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# CMOS逻辑 HD74AC系列 (FACT)

## 概要

FACT\*采用了最新的工艺技术，具有ALS-TTL同等以上的高速性、等同于HS-CMOS的低功耗性、噪声容限高、高扇出、工作电源电压范围广和可靠性高等特点。

本资料记载了产品规格、系统设计时的注意事项以及和其他逻辑族的比较。

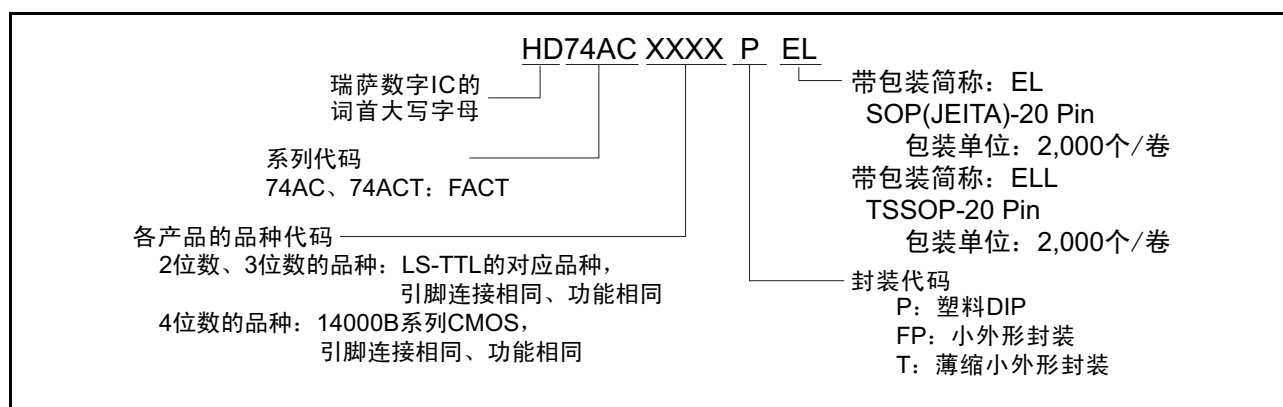
为了能直接替换LS、ALS等TTL族，在FACT族中还推出了以总线驱动器和收发器为中心的TTL型输入逻辑电平的ACT系列。

※1 FACT是美国国家半导体公司的注册商标。

## 1. 特点

- 产品阵容丰富
- 和LS-TTL、HS-CMOS引脚兼容
- 符合JEDEC规格  
以总线驱动器和收发器为中心推出了TTL电平器件 (ACT系列)
- 电流驱动能力高  
全部器件采用共同的输出特性  
 $I_{OL}/I_{OH}=24/-24\text{mA}$   
能驱动 $50\Omega$ 传输线
- 工作电源电压范围广： $V_{CC}=2\sim 6\text{V}$
- 工作温度范围广： $T_a=-40\sim +85^\circ\text{C}$
- 改良了静电击穿保护电路
- 闩锁耐量高

## 2. FACT的型号



## 3. 接口

FACT具有较广的工作电源电压范围 ( $V_{CC}=2\sim 6\text{V}$ ) 和较高的电流驱动能力，并能连接现有的其他逻辑族。

FACT有AC和ACT共2种类型。

**AC:** 是指有CMOS输出缓冲器 (具有CMOS输入逻辑电平和 $I_{OL}/I_{OH}=24/-24\text{mA}$ 电流驱动能力)的器件。

**ACT:** 是指有输入缓冲器 (将TTL输入逻辑电平转换为CMOS输入逻辑电平)的器件。是为了将这些器件的输入引脚连接TTL器件的输出引脚 ( $V_{CC}=5\text{V}\pm 0.5\text{V}$ 、 $V_{OH}=2.4\text{V}$ 、 $V_{OL}=0.4\text{V}$ )而设计的，但是在 $V_{CC}=2\sim 6\text{V}$ 范围内，也能用CMOS输出电平驱动。

输出电路中有和AC型相同的输出缓冲器，能直接驱动CMOS或者TTL器件。

#### 4. 低功耗工作

CMOS最大的特点是超低功耗。在静态时，FACT的功耗至少比LS或者ALS-TTL FACT少几个数量级。

|      |             |
|------|-------------|
| FACT | =0.1mW/Gate |
| ALS  | =1.2mW/Gate |
| LS   | =2.0mW/Gate |
| HC   | =0.1mW/Gate |

