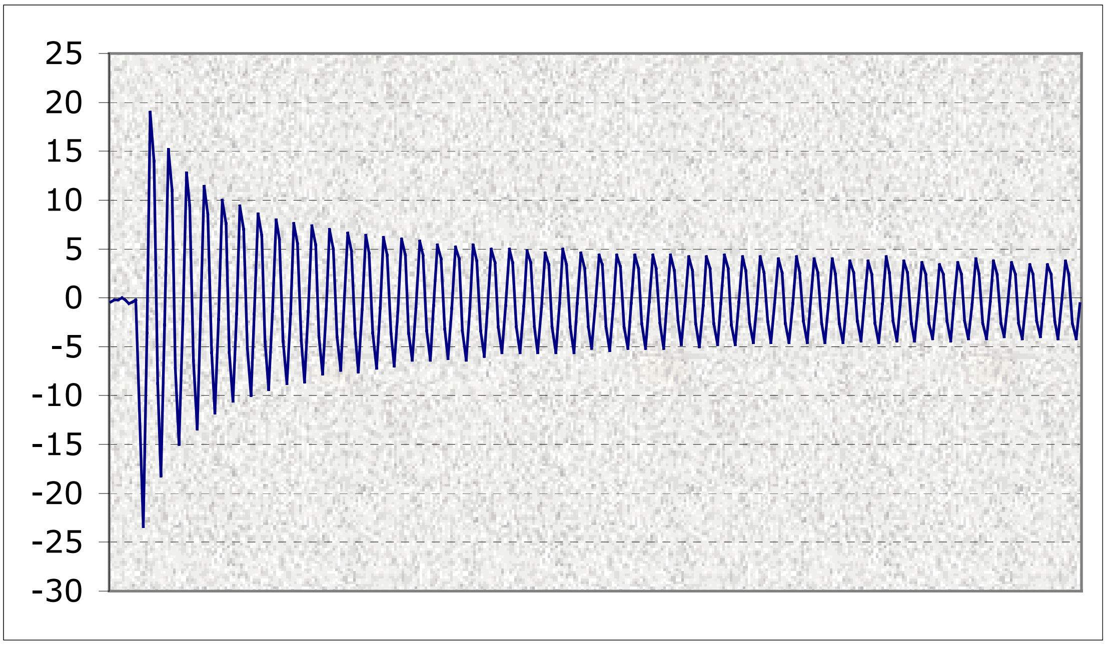
USER'S MANUAL Rev. 01/2002

APPLICATION NOTES

INFRARED



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infrared notes 01/2002 issue

Application Notes for Infrared

Index:

1. INFRARED HEATING TECHNIQUES

Heating plays a central role in the forming and processing of:

- plastic
- paper
- glass
- wood
- metals
- printing
- electronics
- food
- chemical and farmaceutical
- ceramic
- air conditioning
- tobacco

and others applications.

2. INFRARED HEAT MEETS ALL REQUIREMENTS

- Heat transfer is easy. It requires no contact with the material and no intermediate such as air or water.
- High power can be transmitted. Foils, plates and other shapes are heated in seconds.
- The heating process fits in easily with the manufacturing process.
- The process is economical because the heat loss is small as the heating effect is confined to the material to be heated.
- Infrared rediation is safe and can be easily switched ON/OFF.

3. DIFFERENT TYPES OF INFRARED

The temperature of emitter determines the special distribution of the wavelengths. See figure 1, with decreasing temperature the spectrum shifts to the longer wavelengths. The position of the peak intensity in the spectrum gives the emitters their names:

