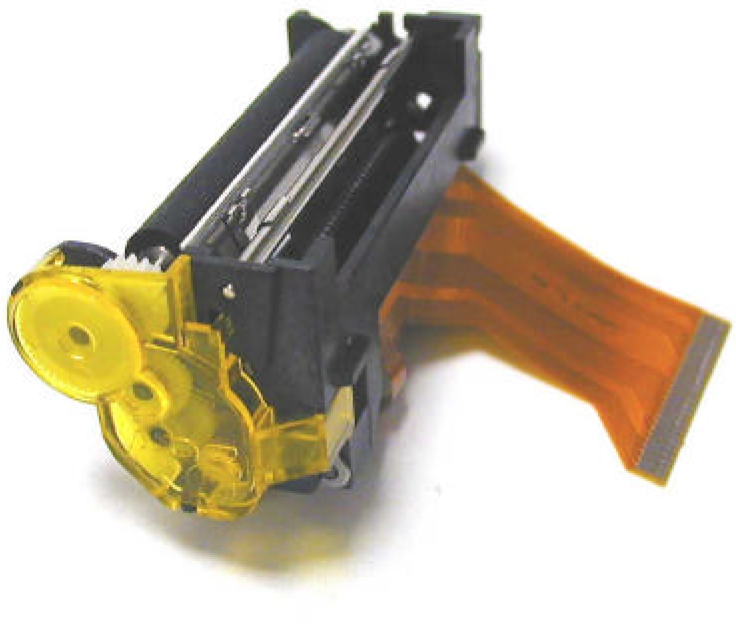
ELM 205

Technical reference



1. Introduction

1.1. ELM 205 Series

The ELM 205 printer has been designed to be the smallest, wide low voltage range (from 2.7v to 8.5v), and high efficiency (20% less than standard 5v mechanisms) easy loading printer on its market. The unique easy loading APS concept makes the ELM 205 an ultra compact, reliable and cost-effective mechanism. The rubber roller can be separated from the mechanism and fixed to the customer's door allowing for very easy integration.
The patented locking system of the rubber roller onto the chassis and easy opening lever makes the door position and rotation axe independent of the cover position, giving the customer a total freedom when designing his housing. Finally, the ergonomic centered paper path allows uniform and aesthetic housing design. Finally no access to the cover's sides is required to open the door.

1.2. ELM 205 features

- Patented Easy loading and Easy Door Opening System
- Ultra compact design (width is 66.7, depth 22.4 mm)
- Up to 90 mm/s printing speed
- Ultra light (35g)
- Starting operating voltage (logic and dots) from 2.7v up to 8.5v
- High resolution printing (8 dots/mm)
- Life of 100 millions pulses, 50 kms
- Low consumption
- Low noise due to its technology (thermal)
- ESD Grounding clip on printhead (ELM205-HS-VRF only)

1.3. Revision history

Rev.	Date	Page	Revision item
A	12/Nov/98	-	Preliminary
B	07/Jun/99	-	Easy Door Opening System + LV/HS Versions
C	02/Jul/99	-	Protection thickness increase (drawing change) + connector pinout HS-LV
D	18/Oct/99	-	Mechanical Drawings information
E	05/Jan/00	-	FPC for LV and HS versions same as ST
F	12/Oct/00	-	Updated photo and overall dimens. drawings
G	14/Jun/01	-	Added ESD clip option on ELM205-HS-VRF

This manual provides complete information about ELM 205 thermal printer mechanism. Further information is available under request such as high speed printing applications and reliability figures.

A.P.S. reserves the right to make changes without notice to the product to improve reliability, functions or design. A.P.S. does not assume any liability arising out of the application or use of the product or circuit described herein.