此低功耗的实现，使系统不需要昂贵的大容量电源、散热器或者用于冷却的风扇，有利于提高系统的可靠性。

工作时的功耗也很小。

当工作频率为1MHz时，各族的功耗如上表所示。

$I_{CC}-V_{CC}$ 的特性如图1所示，这是在1MHz的工作频率下，负载电容分别为50pF和夹具寄生电容的2种情况的测量结果。

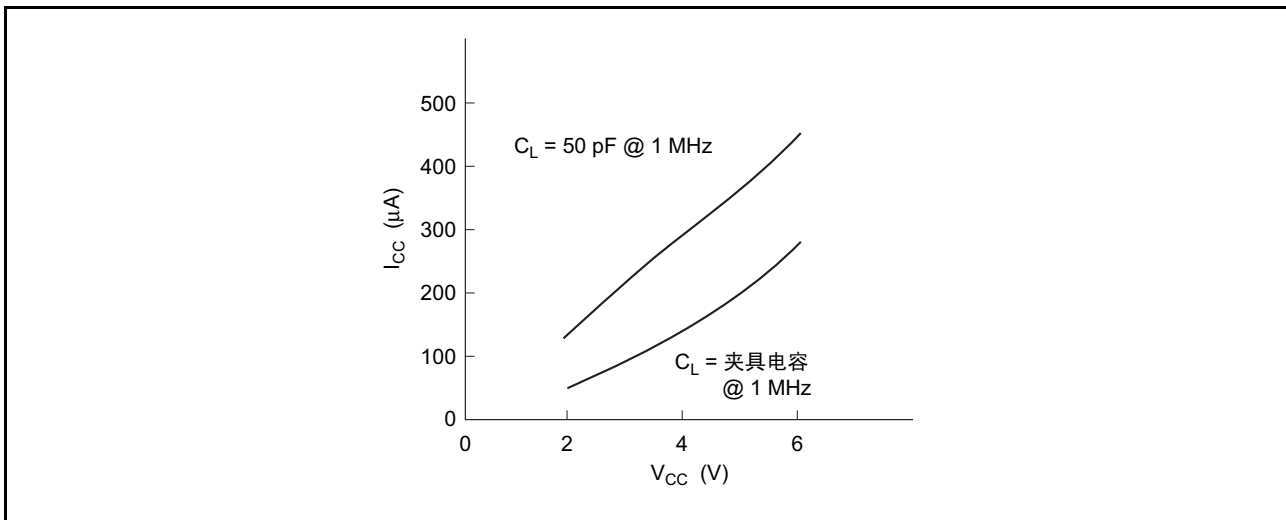


图1  $I_{CC}-V_{CC}$

#### 5. AC特性

和基本门器件的传播延迟时间相同，FACT的每个内部门电路的延迟时间比LS、ALS-TTL、HS-CMOS快。因此，越是提高集成度以及增加门的段数，FACT的速度就越比其他族快。

74XX244 8路驱动器的典型值如下所示：

|          |         |              |
|----------|---------|--------------|
| FACT(AC) | =5.0ns  | @ $C_L=50pF$ |
| ALS      | =7.0ns  | @ $C_L=50pF$ |
| LS       | =12.0ns | @ $C_L=15pF$ |
| HC       | =14.0ns | @ $C_L=50pF$ |

在 $5.0V \pm 0.5V$ 和 $3.3V \pm 0.3V$ 时保证AC特性规格。在 $V_{CC}=2V$ 最坏的条件下设计时，能通过下式求AC特性：

$$AC特性(@V_{CC}=2.0V)=1.9 \times AC特性(@V_{CC}=3.3V)$$

#### 6. 多个输出的同时开关

传播延迟时间受同时变化的输出引脚数的影响。对于输出引脚数为2个以上（含2个）的器件，同时变化的输出引脚数每增加一个，传播延迟时间就比数据手册中的值慢250ps (typ)。对于Octal系列的器件，如果同

时变化的输出引脚数不超过4个，实际上此延迟值几乎可以忽略。此值适用于  $T_a = -40 \sim +85^\circ\text{C}$  和  $V_{CC} = 5\text{V} \pm 0.5\text{V}$  的全部范围。

### 7. 噪声容限

考虑到去耦部件、电源的动态电阻和调整、电路板的布线和信号电缆设计规则等的影响时，逻辑族的噪声容限是重要的成本因素。

|      |             |                           |
|------|-------------|---------------------------|
| FACT | =1.25/1.25V |                           |
| ALS  | =0.4/0.7V   |                           |
| LS   | =0.3/0.7V   | @ $V_{CC} = 4.75\text{V}$ |
| HC   | =1.25/1.25V |                           |

