

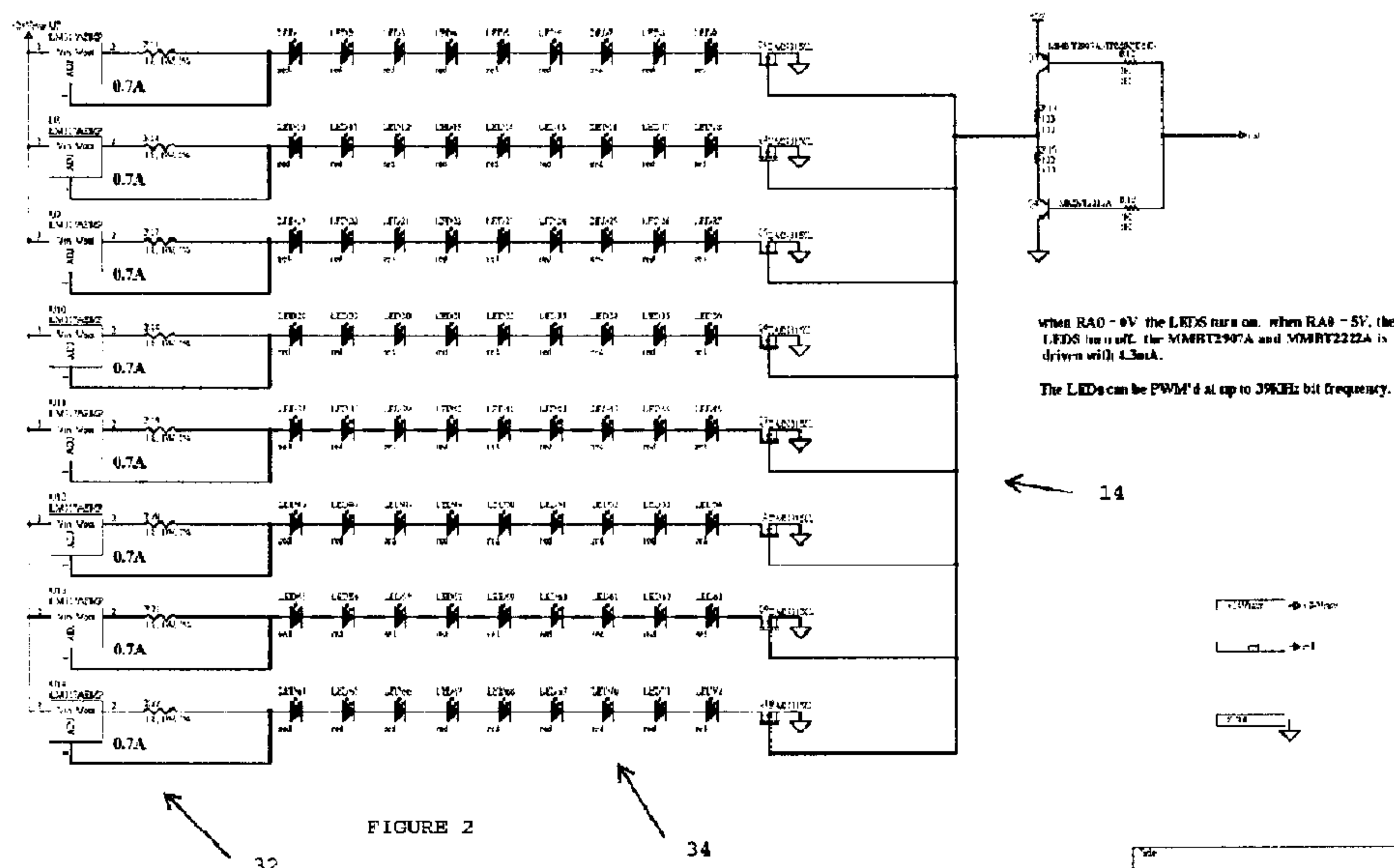


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(54) Titre : APPAREIL ET PROCEDE POUR LA MANIPULATION DU METABOLISME DE VEGETAUX A L'AIDE D'UNE
PUISSANCE SPECTRALE
(54) Title: AN APPARATUS AND METHOD FOR PLANT METABOLISM MANIPULATION USING SPECTRAL OUTPUT

[Fig. 2]



(57) Abrégé/Abstract:

An array or multiple arrays of energy efficient LEDs are configured in proximity to plant life to emit light energy in a variety of photosynthetic promoting frequencies and power outputs. Specific light frequencies are selected after analyzing the photosynthetic properties of the plant of interest. The LEDs are remotely controlled and can be remotely controlled through a handheld device using a GUI adapted for that purpose. A variety of LEDs emitting a variety of photosynthetically useful wavelengths are arrayed together. The array can be controlled to emit pre-dawn and after-sunset glows. The array can also be used to inhibit plant growth by adjusting frequencies.



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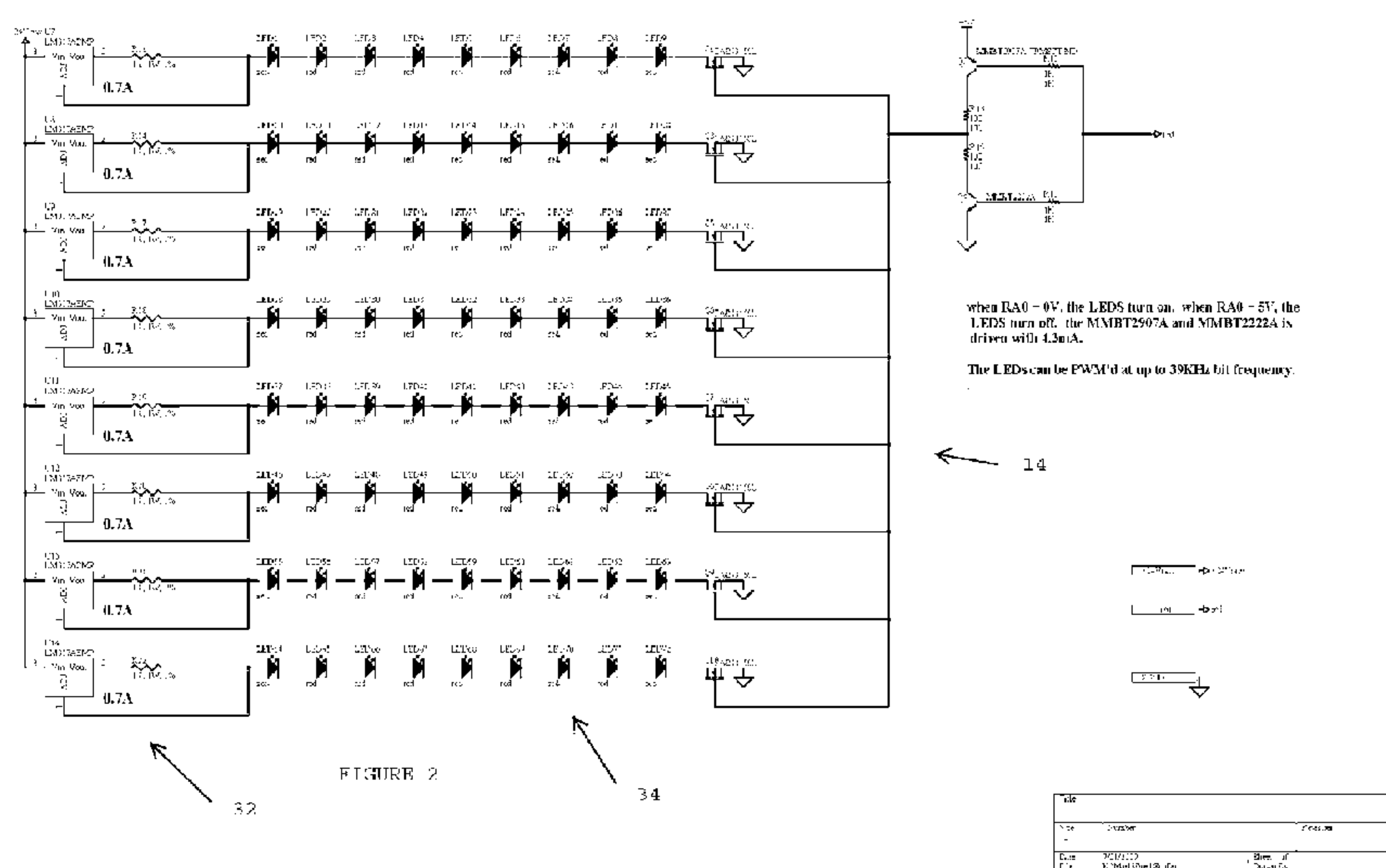
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(54) Title: AN APPARATUS AND METHOD FOR PLANT METABOLISM MANIPULATION USING SPECTRAL OUTPUT

[Fig. 2]



(57) Abstract: An array or multiple arrays of energy efficient LEDs are configured in proximity to plant life to emit light energy in a variety of photosynthetic promoting frequencies and power outputs. Specific light frequencies are selected after analyzing the photosynthetic properties of the plant of interest. The LEDs are remotely controlled and can be remotely controlled through a handheld device using a GUI adapted for that purpose. A variety of LEDs emitting a variety of photosynthetically useful wavelengths are arrayed together. The array can be controlled to emit pre-dawn and after-sunset glows. The array can also be used to inhibit plant growth by adjusting frequencies.

Description

Title of Invention: AN APPARATUS AND METHOD FOR PLANT METABOLISM MANIPULATION USING SPECTRAL OUTPUT

Technical Field

Technical Field

[1]

Background Art

Background Art

[2]

Disclosure of Invention

Technical Problem

[3]

Technical Solution

[4]

Advantageous Effects

[5]

Description of Drawings

[6]

Best Mode

[7]

Mode for Invention

[8]

Industrial Applicability

[9]

Sequence List Text

[10]

[11] **TITLE OF THE INVENTION**

[12] AN APPARATUS AND METHOD FOR PLANT METABOLISM MANIPULATION USING SPECTRAL OUTPUT

[13] **CROSS REFERENCE TO RELATED APPLICATIONS**

[14] This patent application is entitled to the benefit of Provisional Patent Application #61083886 filed on July 25, 2008 in the USPTO.

[15] **FIELD OF THE INVENTION**

[16] This invention relates to illumination and radiant energy, and more specifically, to an apparatus and method for plant metabolism manipulation using spectral output.

[17] **BACKGROUND OF THE INVENTION**

- [18] It has long been well known that proper lighting is a key ingredient in promoting robust and healthy plant growth. It is also known that optimized spectral outputs can be achieved to meet the specific needs of various plants during their growth phases. Known grow lamps are very energy intensive and adapted for delivering a high lumen output. Wattages of these high intensity arc-tube lamps range from 400W to 1100W. In commercial hydroponic and horticultural applications many of these lamps may be required. Therefore, it is readily observed that the aggregate power consumption of these types of lamps in a commercial operation is large and hence expensive. Much of the electrical energy consumed by a high intensity lamp is wasted in the form of heat. With rising energy costs there is a need to reduce the power consumption of grow lamps while maintaining their ability to stimulate desired plant growth. It is further desired to have a low energy consumption device that produces photosynthetically active radiation (PAR) at wavelengths that are usable by the plants. It is also further desired to have a grow lamp able to withstand the humidity and aerosol water droplets commonly found in greenhouse environments. It is further desired to have a lamp which needs little or no maintenance. It is further desired to have a lamp with an exceedingly long depreciation curve and working life.
- [19] Other sources of light, for example light emitting diodes (LEDs), are known to be capable of producing useful PAR with relatively small power consumption, virtually no heat, and a very long life. Therefore, these other sources of light, for example LEDs, can be adapted as grow lamps to offer a solution to the high power consumption of high intensity lamps.
- [20] Another shortcoming of current high intensity grow lamps is that they produce light by electrically arcing open current between an anode and cathode for the purpose of heating of high pressure gasses to a state of excited black body emission. This is essentially the same primitive principle resulting in the glow from an electric range element, except in that case the electricity stays safely within the heating element. The problem is that much of the power released in an arc lamp is emitted as photons which are directionally indiscriminately. Furthermore, the energy released falls largely in bands of the spectrum that are not useful for the stimulation of plant growth. Indeed, there is evidence that the light power emitted by such systems may be detrimental to stages of plant development not directly involved in perennial harvest.
- [21] In our research, we have found that photosynthesis is not the sole use of light made by plants. Although they do get their primary operational energy source from photosynthesis, it has become clearer that many parts of the spectrum are used for environmental signalling in several dimensions. For example, competition for sunlight from other biota, temporal signals of both sidereal and seasonal cycles, atmospheric

temperatures, the presence or absence of cloud cover, are just a few of the photometric environmental signals being read and understood by plant (and other forms of) life.

- [22] It follows that LEDs will be useful in mimicking these environmental signals for existing natural plants of all descriptions, and may indeed be useful for sending specifically pre-programmed signals to genetically modified life forms including but not limited to plants.
- [23] Another useful example implementing this principle is the ability to continuously vary the power outputs of multiple bands of phototropic radiation. The greatest power is placed into those bands which feed photosynthesis. These are 450nm-470nm and 640nm-670nm. However, other notch spectral bands have been added for such environmental signals as day/night cycles (@730nm), seasonal cycles (@600nm), and competitive signals (@525nm). There are other notch spectral bands of interest in the ultraviolet range which is the ultraviolet-A environmental signals lying between 360nm-410nm. These signals may trigger harsh condition preparedness in plant life.
- [24] One advantage of the present invention is that any or all of the wavelengths mounted in a particular manufacture of our light emitting computer (LEC) can be changed during automated assembly without pause to the construction process. When research discovers new spectral power bands of influence to any form of life, biochemical process, or inorganic process; an LEC can be manufactured to provide the power necessary at the time and level to influence or drive multiple (up to six in one embodiment of the invention) spectrally specific phototropic processes, which may be sequential or parallel in their progression through time.
- [25] The LEC of our invention is designed to provide an application program interface (API) to a user programming system or graphical user interface (GUI) for the on board embedded computer. This permits a plurality of programs to be written for execution on the LEC. These programs will provide continuously variable power control over a range of phototropic wavelength specific emitters to energize and otherwise influence specific responses from plant life.
- [26] It is intended that in one embodiment of our invention, the apparatus will be used for implementing Phototropic Morphosis Management System (PMMS) methodology by the larger agronomy community to explore all forms of phototropic signalling and photosynthesis manipulations for an infinite variety of plant growing configurations. Utilizing PMMS with the present invention will result in an increasing range of knowledge in the agronomy community, which is one of humanity's largest and oldest. The present invention is therefore well adapted to the establishment of an open source community within which new knowledge of phototropic influences and optimizations for plant and other forms of life will be implemented, shared, and traded in the form of PMMS programs created to be run on the various embodiments of our invention.

[27] Thus is created an entire domain of intellectual property within the structure of the LEC to run PMMS software for users, who in turn may then create new individual and highly specific implementations of new examples of PMMS software for the purpose of influencing a particular plant to grow in a particular fashion, which new PMMS programs those users may then trade or share within the larger LEC using community.

[28] **SUMMARY OF THE INVENTION**

[29] Our invention comprises the following major components: a front end GUI, the previously mentioned PMMS and the LEC.

