

# APExx16 Series

## DATA SHEET

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## 1.0 General Description

The **APExx16** series are very low cost voice and melody synthesizer with 4-bits CPU. They have various features including 4-bits ALU, ROM, RAM, I/O ports, timers, clock generator, voice and melody synthesizer, and PWM (Direct drive) or D/A current outputs, etc. The audio synthesizer contains one voice-channel and two melody-channels. Furthermore, they consist of 27 instructions in these devices. With CMOS technology and halt function can minimize power dissipation. Their architectures are similar to RISC, with two stages of instruction pipeline. They allow all instructions to be executed in a single cycle, except for program branches and data table read instructions (which need two instruction cycles).

## 2.0 Features

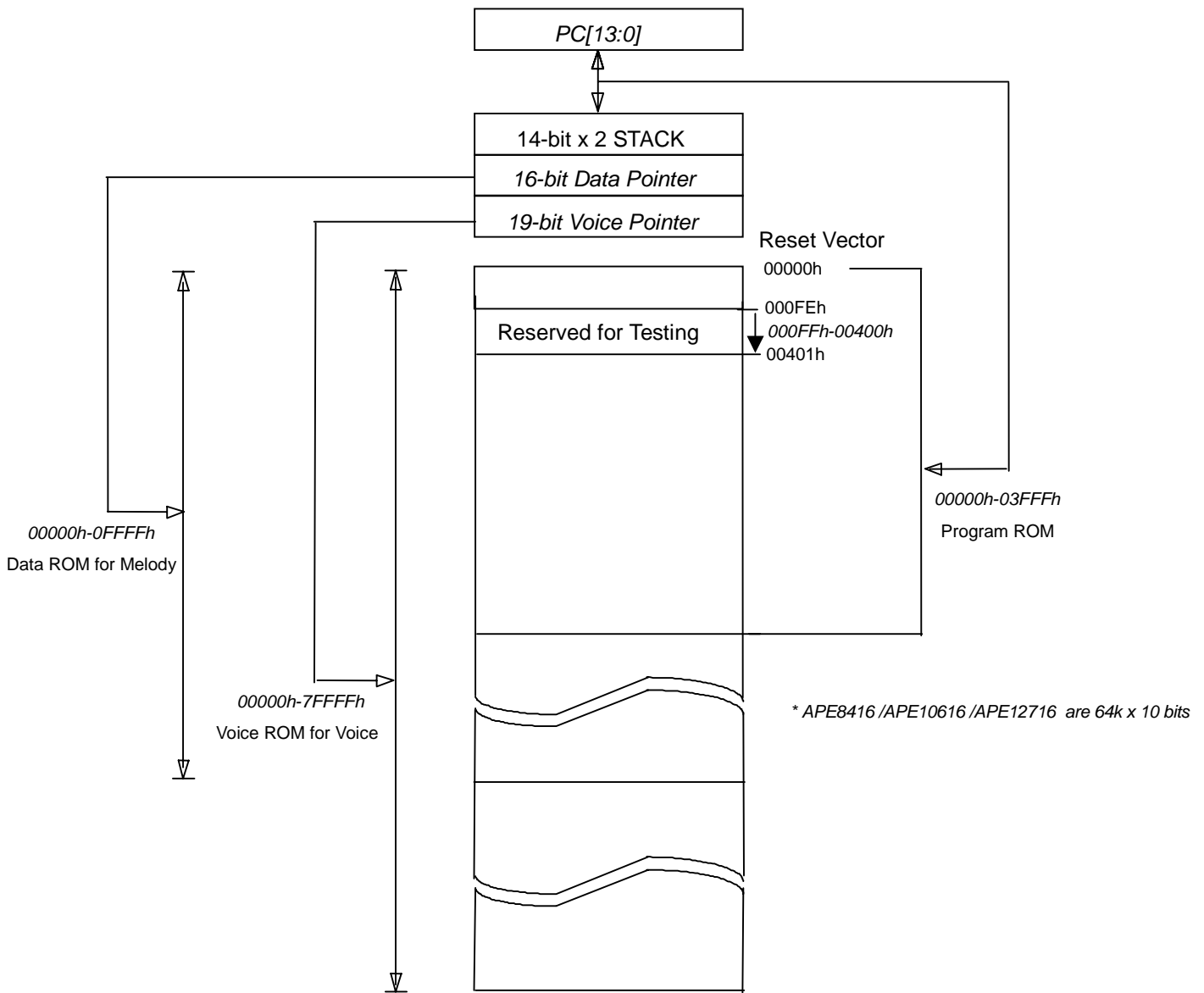
- (1) Single power supply can operate from 2.4V to 5.5V at 4MHz or 8MHz.
- (2) Program ROM: 16k x 10 bits ( *APE8416 /APE10616 /APE12716* are 64k x 10 bits )
- (3) 1 set of 16-bits DPR can access up to 64k x 10 bits melody data memory space, and 1 set of 19-bits VPR can access up to 512k x 10 bits voice data memory space.

