

Thermovisual camera commands decoding and ISI format encrypting

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This study describes wiretapping method for camera and its monitoring codes. Analysis and decoding of specially protected ISI database includes temperature data of an object observed in the process.

Keywords: Decoding, Digital infrared thermography, Monitoring, Thermogram analysis, Thermovision

Introduction

Thermovision [infrared (IR) thermography], a contact less method used to enable information on temperature in each point of an observed object, is implemented for monitoring and diagnostic process of state and stability of electrical power plants, equipment and installations. Monitoring includes measuring, diagnostics and alarming dispatcher in remote control center. Diagnostic process consists of specific program, planned to control camera functions, for encrypting and thermogram analysis. Using such method, camera moderation and control is being done by user applicative program, closed type. R: Such data could be processed and visually presented¹. Reframed or visualized data is called thermogram, which could be produced by digital thermo visual camera².

Camera under Study (Wohler type IK 21)

Chosen camera (Wohler type IK 21), a manual (portable) thermovisual camera, forms a thermal picture by measuring IR radiation of a certain object or entire scene, according to no culled germanium thermoelectric in line detector. Building detector enables registered temperature varieties (0, 1°C) within temperature interval (0-350°C). Camera's software³ considers various weather effects (dust, rain, fog, etc.) and coefficient of an ambient emissivity so that their influence on quality of a measurement should be completely reduced to

minimum range. Wohler IK 21 camera could be installed as a motionless sensor directed from PC. Camera, equipped with specific connecting devices and appropriate software, uses original IR Snap View software package, by Infrared Solutions Inc⁴ (Fig. 1). Apart from control camera's functions, camera's software enables further analysis of recorded thermograms, format of which is crypted and not explained by available producer documentation. Suitable databases carry specific ISI extension. Thermograms could be manually converted into a bitmap form with different extensions (BMP, JPG, PCX, size 120x120 points with 256 colors) and could also be further proceeded by standardized tools for picture processing. Thermogram could be imported and presented into Excel table, where each field represents a temperature of appropriate pixel on thermogram. Functions of supplied applicative software, applied to camera, were not completely suitable for this project. Therefore, a new programming module was designed, introduced and integrated with original software for camera integration to develop completely new system.

This study presents decoding of dictating camera codes due to integration into a new monitoring system and format encrypting.

Experimental Section

Decoding Commands to Thermovisual Camera

Physical connection between thermovisual camera and supervising PC (Fig. 1.) was established directly (back-to-back) by serial communication cable. Original software for camera monitoring⁵ controls data exchange.

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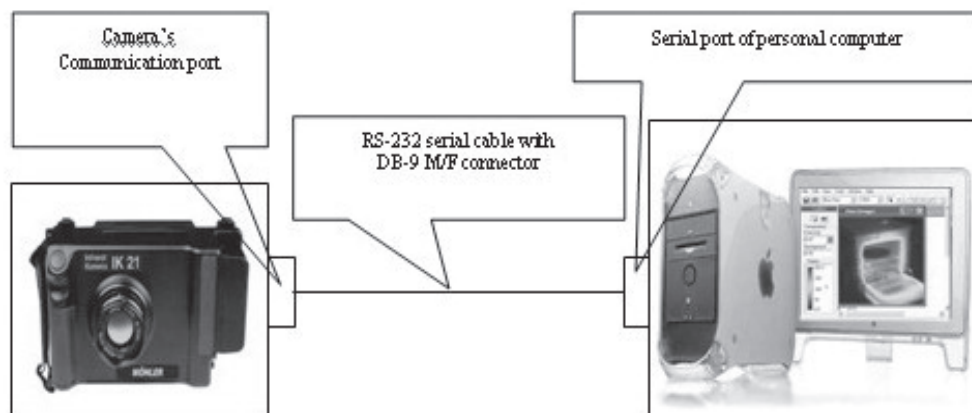