[30] The GUI permits programming of the invention using all currently used operating systems. The GUI is also adaptable to hand held digital devices.

[31] The PMMS ('Phototropic Morphosis Management System') is the application software used to drive the invention.

[32] The LEC is the 'Light Emitting Computer' which emits the appropriate types, strengths, frequencies of photosynthetic light.

[33] The apparatus is an intelligent device which can be networked in large serial and parallel arrays having a single master controller. Other devices can be designed to be placed into and interact with the network, such as environmental sensors and controls or security devices. In this way an LEC network and client side computer can be configured to automate and maintain large installations. Client control is achievable using a portable handheld device, remotely.

[34] Two very adaptable applications of our invention include Aquaponics which are combined land-locked fish and hydroponics farms and High Rise Farming comprising urban conversions of existing skyscrapers and new architectures based on high density vertical farm implementations.

[35] What follows are a few examples of possible configurations of our invention:

[36] In one embodiment of our invention 150 watts of photosynthetically active radiation is emitted. This embodiment includes a twilight sidereal cycle phytochrome manipulator and photosynthesis promoting system.

[37] In another embodiment of our invention 385 watts of photosynthetically active radiation is emitted. This embodiment includes networking means for a grid of up to 31 x 31 units.

[38] In another embodiment of our invention there is a single 4 watt single plant illuminator having full spectral control and continuous power variability over four spectral power bands: 470nm, 525nm, 668nm, and 730nm utilizing and implementing the PPF-RGB-LED with on board physical controls and serial API implementation in arrays of up to 31 x 31 units.

[39] In yet another embodiment of our invention there is a larger 12 watt single plant illuminator with full spectral control and continuous power variability over four spectral

power bands: 470nm, 525nm, 668nm, and 730nm with on board physical controls and serial API implementation in arrays of up to 31 x 31 units.

- [40] In still another embodiment of our invention there is a 13 watt single plant illuminator with full spectral control and continuous power variability of four spectral power bands: 470nm, 525nm, 668nm, and 730nm utilizing and once again implementing the PPF-RGB-LED with on board physical controls and serial API implementation in arrays of up to 31 x 31 units.
- [41] In another embodiment of the invention there an emitter design of 585 watts which is fully programmable and has fully variable power output over six spectral power bands. This embodiment can be fully network.
- [42] In another embodiment of the invention, the emitters are selected to inhibit plant growth. Wavelengths that inhibit plant growth are between 600nm and 610nm. There are many applications where such an array of plant growth inhibiting LEDs can be applied such as street lights to inhibit plant growth around them while at the same time emitting visible yellow-orange light.
- [43] Modular embodiments of up to 10,000 watts for larger scale aeroponic applications are possible.
- [44] Therefore, the shortcomings and deficiencies of traditional technologies cited earlier are resolved by our invention which is an apparatus for plant metabolism manipulation using spectral output comprising an array of light sources having photosynthetic promoting spectral emissions, means for controlling the spectral emissions in a programmable manner operatively connected to the array and a power source operatively connected to the array and the means for controlling the spectral emissions.
- [45] To promote plant growth the array does not contain any sources of spectral emissions that have known deleterious effects on plant growth such as UV-b and UV-c. The array has no known electromagnetic emission of any description beyond those intended by design. However, in other embodiments of the invention the array may have light sources that do contain spectral emissions that inhibit plant growth for applications such as control of unwanted plant growth such as weed control applications. A good example of this application would be to have a lighting array installed on a highway having spectral emissions that would deter plant growth on road shoulders while at the same time providing a suitable level of light for traffic.
- [46] In other embodiments of the invention the lighting array has spectral emissions that are adapted to specific industrial uses such as curing paint, ink or adhesives. Other embodiments may have spectral emissions that aid in non-destructive testing of manufactured parts.
- [47] In one embodiment of the invention the array of light sources comprises a first plurality of identical light sources having a first spectral emission, a second plurality of

identical light sources having a second spectral emission and a third plurality of identical light sources having a third spectral emission.

- [48] In other embodiments of the invention, there may be additional pluralities of light sources having other spectral emission characteristics to suit the application some of which are exemplified above. The photosynthetic characteristics of any plant can be used to design a grow lamp having an array of light sources with photosynthetic promoting characteristics and lacking growth inhibiting spectral emissions.
- [49] In one embodiment of the invention the first, second and third pluralities of light sources populate a respective first, second and third distinct surface areas of the array.
- [50] In another embodiment of the invention the first, second and third pluralities of light sources are mixed to populate the entire surface of the array. Again, the arrangement of light sources on the array is determined by the photosynthetic characteristics of the plant of interest for optimized stimulation or repression of photosynthesis and other phototropic metabolic functions as desired.
- [51] In one embodiment of the invention the light source array is fixed to a circuit board. In another embodiment of the invention the first, second and third spectral emissions are at respective first, second and third photosynthetic promoting wavelengths. In other embodiments of the invention there may be a combination of light sources that promote growth of certain plants but inhibit growth of other plants.
- [52] The control means comprises a programmable microcontroller (with internal battery-backed-up clock) adapted to transmit commands to the array of light sources. The commands include, for each specific light source plurality, on and off commands at up to 36Khz, providing functional intensity control as well as 'on' and 'off' control signals. The array can be programmed to suit any lighting condition desired for optimizing photosynthesis and other phototropic metabolic functions in a plant of interest.
- [53] The commands may also include pre-glow and afterglow commands to simulate dawn and sunset. In other embodiments the commands may include commands that inhibit growth of undesirable plants at specific and vulnerable states of their growth cycle. In operation, the programmable controller is adapted to command the array of light sources to emit predetermined wavelengths of energy falling within a range of photosynthetic promoting energy for a predetermined period of time.
- [54] The power source is an AC power source in one embodiment of the invention and a DC power source in another embodiment of the invention.
- [55] The invention also includes a method for plant metabolism manipulation using spectral output comprising the steps of:
- [56] a. Determining the photosynthetic properties of a plant of interest;
- [57] b. Fabricating an array of light sources comprising in combination desired pluralities of light sources having 6 desired spectral emissions of various maximum power po-

tentials that are compatible with the photosynthetic and other phototropic properties of the plant of interest;

[58] c. Placing the plant of interest in desirable proximity to the array of light sources; and,

[59] d. Operatively connecting a programmable microprocessor to the array of light sources wherein the programmable microprocessor is adapted to transmit commands to the desired pluralities of light sources so that they emit the desired spectral emissions at a desired time and for a desired period at a desired intensity.

[60] The method may also include the step of simulating a predawn glow. The method may also include the step of simulating an after sunset glow. In another embodiment of the invention the method may also include the step of strobing specific pluralities of light sources for desired time intervals at desired intensities for various phototropic effects on plants or other light sensitive systems.

[61] **BRIEF DESCRIPTION OF THE DRAWINGS**

[62] Figure 1 is a schematic of a first embodiment of the invention.

[63] Figure 2 is a schematic of the red LED array of the first embodiment.

[64] Figure 3 is a schematic of the blue LED array of the first embodiment.

[65] Figure 4 is a schematic of the green LED array of the first embodiment.

[66] Figure 5 is a schematic of the yellow LED array of the first embodiment.

[67] Figure 6 is a schematic of the deep red #1 LED array of the first embodiment.

[68] Figure 7 is a schematic of the deep red #2 LED array of the first embodiment.

[69] Figure 8 is a schematic of the deep red #3 array of the first embodiment.

[70] Figure 9 is a schematic of the deep red #4 array of the first embodiment.

[71] Figure 10 is a schematic of the optional array of the first embodiment.

[72] Figure 11 is a schematic of a second embodiment of the invention.

[73] Figure 12 is a schematic of the 730nm array of the second embodiment.

[74] Figure 13 is a schematic of the 660nm array of the second embodiment.

[75] Figure 14 is a schematic of the 610nm array of the second embodiment.

[76] Figure 15 is a schematic of the 530nm array of the second embodiment.

[77] Figure 16 is a schematic of the 450nm array of the second embodiment.

[78] Figure 17 is a schematic of the 430nm array of the second embodiment.

[79] Figure 18 is a schematic of a third embodiment of the invention.

[80] Figure 19 is a schematic of a communication option for the third embodiment.

[81] Figure 20 is a schematic of the switch option for the third embodiment.

[82] Figure 21 is a schematic of a fourth embodiment of the invention.

[83] Figure 22 is a schematic of a communication option for the fourth embodiment.

[84] Figure 23 is a schematic of a switch option for the fourth embodiment of the invention.

[85] **DETAILED DESCRIPTION OF THE INVENTION**

[86] The purpose of the invention is to advance the art of agriculture at the level of photo-sensitive biochemical activity in plants, particularly photomorphogenesis and photosynthesis but not restricted to these positive applications. Specifically, the invention is adapted for programmable and controlled emission of phototropically active portions of the electromagnetic spectrum though both amplitude and time domain modulation which shall be then synchronized and harmonized with related metabolic processes to manipulate the target botanical.

[87] The invention comprises an apparatus and method for plant metabolism manipulation using the spectral output of light sources such as LEDs. The use of a digitally controlled quantum mechanical source of light (such as an LED) rather than high intensity grow lamps offers to the inventor further advantages than merely the low power consumption, low heat output, and incredibly long useful life spans found elsewhere in the LED lighting industry; but further improves the state of the art through the utilization of special properties of LED such as selective spectral wavelength output and most especially through the ability to infinitesimally manipulate the various time domains of plant exposure to specific levels of energy at those specific spectral wavelengths.

[88] The light source emitters can be configured in any combination of desired wavelengths to suit specific plant photosynthesis and other phototropic metabolic functions needs during propagation, vegetation and the fruiting/flowering stage. Alternatively the light source emitters can be configured to inhibit plant growth of unwanted plants as well as other industrial applications such as curing paint or adhesives. As well, the emitters can be oriented in any direction and in close proximity to the plants without burning them with waste heat. The emitter of this invention is computer controlled. As such, it represents a significant step forward in the state of the art of grow lamps. Prior art grow lamps are not capable of accurately simulating the type of light a plant would receive at dawn (pre-glow) or at dusk (after-glow) as the sun rises and sets. The ability to simulate this type of light in a grow lamp has a positive effect on plant growth and improves the ability to manipulate plant metabolism. Other advantages of computer controlled spectral emissions of our invention include the ability to force flowering, manipulate inter-nodal distances, initiate vegetative regression, and drive root propagation.

[89] In one embodiment of the invention which is exemplary only there is a light source comprising an array of LEDs comprising 100 735nm 120mW 5mm thru-hole LEDs, 900 660 100mW 5mm thru-hole LEDs, 1 MCPCB-star mounted 1W 660nm LED, 35 MCPCB-star mounted 1W 640nm LEDs, 4 MCPCB-star mounted 1W 610nm LEDs, 4 MCPCBstar mounted 3W 530nm LEDs and 6 MCPCB-star mounted 3W 450nm

LEDs. These are computer controlled and mounted to a circuit board.

[90] In another embodiment of the invention there is a circuit board populated with a plurality of LEDs to form a grow lamp having 207 x 730nm 180mW SMD-PICC2 LEDs, 2880 x 660nm 60mW SMD-0603 LEDs, 3 x 610nm 3W SMD-Luxeon LEDs, 3 x 530nm 3W SMD Luxeon LEDs and 390 x 430nm 150mW SMD0805 LED. They are bunched in groups according to their spectral frequency and electrical characteristics. The LEDs are computer controlled and therefore we can turn off or on different groups, i.e. spectral frequencies (or ranges of frequencies). A microcontroller is placed on the lamp board which we use to turn on/off the different groups according to a schedule implemented in software which is user controlled by either jumpers on the board, or through a communications channel with some other device sending commands for the on board computer to follow.

[91] In yet another embodiment of the invention there is the ability to vary the output power of each different frequency group by altering the current flowing through any sub-group. Currently, we are using a 24V 500+W power supply that is off board and connected through a cable to the lamp array. We then have current limiting circuits for each subgroup emplaced upon the circuit board to control the current through the various groups of light sources. The micro-controller turns on and off different groups at different times by way of a switch controlling power to said modules. Relays are used for switches. In another embodiment of the invention there is variable output current control having a switching function built in.

[92] The light source array can be programmed to a wide variety of uses in the fields of botanical research and agricultural production techniques.

[93] The light source array can comprise a wide variety of wavelength and intensity 'blends'. For example, one array may comprise:

[94] 5W of 730nm

[95] 30W of 660nm

[96] 10W of 645nm

[97] 10W of 530nm

[98] 20W of 470nm

[99] The light source array can be programmed to strobe at a variety of frequencies, intensities and periods.

[100] In another example of the invention the following proportions of LEDs might be used:

[101] 19% 430nm

[102] 17% 450nm

[103] 2% 530nm

[104] 2% 610nm

- [105] 50% 660nm
- [106] 10% 730nm
- [107] This array of LEDs is supplied by a constant power and programmable for various light on/off cycles such as 6/18, 12/12 and 18/6. There is also an afterglow of 730nm for about one hour right after the lights are turned off for each cycle.
- [108] Another embodiment of the invention uses an array of light sources comprising emissions in the range of 360nm to 410nm, 450nm to 470nm, 520 to 530nm, 590nm to 615nm, 640nm to 670nm, and 720nm to 890nm with each wavelength operated using a dedicated controller. A micro-processor is then used to adjust the quality of the light emitted as the exposed plant matures. Since the light sources are placed on a large sized array, for example 40cm by 40cm, it is necessary to ensure that the exposed plant receives the appropriate amount of energy at the proper wavelength. To this end, the light sources may be equipped with holographic thin film Fresnel lenses that refract light to the plant. The closer the emitters are to the plant the greater the angle will have to be. In one embodiment of the invention emitters with holographic thin film Fresnel lenses creating a radiating arc in the range of 140 degrees are used.
- [109] A First Example of the Invention
- [110] Referring now to Figures 1 to 10 inclusive there is illustrated a first example of the invention. In Figure 1, there is shown a top-level schematic for one embodiment of the invention. The invention comprises a controller 10 electrically connected to a plurality of LED arrays comprising red 14, blue 16, green 18, yellow 20, deep red 1 22, deep red 2 24, deep red 3 26 and deep red 4 28. The circuit permits the addition of an optional array 30. The LED arrays can be made to strobe up to a frequency of 39KHz.
- [111] Figure 2 shows red circuit 14 comprising power connections 32 and a 9 by 8 array of LEDs 34.
- [112] Figure 3 shows blue circuit 16 comprising power connections 36 and a 6 by 12 array of LEDs 38.
- [113] Figure 4 shows green circuit 18 comprising power connections 40 and a 6 BY 3 array of LEDs 42.
- [114] Figure 5 shows yellow circuit 20 comprising power connections 46 and a 2 by 8 array of LEDs 48.
- [115] Figure 6 shows deep red circuit #1 22 comprising power connections 50 and An 11 by 6 array of LEDs 52.
- [116] Figure 7 shows deep red circuit #2 24 comprising power connections 54 and an 11 by 6 array of LEDs 56.
- [117] Figure 8 shows deep red circuit #3 26 comprising power connections 58 and an 11 by 6 array of LEDs 60.
- [118] Figure 9 shows deep red circuit #4 28 comprising power connections 62 and an 11 by

6 array of LEDs 64.