| Product  | Voice Duration (sec) | Voice Pointer (VPR) | ROM Size (10-bits) |
|----------|----------------------|---------------------|--------------------|
| APE1016  | 10                   | 15-bits             | 32k                |
| APE1516  | 15                   | 16-bits             | 48k                |
| APE2016  | 20                   | 16-bits             | 64k                |
| APE3116  | 31                   | 17-bits             | 96k                |
| APE4116  | 41                   | 17-bits             | 128k               |
| APE6316  | 63                   | 18-bits             | 192k               |
| APE8416  | 84                   | 18-bits             | 256k               |
| APE10616 | 106                  | 19-bits             | 320k               |
| APE12716 | 127                  | 19-bits             | 384k               |

- (4) Data Registers:
  - a). 128 x 4-bits data RAM (00-7Fh)
  - b). Unbanked special function registers (SFR) range: 00h-2Fh
- (5) I/O Ports:
  - a). PRA: 4-bits I/O Port A (10h) can be programmed to input/output individually. (Register control)
  - b). PRB: 4-bits I/O Port B (13h) can be configured to input/output individually. (Mask option)
  - c). PRC: 4-bits I/O Port C (14h) can be programmed to input/output individually. (Register control)
  - d). PRD: 4-bits I/O Port D (15h) can be programmed to input/output individually. (Register control)
- (6) On-chip clock generator: Resistive Clock Drive (**RM**) or Crystal oscillator (**HM**)
- (7) Timer: 1-set Voice Interrupt (Timer0: a 9-bits auto-reload timer/counter).
- (8) Stack: 2-level subroutine nesting.
- (9) Built-in 4 Level Volume Control can be programmed.

- (10) Built-in 8 Level DAC current output can be configured. (Mask option)
- (11) Built-in IR Carry Output: Port B[1] can be configured as IR pin by 38k / 56kHz. (Mask option)
- (12) External Reset: Port B[3] can be configured as reset pin. (Mask option)
- (13) HALT and Release from HALT function to reduce power consumption
- (14) Watch Dog Timer (**WDT**)
- (15) Instruction: 1-cycle instruction except for table read and program branches which are 2-cycles
- (16) Number of instruction: 27
- (17) DAC: 1 channel voice and dual tone melody synthesizer (One 9-bits Cout or 8-bits PWM output).