Fig. 1—Camera-PC, back-to-back interconnection

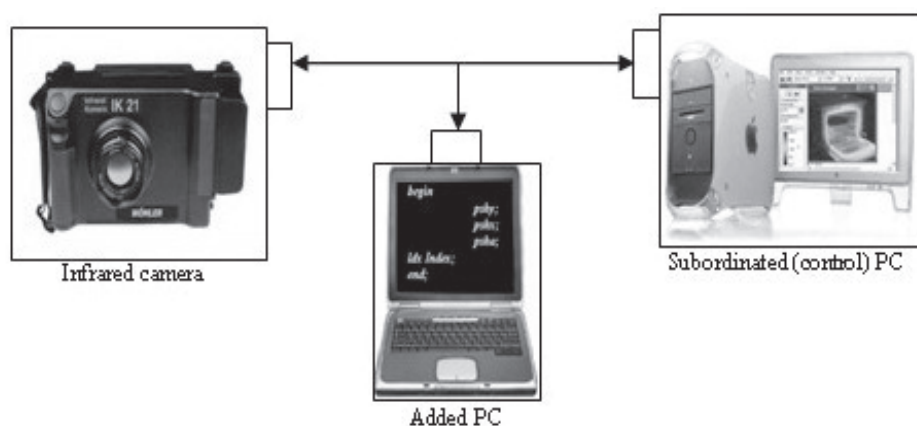


Fig. 2—Simulations system picture

Generated commands are transmitted to camera and data that describe temperature characteristics of an observed object are transferred back to PC. Although there is still a need to proceed and analyze original data, simple selection from applicative program is not possible. There should be a way to receive source information transmitted from PC to visual camera response. Therefore, another specific computer device was applied as a multipoint unit (Fig. 2). Snap View Pro software package (control PC) operates with a thermovisual camera in a simulation system (Fig. 2), by sending messages (commands) within communication sessions. Some of these influences a camera work itself setting parameters (exposition, measuring frequency etc.) and others are for measuring, activating transmission and controlling the process. Communication protocol and message format in both directions remain unknown, so a wiretapping method was used for decoding in two ways: i) Wiretapping of a message from PC to receive a frame, which contains sent order of activating camera functions; and ii)

Wiretapping of a camera response, which is a detailed description of a technical picture of appropriate object. In first case, receiving pin of a serial interface (SC1), RS-232C V-24 recommendation, which is connected onto Txd pin of a supervising PC, receives a message addressed to camera. For this purpose, a procedure (including assembly routines⁶) for message receiving from a communication's line was developed.

Communication process was chosen for variety of basic parameters within this procedure (transmission speed, parity control, stop bits, characters' length and number of bytes), optimal values (9600 N81). After testing of these chosen parameters values, an assembly procedure⁶ (Table 1) is integrated into main program. Preliminary version of a test program for the support of a thermovisual camera's work has already implied a bigger number of assembly procedures (machine language) to establish connection, maintaining of a serial communication (sending and receiving) and plug outs. It is done on lowest OSI model layers (physical and logical).

Although an asynchronous transmission is in the question, form of a message – of both PC commands and camera data – is still defined. Transfer is based on elementary characters' transmission of both PC orders and camera data. In this purpose, a pair of basic assembly procedure was used⁷ for transmission of each character into communication port's line – Procedure SendD and a

procedure for a receiving data – Procedure RcvD (Table 2).

For recognition of elementary rules within the process of a camera work, a simplified sequential program in Windows DOS prompt regime was created. It allows frequent changing of direct parameters easier, and following manipulative process, being finished in assembler Windows platform, was used for complete design and development of a working program. Task priority in Windows is shown through combination of two values (class of a general priority and class of an individual task), established by special function, *SetPriorityClass*^{8,9}. For communication program module, Real-time or high priority level was used. Using described method, received messages were reconstructed and recognized as a stream of characters as well: **Stx** – Start of text is a mandatory ASCII character 01_{hex}; **Addr** – Destination address is a camera network address in this case 91_{hex}; **Cmd** – Command code is an operation code for concrete camera function; **Par** – Parameter is an added byte for the complex camera functions; **Ettx** – End of text is a mandatory ASCII character 03_{hex}; **Bcc** –Block check character is an exor logic function of previous characters. Comparing received characters in **Cmd** message field

