TM87 & TM89 series IC

LCD waveform and selection guide

Application Note

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PRODUCT NAME

TM87& TM89 series MCU

TITLE

LCD waveform and selection guide for TM87 & TM89 series IC

APPLICATION NOTE

Both TM87 and TM89 series MCU include LCD driver function. In the following sections, we will illustrate in detail how to select/ set LCD parameters for these two series of IC.
There are three main LCD parameters, which are DUTY, BIAS, and the operating voltage respectively. These three parameters will be illustrated one by one as follows:

1. The selection of DUTY is mainly decided by the function/setting of the product, such as the number of pixels in the LCD, the size of the LCD, and the specific requirements on the LCD's displaying effect from the customer. The basic rule is the smaller DUTY is, the better the LCD's displaying effect. While the smaller DUTY is, the more MCU resources (SEGMENT lines) it requires. Therefore, it is necessary for the user to pick a reasonable DUTY according to the customer's requirement.

2. The selection of BIAS is mainly decided by the setting of DUTY. According to the principle of multi-segment LCD driver, electrical voltage is applied to not only the gated pixels but also the non-gated pixels. The ratio of the non-gated voltage waveform to the gated voltage waveform is the bias ratio, Bias=1/a。

   In order to make the condition between the gated pixels and the non-gated pixels consistent, it is necessary to have a consistent gating voltage Von and a consistent none-gating voltage Voff. In order to make pixels gated under gating voltage and not gated under none-gating voltage, it is necessary to require the LCD to have a threshold characteristic; the steeper the better. However, the slope of the LCD electro-optical curve is somewhat limited due to the limitation of materials and patterns. Therefore, we can only require a bigger range between Von and Voff, i.e. the bigger Von/Voff the better. Through theoretical computation, when Duty and Bias satisfy the following conditions, Von/Voff will reach a maximum. For those values which satisfy the following equation a are the best bias values （DUTY） with multiplex ratio of N. E.g. for a DUTY=1/4 LCD, its multiplex ratio is 4. Then substitute into the equation and get a=3; the best BIAS value that matches LCD with 1/4 DUTY is 1/3。

$$a = \sqrt{N} + 1$$

3. The LCD operating voltage has different settings and limitations according to the type of IC used, which will be illustrated respectively:

   a. Three power options can be selected in the TM87 series IC (Please note, this is the operating voltage of IC not that of LCD.）， They are respectively 1.5V（Ag）,3.0V（Li, and 4.5V（Ext-V））.

When the operating voltage of IC is1.5V（Ag）, the relationship between the operating voltage of LCD Vlcd and the operating voltage of IC Vic satisfies the following relationship: Vlcd=Vic*a， a=1/BIAS.
For example: assuming Vic=1.6V and BIAS=1/3, then Vlcd=4.8V.

When the operating voltage of IC is 3.0V (Li) or 4.5V (Ext-V), the relationship between the operating voltage of LCD, Vlcd, and the operating voltage of IC, Vic, satisfies the following relationship: Vlcd=Vic/2*a， a=1/BIAS.
For example: assuming Vic=2.8V and BIAS=1/4, then Vlcd=5.6V.

What mentioned above is the selection method for the LCD operating voltage which is commonly followed by the vast majority of TM87series IC. However, there is a rather special IC currently, i.e,TM87R04. TM87R04 adds a 1/3 Bias（1.0V step）option in the BIAS options of MASK OPTION. If this option is used, the LCD operating voltage driven by TM87R04, Vlcd, will be equal to the IC operating voltage, Vic. If this option is not used by TM87R04, the calculation method for its LCD operating voltage will be exactly the same as other TM87 series IC.

b. There are two methods for selection/calculation of LCD operating voltage for TM89 series IC's. One method is when TM89 series IC is working under un-regulated input, the calculation method for its LCD operating voltage is the same as that for the TM87 series IC. This method corresponds to the situation that the External Regulator for LCD in MASK OPTION is set to NO USE in TM89 series IC.

   The other method is when TM89 series IC is working under regulated input, it corresponds to the situation that the External Regulator for LCD in MASK OPTION is set to VL2 or VL1 in TM89 series IC. They will be illustrated in detail as follows: when External Regulator for LCD is set to VL2, if the input voltage of VL2 is Vreg, the operating voltage, at this point of time, will be Vlcd=Vreg /2*a, a=1/BIAS; when External Regulator for LCD is set to VL1, if the input voltage of VL1 is Vreg, the operating voltage, at this point of time, will be Vlcd=Vreg *a， a=1/BIAS.

c. There is another problem needs to be taken care of in selecting the LCD operating voltage ---voltage range; e.g. the operating voltage for the LCD of TM8726 is 1.2V~8.0V（please refer to Allowable operating conditions for detail）. Assuming that TM8726 uses 4.5V operating voltage and 1/4 BIAS, the LCD operating voltage will be 9.0V, which exceeds the operable voltage of VDD4（2.4V~8.0V）in TM8726 and, therefore, should not be adopted. In respect to TM89 series IC, the situation is made slightly more complex due to the addition of external regulated input. When TM89 series IC does not use external regulated input, the situation is basically the same to the TM87 series IC; only needs to make sure the LCD operating voltage will not be higher than maximum voltage, VLx, defined by IC while the minimum voltage will be determined by the minimum IC operating voltage and make sure there will no problems. However, once an external regulated input is used, the minimum voltage of the regulated input will also need to be taken into account; please refer to the Supply Voltage part of the following diagram for TM8959 Allowable operating conditions for

details.

