

# 피부과용 CO<sub>2</sub> 레이저의 공극(1.0mm 및 1.6mm)차이에 따른 동작출력 파형 변화에 관한 특성연구 (Special quality research about action output waveform change by gap(1.0mm and 1.6mm) difference of skin excessive expense CO<sub>2</sub> Laser)

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### 요약

피부과용 레이저 파장은 아주 얇은층의 조직두께에서 물의 흡수가 거의 90% 이상 일어나는데 병소의 표피나 조직은 거의 물로 구성되어 흡수로 인해 증발효과를 가질 수가 있다. 표피를 절개, 층별로 증발 시킬 수 있으며 조직의 정확한 절개가 가능하다. 혈관이나 림프시스템에도 봉합수술이 가능하고 수술부위가 건조하고 눈으로 볼 수 있고 무출혈 수술이 가능하다. 특히, 필스에 대한 튜브양단 출력의 안정이 매우 중요하므로, 본 연구에서는 고주파 방식의 전력변환 장치를 사용하여 부피를 줄이고 의료용 레이저의 전류파형을 쉽게 제어할 수 있어 다양한 치료 효과를 낼 수 있다. ZVS(Zero Voltage Switching)나 ZVZCS(Zero Voltage and Zero Current Switching)를 도입하면 스위칭 손실을 줄일 수 있어 더욱 유리하다. 제안된 의료용 레이저의 전력부에는 1차측 도우메 의한 ZVZCS 기법을 도입하여 넓은 부하 범위에서 안정된 soft-switching을 할 수가 있고 제어부는 microcontroller를 구성하여 출력전류파형을 사용자가 임의의 형태를 갖도록 하였다. 설계 및 제작하여 실험한 결과, 기존장비에 비해 20%의 향상된 결과를 가져왔고, 추후 시스템적으로 보완을 하면 우수한 결과가 될 것으로 사려된다.

### Abstract

Laser wave length can have evaporation effect by absorption because outer skin or tissue of focus is consisted of water almost though absorption of water occurs more than 90% almost in formation thickness of very thin floor. Can operate outer skin, steam by floor and correct incision of formation is available. Suture surgical operation is available to vein or lymph system and surgical operation region can dry and see as eye and radish bleeding surgical operation is available. Specially, stability of tube both end output about pulse by weight very, this research can cause various curative effect because can reduce bulk and control easily current wave style of medical laser using electric power conversion device of high frequency way. If introduce ZVS (Zero Voltage Switching) or ZVZCS (Zero Voltage and Zero Current Switching), is more profitable because can reduce switching damage. Because electric power department of proposed medical laser can do stable soft-switching in wide subordinate extent introducing ZVZCS technique by the first help and control department composes microcontroller, output current waveform user have free form make. Result that experiment because design and manufacture, brought result that improve of 20% than existing equipment, and will be bought to get into superior result if supplement as systematic late.

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### I. Introduce

Though can apply thermal action of beam and cellular tissue in skin treatment, leading person who is optic enemy of skin such as absorption or scattering is affinity in stable conclusion of state examination of laser beam, and various component of cellular tissue can accomplish interatction with beam and cell by selection of different laser kind. Skin does defense function in body and have relation of temperature control with outside through nervous system, nerve class. Laser wave length can have evaporation effect by absorption because outer skin or tissue of focus is consisted of water almost though absorption of water occurs more than 90% almost in formation thickness of very thin floor. If introduce ZVS (Zero Voltage Switching) or ZVZCS (Zero Voltage and Zero Current Switching), is more profitable because can reduce switching damage. Design and result that manufacture and experiment, brought result that improve of 20% than existing equipment, and will be bought to get into superior result if supplement as systematic late.