[119] Figure 10 shows optional circuit 30 comprising a power connection 66 and a 1 by 9 array of LEDs 68.

[120] A Second Example of the Invention

[121] Referring now to Figure 11 to 18 there is shown a second example of the invention.

[122] Figure 1 shows a control schematic of one embodiment of the invention.

[123] Figure 12 shows a circuit comprising a grid array of 9 by 10 LEDs having a wavelength of 730nm.

[124] Figure 13 shows a circuit comprising a grid array of 9 BY 10 LEDs having a wavelength of 660nm.

[125] Figure 14 shows a circuit comprising a grid array of 1 by 3 LEDs having a wavelength of 610nm.

[126] Figure 15 shows a circuit comprising a grid array of 1 by 3 LEDs having a wavelength of 530nm.

[127] Figure 16 shows a circuit comprising a grid array of 5 by 4 LEDs having a wavelength of 450nm.

[128] Figure 17 shows a circuit comprising a grid array of 5 by 10 LEDs having a wavelength of 430nm.

[129] A Third Example of the Invention

[130] Referring now to Figure 18 there is shown a third example of the invention. This embodiment comprises a controller controlling two grid arrays of 4 by 3 LEDs at 740nm.

[131] Figure 19 illustrates a communication option for this example whereby the LED arrays can be controlled remotely.

[132] Figure 20 illustrates an optional switching schema for this example of the invention.

[133] A Fourth Example of the Invention

[134] Figure 21 illustrates a circuit diagram of a fourth example of the invention comprising an array of 8 LEDs at 730nm.

[135] Figure 22 illustrates a communication option for the embodiment shown in Figure 21.

[136] Figure 23 illustrates a switch option for the embodiment shown in Figure 21.

[137] **CLAIMS:**

[138] What is claimed is:

[139] 1. 1. An apparatus for metabolism manipulation of life forms using spectral output comprising: an at least one array of light sources having metabolic promoting spectral emissions, a remotely programmable microcontroller for controlling said spectral emissions in a desired manner operatively connected to said array, software for driving said microcontroller, a memory for storing said software, a power source operatively connected to the array and a graphic

- user interface for an operator input to said apparatus.
- [140] 1. 2. The apparatus of claim 1, wherein said life forms are plants and said at least one array of light sources has photosynthetic promoting spectral emissions.
 - [141] 1. 3. The apparatus of claim 1, wherein said life forms are single-cell animals.
 - [142] 1. 4. The apparatus of claim 1, wherein said life forms are multi-cellular animals.

 - [143] 1. 5. The apparatus of claim 2 wherein said at least one array of light sources comprises a first plurality of identical light sources having a first spectral emission, a second plurality of identical light sources having a second spectral emission and a third plurality of identical light sources having a third spectral emission, wherein each of the first second and third pluralities of identical light sources are controlled by the microcontroller.
 - [144] 1. 6. The apparatus of claim 1 wherein the at least one array of light sources comprises a predetermined number of pluralities of identical light sources having a predetermined number of respective photosynthetic promoting spectral emissions so that said predetermined number of respective photosynthetic promoting spectral emissions is compatible with the photosynthetic characteristics of a plant of interest and sufficient to promote growth thereof.
 - [145] 1. 7. The apparatus of claim 2 wherein said first, second and third pluralities of light sources populate a respective first, second and third distinct surface areas of the at least one array.
 - [146] 1. 8. The apparatus of claim 2 wherein the first, second and third pluralities of light sources are mixed to populate the entire surface of the array.
 - [147] 1. 9. The apparatus of claim 2 wherein the at least one array and the microcontroller is fixed to a single circuit board.
 - [148] 1. 10. The apparatus of claim 2 wherein said first, second and third spectral emissions are at respective first, second and third photosynthetic promoting wavelengths.
 - [149] 1. 11. The apparatus of claim 1 wherein the microcontroller is adapted to transmit illumination commands to the at least first array of light sources.
 - [150] 1. 12. The apparatus of claim 8 wherein said illumination commands include, for each specific light source plurality, on commands, off commands, intensity commands and strobe commands.
 - [151] 1. 13. The apparatus of claim 8 wherein the commands further include preglow and afterglow commands.
 - [152] 1. 14. The apparatus of claim 8 wherein the microcontroller is programmed to command the array to emit predetermined wavelengths of photosynthetic promoting light for a first predetermined period of time.

- [153] 1. 15. The apparatus of claim 14, wherein the microcontroller is programmed to command the array to emit predetermined wavelengths of predetermined power outputs for a second predetermined period of time.
- [154] 1. 16. The apparatus of claim 1 wherein the at least one array of light sources is networked to another at least one array of light sources and wherein the networked array is controlled by said control means.
- [155] 1. 17. The apparatus of claim 1 wherein the at least one array of light sources is programmable remotely from a handheld device over the Internet.
- [156] 1. 18. The apparatus of claim 9 wherein said strobe commands activate the lights at a strobe frequency of 36 KHz.
- [157] 1. 19. The apparatus of claim 1, wherein said software is open source software.
- [158] 1. 20. A method for plant metabolism manipulation using spectral output comprising the steps of:
 - [159] 1. a. Determining the photosynthetic properties of a plant of interest;
 - [160] 1. b. b. Fabricating an array of light sources comprising in combination desired pluralities of light sources having desired spectral emissions that are compatible with said photosynthetic properties of said plant of interest;
 - [161] 1. c. Placing the plant of interest in desirable proximity to said array of light sources; and,
 - [162] 1. d. Operatively connecting a programmable microprocessor to the array of light sources wherein the programmable microprocessor is adapted to transmit commands to the desired pluralities of light sources so that they emit the desired spectral emissions at a desired time and for a desired period at a desired intensity.
- [163] 1. 21. The method of claim 12 further including the step of simulating a predawn glow.
- [164] 1. 22. The method of claim 13 further including the step of simulating an after sunset glow.
- [165] 1. 23. The method of claim 14 further including the step of strobing specific pluralities of light sources for desired time intervals at desired intensities.

[166] **ABSTRACT**

[167] An array or multiple arrays of energy efficient LEDs are configured in proximity to plant life to emit light energy in a variety of photosynthetic promoting frequencies and power outputs. Specific light frequencies are selected after analyzing the photosynthetic properties of the plant of interest. The LEDs are remotely controlled and can be remotely controlled through a handheld device using a GUI adapted for that purpose. A variety of LEDs emitting a variety of photosynthetically useful wavelengths are arrayed together. The array can be controlled to emit pre-dawn and

after-sunset glows. The array can also be used to inhibit plant growth by adjusting frequencies.

CLAIMS:

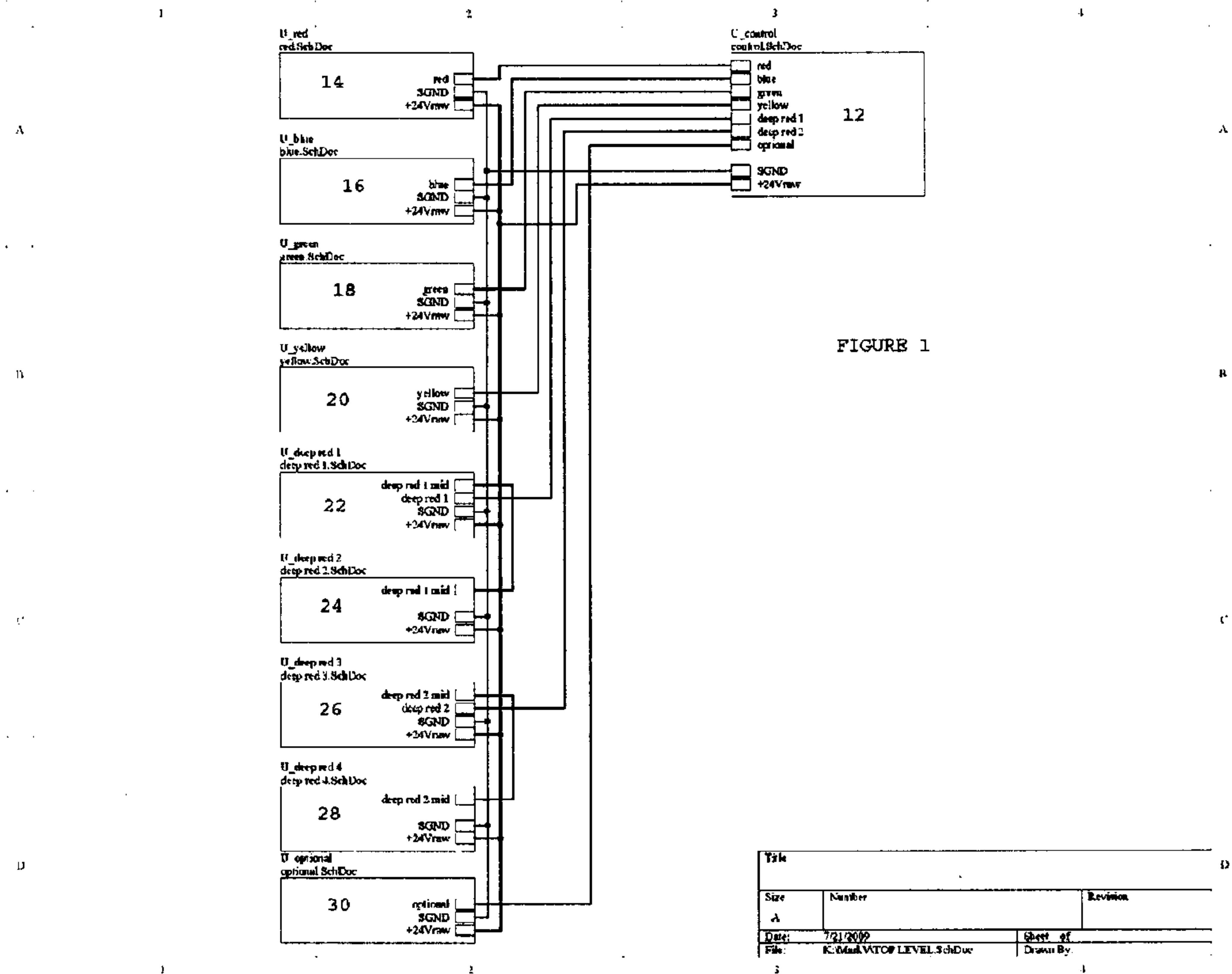
What is claimed is:

1. An apparatus for metabolism manipulation of life forms using spectral output comprising: an at least one array of light sources having metabolic promoting spectral emissions, a remotely programmable microcontroller for controlling said spectral emissions in a desired manner operatively connected to said array, software for driving said microcontroller, a memory for storing said software, a power source operatively connected to the array and a graphic user interface for an operator input to said apparatus.
2. The apparatus of claim 1, wherein said life forms are plants and said at least one array of light sources has photosynthetic promoting spectral emissions.
3. The apparatus of claim 1, wherein said life forms are single-cell animals.
4. The apparatus of claim 1, wherein said life forms are multi-cellular animals.
5. The apparatus of claim 2 wherein said at least one array of light sources comprises a first plurality of identical light sources having a first spectral emission, a second plurality of identical light sources having a second spectral emission and a third plurality of identical light sources having a third spectral emission, wherein each of the first second and third pluralities of identical light sources are controlled by the microcontroller.
6. The apparatus of claim 1 wherein the at least one array of light sources comprises a predetermined number of pluralities of identical light sources having a predetermined number of respective photosynthetic promoting spectral emissions so that said predetermined number of respective photosynthetic promoting spectral emissions is compatible with the photosynthetic characteristics of a plant of interest and sufficient to promote growth thereof.
7. The apparatus of claim 2 wherein said first, second and third pluralities of light sources populate a respective first, second and third distinct surface areas of the at least one array.
8. The apparatus of claim 2 wherein the first, second and third pluralities of light sources are mixed to populate the entire surface of the array.
9. The apparatus of claim 2 wherein the at least one array and the microcontroller is fixed to a single circuit board.
10. The apparatus of claim 2 wherein said first, second and third spectral emissions are at respective first, second and third photosynthetic promoting wavelengths.

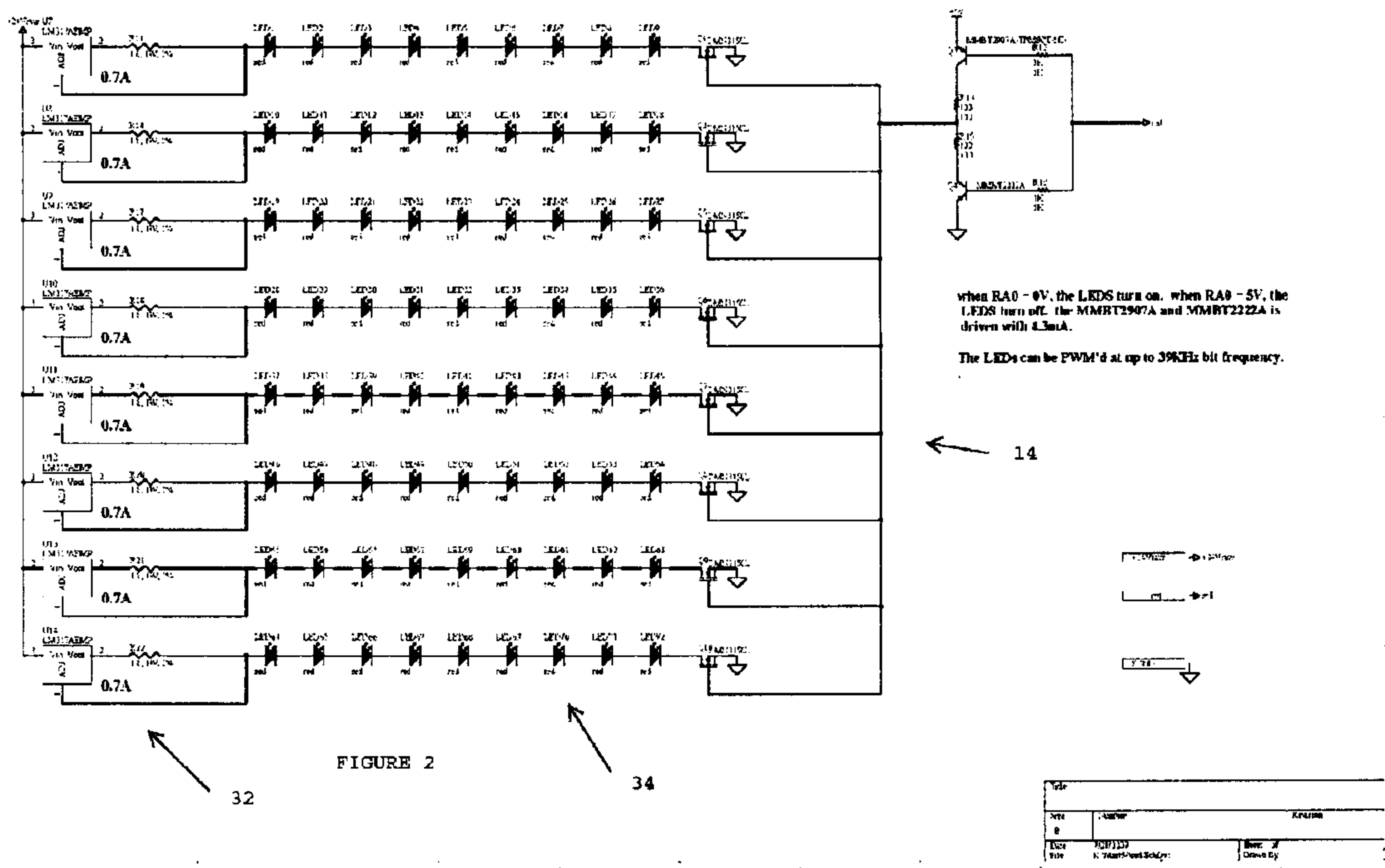
11. The apparatus of claim 1 wherein the microcontroller is adapted to transmit illumination commands to the at least first array of light sources.
12. The apparatus of claim 8 wherein said illumination commands include, for each specific light source plurality, on commands, off commands, intensity commands and strobe commands.
13. The apparatus of claim 8 wherein the commands further include preglow and afterglow commands.
14. The apparatus of claim 8 wherein the microcontroller is programmed to command the array to emit predetermined wavelengths of photosynthetic promoting light for a first predetermined period of time.
15. The apparatus of claim 14, wherein the microcontroller is programmed to command the array to emit predetermined wavelengths of predetermined power outputs for a second predetermined period of time.
16. The apparatus of claim 1 wherein the at least one array of light sources is networked to another at least one array of light sources and wherein the networked array is controlled by said control means.
17. The apparatus of claim 1 wherein the at least one array of light sources is programmable remotely from a handheld device over the Internet.
18. The apparatus of claim 9 wherein said strobe commands activate the lights at a strobe frequency of 36 KHz.
19. The apparatus of claim 1, wherein said software is open source software.
20. A method for plant metabolism manipulation using spectral output comprising the steps of:
 - a. Determining the photosynthetic properties of a plant of interest;
 - b. b. Fabricating an array of light sources comprising in combination desired pluralities of light sources having desired spectral emissions that are compatible with said photosynthetic properties of said plant of interest;
 - c. Placing the plant of interest in desirable proximity to said array of light sources; and,
 - d. Operatively connecting a programmable microprocessor to the array of light sources wherein the programmable microprocessor is adapted to transmit commands to the desired pluralities of light sources so that they emit the desired spectral emissions at a desired time and for a desired period at a desired intensity.
21. The method of claim 12 further including the step of simulating a predawn glow.