Table 1— COMM port 2 programming procedure

```
; Comm Port Preparation
CPort2 proc near; Comm Port2
    mov dx,02FBh      ; LCR
    mov al,83h        ; alternative addressing mode
    out dx,al
    mov dx,02F8h      ; DLL
    mov al,0Ch        ; 0Ch - 9600 bps – transfer rate
    out dx,al
    mov dx,02F9h      ; DLH
    mov al,0          ; 00h - 9600 bps – transfer rate
    out dx,al
    mov dx,02FBh      ; LCR
    mov al,03h        ; 03h - N 8 1
    out dx,al
    ret
CPort2 endp
```

Table 2—Assembly language (Motorola) procedures

Character sending	Character receiving
<i>Procedure SendD;</i>	<i>Procedure RcvD;</i>
<i>begin</i>	<i>begin</i>
<i>pshx;</i>	<i>pshy;</i>
<i>pshy;</i>	<i>pshx;</i>
<i>psha;</i>	<i>psha;</i>
<i>ldy \$1000; {Time out}</i>	<i>ldx Index;</i>
<i>ldx Index;</i>	<i>ldy \$1000; {Time out}</i>
<i>staa x[SCDR]; {sending character}</i>	<i>L3a;;</i>
<i>L4;;</i>	<i>ldaa x[SCSR2]; {status register}</i>
<i>ldaa x[SCSR2]; {status register}</i>	<i>anda \$20; {Character present?}</i>
<i>bita \$40; {40=TC; 80=TDRE}</i>	<i>bne L3b;</i>
<i>bne L4a;</i>	<i>dey; {Time out?}</i>
<i>dey; {Time out?}</i>	<i>bne L3a;</i>
<i>bne L4;</i>	<i>clr [SemRcv]; {no character}</i>
<i>L4a;;</i>	<i>bra L3;</i>
<i>pula;</i>	<i>L3b;;</i>
<i>puly;</i>	<i>ldaa x[SCDR]; {Receive data register}</i>
<i>pulx;</i>	<i>staa [RcvData]; {received character}</i>
<i>rts;</i>	<i>ldaa \$55;</i>
<i>end;</i>	<i>staa [SemRcv]; {receive semafor}</i>
	<i>L3;;</i>
	<i>pula;</i>
	<i>pulx;</i>
	<i>puly;</i>
	<i>end;</i>

Table 3—Thermovision camera command codes

Command symbol	Command hex code	Function (Activity)
Remote	43 45 6E 64 52 0D	In option Remote there are commands equivalent to the tasters on camera panel: ↑ (arrow up), ↓ (arrow down), ← (arrow left), → (arrow right), ↵ (enter), (escape).
↑	75	One position up
↓	64	One position down
←	6C	One position left
→	72	One position right
↵	0D 0A	Enter
Escape (esc)	58	Escape
Focus	46	Contrast adjustment
SnapShot	53	Record and show picture on local display
Upload	79 43 06 43 06 ...06 43 06 30 times for 30 blocks	Transfer data to PC
Start Single	59 43 06 43 06 ...06 43 06 30 times for 30 blocks	Record a picture and transfer it to desired folder on PC

Table 4—Pixel temperature presentation

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	ASCII cod
00000000	01	02	00	00	00	00	0C	01	D6	07	02	00	04	1D	54	7F	Ö.....T•
00000010	1D	74	11	52	17	12	11	78	00	78	00	00	61	A0	11	C8	.t.R...x.x...a .È
00000020	00	82	28	D2	0F	16	00	C4	12	F9	12	00	00	00	00	00	.,(Ò...Ä.ù.....
00000030	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
00000040	00	00	00	43	6F	70	79	72	69	67	68	74	20	49	6E	66	...Copyright Inf
00000050	72	61	72	65	64	20	53	6F	6C	75	74	69	6F	6E	73	20	reared Solutions
00000060	49	6E	63	00	00	00	00	00	00	00	00	00	00	00	00	00	Inc.....
00000070	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	x
00000080	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
00000090	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	y
000000A0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	ê.è.á.ã.
000000B0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	æ.Û.Û.â.â.â.â.â.
000000C0	00	00	00	00	00	00	00	00	EA	11	E8	11	E1	11	E3	11	x.â.Û.Ö.Ý.Ö.Ö.Ñ.
000000D0	E6	11	DB	11	DC	11	E2	11	E3	11	E3	11	E4	11	E1	11	
000000E0	D7	11	E2	11	DA	11	D6	11	DD	11	D5	11	D5	11	D1	11	

in camera, it was possible to generate command code table (Table 3).