### 2. CO<sub>2</sub>Laser

It is important first of all that understand in establishment to use medical laser for rehalitation treatment by war how beam is transmited. Because formation's constituent is complicated, it is very difficult work to expect century distribution of beam. Happen as angle and century of laying eggs beam are related topology and size of laying eggs center and laying eggs is small relatively

molecule of 1/10 degree size of beam wave length or small particle and laying eggs is polarized.

$$dBA / dX = - \sum A XB \text{ -----(1)}$$

When is absorption, scattering, thickness dX, beam century B, absorption century dBA, is same with way (1), laying eggs coefficient

$$dBC / dX = - \sum C XB \text{ -----(2)}$$

Way (3), century of beam is expressing conjunction of scattering and absorption coefficient in way (4)

$$\sum F = \sum A \oplus \sum C \text{ -----(3)}$$

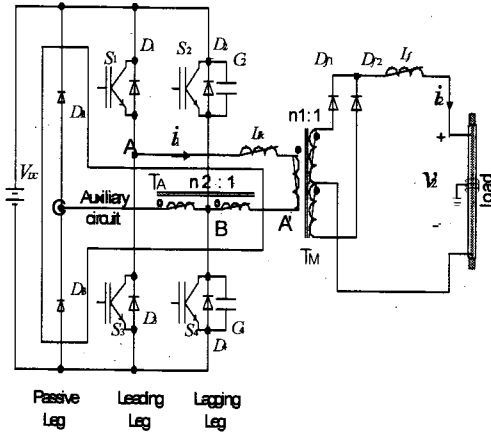
B emanates to space by spread because photon is laid eggs strongly in establishment as power density of entering a company beam. Therefore, space power density has density that spread to wide space in small place. Decrease of space power density by formation's depth expression does possibility by real laying eggs calculation and reciprocal for this cost goes and number transmission of beam deeply.

$$\delta = 1 / \sum Cf \text{ -----(4)}$$

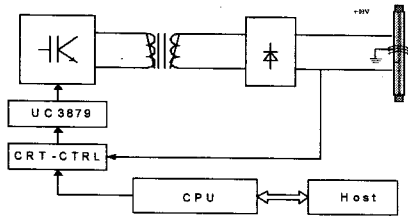
### 3. Design and Embodiment of system

Though load current of designed skin excessive expense laser is controlled by DC/DC converter, DC/DC converter is composed laying stress on full bridge inverter with figure 2 Right side pole (or lagging leg) of this inverter acts by ZVS

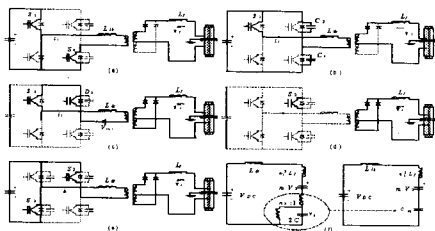
(Zero Voltage Switching) and middle pole (leading leg) acts by ZCS (Zero Current Switching).



[Fig. 1] Schematic diagram of skin excessive expense CO<sub>2</sub> laser that propose



[Fig. 2] Control Mode



[Fig. 3] Control Part hitch

Right side pole of inverter by  $L_{lk}$ ,  $C_2$ ,  $C_4$  relationship help ZVS action and real situation pole by assistance inning by help ZCS action do . Left side pole (passive pole) is used with assistance and is acted

passively according to transformer the first current. If the first current is plus direction, DA3 is, and if is minus direction, DA1 becomes on. ZVS or ZCS does to reduce greatly switching damage of switching element and can heighten action frequency. Voltage of inverter that act by ZV-ZCS are controlled by status change (phase-shift). Uni trode company's UC3879 of status change and spiritual enlightenment order of switch element decides. Make level direct current because there are diode stoppage circuit and filter inductor to the second of transformer. Occurrence department receives issue number of a periodical in high position system through series communication though was composed laying stress on microprocessor. Digital current order that is given by CPU is made by analog through D/A converter. Current controller is consisted of analog controller (error amplifier) and Unitrode company's UC3879. Comparison and compensation with current order and actuality current do in analog controller and UC3879 controls PWM accordingly. Action state of skin excessive expense laser is transmitted by high position computer through series communication. Used high frequency ac from power to transmit electric power by skin excessive expense laser tube and high frequency interchange breeds by high frequency inverter. Inverter circuit composed by IGBT with figure 2 - 1. Output of this inverter is passed in load side through transformer. If heighten frequency to heighten action frequency to shorten size of transformer, switching damage grows. This research used clean bright atmosphere voltage/marks of honor kind (ZV-ZCS : Zero Voltage and Zero Current Switching)