ALLOWABLE OPERATING CONDITIONS

At Ta = -40℃ to 80℃, GND = 0V

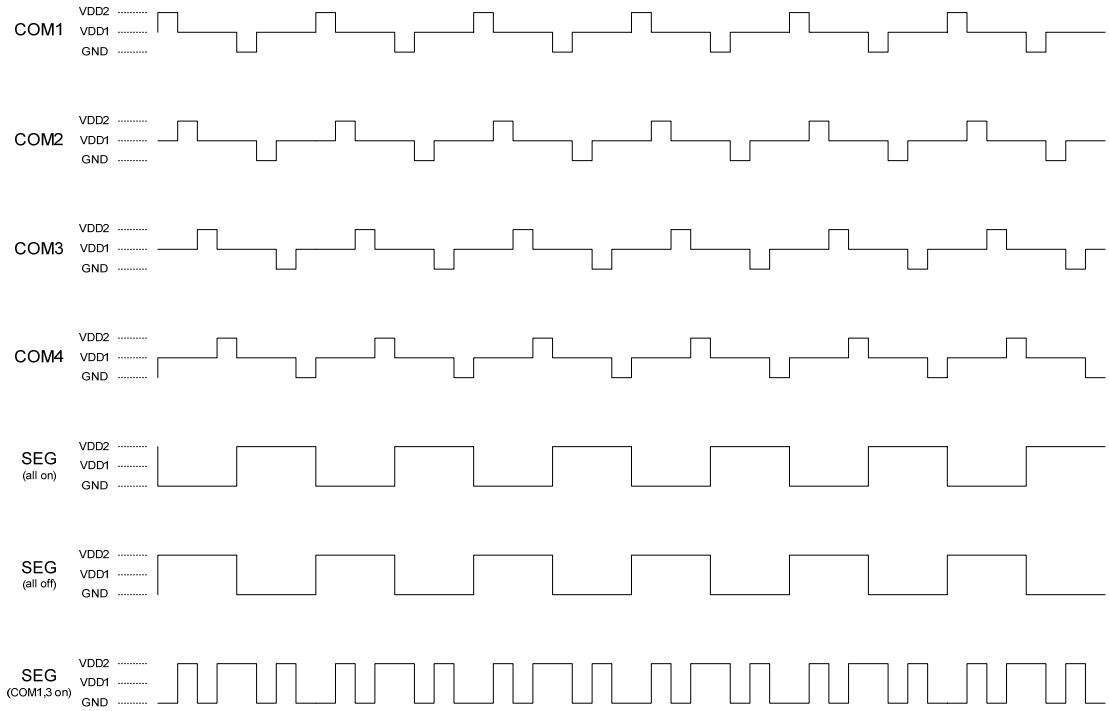
Name	Symb.	Condition	Min.	Max.	Unit
Supply Voltage	VBAT		1.2	3.6	
	VL1		0.95	1.8	V
	VL2		2.0	3.6	V
	VL3		3.0	6.0	V
	VL4		3.0	6.0	V
	VL5		3.0	6.0	V

We can see: the voltage range for VL1 is 0.95V-1.8V in the above table. But there is another condition also needs to be considered at the same time: when MASK OPTION is set to 3.0V（BCF=0，BAK=VL1）, the VL1 voltage must be larger than or equal to 1.1V to ensure the proper operation of the IC oscillator and the kernel. Therefore, when MASK OPTION is set to 3.0V（BCF=0，BAK=VL1）, the VL1 voltage range is 1.1V-1.8V; while the VL1 voltage range will be 0.95V-1.8V as in the table under other conditions. Of course, the maximum voltage will also need to be considered; e.g. the maximum voltage for VL5 is 6.0V. Therefore, in regarding to a TM89 series IC with 1/5 BIAS, its VL1 voltage can not be higher than1.2V（Since the VL5 voltage is equal to the VL1 voltage multiplied by 5）.