如果将  $V_{CC} = 4.5\text{V}$  时的输入阈值电压和输出电压的差  $|V_{IL} - V_{OL}| / |V_{IH} - V_{OH}|$  进行比较，结果就和上述相同。

### 8. 输出特性

FACT 的输出信号全部被缓冲，输出电压和输出电流的规格在整个族中是共同的。在输出引脚的内部连接了2个钳位二极管，抑制了大噪声系统中的阻抗失配引起的正尖峰和负尖峰。在设计 FACT 输出时，考虑到平衡性，调整了边沿速率，使输出的上升时间和下降时间相等。

保证 AC 和 ACT 的所有产品种类为 24mA 的源极电流和吸收电流，能驱动 50Ω 的传输线。

#### $I_{OL}/I_{OH}$ 特性

|      |           |                           |
|------|-----------|---------------------------|
| FACT | =24/-24mA |                           |
| ALS  | =24/-15mA |                           |
| LS   | =8/-0.4mA | @ $V_{CC} = 4.75\text{V}$ |
| HC   | =4/-4mA   |                           |

### 9. 动态输出特性

以前，设计者使用 Bergeron 曲线图来分析所设想的系统上出现的过渡现象波形。在耗费体力和时间的同时，设计者不得不依赖于 IC 制造商提供的输出电流-电压特性的典型曲线的精度和可靠性。而且，在全温度范围和全电压范围内，无法保证所有产品符合此典型特性。为了保证 FACT 在特性阻抗 50Ω 的传输线上进行开关动作时的过渡现象波形，进行了以下分析。

从“High”电平变为“Low”电平以及从“Low”电平变为“High”电平时的开关 Bergeron 曲线图如图 2 所示。

曲线图的右半部分 ( $I_{out} > 0$ ) 为 FACT 的  $V_{OH}$  和  $I_{IH}$  特性曲线，左半部分 ( $I_{out} < 0$ ) 为  $V_{OL}$  和  $I_{IL}$  特性曲线。在此，只叙述“Low”电平变为“High”电平的情况，它也适用于“High”电平变为“Low”电平的情况。

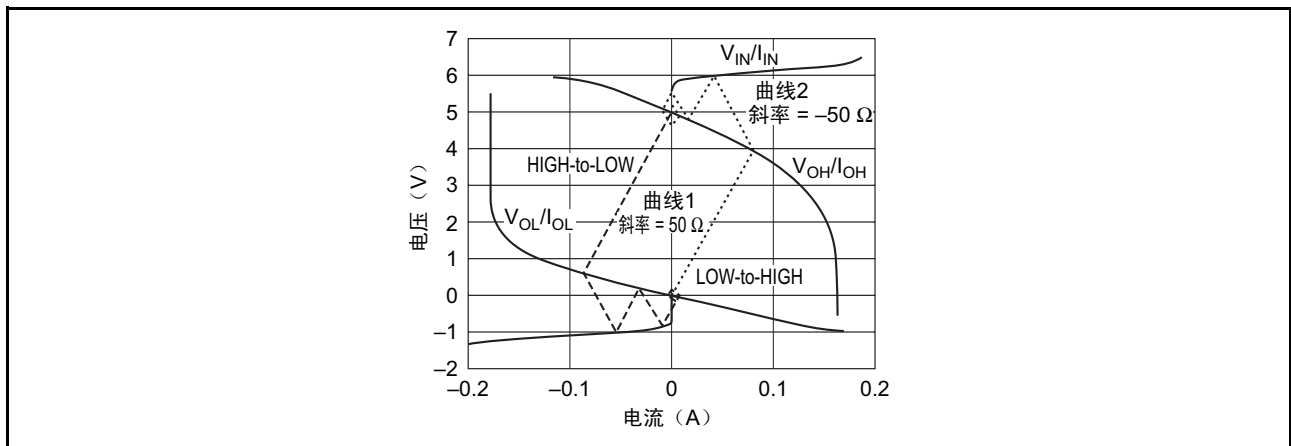


图2 50Ω传输线的反射分析

从  $V_{OL}$  的静态点开始分析，此点是输出  $V_{OL}-I_{OL}$  特性曲线和输入  $V_{IN}-I_{IN}$  特性曲线的交点，在 CMOS 输入和输出时，此点约为 100mV。

如曲线1所示，从此交点向  $V_{OH}-I_{OH}$  特性曲线画一条  $50\Omega$  的负载线，此交点为过渡波形具有的电压值。在 FACT 情况下，此点约为 3.95V。如曲线2所示，从此交点向  $V_{IN}-I_{IN}$  特性曲线画一条  $-50\Omega$  的负载线，第2个交点是从输入门返回的最初的反射点。如此重复从各交点向下一个交点画负载线的过程。朝着  $V_{OH}-I_{OH}$  特性曲线画的负载线为正斜率，朝着  $V_{IN}-I_{IN}$  特性曲线画的负载线为负斜率。

