THE CHARACTERISTICS OF OUTPUT FOR INVERTER TYPE X-RAY GENERATOR

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ABSTRACT - This paper deals with the output characteristics of resonant PWM inverter type X-ray generators connected to different DC power units i.e. a single phase full bridge rectifier, a three phase full bridge rectifier and a power storage unit(PSU).

The quality of X-ray beam depend on the pulsating waveforms of DC voltage supplied to the X-ray tube. In a X-ray generator, the waveform of DC output voltage can be affected from hramonic distortion of DC input power. When a tube voltage waveform is distorded, the property of X-ray beam such as reproducibility, direcibility and doesage can be reduced.

Therefore, we compared DC output waveforms and doesages with three type of DC power units and show the experimental results in this paper.

1. INTRODUCTION

In order to radiate X-ray, the low ripple stabilized high voltage DC over the range of 40kV to 150kV is directly inflicted to X-ray tube. This means X-ray generators are required as a high-voltage DC power supply. In general, the low ripple voltage waveforms with fast rising time lest the exposure time should be longer in order that the motion artifacts of an subject may be estimated in actual. The current fllowing through the X-ray tube, called the tube current, is set between 1mA and over 1000mA. Therefore the output power of X-ray generator can be regulated from over 20kW to 100kW. Up to the present, line frequency transformer were mainly used to generate the DC high-voltage from the AC utility system with a high voltage transformer. These conventional type of X-ray generators were bulky in physical size and heavy in weight, and the control accuracies of the output voltage were not always satisfactory. In order to reduce both the volume and the weight of high voltage transformer, and to stabilize a high frequency PWM type inver is connected between DC source and high voltage transformer. Therefore, the quality of power sources linked with inverter and converter affects to the output characteristics.

The authors compared and analyzed the output characteristics of X-ray generator ; single phase, three phase, PSU source.

2. RESONANT PWM INVERTER TYPE X-RAY GENERATORS

Fig.1 shows the schemetic structure of high-frequency resonant PWM inverter linked X-ray generator. This inverter consist of resonant inverter to convert DC voltage to high frequency AC voltage which processes a high voltage transformer to boost the inverter output voltage corresponding to a setting value that used IGBT switching power semiconducter devices. The diode rectifier directly connected to the output power stage of high-voltage cable which are used as the X-ray tube voltage feeder. In practice, the high voltage transformer includes inherently parasitic impidences and inductances, and stray capacitances which exist between the layers of secondary windings because the turn ratio of the transformer is so large as 100~1000 owing to increasing the input voltage up to the required level.

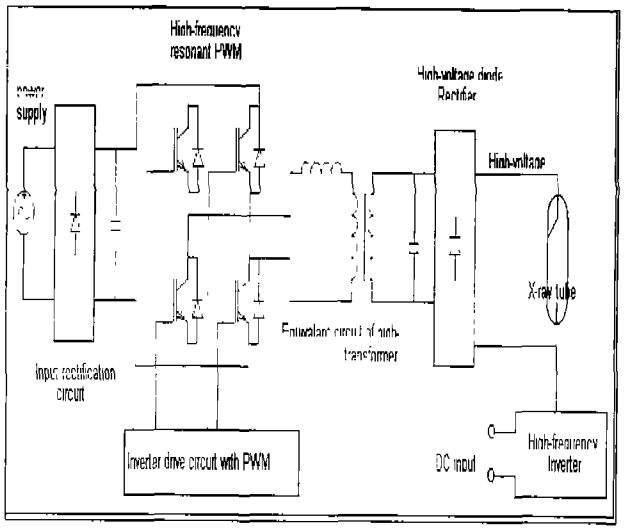

Fig.1 Schemetics diagram of transformer resonant inverter type X-ray power generator

The secondary windings are wound by many layers and the high voltage cable has input capacitance. The high voltage transformers makes use of both leakage inductances and winding stray capacitances as LC resonant components. Fig.2 shows the control block diagram of high frequency inverter type X-ray generators.