Short wave: maximum emition ~ 1,3μm

Medium wave: maximum emition ~ 2,3 ÷ 3,4μm

Long wave: maximum emition ~ 3 ÷ 5μm

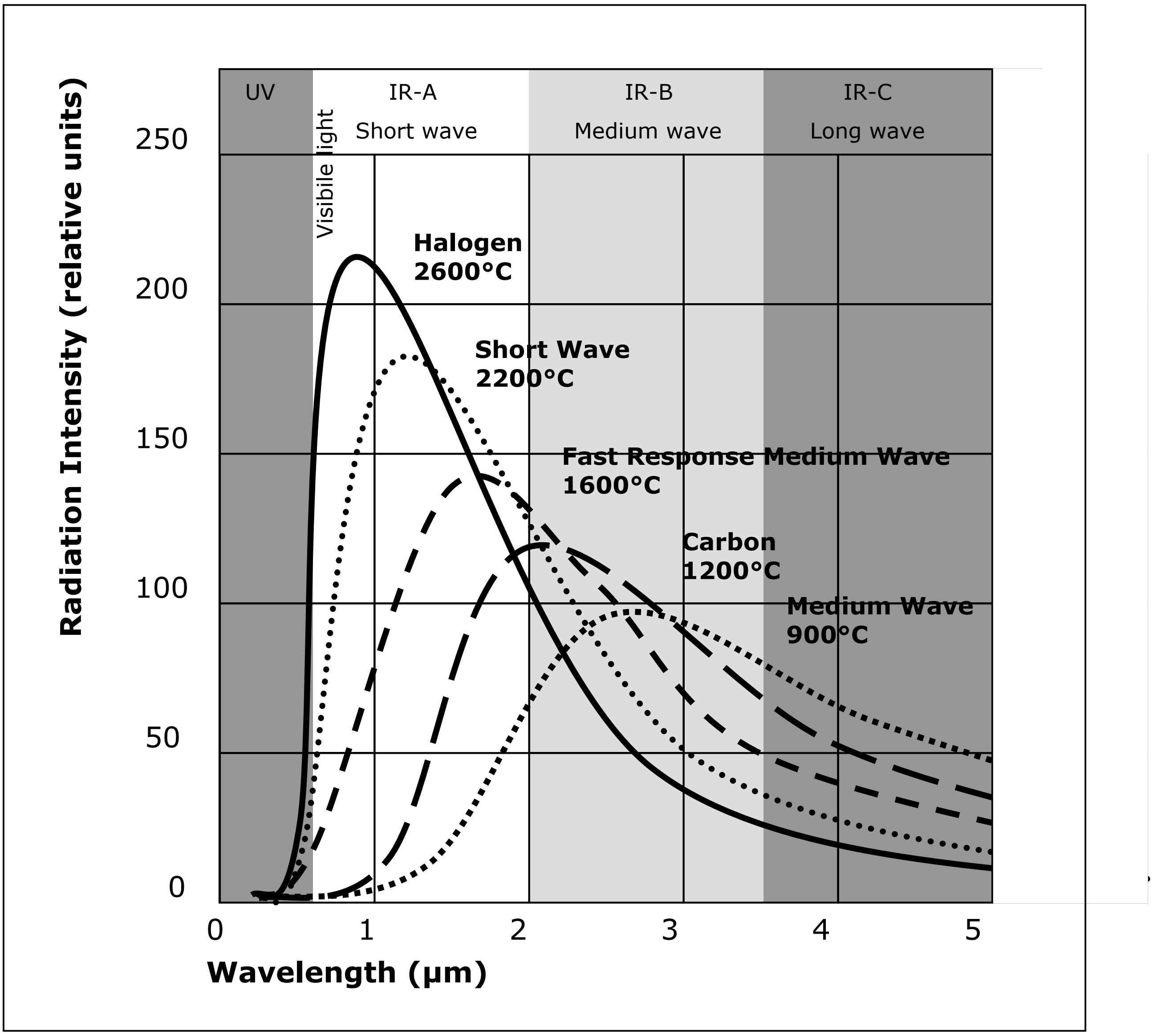

Figure 1. Infrared spectra of different emitters

Just like visible light, part of the broad spectrum of the IR radiation is reflected from the surface of the material, part is absorbed within the material and part penetrates through the material. The reflected component is usually very small. The component of the rediation spectrum which is absorbed is that which coincides with the wavelength of the molecular oscillation in the material. When the radiation is absorbed, it gives up its energy to the molecules so that the material is heated.

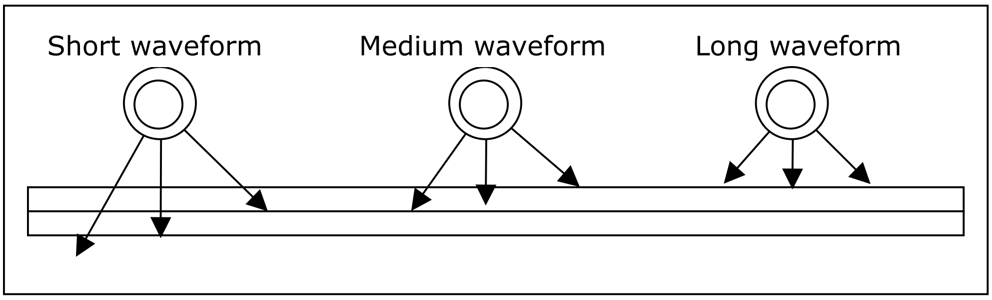

Figure 2. Penetration of different IR waveform

4. ELECTRONIC PANEL

CD Automation has developed a product range of Thyristor unit to drive IR.

It’s possible to drive power with different types of firing modes: Single Cycles, Burst Firing and Phase Angle.

In the next pages will be described the different techniques.

CD Automation can provide a complete panel including:

- cabinet
- thyristor unit
- temperature or humidity controller with Auto/Manual command. The temperature can be detected with thermocouple or pyrometer
- an input for speed can be the main setpoint or a trim set of the power

5. INFRARED APPLICATIONS

We have metioned that there are different types of infrared: short, medium and long waveform. Let’s see in particular the different kinds of infrared:

a) short waveform: peak current ~ 7 times I nominal. Attention must be payed in sizing the thyristors

b) ultrashort waveform: peak current ~ 16 times I nominal. Attention must be payed in sizing the thyristors

c) medium waveform: I peak equal to I nominal. No attention must be payed to peak current

d) fast medium: These elements are in thungsten like short type and the peak current is lower but the necessary time to be heated is longer and this stresses the thyristors

e) long: I peak equal to nominal. No attention must be payed in sizing the thyristors

f) In car industry and in other special applications the short IRW are supplied with very low voltage compared with the nominal one to change the IRW penetration. Cure must be used for these applications for current sizing of thyristors. In fact, must be used the normal precaution for short waveform plus extra precaution for voltage supply lower than the nominal that causes a lower peak but a very long overcurrent that stresses the thyristors. For sizing contact CD Automation, it will be necessary to collect more informations from the supplier of the IRW short.

6. CURE OF INRUSH CURRENT ON SHORT AND ULTRASHORT IRSW

When there is inrush current, the first technique that an engineer can adopt is to limit it with Current Limit and Phase Angle firing. This technique cannot be used for the following reasons:

The current with Phase Angle and Current Limit is not really limited for the first 5 periods (100msec). In fact, Current Limit function is an electronic circuit that has a delay of ~ 100msec due to the current transformer inertia and passive components. See the graph below.

