda = 300{,}000 \div f$.

KA7OEI SIMPLE L.E.D. MODULATOR with MODIFICATIONS. Dale Clement, AFIT. 13 November, 2018.



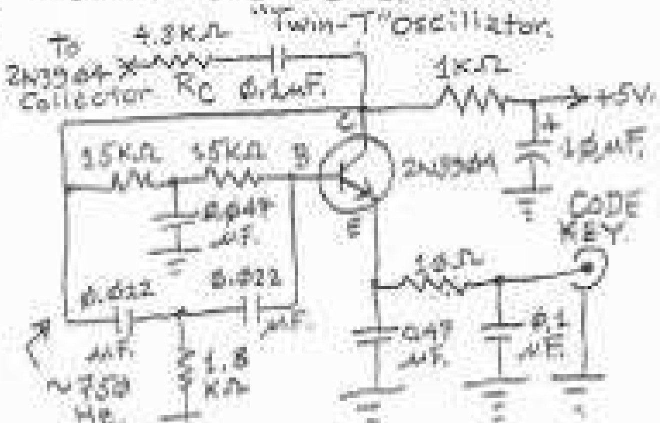
Simple high-current, adjustable LED modulator
Ver. 1.03b KA7OEI

ADDED MIC. PRE-AMPLIFIER.



Select RA, RB for $V_C \simeq +2.6$ to $+2.7$ V, and $V_E \simeq +0.2$ V
Alternative Values: $R_B = 240$ KΩ, $R_A \approx 560$ KΩ.
A capacitor (up to 0.047 μF) may be added from 2N3904 Collector to Ground, to reduce High-Frequency Response.

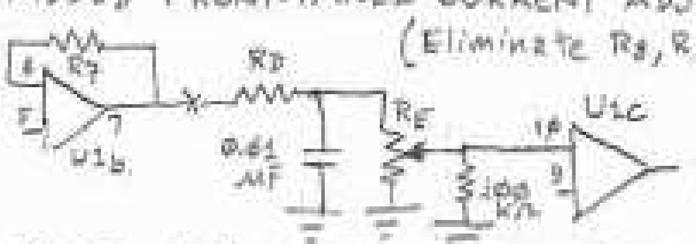
ADDED TONE GENERATOR.



Select R_C for 100 Modulation (No Clipping on negative peaks) on Oscilloscope.

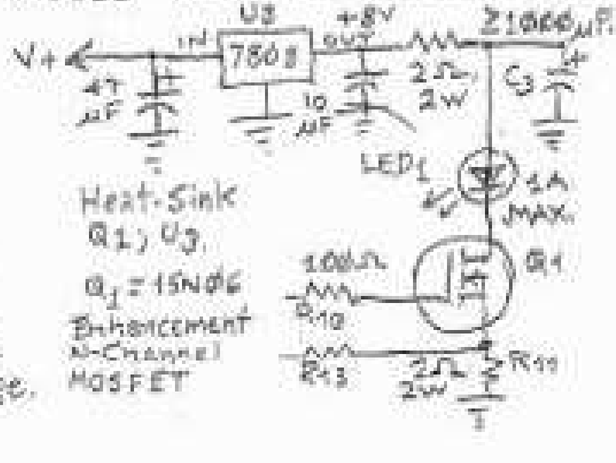
ADDED FRONT-PANEL CURRENT ADJUST.

(Eliminate R_8, R_9)



RE = Front-Panel Potentiometer (1KΩ or 5KΩ)
Select RD for Safe Maximum L.E.D. Current (Typically 3 Times RF for 1 A max.; 3KΩ or 15KΩ).
Calibrate Dial for L.E.D. Current; Measure R_{11} Voltage.