Camera Message Wiretapping and Analyzing

Generating and sending above commands to a thermovisual camera was done by original control PC on subordinated computer. Additional computer device was implemented under wiretapping principle (Fig. 2). In this case, camera was under wiretapping process, which has resulted with 30 blocs of sent data describing recorded object. This transfer was initiated and enabled by adequate PC command (Table 3).

Encrypting Thermal Picture ISI Format

There are many examples of formats of thermovisual data recording and analyzing¹⁰. ISI service as a standardized form for byte-mapped graphics of a recorded thermograph, produced by Infrared Solutions Inc.⁵, is one of a closed type data and could be readable only by using original control PC. Following the need of a thermovisual system for monitoring and state diagnostics of energetic and measuring transformers and other elements within processes, content of named format has been encrypted.

Table 5—Data conversion rules

Address	Contents	Meaning	Relation	Format	Result
0000-0005	010200000000	Camera description	$\sum_{n=1}^6 \text{ascii}_n \sum_{i=1}^0 (H_{dk} * 16^i)$	6-Byte data: $n=1,...,6$, $i=1,0$, $H_d=01..., k=1,2$	120000
0006-0009	0C01D607	Recording date		4-Byte data: dd.mm.yyyy.	
		Day (dd)	$\sum_{i=1}^0 (H_{dk} * 16^i)$	First Byte: $i=1,0$: $H_d=0C:k=1,2$	dd&...“&mm&...“
		Month (mm)		Second Byte: $i=1,0$: $H_d=01:k=1,2$	&yyyy (12.01.2006)
		Year (yyyy)	$\sum_{i=3}^0 (H_{dk} * 16^i)$	Last two Bytes: $i=3,2,1,0$: $H_d=D607:k=3,4,1,2$	
000b-000F	00041D54	Recording time		4-Byte data, Real time format: hh.mm.ss.s/100	dd&...“&mm&...“ &yyyy (12.01.2006)
		Hour		First Byte: $i=1,0$: $H_d=00:k=1,2$	
		Minute	$\sum_{i=1}^0 (H_{dk} * 16^i)$	Second Byte: $i=1,0$: $H_d=04:k=1,2$	hh&...“&mm&...“ &
		Second		Third Byte: $i=1,0$: $H_d=1D:k=1,2$	ss&...“&ss/100 (0:04:29:84)
		Second /100		FourthByte: $i=1,0$: $H_d=54:k=1,2$	
000F-0100	7F1D	Max. Temperature	$\sum_{i=2}^{-1} (H_{dk} * 16^i) - 273,15 + 0,05$	2-Byte data: a,b,c,d : $i=2,1,0,-1: k=3,4,1,2$: $H_d=7F1D$	198,73 °C
0101-0102	7411	Min Temperature		2-Byte data: a,b,c,d : $i=2,1,0,-1: k=3,4,1,2$: $H_d=7411$	6,15 °C
0107-0108	7800	Thermogram dimension x	$\sum_{i=3}^0 (H_{dk} * 16^i)$	2-Byte data: $i=3,2,1,0$: $H_d=7800:k=3,4,1,2$	120 &...x“& 120
0109-010F		Thermogram dimension y			
0403-0602	436F7079726 967687420496 E667261726 564 20536F6C757 4696F6E7320 496E630000 00	Header	$\sum_{n=1}^{132} \text{ascii}_n \sum_{i=1}^0 (H_{dk} * 16^i)$	132-Bytes data: $I=1,0$: $H_d=43...:k=1,2;n=1,...,132$	Copyright Infrared Solutions Inc...
0C08-....	EA11	Temperature data	$\sum_{i=2}^{-1} (H_{dk} * 16^i) - 273,15 + 0,05$	2-Byte data: a,b,c,d : $i=2,1,0,-1: k=3,4,1,2$: $H_d=EA11:n = 287800$	The first thermogram pixel temperature: 13,62 °C