各交点为传输线上反射的各波形的电压， $V_{OH}-I_{OH}$  特性曲线上的交点为驱动器到接收器的波形， $V_{IN}-I_{IN}$  特性曲线上的交点为接收器到驱动器的波形。

分析结果和实际测量值分别如图 3a 和图 3b 所示。时间轴的 1 个刻度表示传输线的延迟时间。

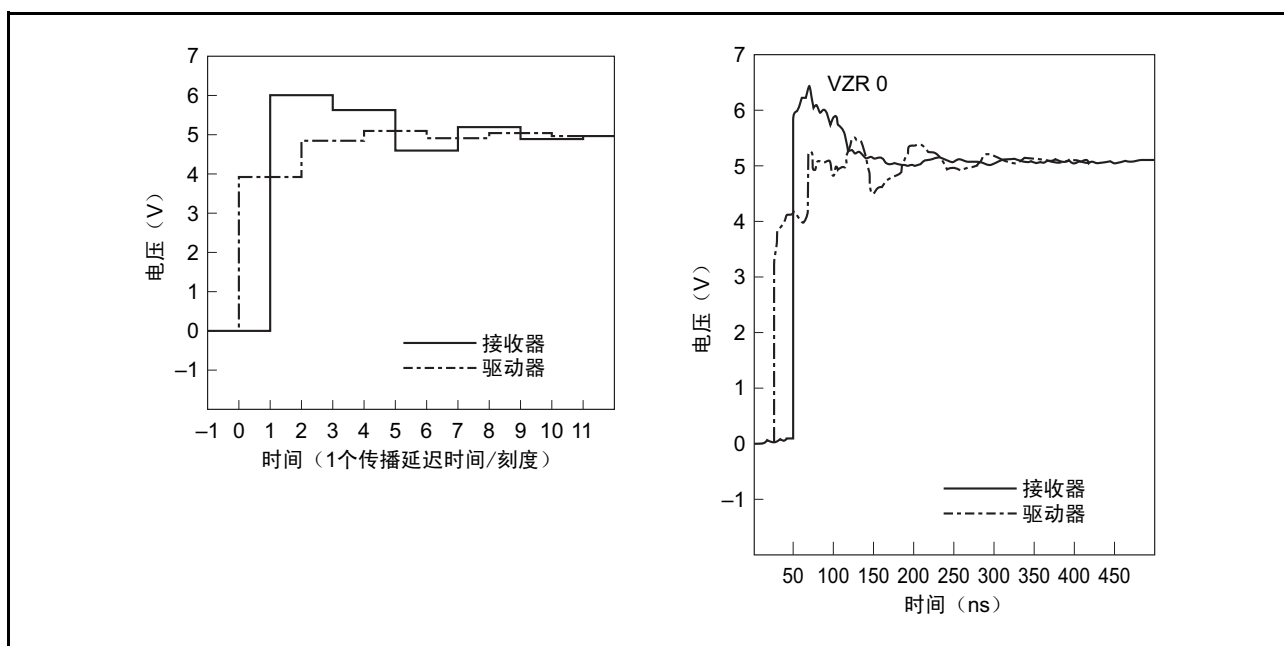


图 3a 50Ω 传输线的驱动波形

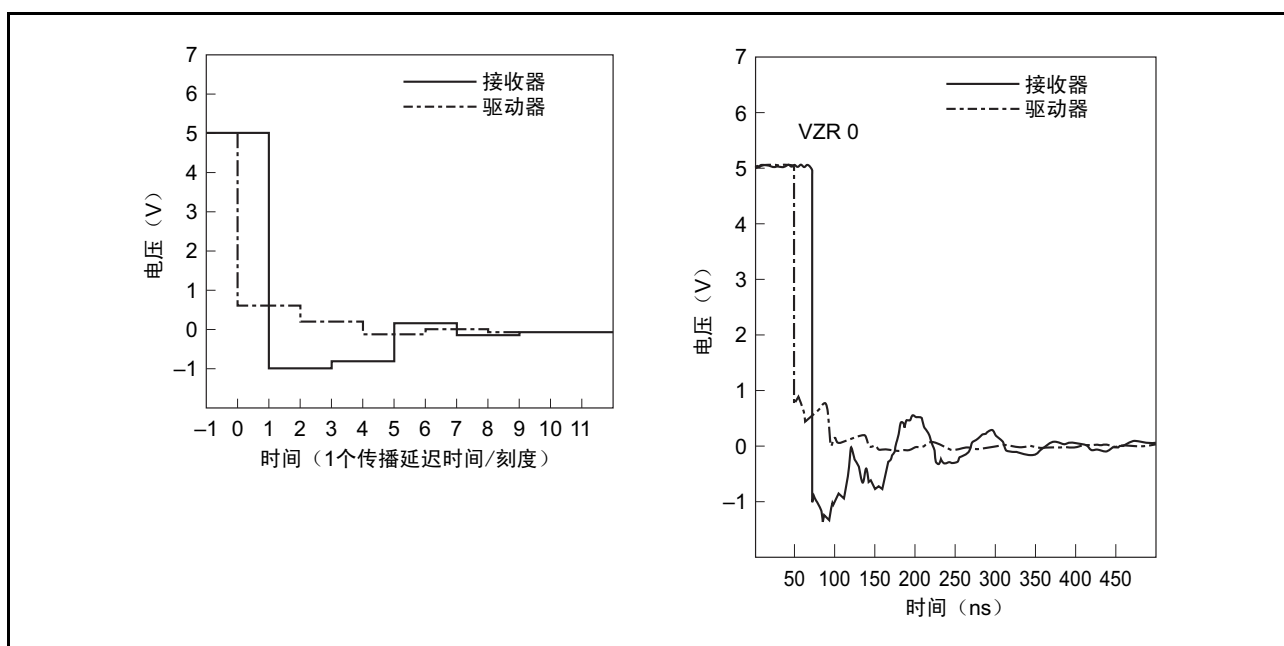


图 3b 50Ω 传输线的驱动波形

这是对FACT的分析，但是用户在实际使用FACT时不需要进行分析。

保证FACT有充分输出过渡电压波形的驱动能力，以驱动其他FACT的输入。

通过Bergeron曲线图能计算出需要多少电压值。在静止状态下，传输线上的电压在GND~100mV或者 $V_{CC} \sim (V_{CC}-100mV)$ 范围内。为了能正常工作，接收器输入的电压值必须大于等于 $V_{CC}$ 的70%或者小于等于30%。所需的电流和电压值为 $|(V_{OQ}-V_I)/Z_O|$ 和 $V_I$ 。假设 $V_{OQ}=100mV$ 、 $V_{IH}=3.85V$ 、 $V_{CC}=5.5V$ 、 $Z_O=50\Omega$ ，则需要的 $I_{OH}$ 为75mA (@ $V_I=3.85V$ )。当从“High”电平变为“Low”电平时，假设 $V_{OQ}=5.4V$ 、 $V_{IL}=1.65V$ 、 $Z_O=50\Omega$ ，则 $I_{OL}=75mA$  (@ $V_I=1.65V$ )。

FACT的输入/输出规格对这些电流和电压值已经标准化。因为在特性阻抗大于 $50\Omega$ 的传输线上，需要的电流值会变小，所以也能保证开关动作。

必须注意：通常的24mA驱动能力无法充分保证过渡时的开关动作，只有保证传输线从输出的静止状态变为正常的 $V_{IN}$ 电平时所需的电流值，才能保证过渡时的开关动作。