22. The method of claim 13 further including the step of simulating an after sunset glow.
23. The method of claim 14 further including the step of strobing specific pluralities of light sources for desired time intervals at desired intensities.

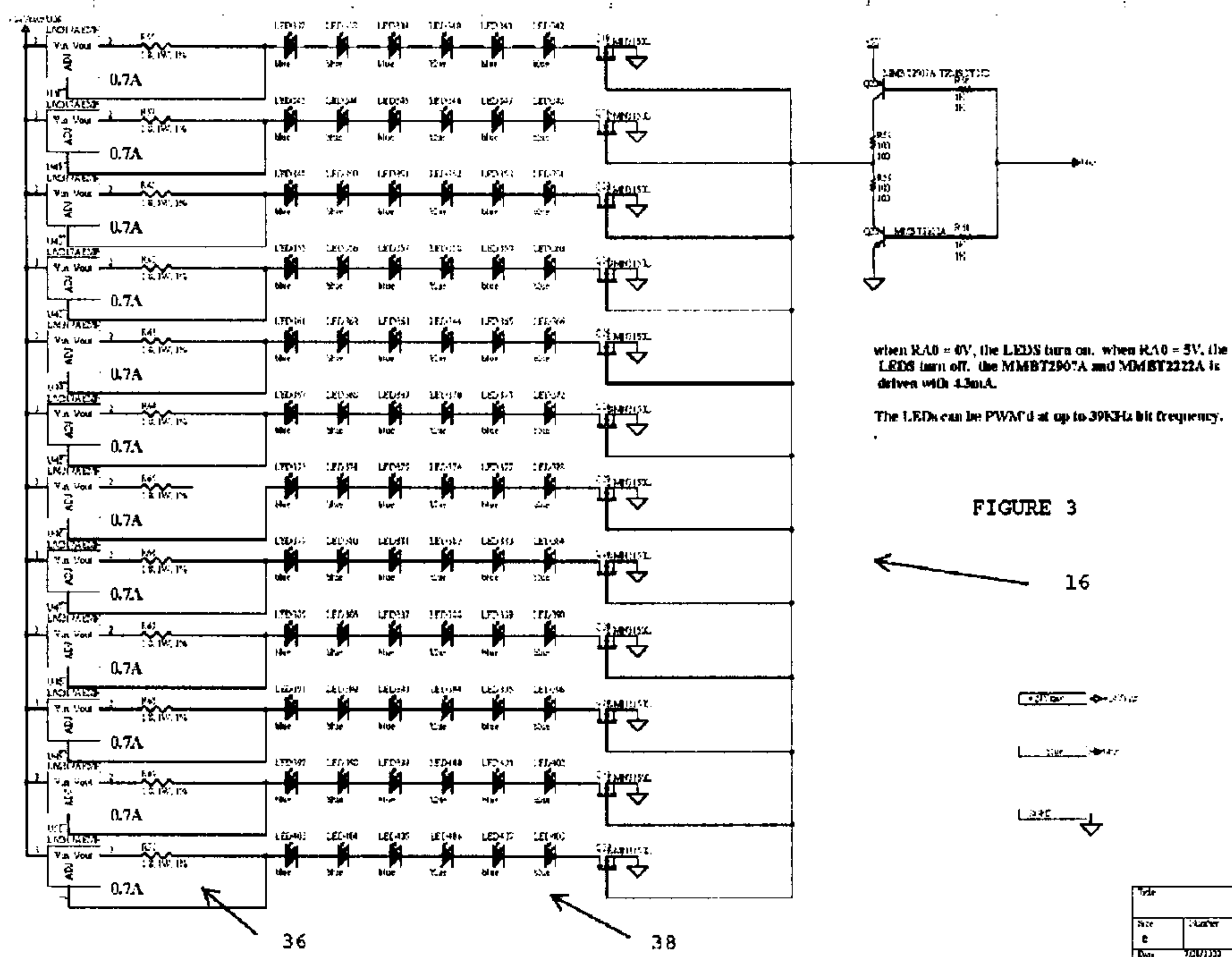
[Fig. 1]



[Fig. 2]



[Fig. 3]



[Fig. 4]

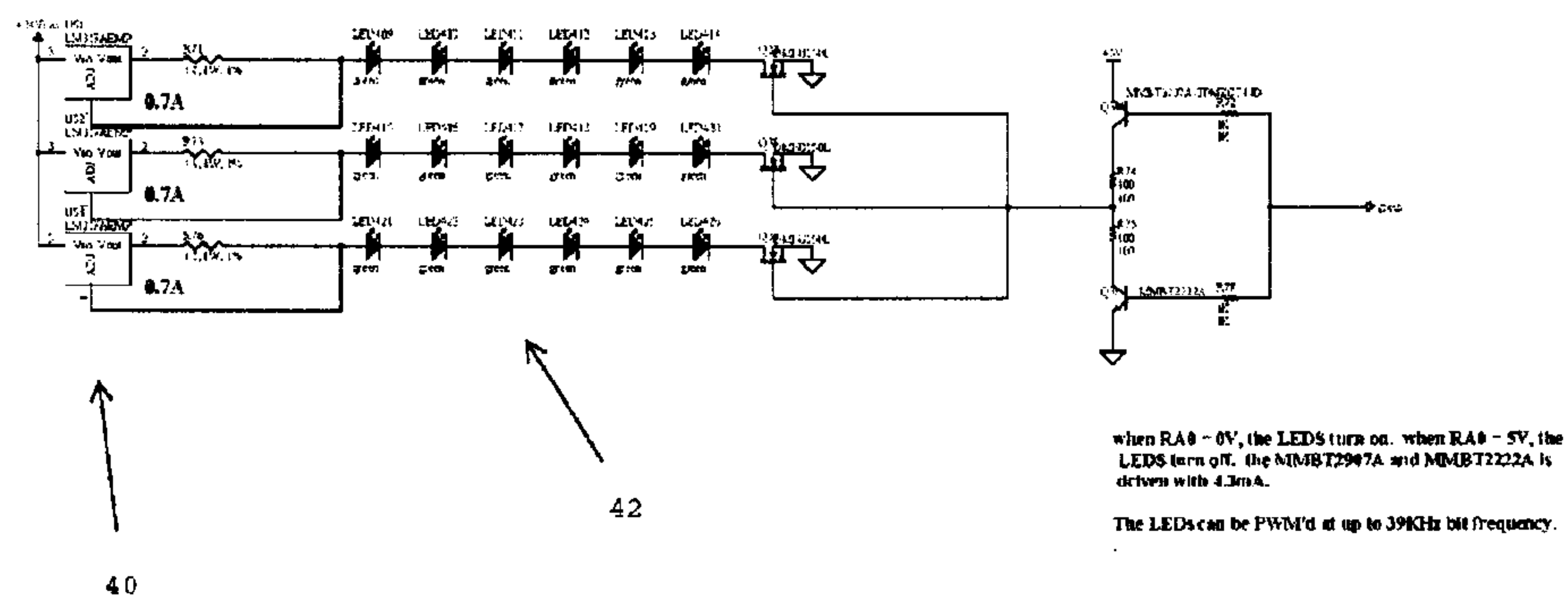


FIGURE 4

[Fig. 5]

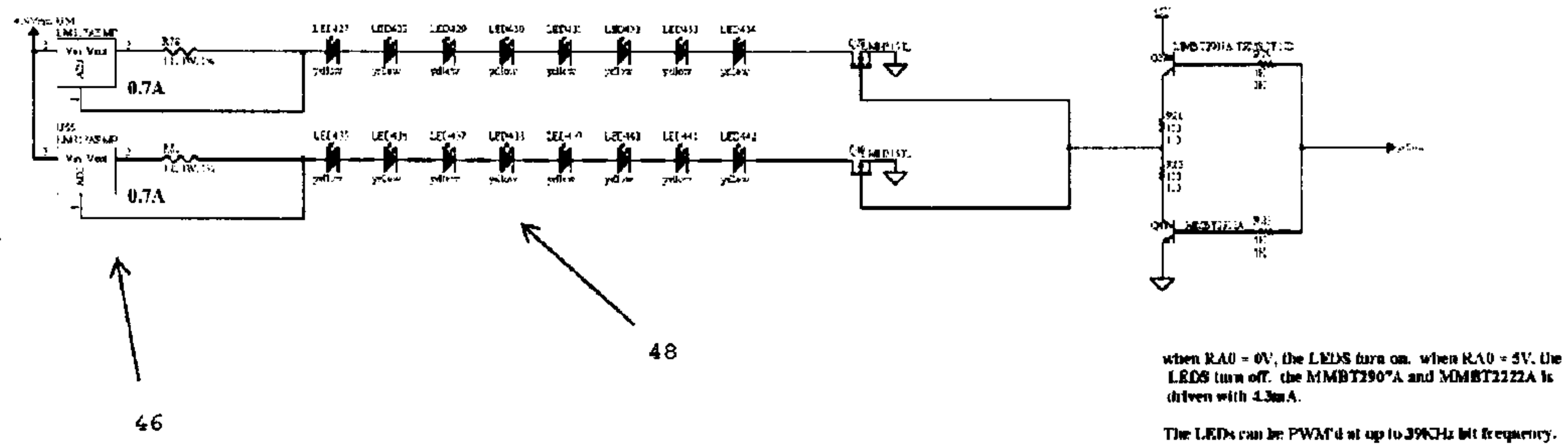


FIGURE 5

[Fig. 6]