**FIGURE 1 : ROM Map of APExx16 Series**



**3.0 Pin Description**

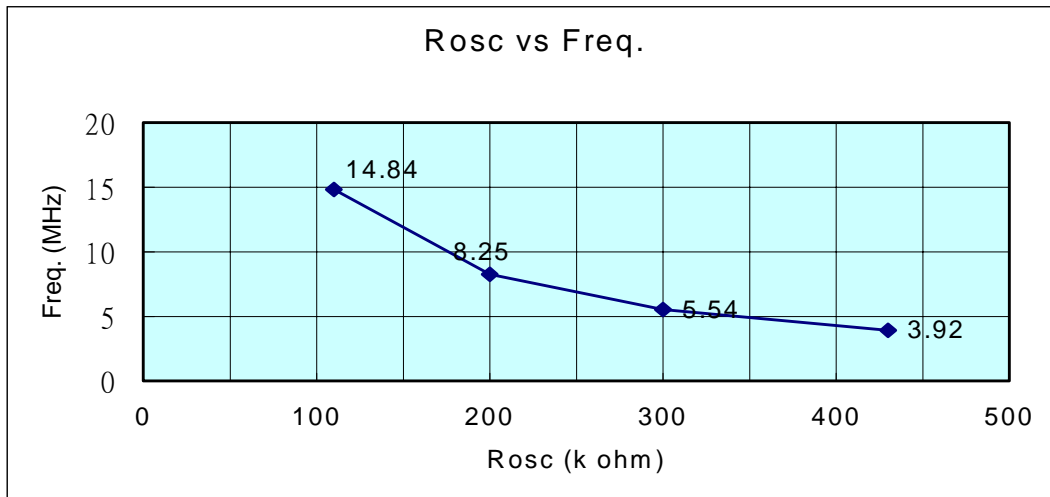
| Pad Name                   | Pin Attr. | Description   |
|----------------------------|-----------|---|
| PWM2/Cout                  | O         | PWM2 output, or Current Output of Audio.  |
| PWM1                       | O         | PWM1 output.  |
| Vdd1~3                     | Power     | Power supply during operation.  |
| PRA0~3<br>PRC0~3<br>PRD0~3 | I/O       | I/O port can be programmed to input/output individually.<br>Input type with weak pull-low or fix-input-floating capability.<br>Buffer Output type.  |
| PRB0 / OSC2                | I/O       | I/O port can be configured to input/output individually or <b>HM</b> OSC pad.<br>Input type with weak pull-low or fix-input-floating capability.<br>Buffer Output type.   |
| PRB1 / IR                  | I/O       | I/O port can be configured to input/output individually.<br>Input type with weak pull-low or fix-input-floating capability.<br>Buffer Output type.<br><i>Mask option selected as an IR Carrier Output with 38k / 56kHz</i>                |
| PRB2                       | I/O       | I/O port can be configured to input/output individually.<br>Input type with weak pull-low or fix-input-floating capability.<br>Buffer Output type.  |
| PRB3 / Reset               | I/O       | I/O port can be configured to input/output individually.<br>Input type with weak pull-low or fix-input-floating capability.<br>Buffer Output type.<br><i>Mask option selected as an external RESET pin with weak pull-low capability.</i> |
| OSC1                       | I         | RM/HM mode Oscillator input   |
| GND1~4                     | Power     | Ground Potential  |

**4.0 DC Characteristics**

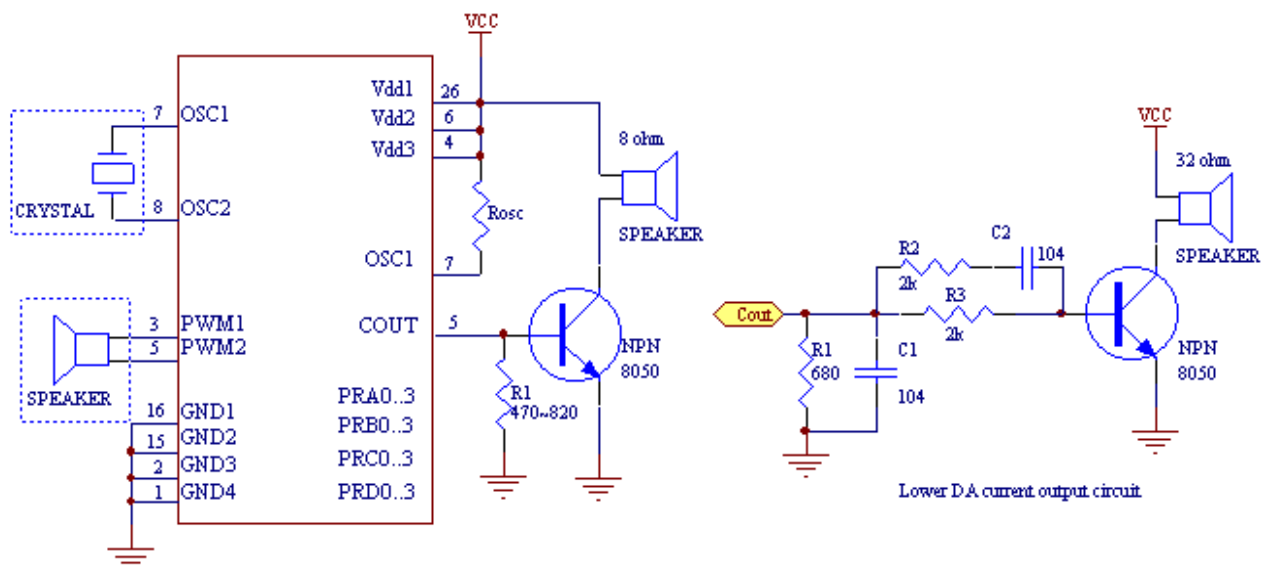
| Symbol | Parameter                              | Vdd       | Min. | Typ.      | Max. | Unit | Condition                              |
|--------|--|-----------|------|-----------|------|------|--|
| Vdd    | Operating voltage                      |           | 2.4  | 3         | 5.5  | V    | depending on Freq.                     |
| Isb    | Supply current                         | Standby   | 3    |           | 1    | uA   | 4MHz, RM,<br>in HALT Mode              |
|        |  |           | 4.5  |           | 1    |      |  |
| Iop    | Supply current                         | Operating | 3    | 2         |      | mA   | 4MHz, RM,<br>IO Floating               |
|        |  |           | 4.5  | 7         |      |      |  |
| Iih    | Input current<br>(Internal pull low)   | 3         |      | 3         |      | uA   | Input ports with weak<br>pull-low      |
|        |  | 4.5       |      | 10        |      |      |  |
| Ioh    | Output-high current                    | 3         |      | -3        |      | mA   | 4MHz, RM<br>(IO ports)                 |
|        |  | 4.5       |      | -10       |      |      |  |
| Iol    | Output-low current                     | 3         |      | 7         |      | mA   | 4MHz, RM<br>(IO ports)                 |
|        |  | 4.5       |      | 19        |      |      |  |
| Cout   | DAC output current<br>(8-level option) | 3         |      | 0.8 ~ 4.8 |      | mA   | 4MHz, RM<br>(Full scale)               |
|        |  | 4.5       |      | 0.9 ~ 6.5 |      |      |  |
| dF/F   | Frequency stability                    |           | -5   |           | 5    | %    | $\frac{F_{osc}(3v-2.4v)}{F_{osc}(3v)}$ |
| dF/F   | Fosc lot variation                     |           | -10  |           | 10   | %    | Vdd=3V, Rosc=180k,<br>4MHz             |