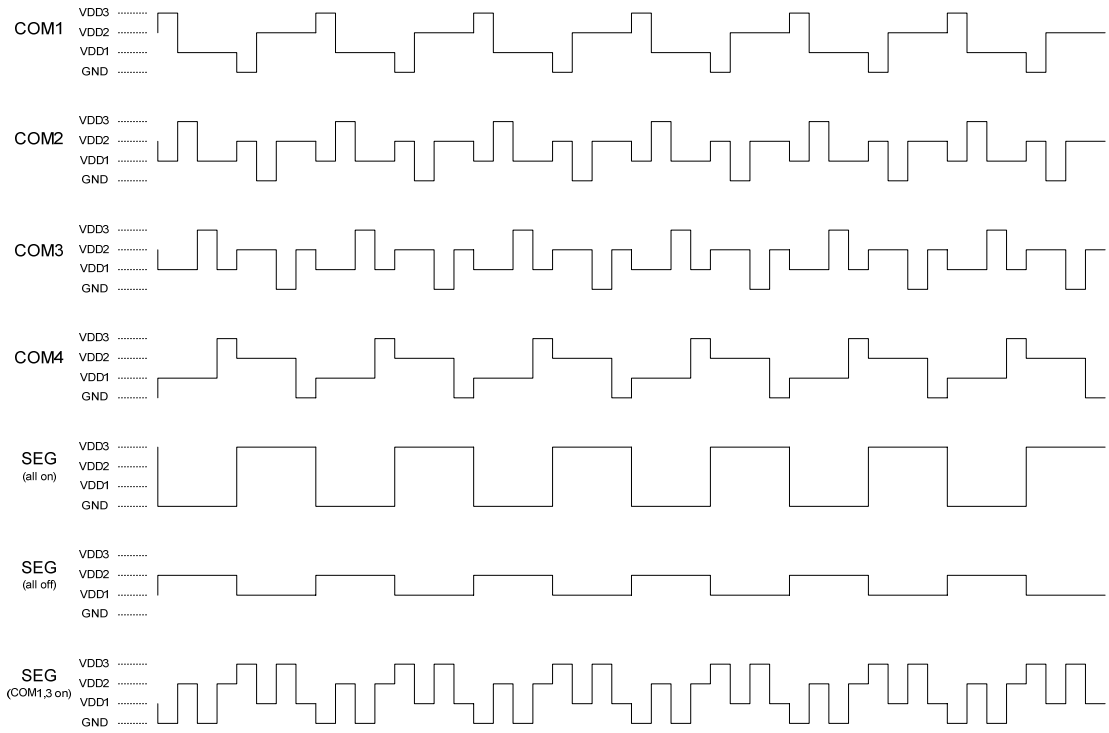
4. It is necessary to consider all the factors mentioned above in selecting the LCD parameters. And, then, the cost factor and the characteristics of the product application can be added in the end to finalize a parameter setting that can satisfy all or most of the requirements.

Appendix: the LCD driver waveform for TM87 and TM89 series (partial).

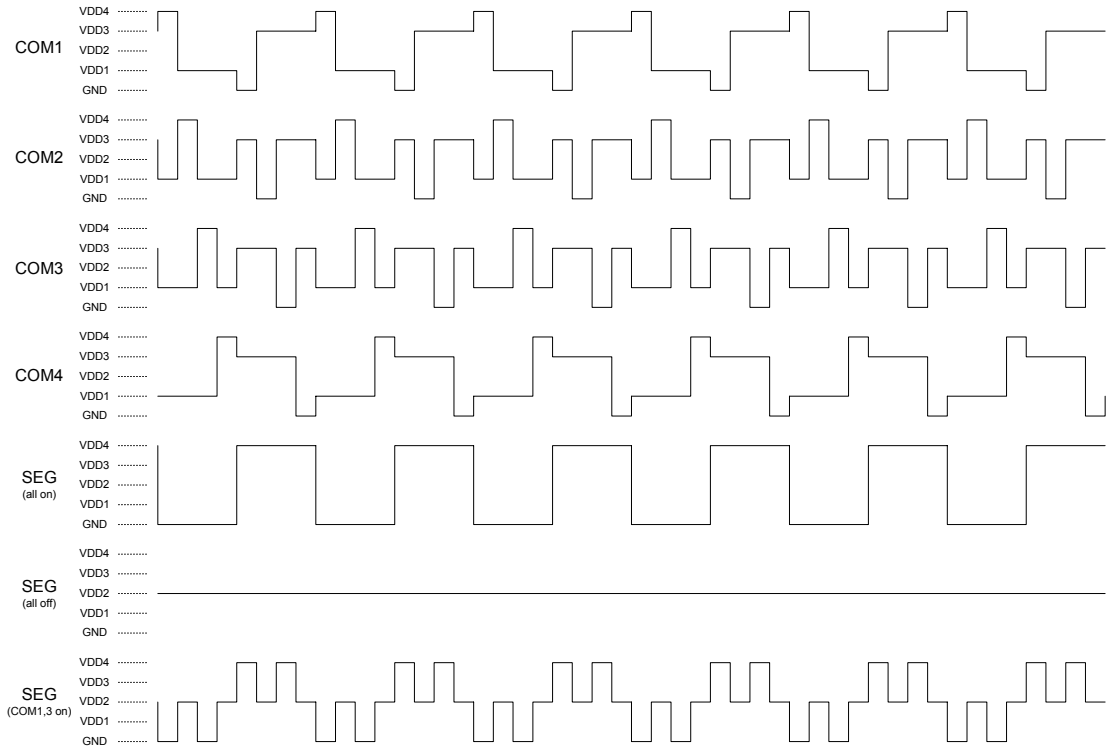
1/4 duty, 1/2 bias



1/4 duty, 1/3 bias



1/4 duty, 1/4 bias



1/4 duty, 1/5 bias