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2. General characteristics

ITEM	ELM 205
Printing Method	Thermal dot line printing
Number of dots/line	384
Dots density (dot/mm)	8
Printing Width (mm)	48
Paper Width (mm)	58 +0/-1
Paper feed pitch (mm)	0.125
Paper Feed tension (g)	50 or more
Paper Hold tension (g)	80 or more
Dimension WxDxH (mm)	68.2 x 22.4 x 15
Weight (g)	35
Head temperature detection	Thermistor
Head-up detection	Photo-interruptor (gathered with the paper end sensor)
Paper end detection	Photo-interruptor
Operation voltage range (V)	ELM205-LV Dots : 2.7-7.2/Logic: 2.7-5.25 ELM205-ST Dots : 4.5-8.5/Logic :4.75-5.25 ELM205-HS Dots : 4.5-8.5/Logic : 2.7-5.25
Current consumption (A)	At printing: 5 V: 1.9 A (Head) (64 dots ON) 0,5A (Motor) 5V: 50 mA (Head) At paper feeding : 5V: 0,5A(Motor) 5V: <100uA (Head)
Recommended Paper	KF50-HDA or equivalent
Operating temperature range (°C)	0/+50
Operating humidity (RH%)	20-85 (no condensation)
Storage temperature range (°C)	-25/+70
Storage humidity (RH%)	10-90 (no condensation)

3. Thermal Printhead and printing configuration

3.1. Outlines

Heat element structure	2 heaters/dot
Number of heat elements	384 dots
Heat element pitch	0.125 mm
Print width	48 mm (centered on paper)
Total width	54 mm
Average resistance	LV - 123 Ohms +/-4% (2.7v-7.2v low voltage) ST - 142 Ohms +/- 4% (5v standard) HS - 176 Ohms +/-4% (7.2v high speed)

3.2. Maximum conditions at 25°C

ITEM	MAXIMUM CONDITIONS			UNIT
	LV	ST	HS	
Supply energy (25°C)	0.26	0.7	0.2	mJ/dot
Print Cycle (25°C)	2.5	5.0	1.25	ms/line
Supply voltage	7.2	8.5	8.5	volts
Logic voltage	7			volts
Head Temperature	65			°C
Number of dots to be energized simultaneously[1]	192			dots

1/ If energy above the maximum at the indicated printing speed is applied to one dot, the print quality of this dot may be affected (usually by making a “light” print-out).
2/ If the print cycle is less than that the one indicated above, then the maximum supply energy value is decreased. For these applications, please contact APS for further information.
3/ In the case of double-ply paper or special low energy paper, please contact APS for more information.

[1] This condition satisfies the print density as defined in section 3.3

3.3. Typical printing conditions

Item	Symbol	Electrical conditions			Unit		
		LV	ST	HS			
Supply voltage	Vh	3.6	5.0	7.2	V		
Power consumption	Po	0.07	0.123	0.24	W/dot		64 dots fired at the same time
Print cycle	S.L.T	2.5	5.0	1.25	ms/line		
Energy consumption (on time)	Eo (Ton)	0.17	0.36	0.16	mJ/dot	5° C	
		(2.28)	(2.96)	(0.67)	ms		
		0.15	0.31	0.13	mJ/dot	25° C	
		(2.01)	(2.53)	(0.54)	ms		
		0.13	0.28	0.11	mJ/dot	45° C	
		(1.74)	(2.28)	(0.46)	ms		
Supply current	Io	1.6	1.9	2.4	A		

The print optical density is then 1.0 minimum with a maximum variation of 0.3. This measurement is done at the full black pattern by Macbeth densitometer RD-914. Full black pattern is defined as all dots printing pattern (100% black area) printed under correct paper speed.

3.4. General printing conditions

The following formula allows to calculate the heating time T_{on} depending on driving voltage V_H:

$$T_{on} = \frac{E_0}{P_0} = E_0 * \frac{(N * R_{com} + R_{av} + R_{ic} + R_l)^2}{V_H^{\,2} * R_{av}}$$

Where:

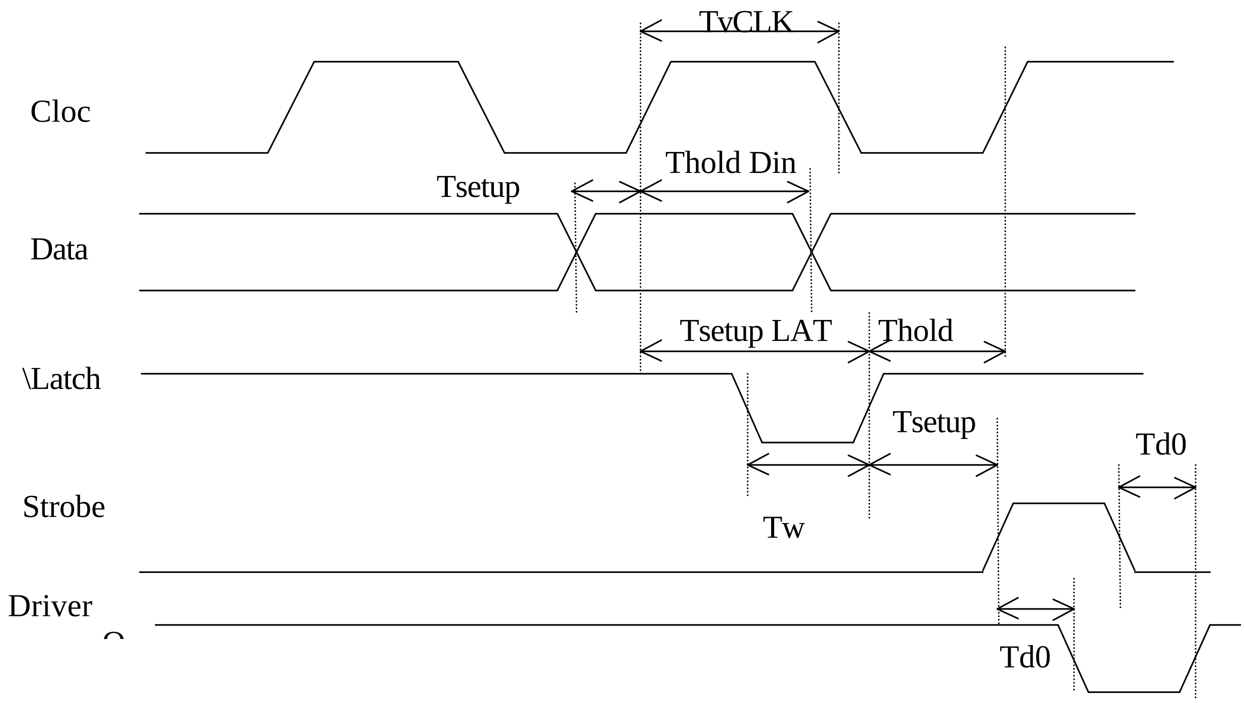
E_0 is the nominal energy
V_H is the driving voltage
R_{av} is the average resistance
N is the number of dots energized simultaneously
R_{com} is the common resistance (0.05 Ohm)
R_{ic} is the driver saturated resistance (10 Ohms)
R_l is the lead resistance (10 Ohms)

3.5. Operation precautions

1/ When performing continuous printing, the supply energy should be reduced so that the substrate temperature monitored through the thermistor will remain below 65°C.
2/ When the printhead operation is finished, the print supply voltage should be reduced to the ground level and remain there until next printhead operation.
3/ If sticking sound is heard during printing, adjust the paper feed speed or pulse to avoid this mechanical resonance.
4/ To avoid surge and voltage drops across power wires, Vh and Gnd cable length should be less than 100 mm, and 47uF aluminum capacitor is required between Vh and Gnd at controller board side.
5/ Make sure that the paper does not have characteristics which could affect the printhead life, such as high abrasivity, too low sensitivity or abnormal chemicals.

3.6. Electrical Characteristics

The following chart gives the timing for driving the printhead:



!!! CAUTION!!!
To prevent any dot element damage, at power up make sure that logic voltage is present simultaneously or before Vbat. At power down make sure that Vbat is at 0v before removing logic voltage.

The following table gives all the printhead electrical characteristics:

ITEM	SYMBOL	MINI	TYP.	MAXI	UNIT
Print voltage	VH	-	5.0	ST/HS = 8.5 LV = 7.2	V
Logic voltage	Vdd	LV/HS = 2.7 ST = 4.75	5.00	5.25	V
Logic current	Idd	-	-	48	mA
Input voltage (High)	VIH	0.8vdd	-	vdd	V
Input voltage (Low)	VIL	0	-	0.2vdd	V
Data input current (DI) High	ILHDI	-	-	0.5	uA
Data input current (DI) Low	ILLDI	-	-	-0.5	uA
STB 1 to 6 input current (High)	IIHSTR	-	-	30	uA
STB 1 to 6 input current (Low)	IILSTR	-	-	-0.5	uA
Clock input current (High)	ILH CLK	-	-	3	uA
Clock input current (Low)	ILL CLK	-	-	-3	uA
Latch input current (High)	IIH LAT	-	-	3	uA
Latch input current (Low)	IIL LAT	-	-	-3	uA
-	-	-	-	-	-
-	-	-	-	-	-
Data out output voltage (High)	VDOH	4.45	-	-	V
Data out output voltage (Low)	VDOL	-	-	0.05	V
Output voltage (driver out)	VOL	-	1.0	-	V
Clock frequency	fCLK	-	-	8	MHz
Clock width	twCLK	30	-	-	ns
Data setup time	tsetupDI	30	-	-	ns
Data hold time	tholdDI	10	-	-	ns
Latch width	twLAT	100	-	-	ns
Latch setup time	tsetup LAT	200	-	-	ns
Latch hold time	tholdLAT	50	-	-	ns
Data out delay time	tdDO	-	-	120	ns
STR setup time	tsetup STB	300	-	-	ns
Driver out delay time	tdo	-	-	5	us

Note: 1/The first bit of data (dot 1) entered is the first bit of data printed (FIFO), left side of TPH, top view (gearing side of the printer).
2/ STB 1 to STB 6 are driving one sixth of the printhead, starting from dot 1.

3.7. Thermistor

When performing continuous printing, it is recommended that the supply energy be reduced so that the substrate temperature monitored through the thermistor will remain below the maximum temperature shown in section 3.2.

The thermistor specification is the following:

- R25, resistance at 25°C:	30 KOhms +/- 5% at 25°C
- B value:	3950 KOhms +/- 2%
- Operating temperature:	-20°C to +80°C
- Time constant:	Max. 30 sec (in the air)

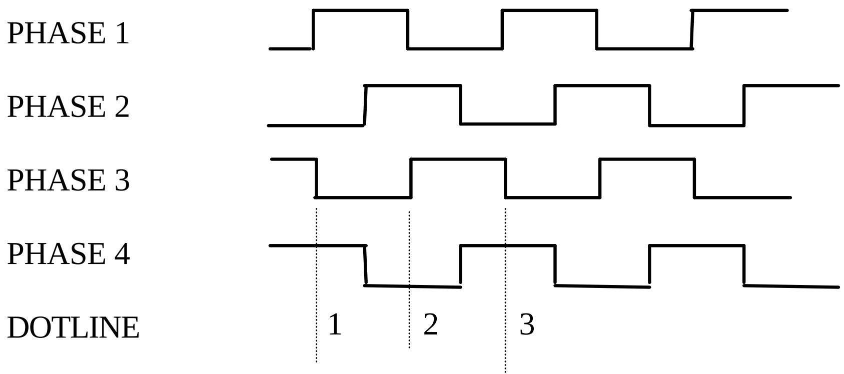
Then the resistance value, *R*, versus temperature, *T* (in °C), is given by the formula:

$$R(T) = R25 * e^{B*(\frac{1}{T+273}-\frac{1}{25+273})}$$

4. Stepper motor

4.1. Stepper motor Timing

The paper feed pitch for stepper motor is 2 steps for one dotline (0,125 mm). For good print quality it is advised to keep the current into the windings between two successive dotlines.
The timing diagram is then as follows:



There are four different positions for the stepper motor. The driving is bipolar and can be achieved with circuits like Rohm BA6845FS, Sanyo LB1836 or LB1838 or Hitachi HA13421. Please refer to the IC's data sheet for further information. It is recommended not to exceed 0.2v like voltage drop in the stepper motor driver circuit.
Coil resistance is 12 Ohms, rated current is 300 mA (5 volts) per phase while feeding at 10mm/s.
In case of high voltage or continuous printing application, contact APS for current application circuitry.

4.2. Paper feed speed versus voltage

The following chart gives the maximum paper feed speed versus the stepper motor voltage

ELM205	PAPER FEED	Duty Cycle (%)
Voltage	ELM205-LV/ST/HS	ELM205-LV/ST/HS
2.7	23	100
3	35	100
3.3	37	100
3.6	40	100
4	47	100
4.5	50	80
5	56	60
5.5	59	50
6	62	40
6.5	68	35
7	72	30
7.5	80	25
8	85	20
8.5	90	15

In order to avoid stepper motor overheat, it is strongly advised to respect the maximum ON/OFF duty cycle as indicated above. Note that the maximum period for the ON time is 30 seconds (when the duty cycle is not 100%).