**FIGURE 2 : Frequency vs. Rosc (at 3V)**

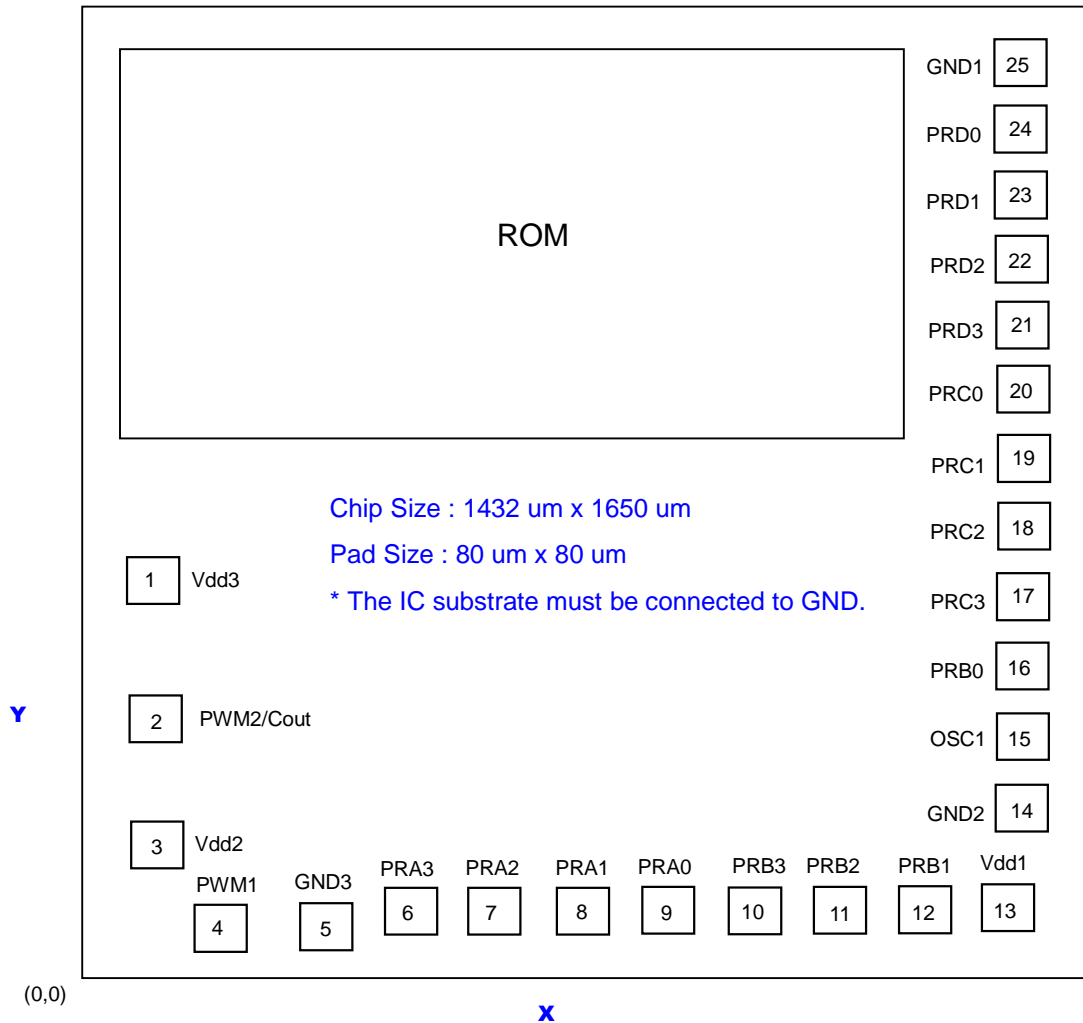
| Resistor (Rosc ohms) | 110k  | 200k | 300k | 430k |
|----------------------|-------|------|------|------|
| Frequency (MHz)      | 14.84 | 8.25 | 5.54 | 3.92 |