Every byte is a two hex digit format, a and b ; n , block length in bytes; I , hex digit ordinal numeral; H_d , hexadecimal record (number); k , digit position in a hex number

Results and Discussion

Structure of ISI Format

ISI file's structure includes header and temperature data (image data). Header includes an informational part of a recorded thermograph (camera info, user's info, comments, and date of recording, max. and min. temperature of an object recorded). Image data includes entire thermograph's temperature data (Table 4). Thermograph's resolution is 120 x 120 pixels.

Temperature within two-byte script has recorded each pixel, so it takes 28800 bytes. Temperature script also includes typical machine (Intel) line with special decoding formula. Header includes a number of fields that entirely occupy 200 bytes. Length of a database field is 28800 bytes, starting with an address C8 (hex) until the end of a database. Each pixel on thermograph was represented with two bytes in inverted order (lower to higher byte) and data to each pixel represents its absolute temperature

(K). First data in database matches a pixel in upper left angle one (coordinate 0, 0 in standardized regime of a mapping). Analyzing a script research within a decoded database, formulas for conversion of necessary data (Table 5) were defined. Each temperature data in single pixel was located onto two bytes in $a\ b\ c\ d$ format (of a hexadecimal script). Absolute temperature was calculated as

$$\Theta = c * 16^2 + d * 16^1 + a * 16^0 + b * 16^{-1} \quad \dots(1)$$

(Calvin's degrees)

For temperature ($^{\circ}\text{C}$)

$$\theta = \sum_{i=2}^{-1} (H_{dk} \cdot 16^i) - 273.15 + 0.05 \quad \dots(2)$$

where H_{dk} – decimal digit value of two byte hexadecimal number for digit (position $k = 3, 4, 1, 2$ respectively). Eqs (1) and (2) could be used for minimal and maximal temperature calculation for offset addresses $00F_{\text{hex}}$ and 011_{hex} as well. Temperature data for all thermogram points occupy $120 \times 120 \times 2 = 18800$ bytes.

Conclusions

Portable thermovisual camera, Wohler IK 21, as a fixed plant's sensor, was implemented permanently to monitor process equipment and plant's power installations to detect or predict some faults or defects producing

higher temperature. Main problems were to solve commands generation and data analyzing and interpretation. Using configured wiretapping system, an efficient monitor system was developed. New camera control application software was designed and realized.

References

- 1 The computer controlled monitoring system for power and measuring transformers fault diagnostic in transformer station ED Bor, Annual Report, 2006-2008 (Scientific Department, Govt of Republic of Serbia, Serbia).
- 2 Compton D L, Use of an infrared-imaging camera to obtain convective heating distributions, *AIAA J*, **10** (1972) 1130-1132.
- 3 Rahman A Al-Kassir, Fernandez J, Tinaut F V & Castro F, Thermographic study of energetic installations, *Appl Therm Engg*, **25** (2005) 183-190.
- 4 Thomann H & Frisk B, Measurement of heat transfer with an infrared camera, *Int J Heat Mass Transfer*, **11** (1968) 819-826.
- 5 Infrared Solutions Inc.: <http://www.infraredsolutions.com>
- 6 Rector R & Alexy G, *The 8086 Book* (Osborne/McGraw-Hill, Berkeley) 1980.
- 7 Motorola Inc., *M68HC11 Reference Manual*, 1990.
- 8 Bjarne Stroustrup, *Programming language C++*, Micro book, Belgrade 1991.
- 9 John P Mueller, *Visual Studio 6*, Computer Library, OSBORNE 1000, 1998.
- 10 Dudzik S & Minkina W, Application of the numerical method for the propagation of distributions to the calculation of coverage intervals in the thermovision measurements, in *9th Int Conf on Quantitative InfraRed Thermography* (Krakow) 2-5 July 2008.