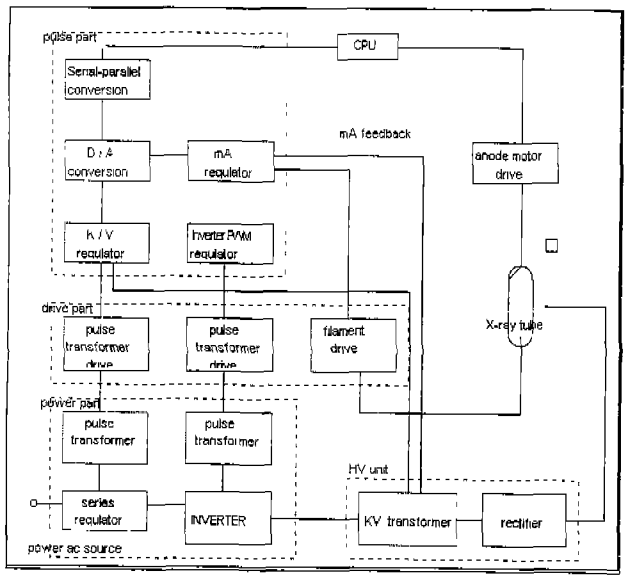

Fig.2 Control block diagram of high frequency inverter type X-ray generator

3. EXPERIMENTAL EQUIPMENT AND METHOD

3.1 Experimntal equipment

1) Inverter type of X-ray generator :
SUPER-X-HF(DONG-A)
DXGH-325R(DONG-A)
DXGH-325-R/PSU(DONG-A)
2) Tube voltage meter, Tube ampere meter :
Dynalyzer Ⅲ high voltage unit (Radical USA)
3) Radiation meter :
Ionization chamber 2027C Radiation Monitor (Radical co USA)
4) Oscilloscope : Tektronix TDS 380 (USA)

3.2 Experimental Method

The characteristics of device were measured with the equipment ; tube voltage , tube current, exposure time, output radiation, tube wave form ; linked X-ray tube with high-voltage cable to high voltage transformer. In order to compare and analyze the output radiation does of X-ray based input power supply, the authors measured the output radiation does per mA at each situation ; tube voltage 60, 80, 100, 120 kV, tube current 50, 100, 200, 300mA. Here, the focus ionization chamber distance is 10Cm. In the same condition, the authors examined the output radiation of direcibility and reproducibility, a everage values of 10 time at morning, noon and afternoon.

4. RESULTS AND EXAMINATION

4.1 The characteristics of HF inverter type X-ray generator using single phase power source

When the tube voltages changed up each other 60, 80, 100, 120 kV values that used the resonant inverter type of X-ray generator using single phase source at the tube current 100mA, exposure time 100msec, Fig.3 appeares ripple factor of tube voltage waveforms stablized. But in the clinical works, when it is radiographic taked from 50mA to 1000mA level for tube current range the more then the tube current of resonant inverter type X-ray generator, the exposure time is short radiographic for the sake of decrease in exposure dosage of patient. When the load condition got to changed in X-ray tube, the tube current is low and exposure time is long. Ripple factor of tube voltage waveforms are stable like to in Fig.4 When an identical per mAs of condition increase for the tube current, for the sake of shorten

exposure time(200mA, 50msec), the ripple factor of tube voltage waveforms are showed unstably in the fig.5. Under the each condition, the doseage of X-ray output show a measurement of result fallowed at table 1.

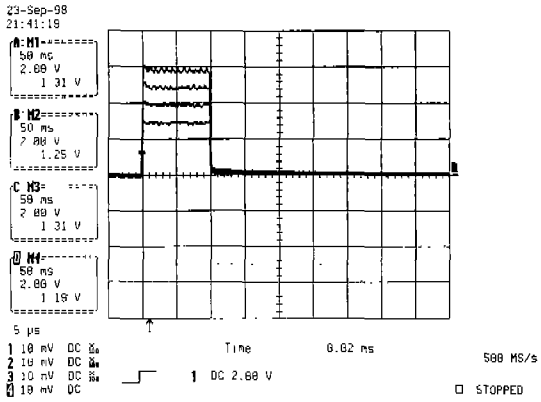

Fig.3 tube current:100mA exposure time:100ms tube voltage:60, 80, 100, 120kV

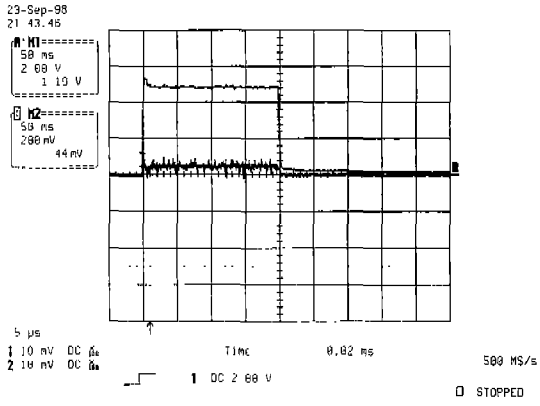

Fig. 4 tube current:50mA exposure time:200ms tube voltage:120kV

Table 1 Output radiation dose of resonant inverter type X-ray generator (mR)

mAs / KV	10 mAs			
	50mA*0.2s	100mA*0.1s	200mA*0.05s	300mA*0.032s
60	45.68	46.53	47.53	49.13
80	77033	80.67	80.6	83.3
100	115.17	119.4	120.23	122.73
120	154.3	158.17	148.8	133.2

By relatively, as at the low tube voltage without regard large or small of tube current show dose of distribution, in high tube voltage to high tube current translation have been appearanced unstable to output.(Fig.6) Smaller to the present condition, ripple factor of tube voltage show hardly the more and more in time at measurement with difference waste of electric power.