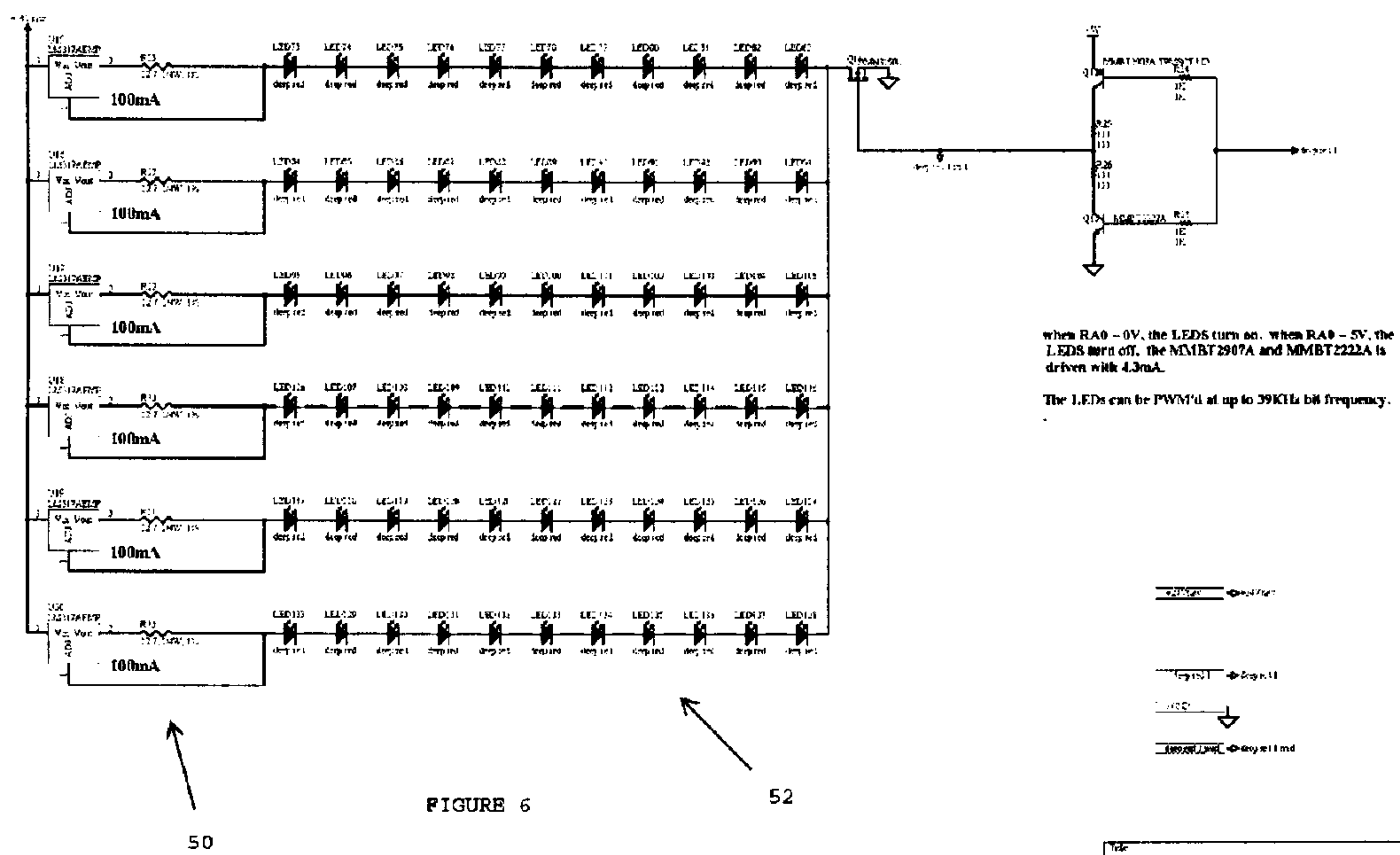
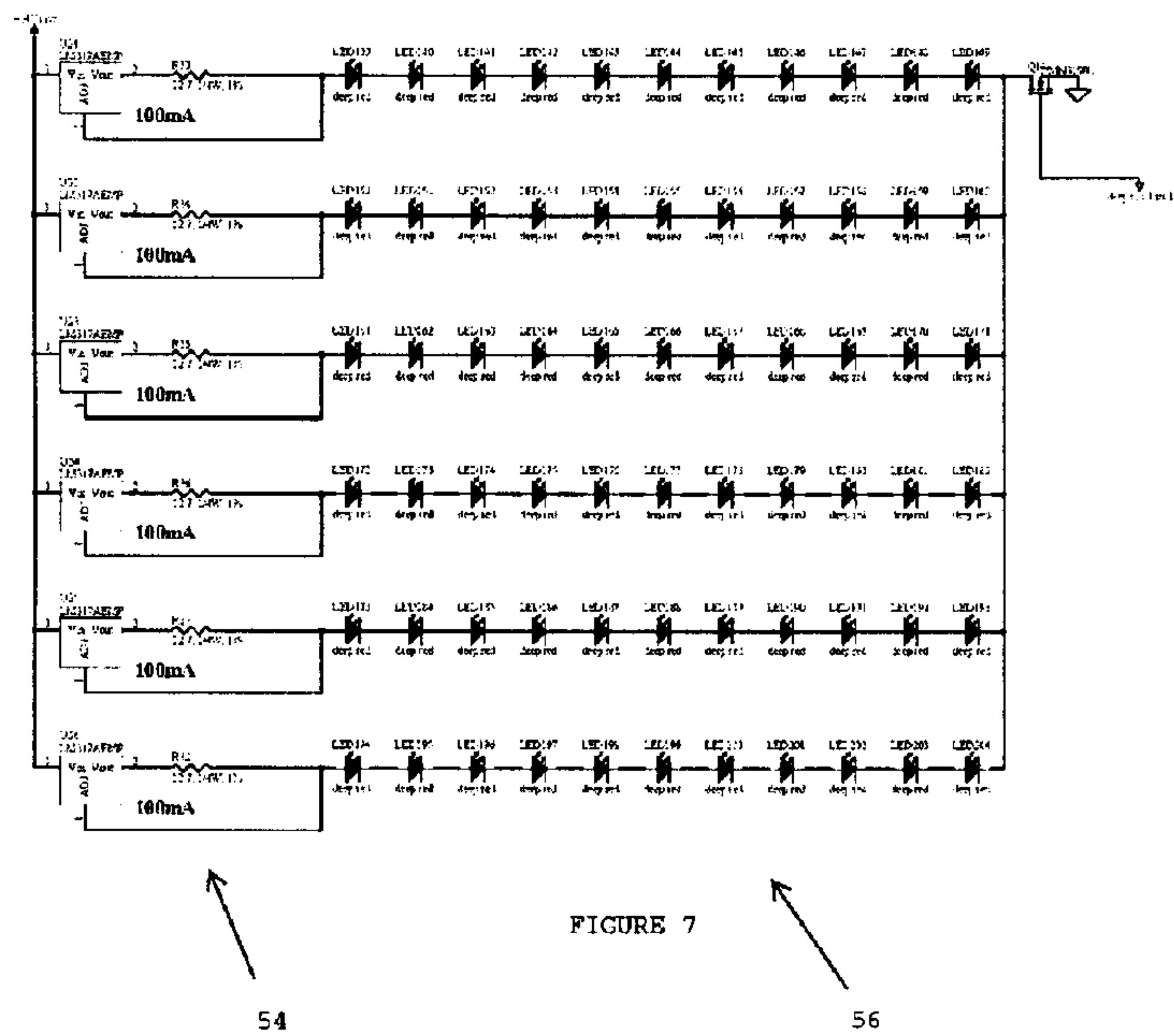


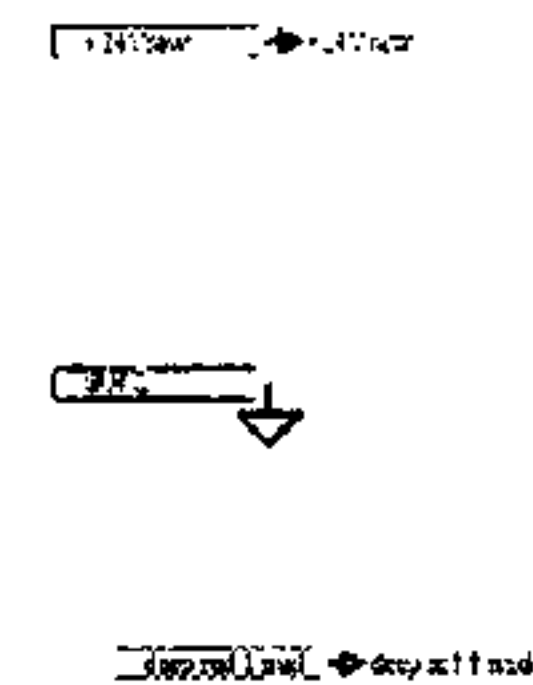
FIGURE 6

[Fig. 7]



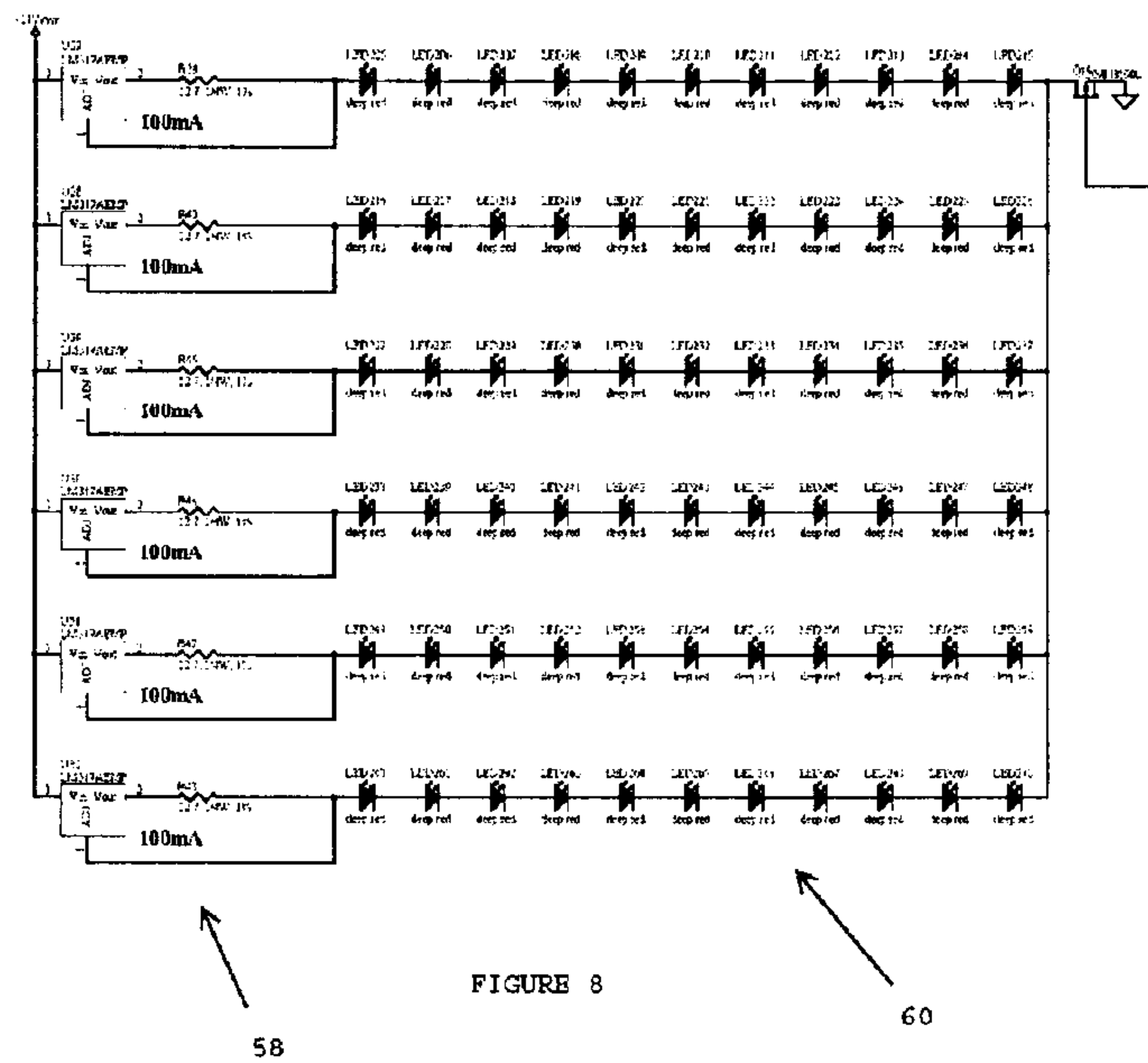
when RA0 = 0V, the LEDs turn on, when RA0 = 5V, the LEDs turn off, the MMBT2907A and MMBT2222A is driven with 4.3mA.

The LEDs can be PWM'd at up to 39KHz bit frequency.



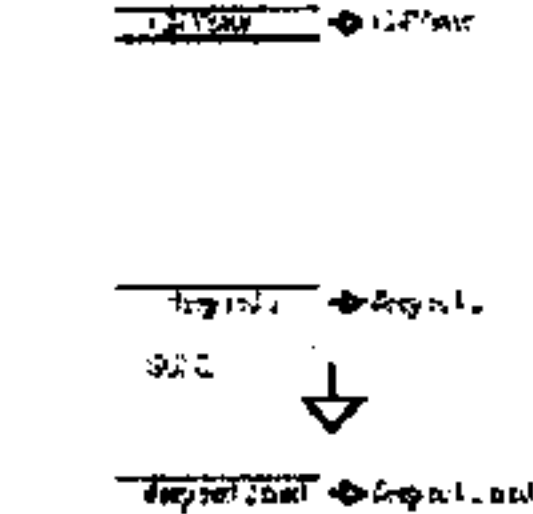
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Rev	20	Author

[Fig. 8]



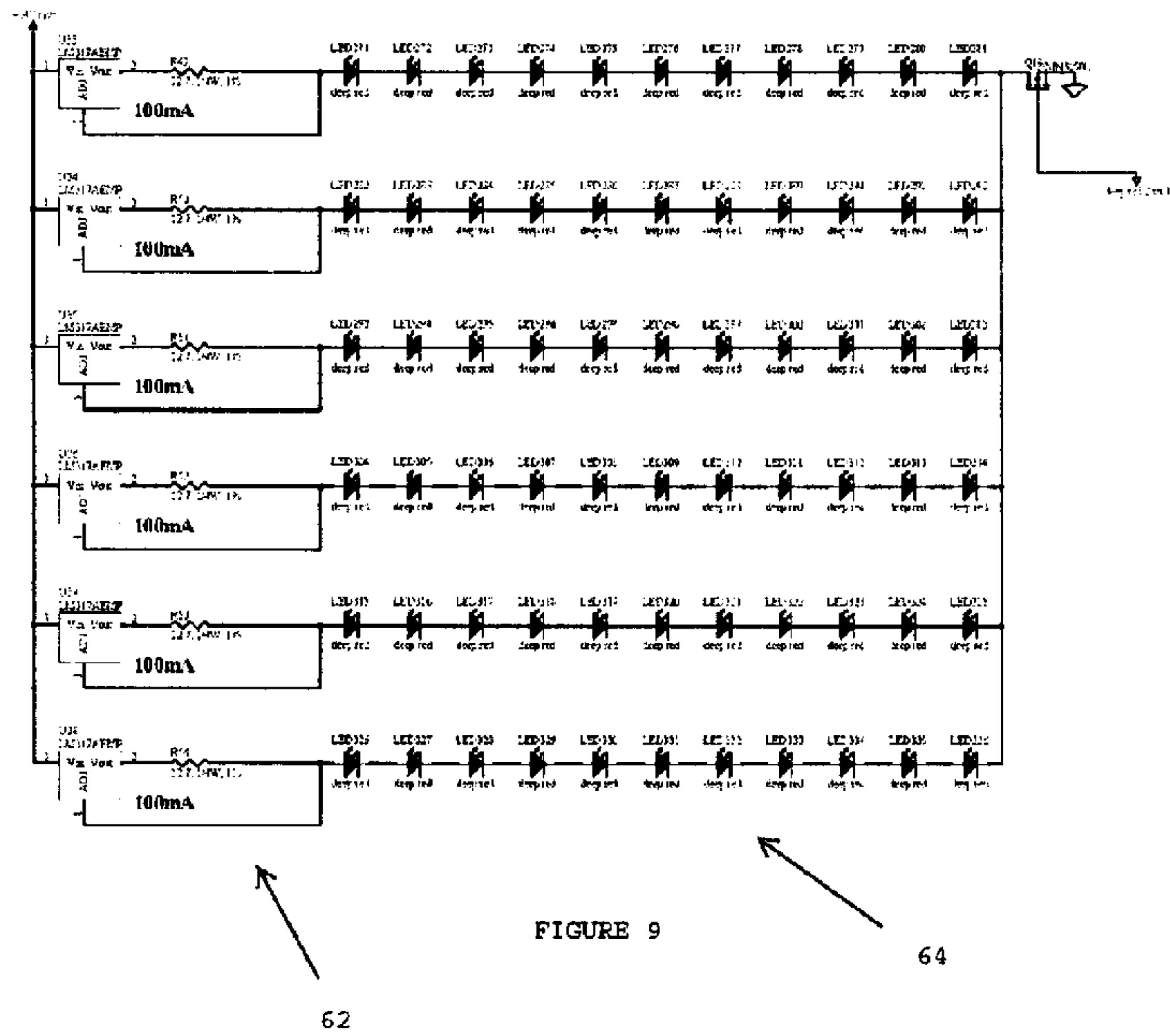
when RA0 = 0V, the LEDs turn on, when RA0 = 5V, the LEDs turn off, the MMBT2907A and MMBT2222A is driven with 4.3mA.

The LEDs can be PWM'd at up to 39KHz bit frequency.