### 5.0 Application Circuit

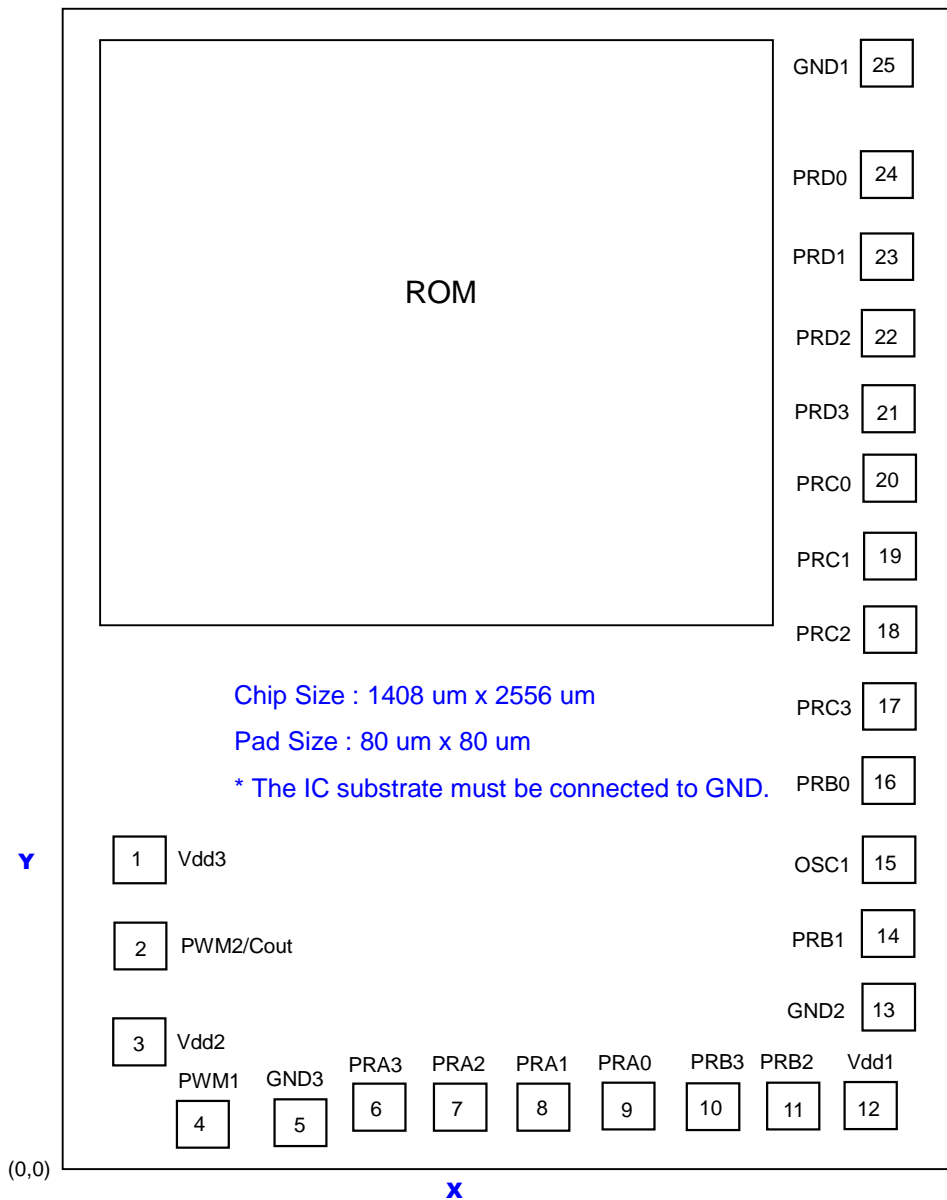


## 6.0 Bonding Diagram of APE1016 /APE1516 /APE2016



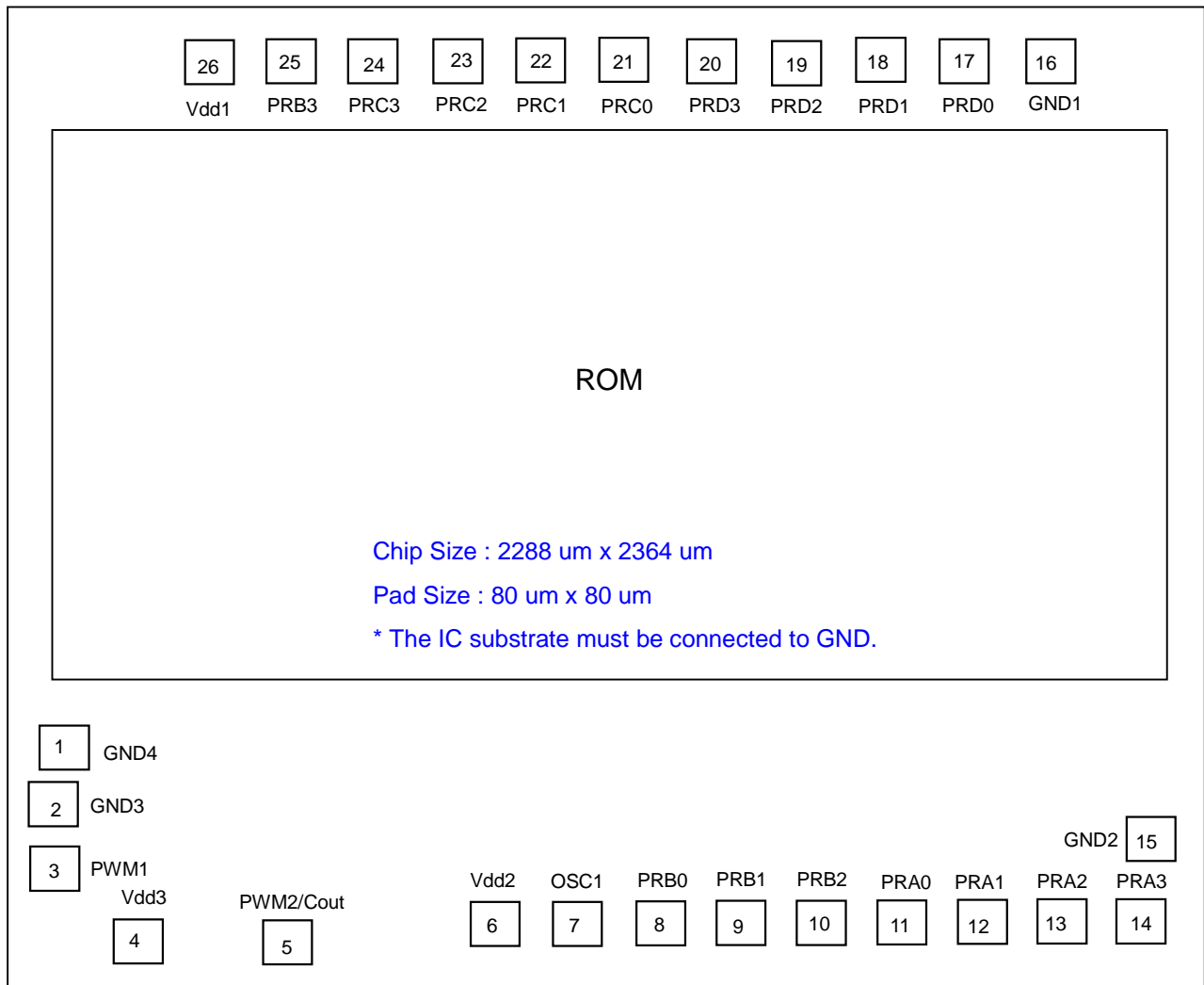
| Pad # | Pad Name   | X    | Y   | Pad # | Pad Name  | X    | Y    |
|-------|------------|------|-----|-------|-----------|------|------|
| 1     | Vdd3       | 56   | 647 | 14    | GND2      | 1261 | 235  |
| 2     | PWM2/Cout  | 58   | 466 | 15    | OSC1      | 1261 | 350  |
| 3     | Vdd2       | 58   | 182 | 16    | PRB0/OSC2 | 1261 | 465  |
| 4     | PWM1       | 145  | 58  | 17    | PRC3      | 1261 | 580  |
| 5     | GND3       | 293  | 58  | 18    | PRC2      | 1261 | 695  |
| 6     | PRA3       | 413  | 87  | 19    | PRC1      | 1261 | 810  |
| 7     | PRA2       | 533  | 87  | 20    | PRC0      | 1261 | 925  |
| 8     | PRA1       | 653  | 87  | 21    | PRD3      | 1261 | 1040 |
| 9     | PRA0       | 773  | 87  | 22    | PRD2      | 1261 | 1155 |
| 10    | PRB3/Reset | 893  | 87  | 23    | PRD1      | 1261 | 1270 |
| 11    | PRB2       | 1013 | 87  | 24    | PRD0      | 1261 | 1385 |
| 12    | PRB1/IR    | 1133 | 87  | 25    | GND1      | 1261 | 1500 |
| 13    | Vdd1       | 1253 | 87  |       |           |      |      |