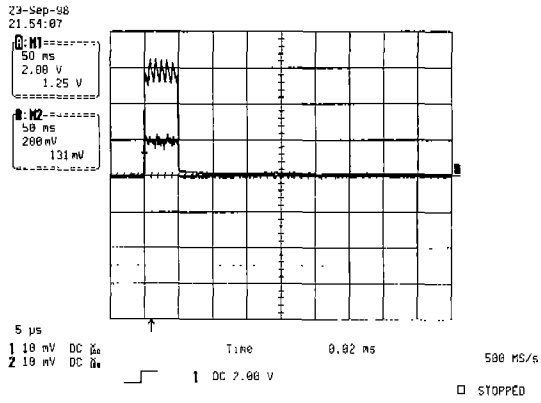

Fig. 5 tube current:200mA exposure time:50ms tube voltage:120kV

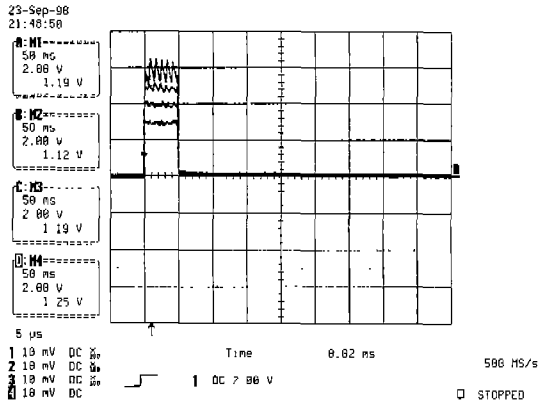

Fig. 6 tube current:200mA exposure time:50ms tube voltage:60, 80, 100, 120kV

4.2 The characteristics of HF inverter type X-ray generator using three phase power source

In the condition of tube current 10mA and exposure time 200msec, the tube voltage waveform was static eatch other 60, 80, 100, 120 kV in the resonant inverter type x-ray generator (Fig.7). And the ripple factor of tube voltage waveform was smaller than single phase The output dose was indicated the table 2 for change the exposure time. The dose distribution was uniformly indicated for exchanging the tube voltage because output dose was affected by ripple factor of tube voltage.

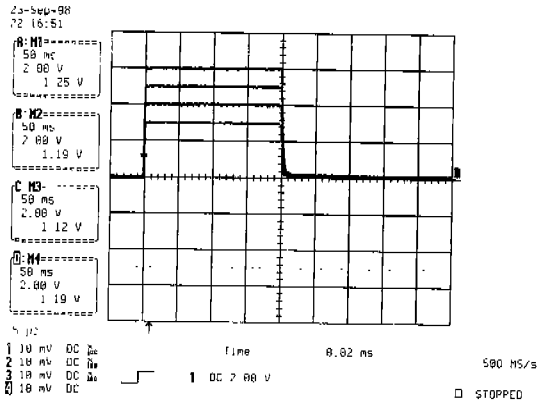

Fig. 7 tube current:50mA exposure time:200ms tube voltage:60, 80, 100, 120kV

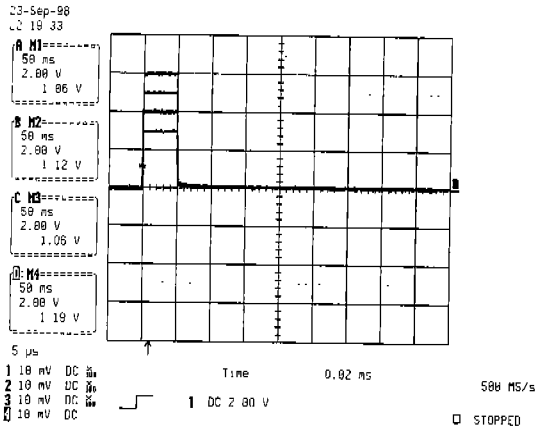

Fig. 8 tube current:200mA exposure time:50ms tube voltage:60, 80, 100, 120kV

Table 2 Output radiation dose of resonant inverter type X-ray generator using three phase power source. (mR)

mAs / KV	10 mAs			
	50mA*0.2s	100mA*0.1s	200mA*0.05s	300mA*0.032s
60	45.09	45.42	46.50	47.56
80	78.34	79.04	81.40	81.59
100	113.25	114.42	115.29	116.54
120	150.29	152.45	115.41	156.14