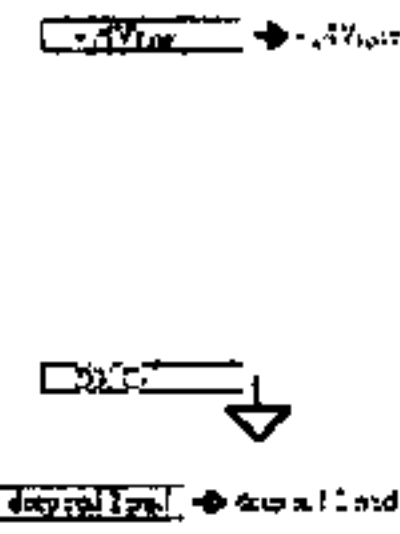
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Rev	20	Author

[Fig. 9]



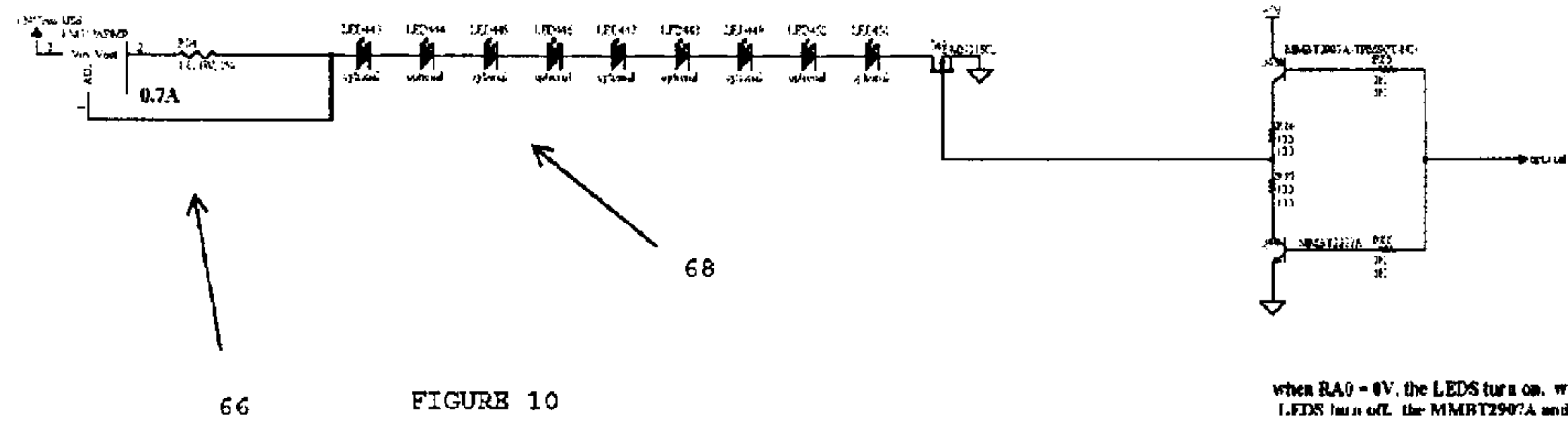
when RA0 = 0V, the LEDs turn on. when RA0 = 5V, the LEDs turn off. the MMBT2907A and MMBT2222A is driven with 4.3mA.

The LEDs can be PWM'd at up to 39KHz bit frequency.



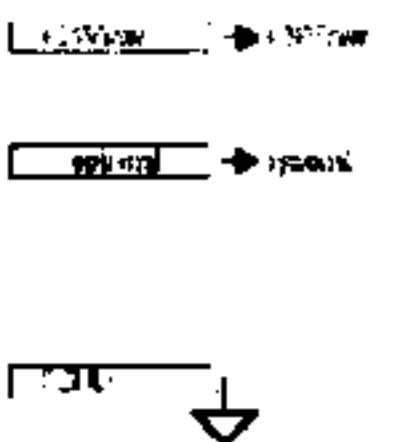
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Rev	000000	Rev. of

[Fig. 10]



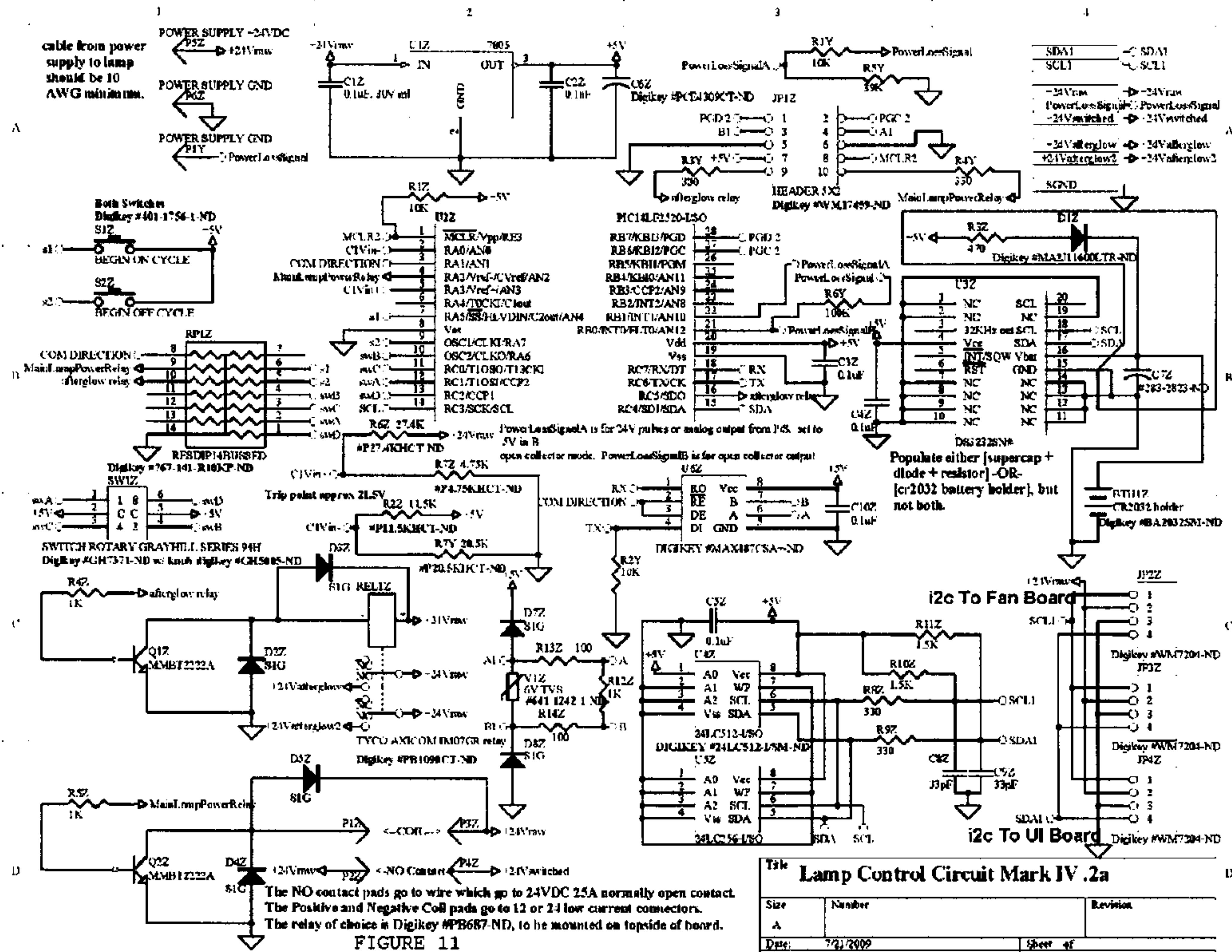
when RA0 = 0V, the LEDs turn on. when RA0 = 5V, the LEDs turn off. the MMBT2907A and MMBT2222A is driven with 4.3mA.

The LEDs can be PWM'd at up to 39KHz bit frequency.

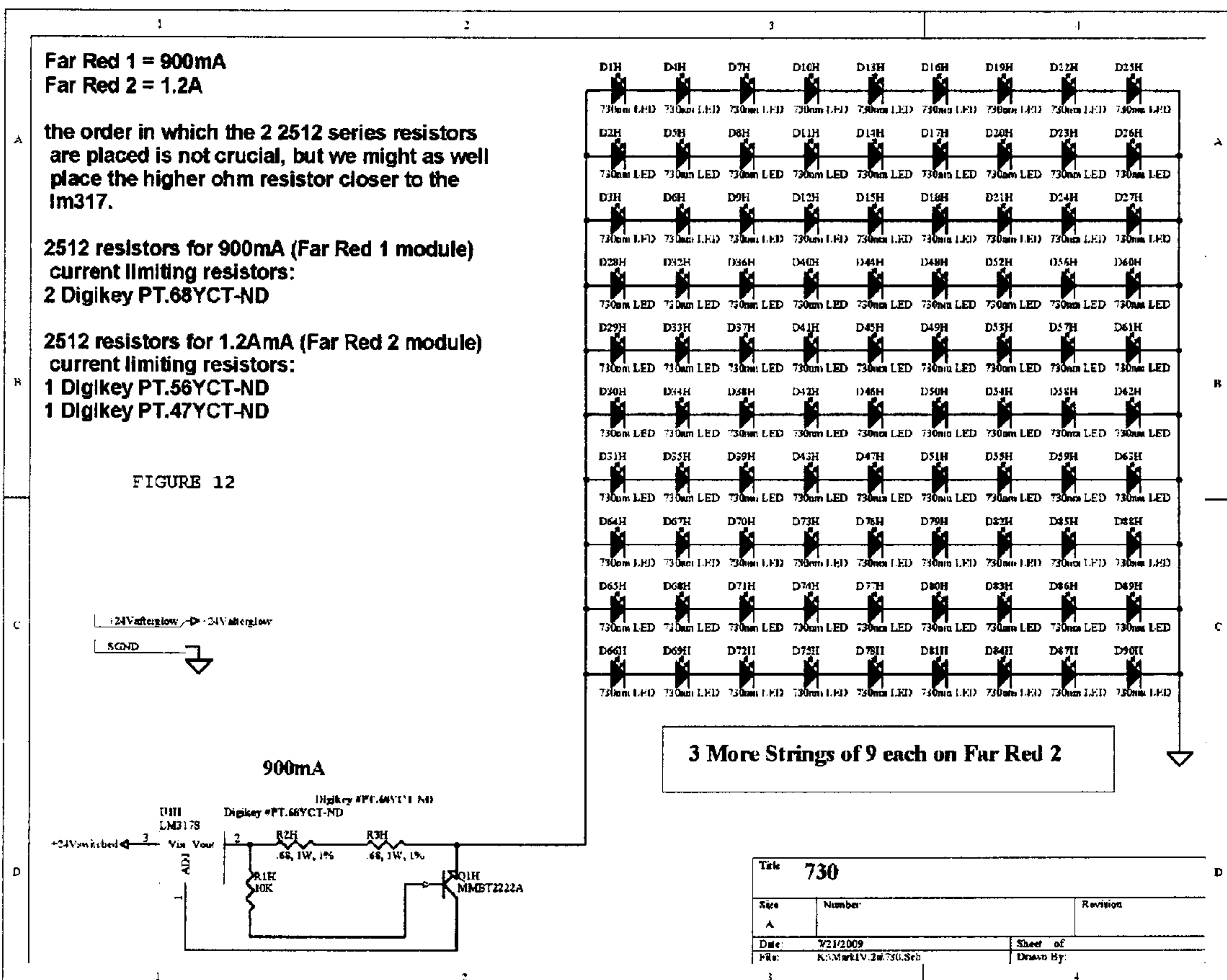


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Rev	000000	Rev. of

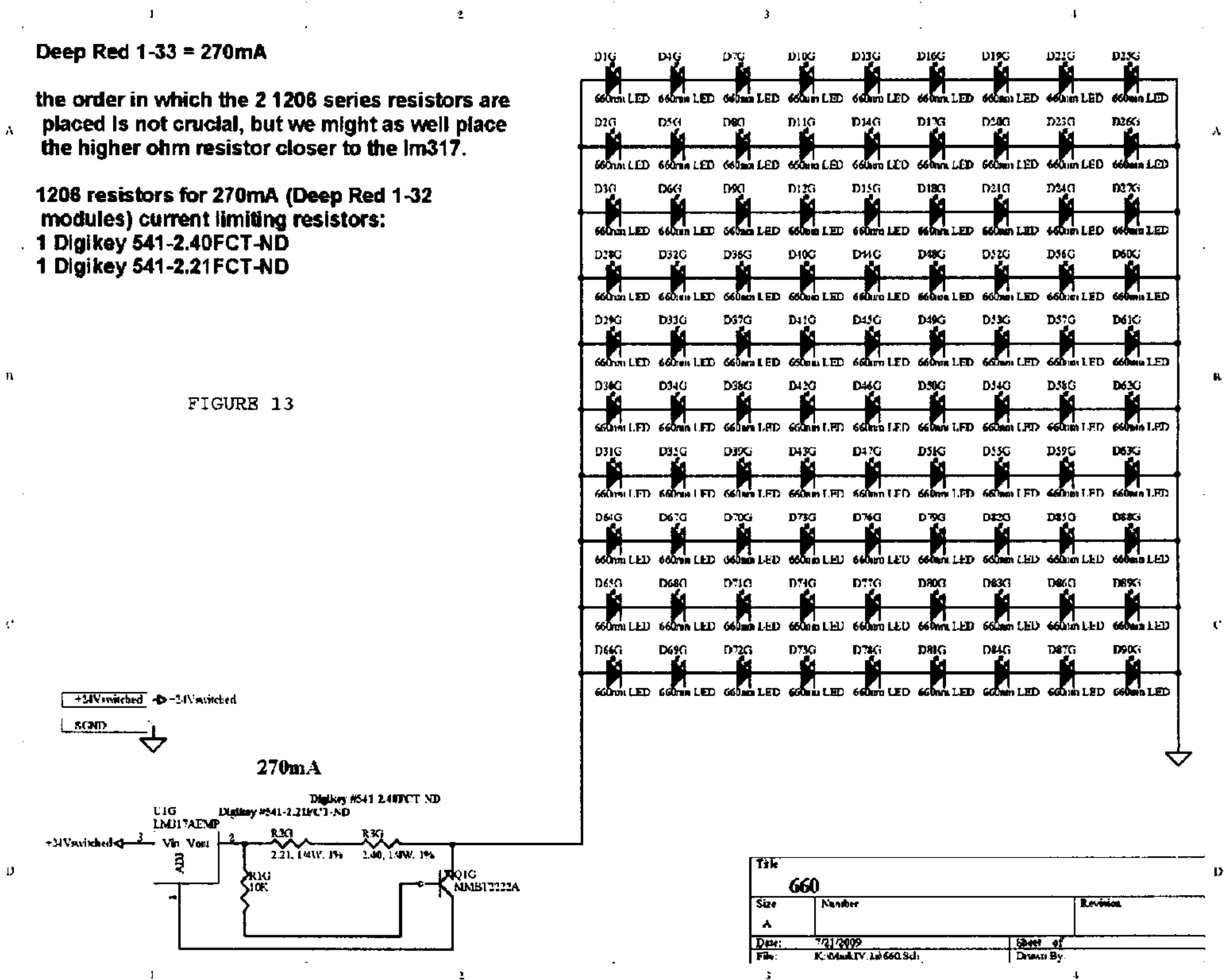
[Fig. 11]