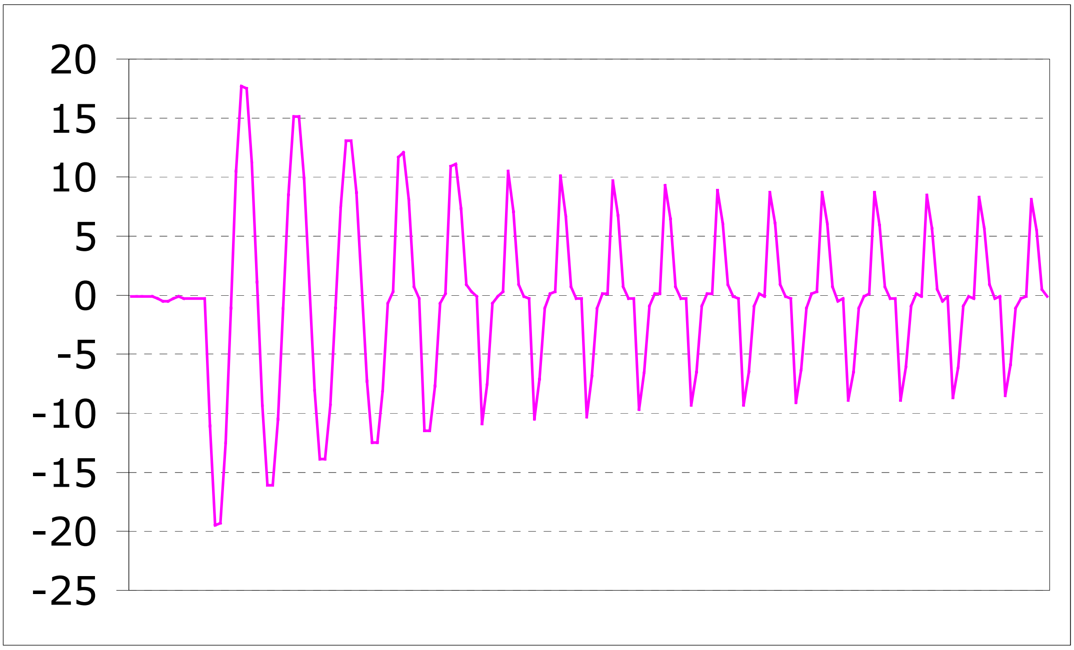

Figure 3. How Current Limit works: the graph represents the current absorption of a cold IR lamp starting with CL (10V 50ms)

To reduce this phenomenon is used a long soft start.

Phase Angle technique with Current Limit cost more than Single Cycle technique, specially for 3 phase loads.

In addition, the overload current remains for a longer time than with no Current Limit. This can be explained by the fact that short infrared are cold resistances. When those elements are colds there is the maximum current with low resistance. Increasing the temperature this will increase the resistance too.

If we reduce the voltage, we reduce the energy supplied and it will take more time to heat itself.

In the next pages we must keep in mind this phenomenon. See the graphs below.

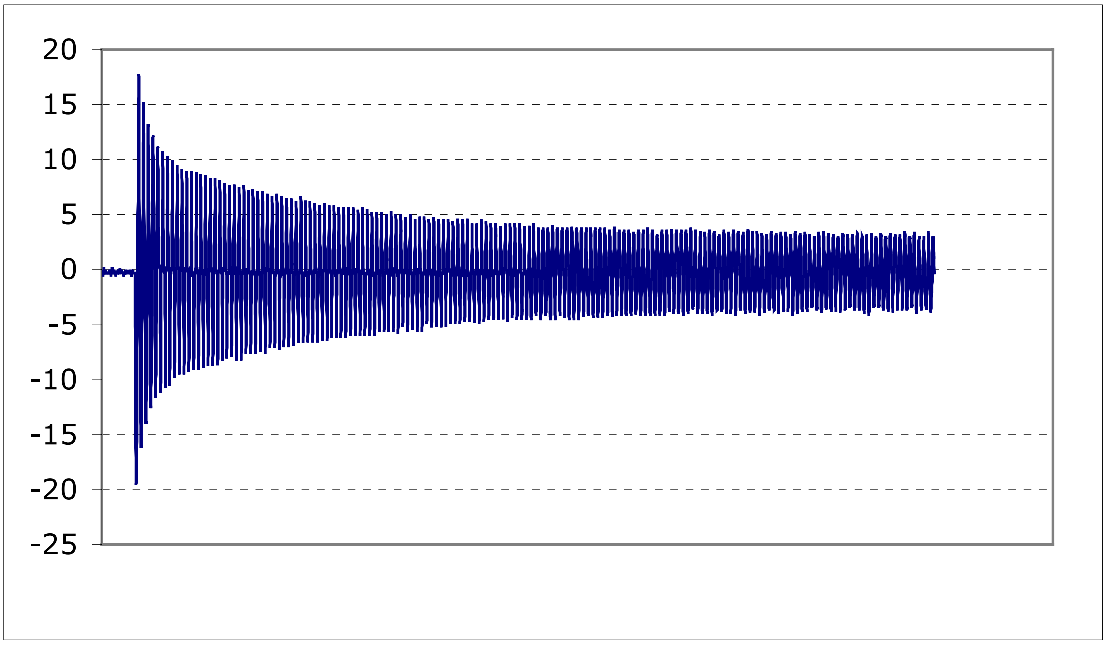

Figure 4. The graph represents the current absorption of a cold IR lamp with Current Limit (10V 500ms)