4.3 The characteristics of HF inverter type X-ray generator using PSU source

Inverter type X-ray generator using single phase source is when control high tube voltage and high tube current ripple factor of tube voltage waveform decrease and output is appear instability, if three phase source use, unstable point should fewest. But point is cost of power source installation is more addition. Therefore X-ray tube of clinic is no popularization. Special power source installation is useless, it is exploitation is move easily to HF generator using PUS(Power Storage Unit) is result of measure to tube voltage waveform is Fig. 9, when low tube current(50mA), ripple factor is safely. When the condition of exposure is high tube voltage and high tube current(200mA) at 50msec for output waveform is Fig. 10. according exposure time is grow, because tube voltage waveform is characteristic of condenser discharge to decrease waveform. Each condition is result of measure to output dose is table 3. When long exposure, tube voltage is mAs. Tube voltage is decrease output dose than short exposure time.

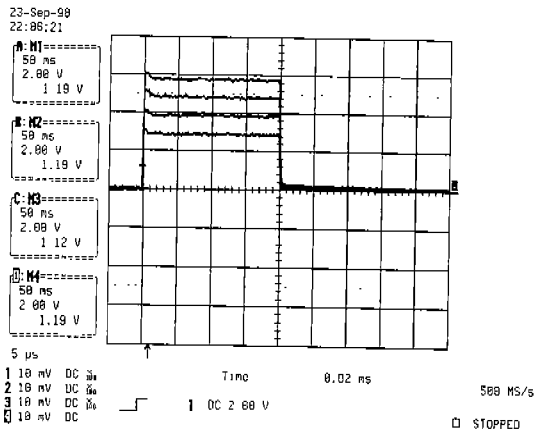

Fig. 9 tube current:50mA exposure time:200ms tube voltage:60, 80, 100, 120kV

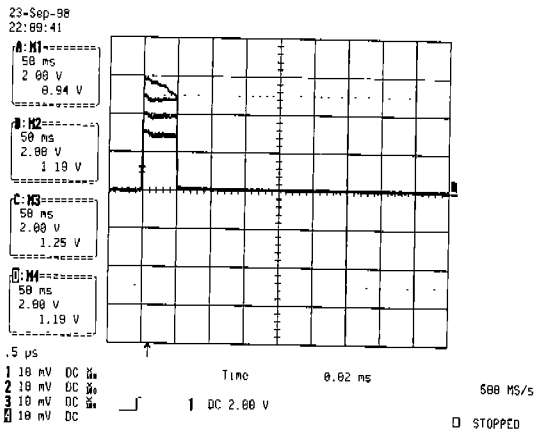

Fig. 10 tube current:200mA exposure time:50ms tube voltage:60, 80, 100, 120kV

Table 3 Output radiation dose of resonant inverter type X-ray generator using PSU source. (mR)

mAs / KV	10 mAs			
	50mA*0.2s	100mA*0.1s	200mA*0.05s	300mA*0.032s
60	46.50	47.12	47.08	46.59
80	79.25	81.04	82.12	80.58
100	116.45	117.21	116.30	116.89
120	155.41	156.14	154.90	153.28

4.4 Reproduction of X-ray output

As source vary, reproduction study of inverter type X-ray generator is occur from tube voltage, tube current, exposure time to safety when X-ray same term is exposure Tube voltage 80kV, 100kV, Tube current 50, 100, 200, 300mA, (10mAs). The result measured is coefficient of variation Table 4 Study is who using three phase coefficient of variation is fewest and all coefficient of variation is 0.05. Table 4 X-ray output reproducibility of inverter type generator using single, three phase, PSU source.

source / CV	single phase	three phase	PSU
0 ~ 0.009	4	5	5
0.01 ~ 0.019	3	3	2
0.02 ~ 0.029	1	·	1
0.03 ~ 0.039	·	·	·
0.04 ~ 0.05	·	·	·

5. CONCLUSION

The rippple factor of tube waveforms affected to the output characteristics according to used changing the input power source used resonant PWM inverter type of X-ray generator. The results of analyzing have the following characteristics;

1. On applying the resonant PWM inverter that raised the operating frequency to X-ray generator, high voltage transformer could be miniaturized.

2. The ripple factor tube waveforms remarkabley affected to the radistion output of X-ray in the resonant high-frequency inverter type of X-ray generator

3. The PSU source unit that linked the system are more stable than the single phase power source, and the three phase power sources are the most stable in the output characteristics.

4. Furthermore, would discusse the prototypes of the HF inverter type of X-ray generators linked high-voltage transformers in terms of decreasing the high frequency distortion and ripple factor.

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