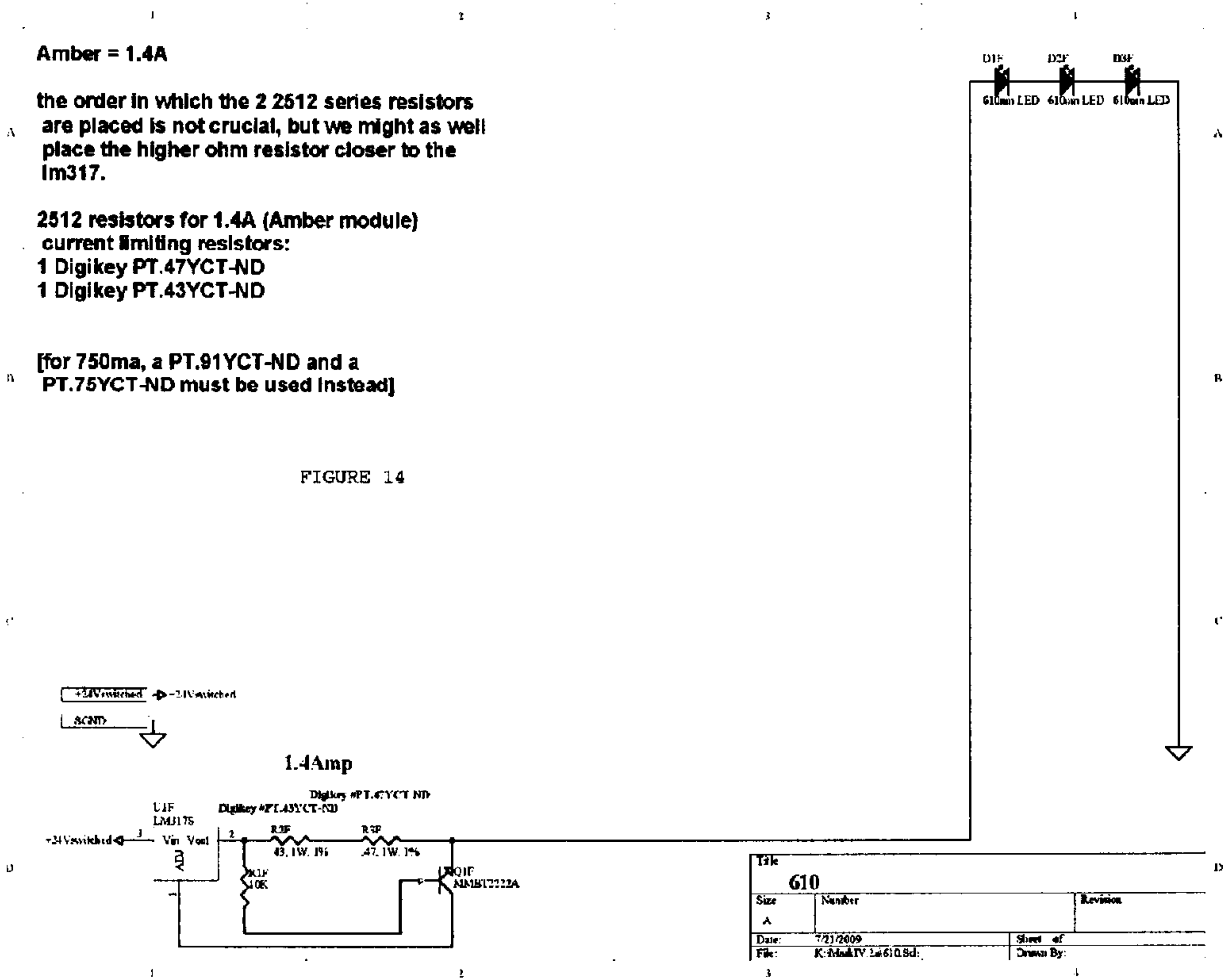
[Fig. 12]



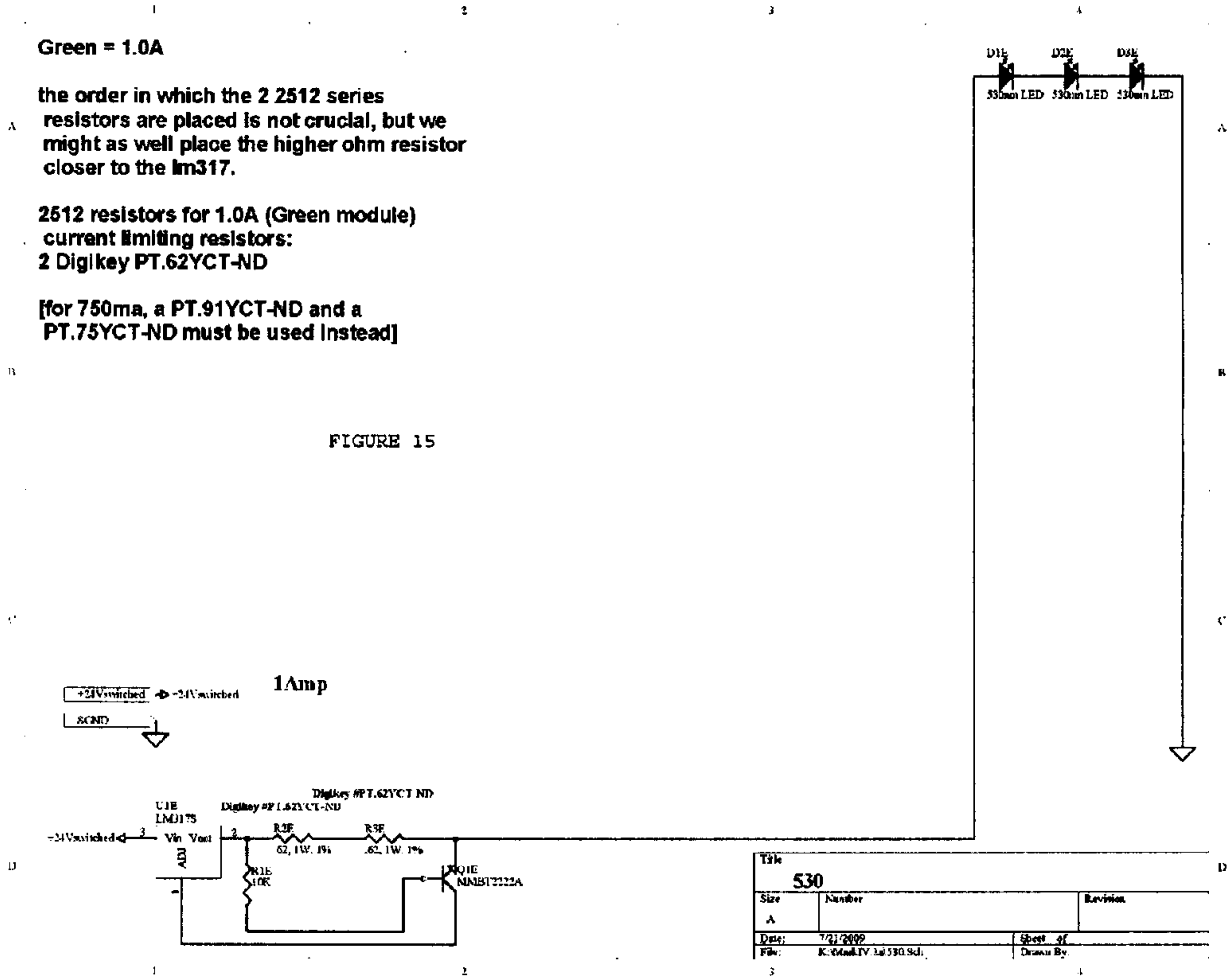
[Fig. 13]



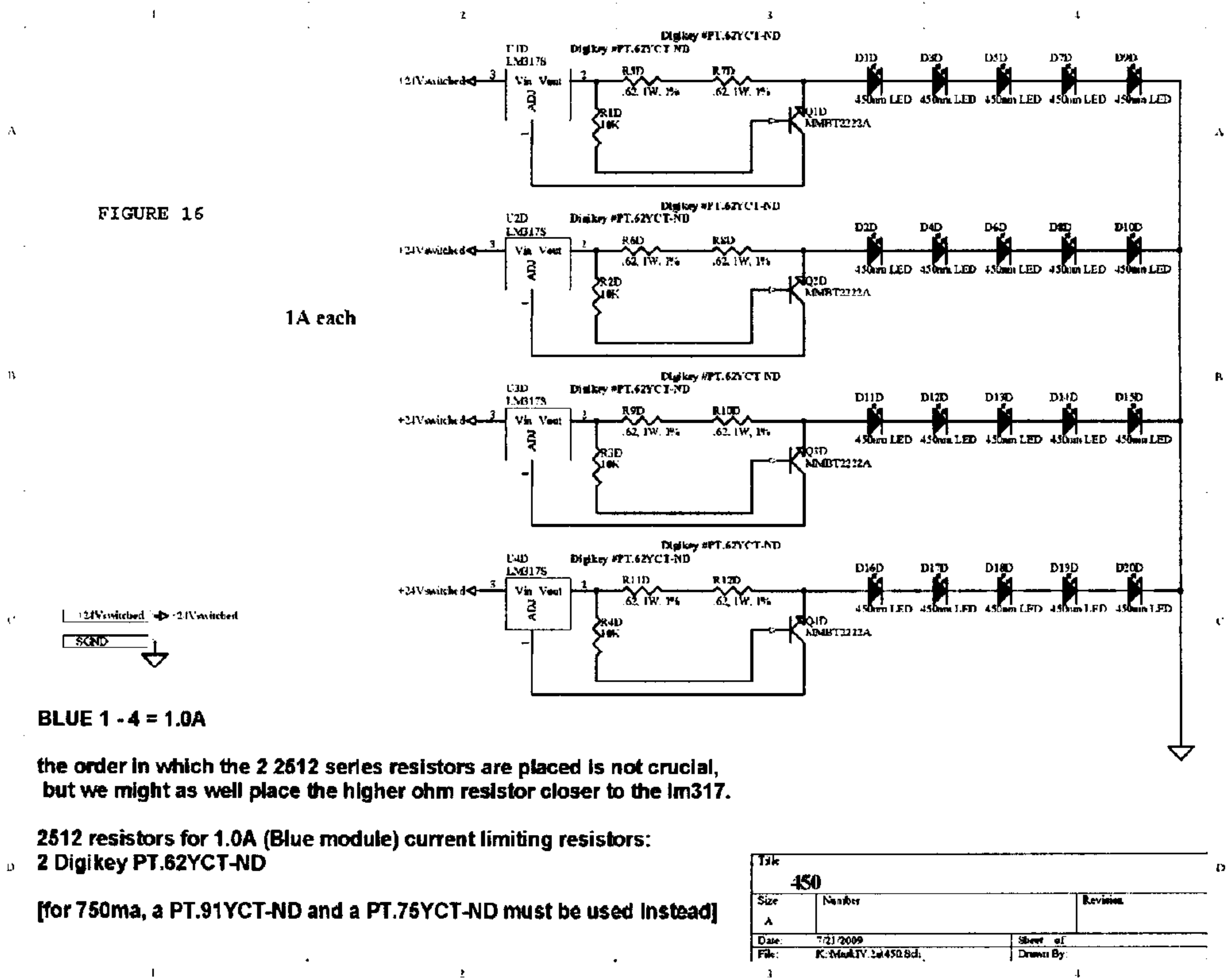
[Fig. 14]



[Fig. 15]



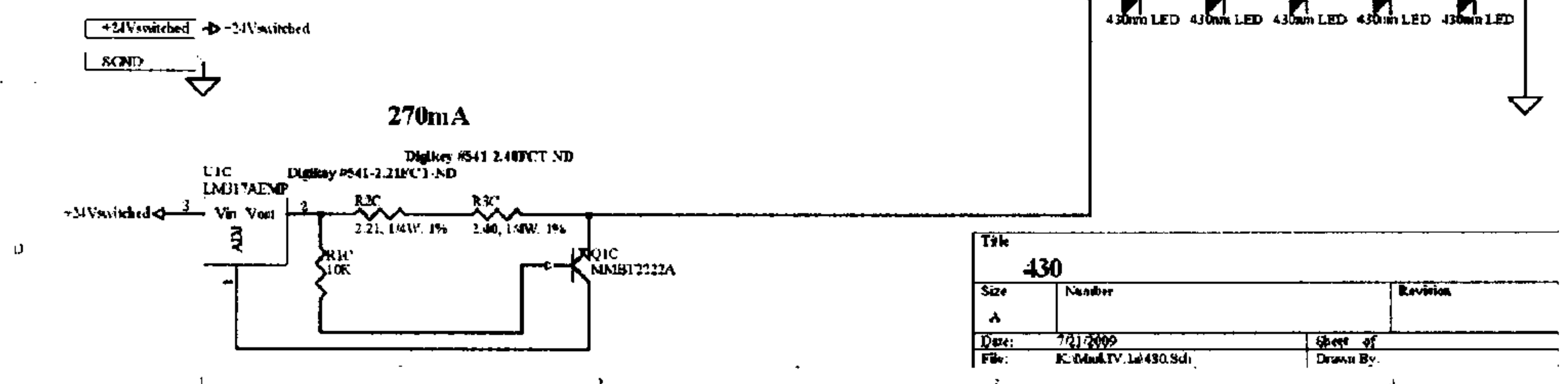
[Fig. 16]



Deep Blue 1-8 = 270mA

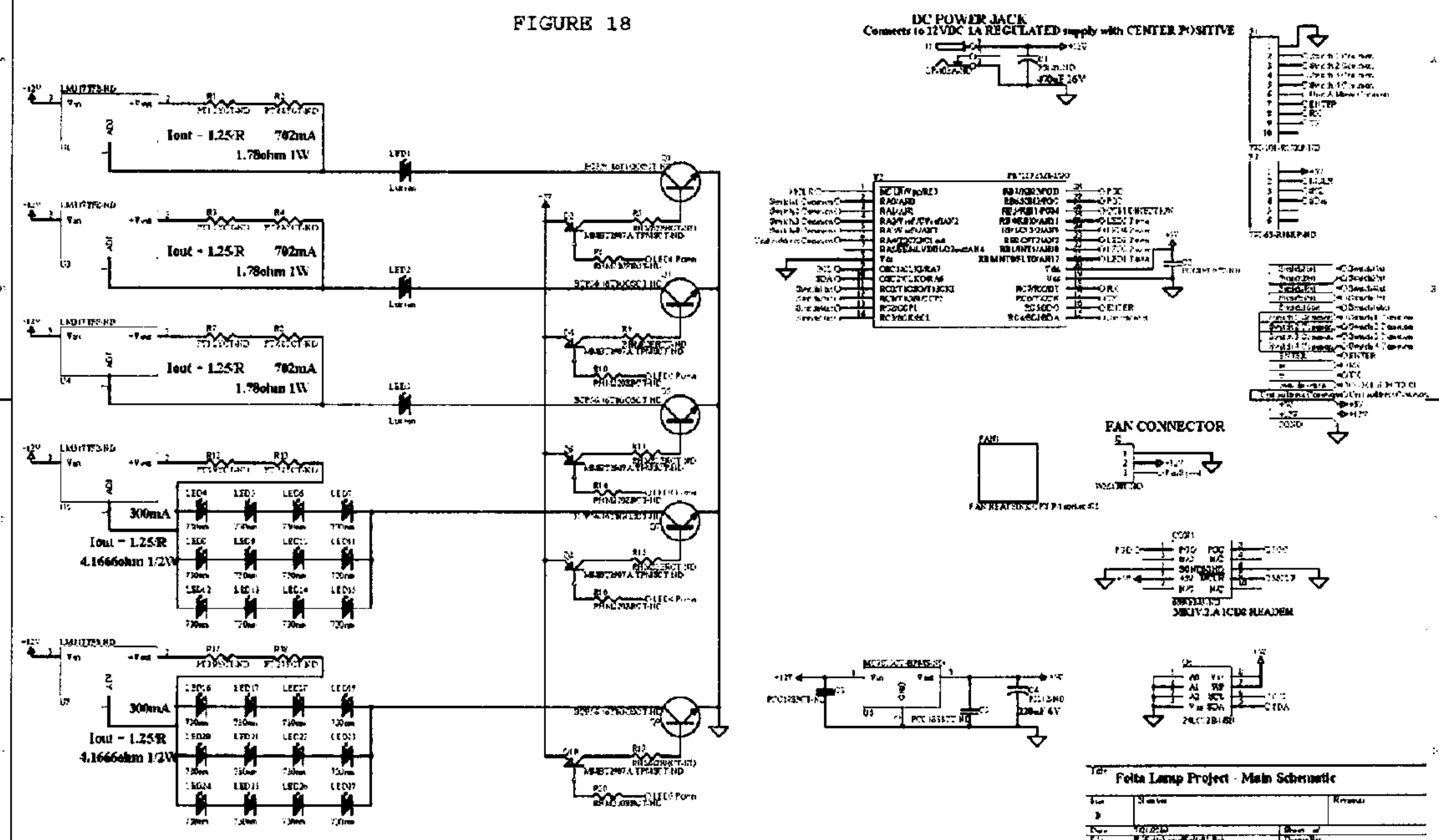
1208 resistors for 270mA (Deep Blue 1-7 modules)
current limiting resistors:
1 Digikey 541-2.40FCT-ND
1 Digikey 541-2.21FCT-ND