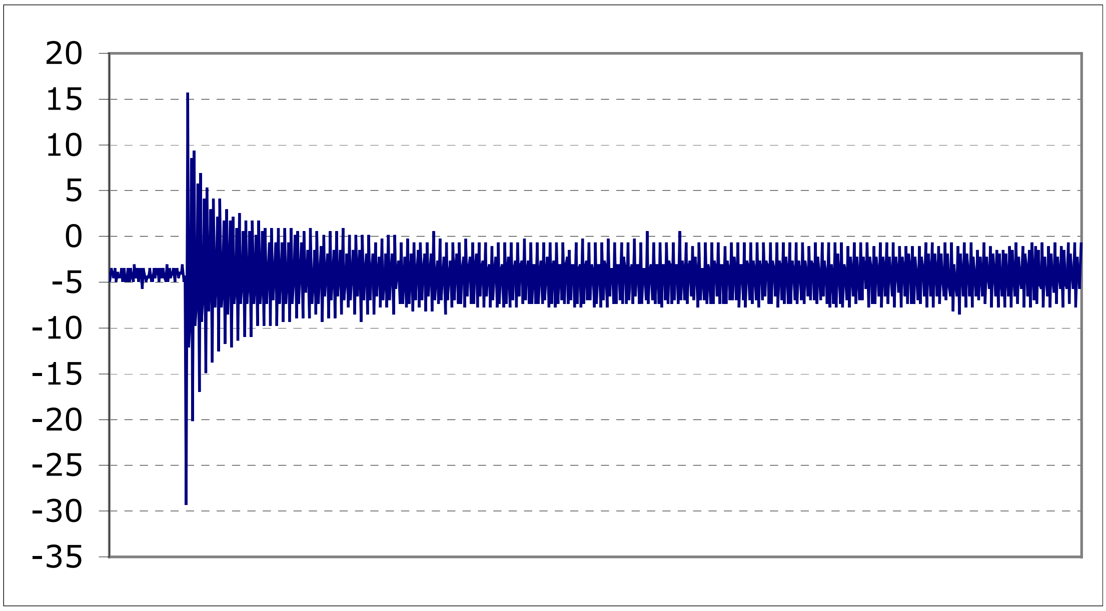

Figure 5. The graph represents the current absorption of a cold IR lamp without Current Limit

As you can see in the above graphs, with Current Limit the inrush current remains high for a longer time.

Let's see the technical data.

	IR lamp without CL	IR lamp with CL
Measure mode	Min/Max	Min/Max
Period	20ms	20ms
Frequency	50.1Hz	50.1Hz
Pos. Pulse Width	10.4ms	10.4ms
Neg. Pulse Width	9.52ms	9.66ms
Rise Time	5.95ms	5.93ms
Fall Time	n/a	6.77ms
Pos. Duty Cycle	52.31%	51.73%
Neg. Duty Cycle	47.69%	48.27%
Pos. Overshoot	0.00%	0.00%
Neg. Overshoot	0.00%	0.00%
Peak to Peak	44.4V	37.2V
Amplitude	44.4V	37.2V
High	20.9V	17.7V
Low	-23.5V	-19.5V
Maximum	20.9V	17.7V
Minimum	-23.5V	-19.5V
Mean	-227mV	-235mV
Cycle Mean	1.69V	1.08V
RMS	3.18V	3.03V
AC RMS	3.17V	3.02V
Cycle RMS	14.5V	12.5V
Cycle AC RMS	14V	12.3V
Burst Width	3.82s	3.84s

Test with IR lamps using a CD3000 with Current Limit.

Single Cycle	1	Oscilloscope		Clamp power meters		
	POWER	Inom	I peek	I RMS	I Peek	I Avg
Ilimit = Inom						
	100	7.4	7.4	4.86	7.22	4.33
	90	7.4	7.4	4.69	7.39	4.01
	80	7.4	7.6	4.61	7.64	3.68
	70	7.4	7.8	4.41	7.87	3.46
	60	7.4	8	4.22	8.04	3.02
	50	7.4	8.4	4.02	8.35	2.75
	40	7.4	8.6	3.78	8.75	2.35
	30	7.4	9.4	3.46	9.42	1.94
	20	7.4	10	3.21	10.3	1.6
	10	7.4	15	2.8	12.57	1
	1	7.4	41			

Single Cycle	1	Oscilloscope		Clamp power meters		
	POWER	Inom	I peek	I RMS	I Peek	I Avg
Ilimit = 1.5 x Inom						
	100	7.4	7.4	4.86	7.22	4.37
	90	7.4	7.4	4.69	7.39	3.98
	80	7.4	7.6	4.61	7.64	3.68
	70	7.4	8	4.41	7.87	3.46
	60	7.4	8	4.22	8.04	3.05
	50	7.4	8.4	4.02	8.35	2.75
	40	7.4	8.6	3.78	8.75	2.35
	30	7.4	9.5	3.46	9.37	1.97
	20	7.4	10	3.21	10.5	1.6
	10	7.4	15	2.8	12.58	1
	1	7.4	40			

Single Cycle	1	Oscilloscope		Clamp power meters		
	POWER	Inom	I peek	I RMS	I Peek	I Avg
Ilimit = 2 x Inom						
	100	7.4	7.4	4.86	7.3	4.33
	90	7.4	7.3	4.69	7.41	4.01
	80	7.4	7.6	4.61	7.64	3.68
	70	7.4	8.1	4.41	7.87	3.46
	60	7.4	8.24	4.22	8.04	3.02
	50	7.4	8.4	4.02	8.36	2.75
	40	7.4	8.6	3.68	8.9	2.12
	30	7.4	9.4	3.45	9.52	1.63
	20	7.4	9.8	3.13	9.98	1.25
	10	7.4	15.1	2.8	12.6	0.92
	1	7.4	41			

7. SINGLE CYCLE AND BURST FIRING

The technique of Single Cycle is the most used to drive infrared short waveform.
Single Cycle is the fastest mode with zero crossing to control in non-continuous mode the load power.
For example:
25% of power = 1 cycle ON + 3 cycles OFF
50% of power = 1 cycle ON + 1 cycle OFF
75% of power = 3 cycles ON + 1 cycle OFF
To have more details see firing modes in application notes.
This firing technique is important for infrared short because inrush current is present in the following cases:

a) when the load is cold and is switched ON for the first time
b) when controlling the power the load is switched OFF and after a time it is switched ON. During the OFF time the IRSW element become cold (due to their low inertia) and when it is switched ON again there is a peak of current.