图4、图5和图6所示的特性图有助于用户确定FACT在各种电源电压下的动态驱动电流。

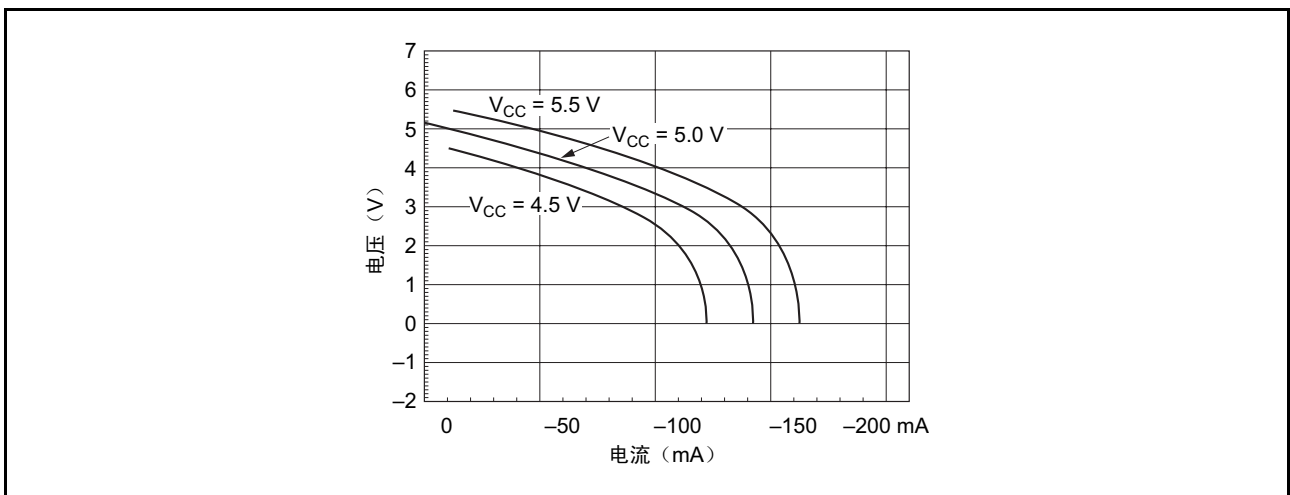


图4 AC00  $V_{OH}$ - $I_{OH}$  输出特性

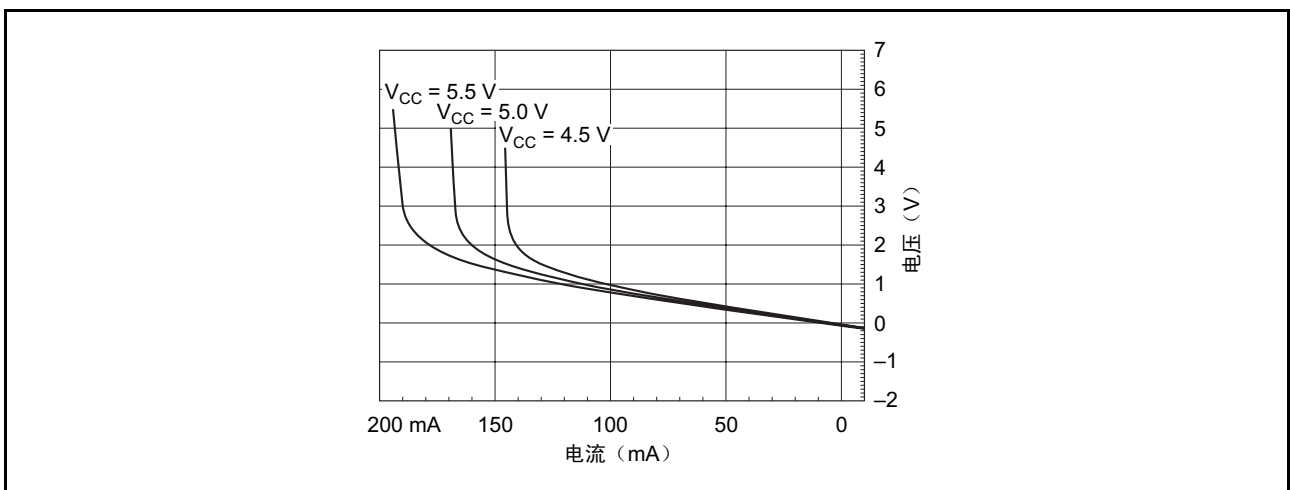


图5 AC00  $V_{OL}$ - $I_{OL}$  输出特性

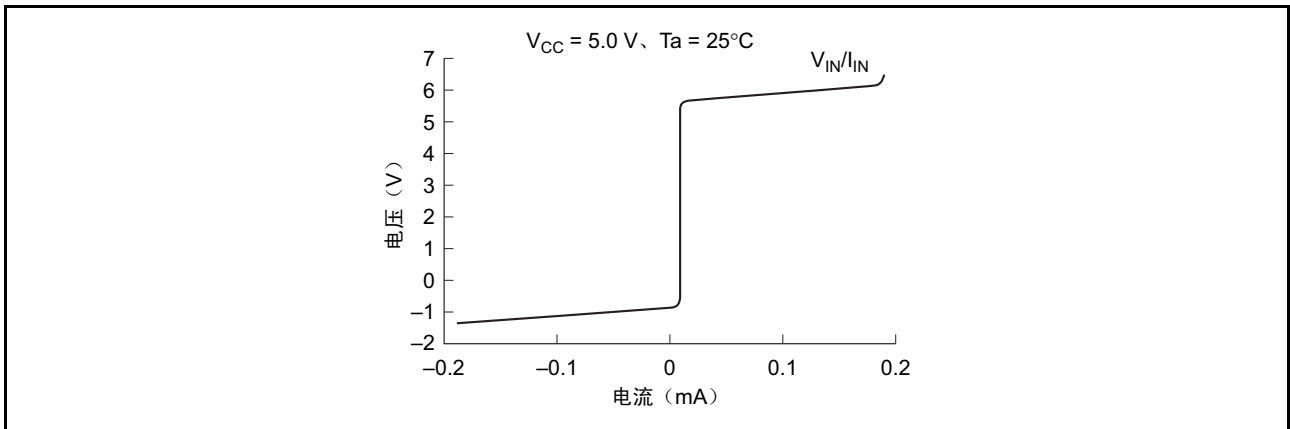


图6  $V_{IN}$ - $I_{IN}$  输入特性

### 10. 大电源电压范围内的特性保证

为了进一步提高FACT的性能和集成度，半导体技术在横向和竖向方面逐渐缩小了器件的结构。由于需要对VLSI制造上的各种电特性控制以及存储卡的低电压工作，JEDEC规定了在 $3.3V \pm 0.3V$ 下工作的器件接口标准。因此，能保证FACT的全部产品在 $V_{CC} = 3.3V \pm 0.3V$ 下工作。另外，在 $3.0V \sim 5.5V$ 范围内保证AC特性和DC特性，在 $2.0V \sim 6.0V$ 范围内保证产品的逻辑运行。

#### 工作电源电压范围

|           |                  |