Example : at 7 volts, the duty cycle must be less than 30%. So the maximum ticket length at the maximum speed is 30s at 72mm/s so 2.16 meters. Then the printer must rest for 70/30*45s = 70 seconds.

5. How to optimize speed consumption and maximum peak current

The printing speed is always a compromise between 3 parameters :

- Paper feed speed (function of voltage)
- Head activation time (function of voltage)
- Maximum peak current available (function of voltage and maximum number of dots simultaneously activated)

For a given voltage, and a maximum current available, it is easy to determine the maximum paper feed speed (MaxPFS), as indicated on the above chart. Then if the two others parameters are not limiting this speed this will also be the printing speed (MaxPS).

MaxPFS gives a time (by inverting) called SLT (scanning line time). In this time, the head must be activated. If this time is not long enough, MaxPS will be subsequently affected.

Then, the way of driving the head is a critical point in the thermal printing application. There are basically two ways of limiting the current in the head.:

1. Divide the head into fixed blocks (by 64 dots for example) and use the strobe lines to control the blocks to be activated. In this case. It is easy to implement but the printing speed will be very slow because the MaxPS will be the invert of the activation time times the number of blocks the head is divided in.

   Example: at 6 volts with the ELM205ST, the activation time is 2.53ms*(25/36) = 1.76ms. If the maximum current available for the head is 2.4A, the maximum number of dots to be simultaneously activated will be 2.4Amps/(6volts/160Ohms)=64 dots. So the number of activation per SLT will be 384/64=6, giving a SLT of 6*1.76ms=10.6ms. then MaxPS will be 1/(8*10.6ms) = 11.8 mm/s. And MaxPFS is 62mm/s. So there is a big margin and the printing speed is relatively slow.

2. Divide the head dynamically, by counting the number of dots actually activated. The software is counting while loading the printhead, the actual number of “black” dots. When the number of black dots has reached the maximum value (in this example the value will be 64) the software will fill the remaining dots with “0” and activates the strobes line. Doing so the activation will be always done with the maximum number of black dots allowed, so optimizing the number of times the head needs to be activated. Printing standard text, the average number of black dots is usually less than 64 and sometimes reach 128.

   Example: In the same conditions of the previous example, MaxPS will be multiplied by 6, or sometimes by 3. Let take that 30% of the lines contains from 64 to 128 black dots, the average MaxPS will be (62(#))*0.7 + (11.8*3)*0.3 = 60.2 mm/s, getting very close to the MaxPFS, and optimizing all the parameters.
   (#) : we take 62 because 11.8*6 =70.8 > MaxPFS.

6. Sensors

6.1. *Door open*

In order to optimize and decrease the number of elements of the ELM 205, the opto sensor performs dual functions - door open and end of paper detection. The shape and distance from the opto sensor to the paper is designed in a way that as soon as the door is opened, the distance between the paper and the sensor increases, and this causes the end of paper sensor is to trigger.

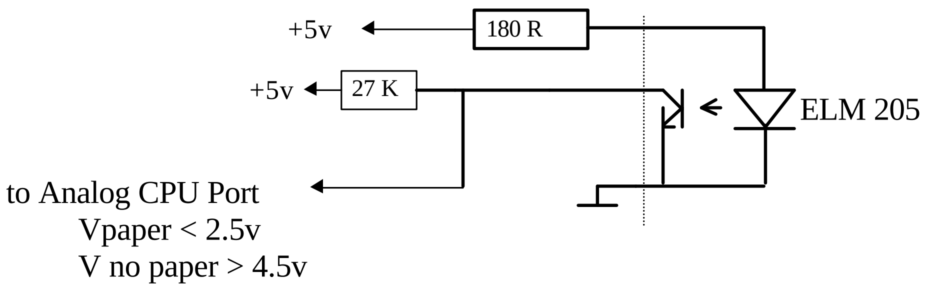
6.2. *End of paper sensor*

ELM 205 has an end of paper sensor achieved by a photo-transistor. Arrange the circuitry so that no energy is applied to the head when there is no paper. If the head is energized when there is no paper and the head is in the down position, then both roller and head may be strongly damaged.