The best technique is to reduce at the minimum the OFF time providing to be able to control the power. The firing mode able to do this is Single Cycle.

In the graph below is possible to see the overcurrent as a function of the power demand with Single Cycle.

To reduce the thyristor's stress, the unit starts working at 10% because at 1% of power demand the peak of current is 2,75 I nom. This means that thyristor unit for IRSW starts working when input signal is 10% of the power.

If with input 0÷10V the signal is 1V, the thyristor doesn't go in conduction. This is because normally the thyristor is controlled by a temperature controller (closed loop) and if the process is well designed the power demand is ~ 60%.

If is necessary to use a power below 10%, inform CD Automation to have the units working also below 10% of power demand.

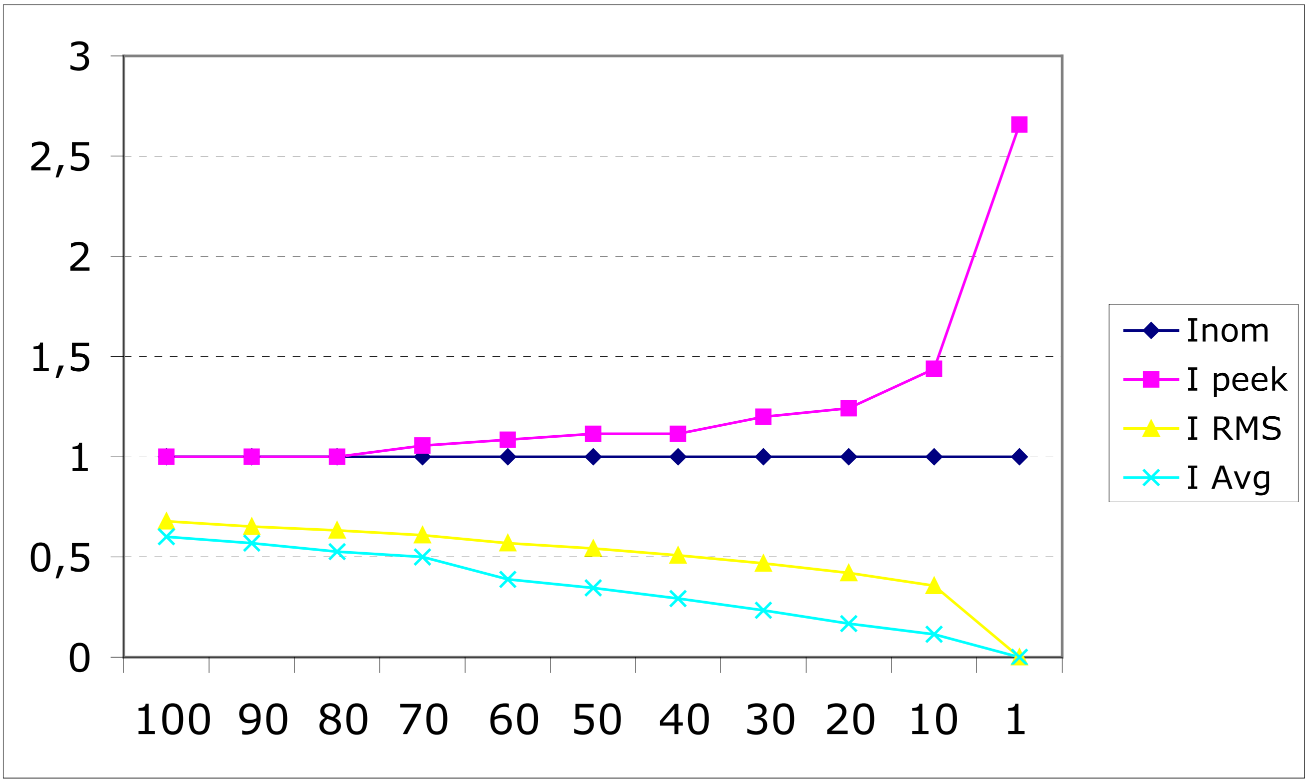

Figure 6. The overcurrent as a functin of power demand with Single Cycle

8. PEAK OF CURRENT AS FUNCTION OF NUMBER OF BURST FIRING CYCLES

To demonstrate that OFF time must be as short as possible to reduce the peak of current, look at the graph below.

There are 4 curves using the 50% of power demand:
Curve 1 – 1 cycle ON + 1 cycle OFF at 50% of power
Curve 2 – 2 cycles ON + 2 cycles OFF at 50% of power
Curve 3 – 3 cycles ON + 3 cycles OFF at 50% of power
Curve 4 – 4 cycles ON + 4 cycles OFF at 50% of power