technology to reduce switching damage. Because both end voltage of on/off city switch element of switch element are "0" in ZVS, electric power damage decreases and on/off of flowing current consists in "" state on switch element in ZCS and electric power damage at switching decreases. Inverter generates interchange via process such as figure 2 - 4. ZV-ZCS action of inverter is explained in waveform of figure 2 - 5. Figure 2 - 4 of (a) of mode 1 S1 be, military strength is early state to 2 roads supplied section in transformer the first S4 element is lighted. Mode2 of (b) S4 because turn off to begun resonance section S4's ZVS off consist . If voltage of B point arrive on top portion advance guard of dc, S4's ZVS off is completed. Practical equivalent circuit is same with picture (f) that picture (b) omits part for conveniences sake by assistance inning. After current becomes "0" by step that remove current that Mode 3 of (c) passes to transformer the first by reset voltage by assistance inning, S1 becomes ZCS off if put out S1. Assistance transformer the second is linked in dc through DA3 and D2 for this section and dc voltage are approved adversely to the first through assistance transformer. If current turns on S2 in passing Mode 3 interval by D2, ZVS on two consists. Mode 4 of (d) transformer the first current pass and free-wheel through the second do section that know be . Mode5 of (e) S3 section that do layer ZCS on be . During this section primary current by current that have and increase and flow to Df1 in secondary slant by Df2 move. Pumping gas (pumping source) makes energy in ground state by here state (excited state) as device that laser consists

of vitality media that surround by optical activity (optical cavity). If collision occurs between particle of two of here state (excited state), photon that receive stimulation (that high energy is massed) happens and it is that extended electromagnetism energy comes out for laser. Laser beam can converge on microscopic part as is easy because is monochrome, and thin stamen is achieved because taking advantage of this prognostication. Liquid laser consists of numerator of old tomb self-examination weight that is smelted in liquid. Gas mixture has electrode and is built-in inside glass laser tube. Because whole system divides greatly, resonator and pulse is composed, and do number cold storage all by device, do gas supply chapter, there is vacuum pump and manometer etc. Discharge department made attaching cathode of cylindrical and anode of saliva shape that make from aluminum to discharge tube, and distance between electrode did by about 75 cm. If momentary complete work kind passes to discharge tube, pressure difference occurs cathode of discharge tube and anode. Laser eruption efficiency drops on this account and state of eruption suspension and so on happens. In figure 2 - 1 to prevent this with bypass (Bypass) pipe establish and reduced occurrence of impurities by CO2 molecular Harry when flowing of gas minishes temperature upswing and pressure difference of discharge within the jurisdiction by gas overheating round electrode as help and discharges because inserting small fan. Laser output made control to be possible as that vary the pulse repeat rate in fixed pulse width. Designed so that can be variable to repeat rate 100Hz ~ 1kHz and maximum pulse

voltage that can get in rural districts were about 20kV.

$$\text{Cycle time (T)} = \text{ON time} + \text{OFF time} \quad (5)$$

Time that it is known that this time is all time (On-time) and laser malfunctions during cycle of all time and off time is continued when time that laser operates within cycle is continued.

Efficiency does that (duty cycle) expresses ratio between all time and total cycle by percent.

$$\text{Duty cycle (\%)} = \text{On time} / T \times 100 \quad (6)$$

Maximum output voltage (P peak) is being supplied maximum output while laser emits, and average output voltage (P av) expresses mean value of output that occur while laser emits, pulse width (r) as continue that pulse width at way point of maximum output from this part all time (ON time), off time (OFF time), efficiency terminologies such as (duty cycle) are thing about laser operation mode cell exposure mode be . To change by average output in rated power (constant peak power) by this way, efficiency (duty cycle) according to this adjust must . In general cycle function the most resemblant equation

$$P_{av} = P_{peak} \times \tau \times f \quad (7)$$

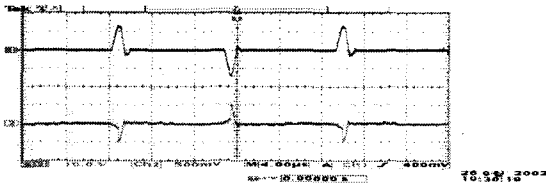
Average output can control by alter maximum output or synthesize and change pulse width, pulse frequency or these parameter. Under supermarket pulse laser operation mode, dream pulse system can supply maximum rated power getting maximum rated power getting average