General specifications:

ITEM	Symbol	CONDITIONS	Min	Typ	Max	Unit
Forward current photodiode	I_F	$V_F = 5v \pm 5\%$	-	20	30	mA
Reverse current	I_R	$V_r = 5V$	-	-	10	uA
Output dark current	I_{CEO}	$V_{CE} = 10V$	-	-	0.2	uA
Light current	I_L	$V_{CE} = 5V$ $I_F = 20mA$	90	-	660	uA
Time	T_R	$V_{CE} = 2\ V$ $I_C = 0.1\ mA$ $R_L = 1K\Omega$	-	30	-	us
Fall time	T_F		-	25	-	us

One possible interfacing is as follows:



7. Pin out assignment

One flexy cable is gathering all signals. The pitch at the end of the flexy is 1mm.
FPC connector can be : JST 27FMN-BMT-TF

ELM205-ST-LV-HS		
Pin Number	Signal name	Function
1	CO	Collector of photo-transistor
2	VF	Anode of photo-sensor
3	L-GND	Gnd for logic
4	VH	Dotline voltage
5	VH	Dotline voltage
6	DI	Data input
7	STB6	Sixth strobe
8	STB5	Fifth strobe
9	STB4	Fourth strobe
10	P-GND	Gnd for dotline
11	P-GND	Gnd for dotline
12	P-GND	Gnd for dotline
13	P-GND	Gnd for dotline
14	TM	Thermistor first terminal (second is Gnd)
15	STB3	Third strobe
16	STB2	Second strobe
17	STB1	First strobe
18	Vdd	Logic voltage
19	CLK	Serial clock
20	\LAT	Latch
21	DO	Data output
22	VH	Dotline voltage
23	VH	Dotline voltage
24	SM4	Fourth phase of stepper motor
25	SM3	Third phase of stepper motor
26	SM2	Second phase of stepper motor
27	SM1	First phase of stepper motor

<u>NOTE</u> - For pin #1 position, please refer to the drawings at the end of this document
- In ELM 205-HS-VRF a ESD grounding clip is provided to connect GND (pins 10, 11, 12 and 13) to printhead metal heat sink

8. Life under standard printing conditions

Life is defined as a change in the resistance value of any dots equal to or exceeding 15% from their initial value. Head temperature shall not exceed the maximum 60°C with thermistor reading.
Then: - Pulse life : 100.10^6 Pulses
- Abrasion life: 50 kms

9. Mechanical & Housing

The 3 versions of the ELM are mechanically identical (fixing points, dimensions)

9.1. Designing the door

The function of the door is to bring the rubber roller to the chassis' window entrance and to make it follow the external path of the chassis' window.
Given the shape of the chassis and the example in the mechanical drawing section (end of the specification), the cover is fairly easy to design.
In order to keep a good alignment, it is strongly advised to keep the rubber roller fully floating inside the cover to compensate any tolerance problem inside the cover.
Moreover this play must be present in order to allow the rubber roller to follow the shape of the chassis.

9.2. The Easy Door Opening System

Because the rubber roller is only referenced to the chassis and has no dependence on the cover, the mechanism is very reliable. To achieve this reliability, the rubber roller must be strongly locked inside the chassis.
To avoid any twist, and mechanical stress on the cover and more generally on the customer plastic, so increasing the reliability and quality, APS developed a unique and patented feature to ease the opening of the door, that makes the mechanism very easy to open, and does not require any access to the cover's sides, giving more flexibility and ergonomics to the customer design.
This is achieved by clipping an internal lever inside the cover, that pushes symmetrically on both sides of the mechanism. So the mechanism's shape has been optimized to concentrate the effort locally and always refer this effort to the chassis.
Doing so there is no need to have access to the cover side, giving more freedom to deign the cover, and allowing to reduce the width of the unit.
Please contact APS to obtain the *application notes* and for any assistance in designing the lever.

9.3. General mechanical specification

(See attached drawing)

10. Ordering code

ELM 205 Low Voltage (from 2.7v):	ELM 205-LV
ELM 205 Standard 5v:	ELM 205-ST
ELM 205 High Speed (80mm/s):	ELM 205-HS
ELM 205 HS with ESD grounding clip:	ELM 205-HS-VRF