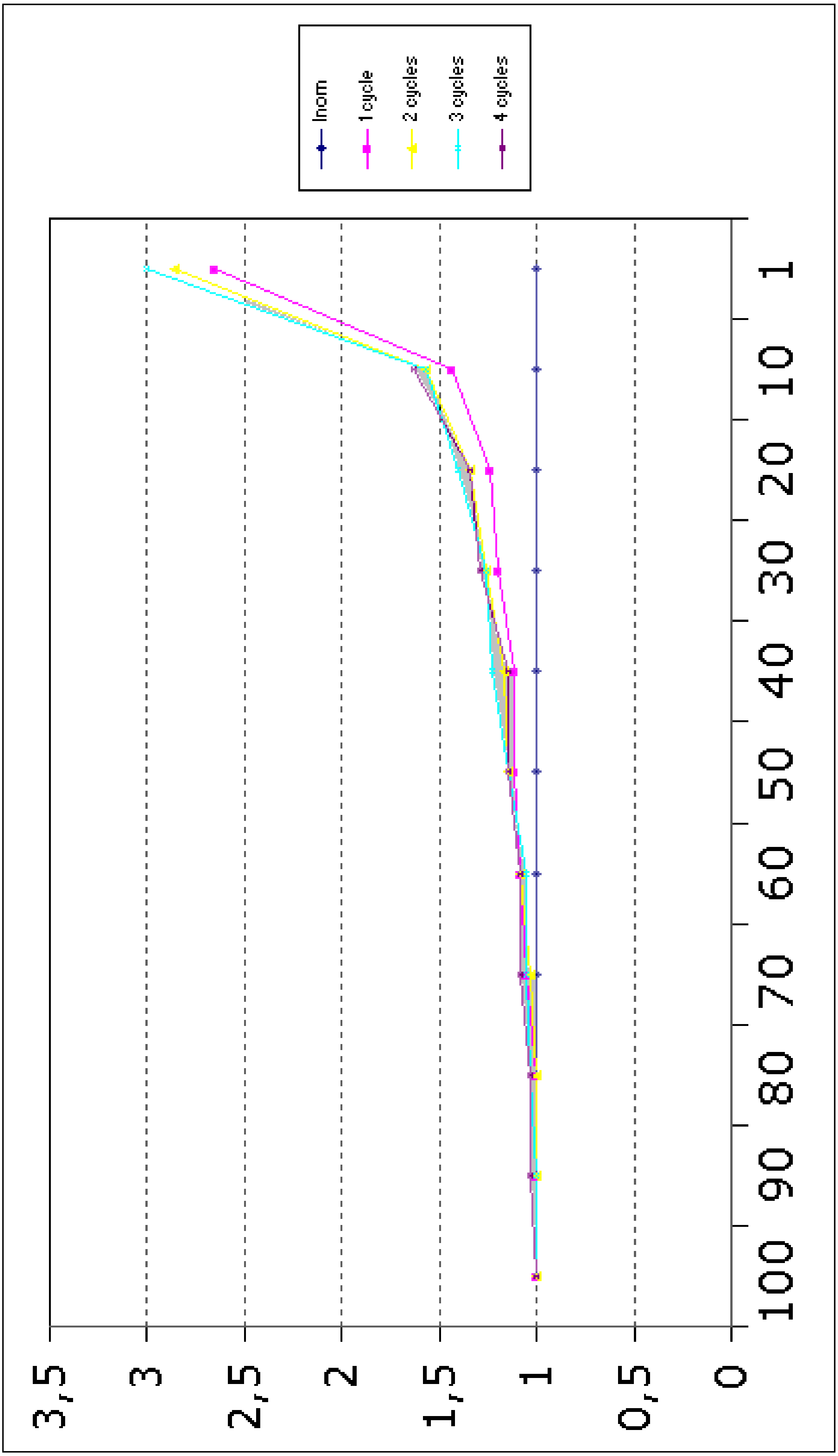

Figure 7. Peak of current as a function of the power

In figure 7 (previous page) is possible to see that at 10% the current with 1 cycle is lower than the current at 2, 3 or 4 cycles.

This is because the OFF time is lower and the IRSW has not time enough to become cold.

Measure mode	Min/Max
Period	19.9ms
Frequency	50.3Hz
Pos. Pulse Width	10.6ms
Neg. Pulse Width	9.29ms
Rise Time	6.39ms
Fall Time	n/a
Pos. Duty Cycle	53.28%
Neg. Duty Cycle	46.72%
Pos. Overshoot	0.00%
Neg. Overshoot	0.00%
Peak to Peak	42.4V
Amplitude	42.4V
High	19V
Low	-23.4V
Maximum	19V
Minimum	-23.4V
Mean	-253mV
Cycle Mean	2.69V
RMS	2.77V
AC RMS	2.76V
Cycle RMS	13.9V
Cycle AC RMS	12.3V
Burst Width	9.63s