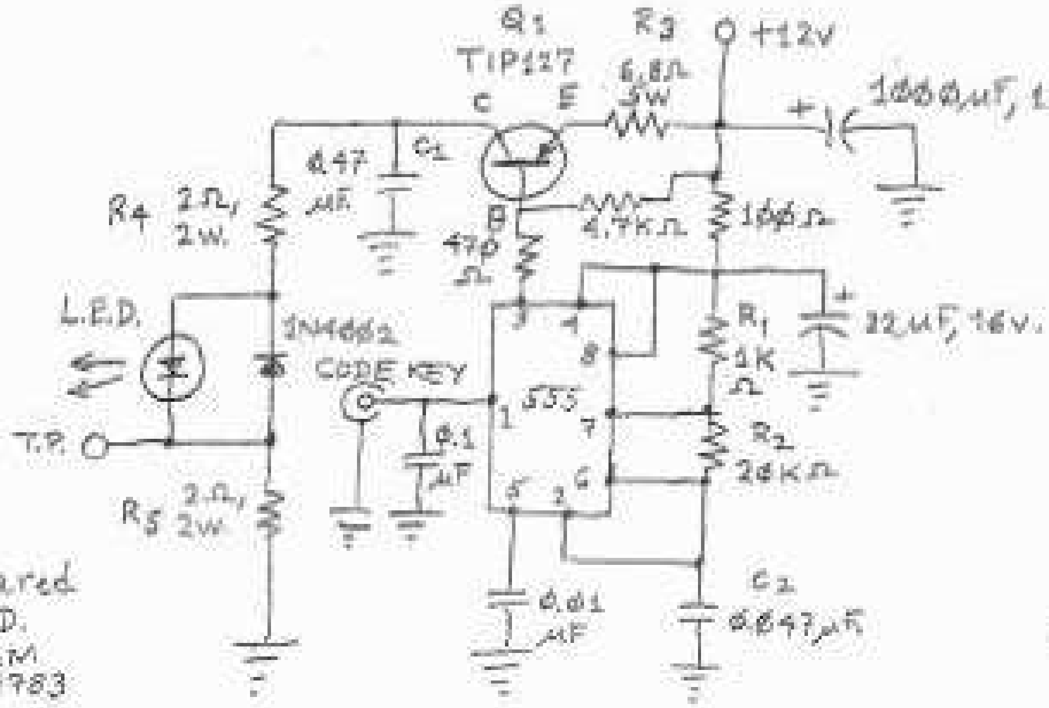
ADDED VOLTAGE-REGULATION.



SIMPLE C.W. L.E.D. OPTICAL TRANSMITTER.

Dale Clement, AF1T 13 November, 2018

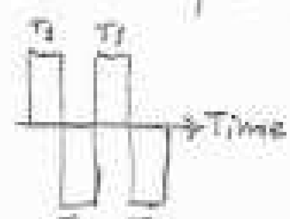
L.E.D. is activated only when KEY is closed.



Infrared L.E.D. OSRAM SFH 4783 (860nm, 1W)

Bottom View

Oscilloscope.



The 555 I.C. produces Square waves at Pin 3 when Pin 1 is keyed to Ground. R_1, R_2, C_2 determine Frequency: $f \approx \frac{1.46}{(R_1 + 2R_2)C}$ R in Ohms, C in Farads. The Ratio of R_1, R_2 determines T_1 vs T_2. Values shown give $T_1 \approx T_2$ (50% Duty Cycle, which is Best), and $f \simeq 750$ Hz. $R_1 = 10$kΩ and $C_2 = 0.1\mu F$ may be used instead.

R_1, R_2, R_3 are chosen to set the <u>maximum</u> current through the L.E.D. Subtract the L.E.D. voltage from the 12V supply (Use ~2.0V for a Red L.E.D., and ~1.5V for an Infrared L.E.D.), and test by shorting Q_1 Emitter to Collector. Measure Voltage accross R_5 at T.P. (e.g., 1V indicates current of 1A). With Square Wave 50% Duty-Cycle, the D.C. voltage at T.P. will average to ~ ½ this value, and the L.E.D. will have ~ ½ the chosen maximum current.

Q_1 = P.N.P. switching Transistor (may not need Heat Sink).

C_1 may be increased to round-off Square Waves (Reduce Harmonics)