|-----------|------------------|
| FACT(ACT) | $=5.0V \pm 10\%$ |
| FACT(AC)  | $=2.0 \sim 6.0V$ |
| ALS       | $=5.0V \pm 10\%$ |
| LS        | $=5.0V \pm 5\%$  |
| HC        | $=2.0 \sim 6.0V$ |

### 11. 和LS、ALS、HC-CMOS的替换

FACT的性能超过LS、ALS和HS-CMOS族，FACT和其他族在速度-功率特性上的相对位置如图7所示。逻辑族的比较表如表1所示。

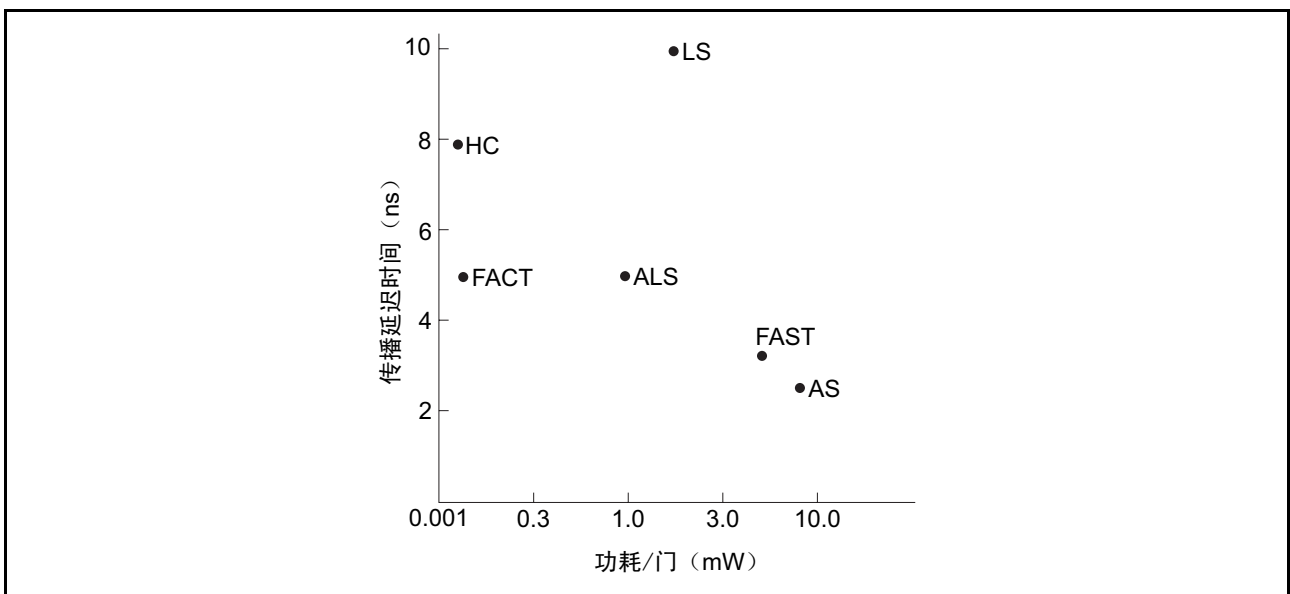


图7 传播延迟时间 速度-功率

表1 逻辑族的比较表

条件: (LS) $V_{CC}=5.0V$ 、 $C_L=15pF$ 、 $25^{\circ}C$ ;  
 (ALS/HC/FACT) $V_{CC}=5.0V\pm 10\%$ 、 $C_L=50pF$ 、Typ 值为  $25^{\circ}C$ ，ALS 族的最大值为  $0\sim 70^{\circ}C$ ，  
 HC/FACT 族的最大值为  $-40\sim +85^{\circ}C$