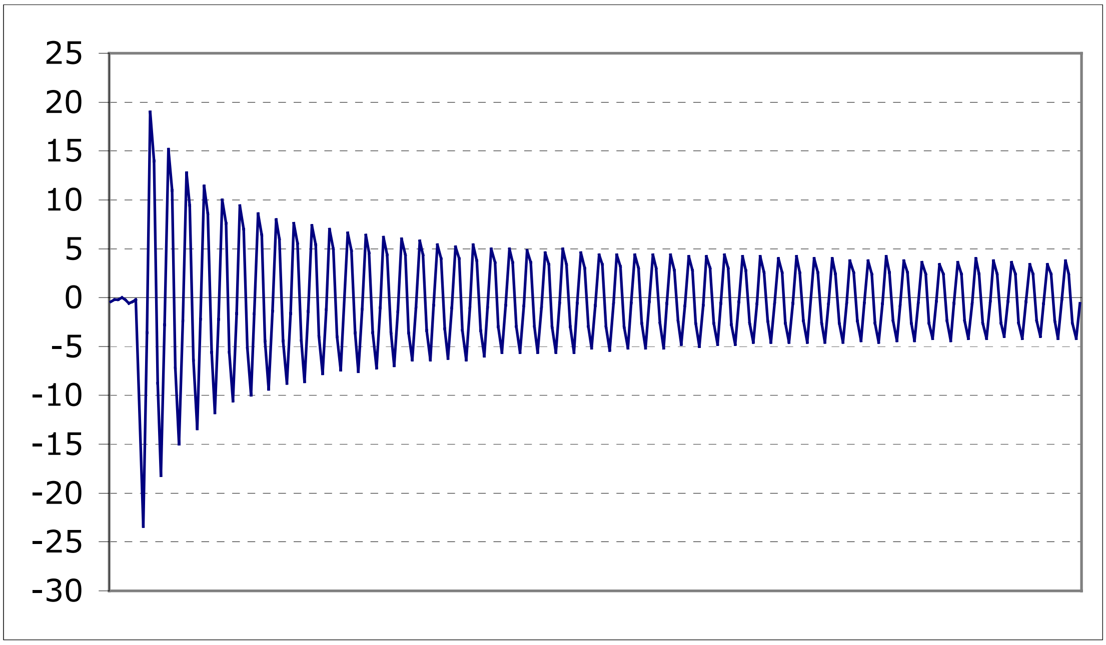

Figure 8. Behaviour of an IR cold lamp

Burst	1	Oscilloscope		Clamp power meters		
	POWER	Inom	I peek	I RMS	I Peek	I Avg
	100	7	7	4.74	7.62	4.2
	90	7	7	4.56	7.72	3.98
	80	7	7	4.43	7.84	3.68
	70	7	7.4	4.26	8.07	3.5
	60	7	7.6	3.98	7.27	2.72
	50	7	7.8	3.79	7.6	2.42
	40	7	7.8	3.56	7.98	2.04
	30	7	8.4	3.28	8.53	1.64
	20	7	8.7	2.95	9.3	1.18
	10	7	10.08	2.49	11	0.8
	1	7	18.6	n.m.	n.m.	n.m.

Burst	2	Oscilloscope		Clamp power meters		
	POWER	Inom	I peek	I RMS	I Peek	I Avg
	100	7	7	4.66	6.65	4.17
	90	7	7	4.6	6.81	4.6
	80	7	7	4.35	6.91	3.5
	70	7	7.2	4.2	7.13	3.25
	60	7	7.6	4.01	7.35	2.83
	50	7	8	3.8	7.62	2.5
	40	7	8.2	3.63	8.05	2.02
	30	7	8.8	3.4	8.57	1.5
	20	7	9.4	2.97	9.5	1.22
	10	7	11	2.5	11	1
	1	7	20	n.m.	n.m.	n.m.