output that want. When do not select supermarket pulse laser operation mode, series welsh onion laser operation mode is goosed at early. In this mode, series welsh onion laser beam is displayed within output extent between 0.5 - 30 W. Specially, cell exposure mode regulates form of laser beam passed continuously to establishment, robber who laser comes inside of skin A ~ by 8 steps that led to H make . Composed by continue, single pulse, repeat pulse three ways in cell exposure mode. Stoppage department is consisted of condenser for up transformer, inrush current limitation and single phase bridge diode rectifier, archery practice bow. Therefore, winding ratio a of transformer that manufacture design could know the first, elegy of transformer of the second about 1 : 25 last of the 24 hour period as about 25. Finally, do so that may do Hamchim in insulation oil and strengthened dielectric strength of transformer.

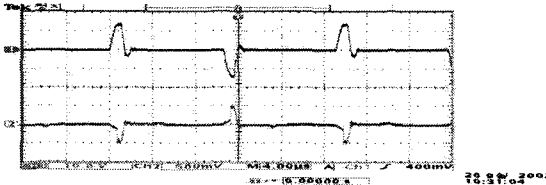
#### 4. Experiment Result

Is expressing laser output special quality by the pulse repeat rate schedule pressure and schedule gas mixture ratio (CO<sub>2</sub> : N<sub>2</sub> : He = 1 : 3 : 10, 1 : 1.5 : 5, 1 : 9 : 15). Each experiment data is marking mean value with wave that experiment. According as the repeat rate increases, laser output is increasing but decreases gradually from the increase width 500Hz and 900Hz can know that the output is decreasing quantity in 700 Hz. Because though output got saturated in pulse repeat rate 700Hz, this if the repeat rate increases, input energy is augmented and accordingly because electron density of

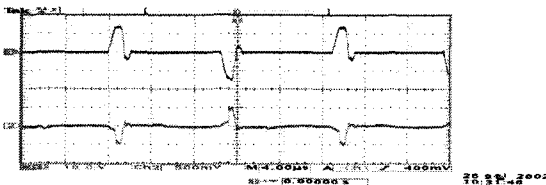
discharge within the jurisdiction rises, the pumping rate increases as high position sub-officer and density reversal is grown, output increases. If gaseous temperature is ascending, bring decrease of high position sub-officer density because the attenuation rate by collision in high position laser sub-officer increases rapidly, and because thermal density of low rank sub-officer increases relatively, density reversal is disappeared. Because gas temperature invincible effect becomes overbearingly gradually although in childhood that increase the repeat rate, density reversal and gains increase, show decrease of output.



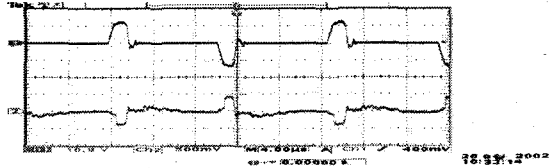
[Fig .4] gap 1mm F- 22T, S-28T CW



[Fig .5] gap 1mm F- 22T, S-30T CW



[Fig .6]gap 1mm F- 22T, S-32T CW



[Fig .7]gap 1mm F- 22T, S-33T CW

## 5. Conclusion

Developed high repetition pulse style CO<sub>2</sub> laser device of new way because do to graft together number ten k high tension pulse power device that use suitable IGBT in switching of Hz to laser resonator coming high voltage, high frequency to develop economical and compact pulse style CO<sub>2</sub> laser that have the 1kHz nearby pulse repeat rate. Gas mixture ratio of completed device, the pulse repeat rate, gas mixture ratio CO<sub>2</sub> through a laser output special quality experiment by working pressure : N<sub>2</sub> : Achieved maximum laser output about 20.5 W, maximum efficiency about 8% in He = 1 : 9 : 15, pulse repeat rate 700Hz, working pressure 15 Torrs. Here after, is expected to expect higher output if apply high speed gas circulation way improving some of resonator system.

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