## • 各族的共同特性 (规格值)

| 特性        | 符号             | LS         | ALS      | HS-CMOS                 | FACT                  |                       | 单位          |
|-----------|----------------|------------|----------|-------------------------|-----------------------|-----------------------|-------------|
|           |                |            |          |                         | AC                    | ACT                   |             |
| 工作电源电压范围  | $V_{CC/EE/DD}$ | 5±5%       | 5±10%    | 2.0 to 6.0              | 2.0 to 6.0            | 4.5 to 5.5            | V           |
| 工作温度范围    | $T_{opr}$      | -20 to +75 | 0 to +70 | -40 to +85              | -40 to +85            | -40 to +85            | $^{\circ}C$ |
| 输入电压 (极限) | $V_{IH(min)}$  | 2.0        | 2.0      | 3.15                    | 3.15                  | 2.0                   | V           |
|           | $V_{IL(max)}$  | 0.8        | 0.8      | 1.35                    | 1.35                  | 0.8                   | V           |
| 输出电压 (极限) | $V_{OH(min)}$  | 2.7        | 2.7      | $V_{CC}-0.1$            | $V_{CC}-0.1$          | $V_{CC}-0.1$          | V           |
|           | $V_{OL(max)}$  | 0.5        | 0.5      | 0.1                     | 0.1                   | 0.1                   | V           |
| 输入电流      | $I_{IH}$       | 20         | 20       | +1.0                    | +1.0                  | +1.0                  | $\mu A$     |
|           | $I_{IL}$       | -400       | -200     | -1.0                    | -1.0                  | -1.0                  | $\mu A$     |
| 输出电流 (极限) | $I_{OH}$       | -0.4       | -0.4     | -4.0<br>@ $V_{CC}-0.37$ | -24<br>@ $V_{CC}-0.8$ | -24<br>@ $V_{CC}-0.8$ | mA          |
|           | $I_{OL}$       | 8.0        | 8.0      | 4.0@0.33V               | 24@0.4V               | 24@0.4V               | mA          |
| DC噪声容限    | DCM            | 0.3/0.7    | 0.4/0.7  | 1.25/1.25               | 1.25/1.25             | 0.7/2.4               | V           |

## • 速度/功率特性 (Typical 值)

| 特性        | 符号        | LS  | ALS | HS-CMOS | FACT(AC) | 单位  |
|-----------|-----------|-----|-----|---------|----------|-----|
| 静态消耗电流/门  | $I_G$     | 0.4 | 0.2 | 0.0005  | 0.0005   | mA  |
| 静态功耗/门    | $P_G$     | 2.0 | 1.2 | 0.0025  | 0.0025   | mW  |
| 传播延迟时间    | $t_P$     | 10  | 5.0 | 8.0     | 5.0      | ns  |
| 速度和功率的积   | —         | 20  | 6.0 | 0.02    | 0.01     | pJ  |
| 时钟频率 D/FF | $f_{max}$ | 33  | 50  | 50      | 160      | MHz |

## • 传播延迟时间

| 项目                                | 产品名     | 规格  | LS   | ALS  | HS-CMOS | FACT(AC) | 单位 |
|-----------------------------------|---------|-----|------|------|---------|----------|----|
| $t_{PLH}/t_{PHL}$                 | 74XX00  | Typ | 10.0 | 5.0  | 8.0     | 5.0      | ns |
|                                   |         | Max | 15.0 | 11.0 | 23.0    | 8.5      | ns |
| $t_{PLH}/t_{PHL}$<br>(Clock to Q) | 74XX74  | Typ | 25.0 | 12.0 | 14.0    | 8.0      | ns |
|                                   |         | Max | 40.0 | 18.0 | 40.0    | 10.5     | ns |
| $t_{PLH}/t_{PHL}$                 | 74XX244 | Typ | 12.0 | 6.5  | 12.0    | 5.0      | ns |
|                                   |         | Max | 18.0 | 10.0 | 23.0    | 7.0      | ns |

修订记录

| Rev. | 发行日        | 修订内容 |      |
|------|------------|------|------|
|      |            | 页    | 修订处  |
| 1.00 | 2008.03.25 | 一    | 初版发行 |

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