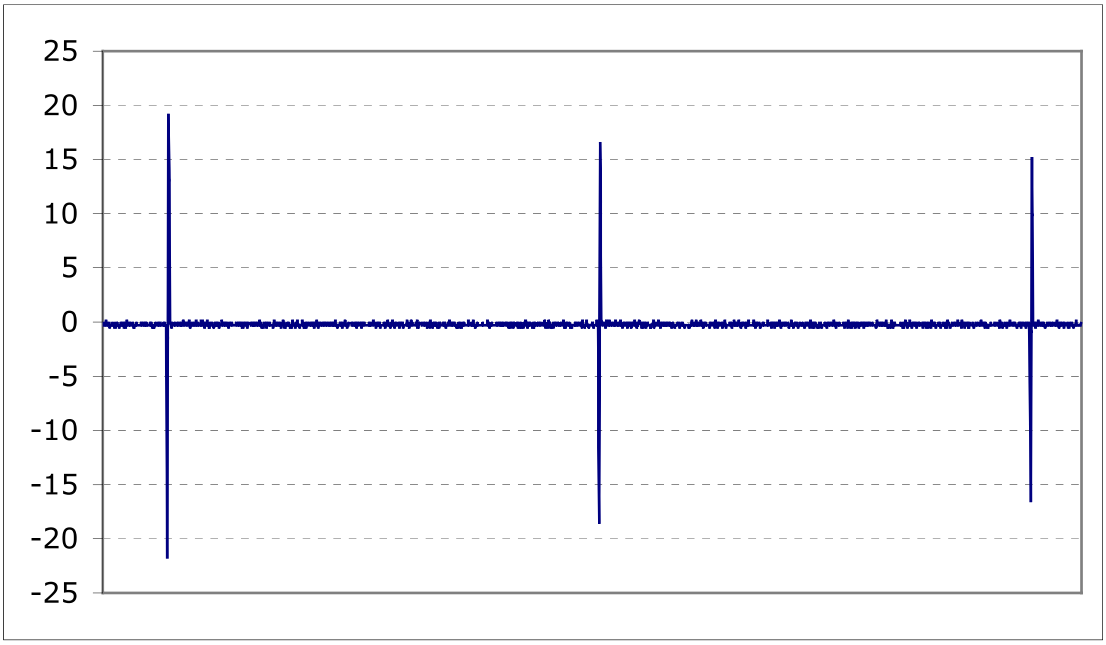

Figure 9. Peak with power 1% with cold lamp A

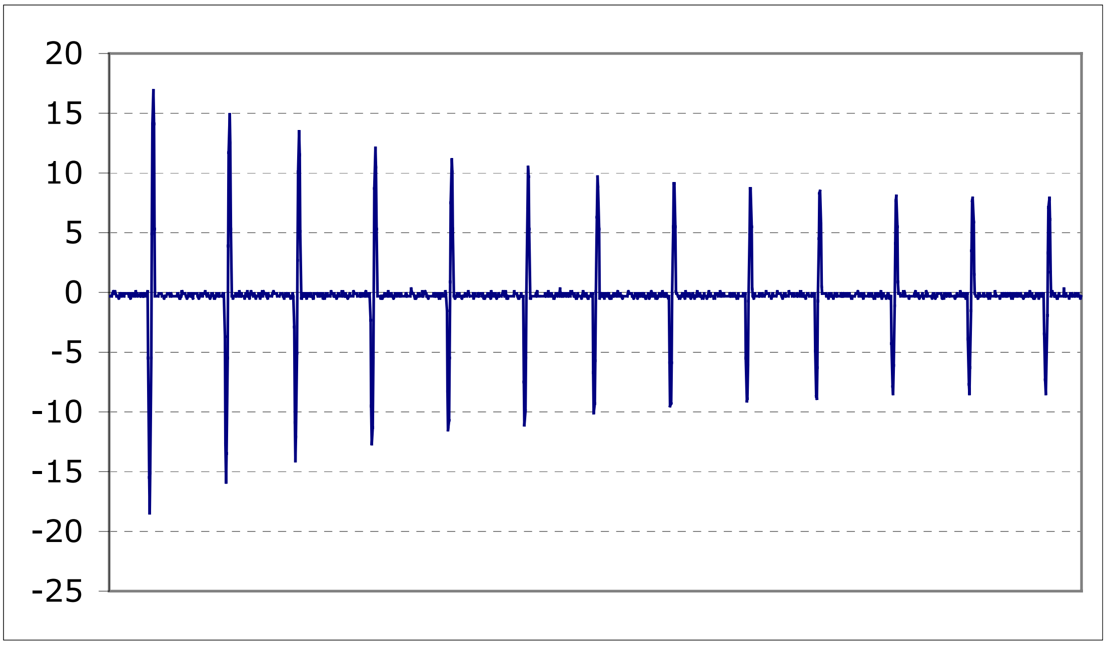

Figure 10. Peak with power 10% with cold lamp A

	IR cold lamp A	IR cold lamp B
Measure mode	Min/Max	Min/Max
Period	220ms	3s
Frequency	4.54Hz	333mHz
Pos. Pulse Width	210ms	2.99ms
Neg. Pulse Width	10.2ms	11.6ms
Rise Time	6ms	6.4ms
Fall Time	n/a	2.99s
Pos. Duty Cycle	95.37%	99.61%
Neg. Duty Cycle	4.63%	0.39%
Pos. Overshoot	0.00%	0.00%
Neg. Overshoot	0.00%	0.00%
Peak to Peak	44V	40.8V
Amplitude	44V	40.8V
High	20.5V	19.1V
Low	-23.5V	-21.7V
Maximum	20.5V	19.1V
Minimum	-23.5V	-21.7V
Mean	-233mV	-243mV
Cycle Mean	-5.57V	-222mV
RMS	2.31V	1.08V
AC RMS	2.3V	1.05V
Cycle RMS	4.22V	1.17V
Cycle AC RMS	4.08V	1.05V
Burst Width	4.3s	6s

9. BURST FIRING AND SINGLE CYCLE IN CONTINUOUS PROCESS

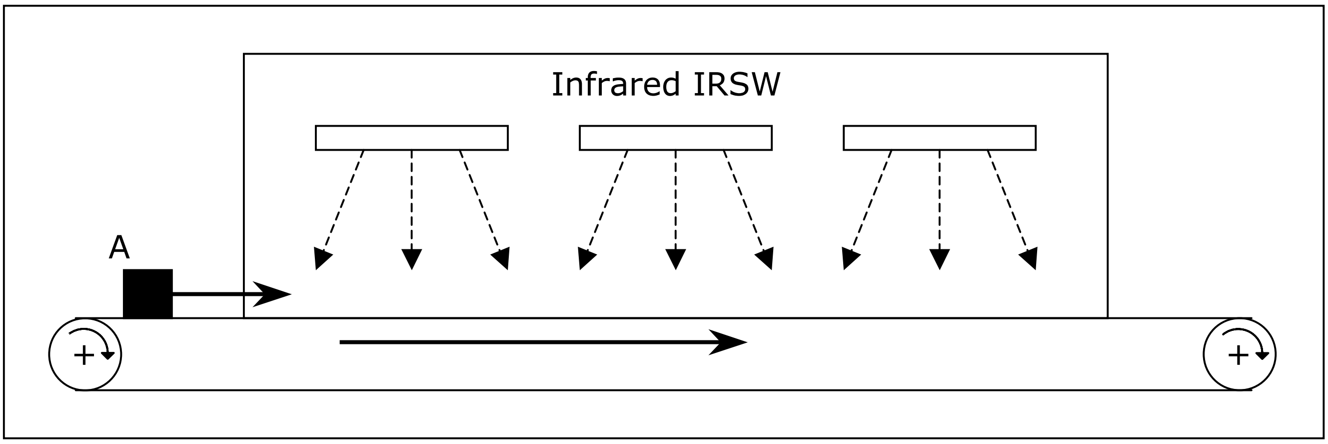

Figure 11. Tunnel fournace for heating treatment

In the figure 7 is shown a tunnel fournace for the heating treatment of product A (on the left). The product is moving on the conveyor at high speed to increase production.

Let’s say that the product takes 5 seconds to go throught the tunnel and power demand is 50%.

If cycle time (time ON + time OFF) is 20 seconds the ON time will be 10 seconds, then could happen that the product A will not be treated because the transit will be in OFF time.

Now, if we use cycle time of 40msec (20msec ON + 20 msec OFF) we are sure that the product will be treated.

CD Automation Thyristor units can be setted in power for a fixed speed value of conveyor and compensated for speed variations.

If we twice the speed, then the power will also become double.