FIGURE 17

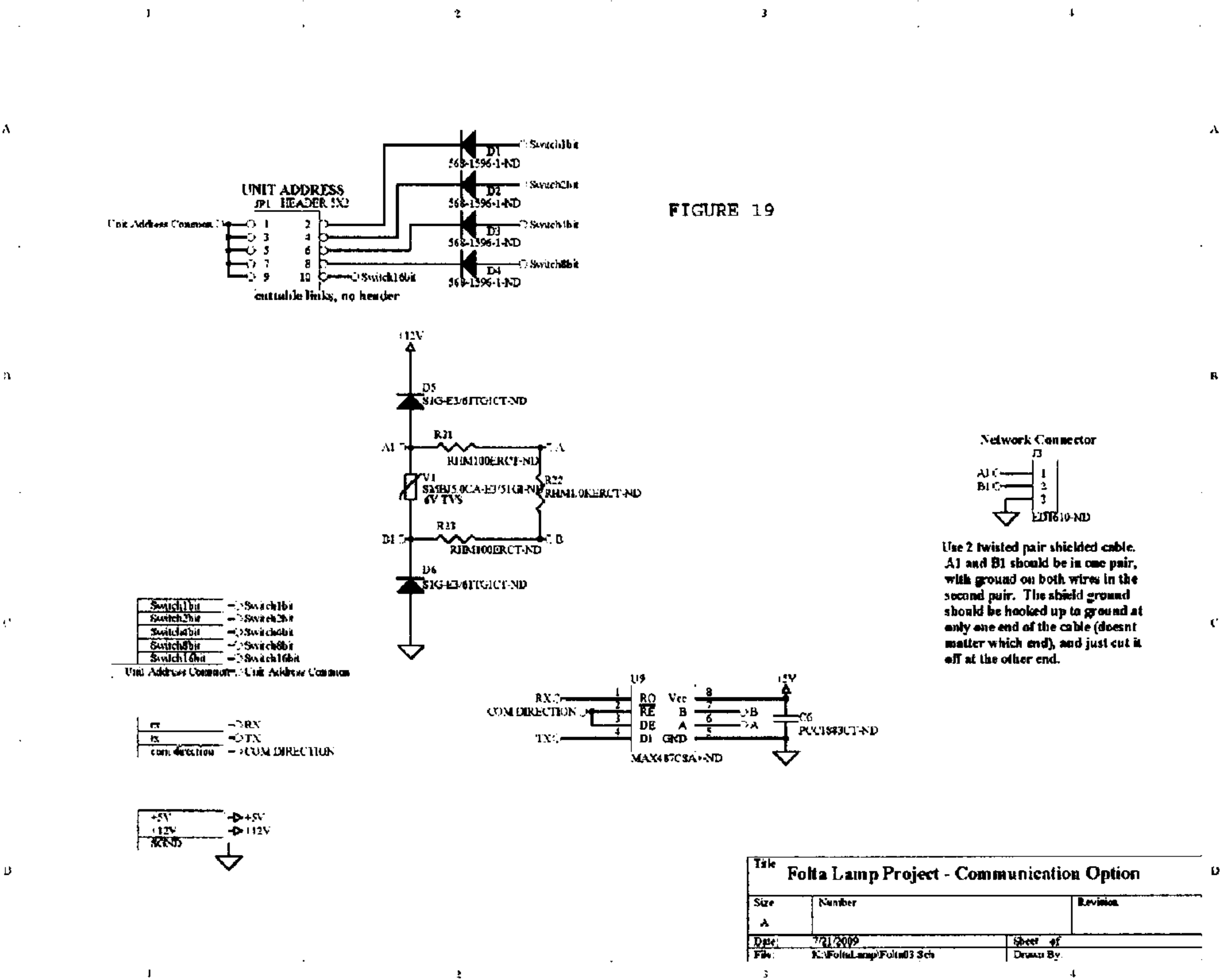


[Fig. 18]

FIGURE 18



[Fig. 19]



[illegible]

UNIT ADDRESS JP1 HEADER SN2

Unit Address Common: 1 2 3 4 5 6 7 8 9 10

cuttable links, no header

D17 D18 D19 D20 D21
568-1596-14ND
568-1596-14ND
568-1596-14ND
568-1596-14ND
568-1596-14ND

Switch1bit
Switch2bit
Switch3bit
Switch4bit
Switch5bit

FIGURE 22

12V

D21 SIG-E3-6ITGCT-ND

A1 R1 R1M100KCT-ND C A

V1 SMD/S PCA-E351GF-ND 5V TVS

B1 R1 R1M100KCT-ND C B

D22 SIG-E3-6ITGCT-ND

Network Connector

R1

A/B 1

B/C 2

3

E/D 610 ND

Use 2 twisted pair shielded cable. A1 and B1 should be in one pair, with ground on both wires in the second pair. The shield ground should be hooked up to ground at only one end of the cable (doesn't matter which end), and just cut it off at the other end.

Switch1bit	=> Switch1bit
Switch2bit	=> Switch2bit
Switch3bit	=> Switch3bit
Switch4bit	=> Switch4bit
Switch5bit	=> Switch5bit
Switch10bit	=> Switch10bit

Unit Address Common - Unit Address Common

FX	=> RX
Fx	=> TX
com direction	=> COM.DIRECTION

+5V +5V

+12V +12V

SGND SGND

U1 MAX487CSA-ND

RX 1 RO Vcc 8 15V

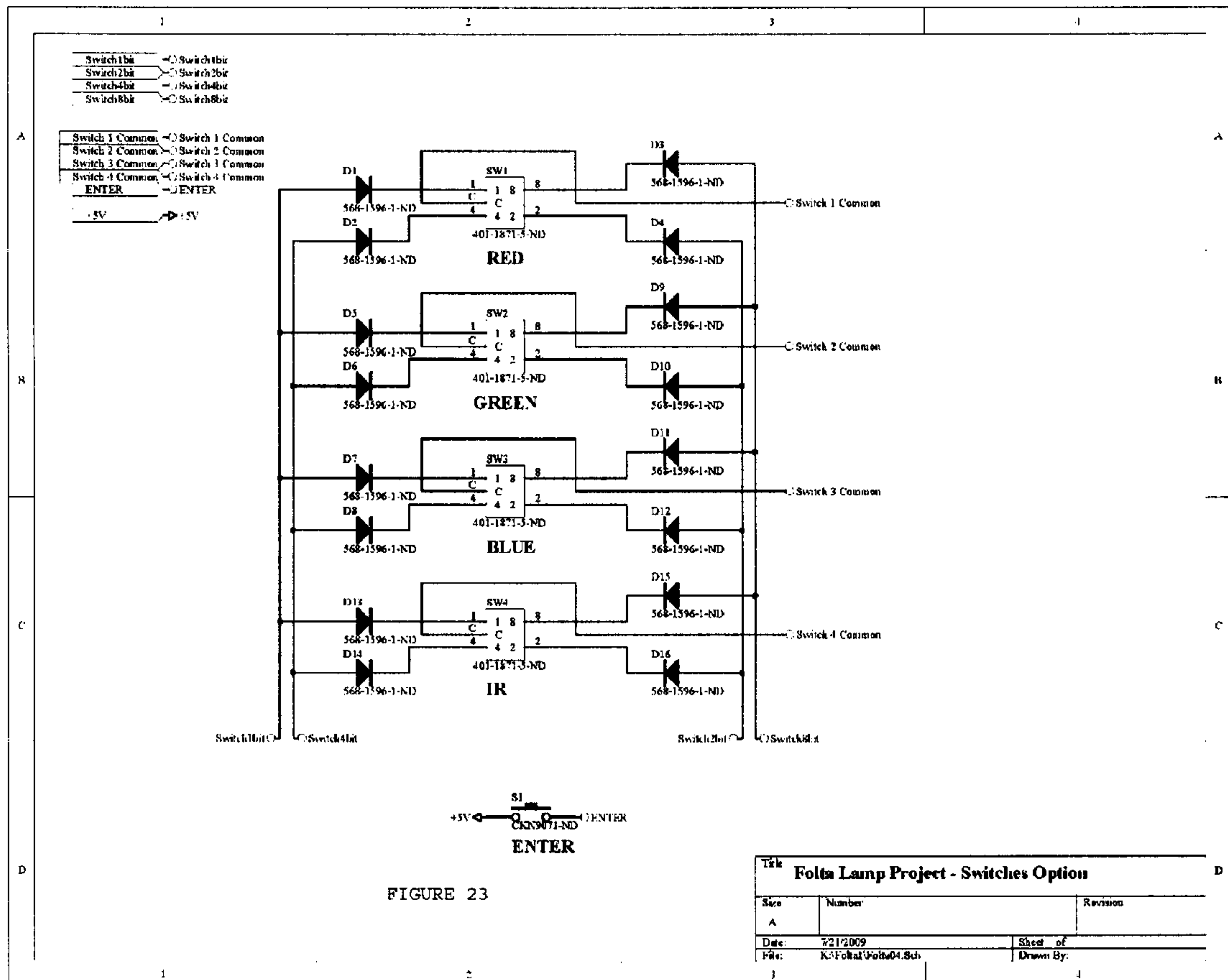
COM.DIRECTION 2 RE B 7 /B

TX 3 DE A 6 /A

DI GND 5

CJ PXC2344C1-ND

[Fig. 23]



[Fig. 2]

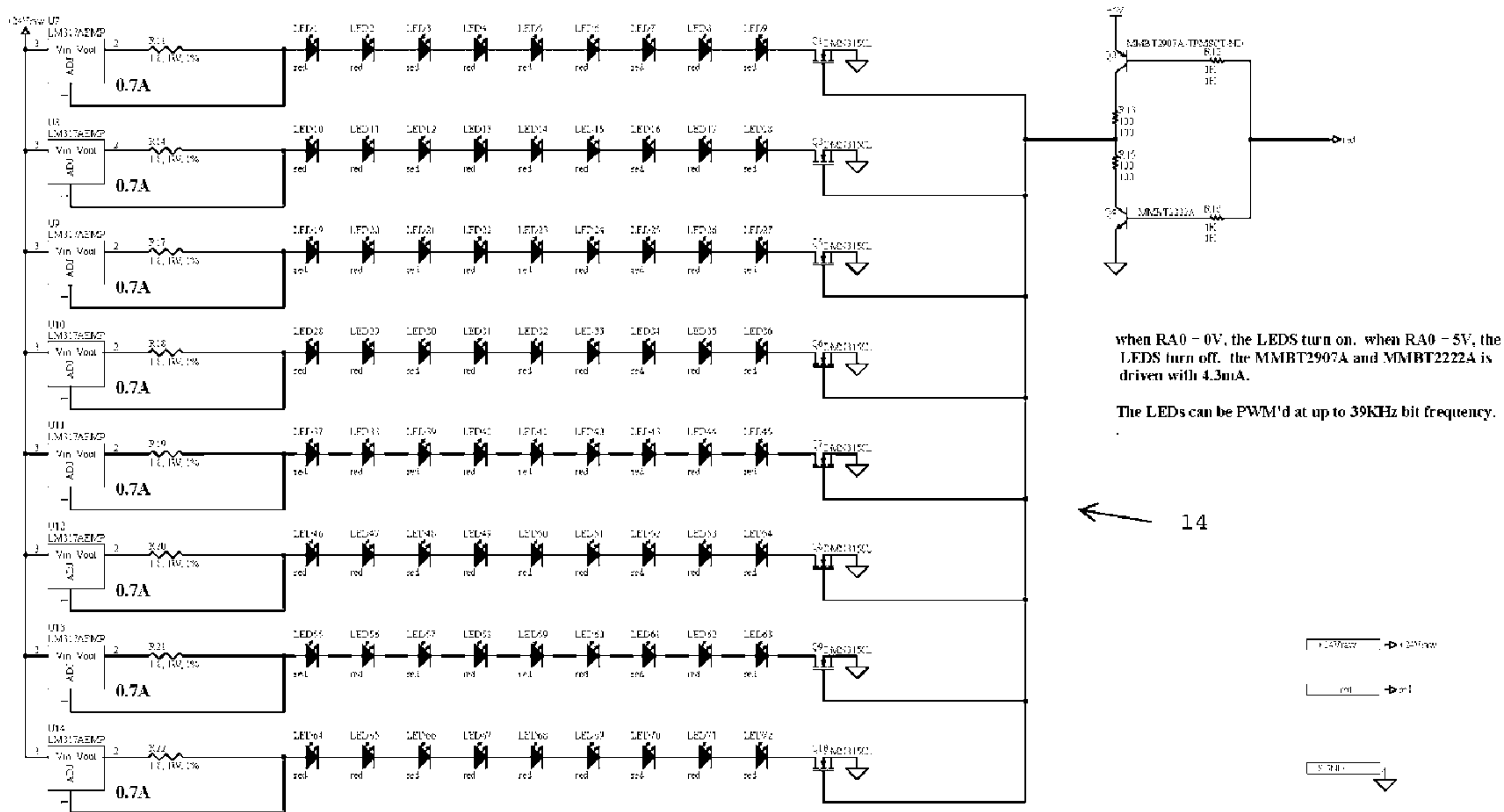


FIGURE 2

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