## 6.1 Bonding Diagram of APE3116 /APE4116 /APE6316



| Pad # | Pad Name   | X    | Y   | Pad # | Pad Name  | X    | Y    |
|-------|------------|------|-----|-------|-----------|------|------|
| 1     | Vdd3       | 56   | 647 | 14    | PRB1/IR   | 1248 | 405  |
| 2     | PWM2/Cout  | 58   | 466 | 15    | OSC1      | 1248 | 570  |
| 3     | Vdd2       | 58   | 182 | 16    | PRB0/OSC2 | 1248 | 733  |
| 4     | PWM1       | 145  | 58  | 17    | PRC3      | 1248 | 896  |
| 5     | GND3       | 293  | 58  | 18    | PRC2      | 1248 | 1056 |
| 6     | PRA3       | 430  | 87  | 19    | PRC1      | 1248 | 1218 |
| 7     | PRA2       | 563  | 87  | 20    | PRC0      | 1248 | 1379 |
| 8     | PRA1       | 696  | 87  | 21    | PRD3      | 1248 | 1540 |
| 9     | PRA0       | 829  | 87  | 22    | PRD2      | 1248 | 1700 |
| 10    | PRB3/Reset | 962  | 87  | 23    | PRD1      | 1248 | 1861 |
| 11    | PRB2       | 1095 | 87  | 24    | PRD0      | 1248 | 2022 |
| 12    | Vdd1       | 1228 | 87  | 25    | GND1      | 1248 | 2310 |
| 13    | GND2       | 1248 | 272 |       |           |      |      |

## 6.2 Bonding Diagram of APE8416 /APE10616 /APE12716



(0,0)

X

| Pad # | Pad Name  | X    | Y   | Pad # | Pad Name   | X    | Y    |
|-------|-----------|------|-----|-------|------------|------|------|
| 1     | GND4      | 76   | 404 | 14    | PRA3       | 2109 | 76   |
| 2     | GND3      | 59   | 294 | 15    | GND2       | 2128 | 212  |
| 3     | PWM1      | 59   | 146 | 16    | GND1       | 1927 | 2204 |
| 4     | Vdd3      | 183  | 59  | 17    | PRD0       | 1765 | 2204 |
| 5     | PWM2/Cout | 467  | 59  | 18    | PRD1       | 1603 | 2204 |
| 6     | Vdd2      | 815  | 76  | 19    | PRD2       | 1441 | 2204 |
| 7     | OSC1      | 976  | 76  | 20    | PRD3       | 1279 | 2204 |
| 8     | PRB0/OSC2 | 1140 | 76  | 21    | PRC0       | 1117 | 2204 |
| 9     | PRB1/IR   | 1304 | 76  | 22    | PRC1       | 955  | 2204 |
| 10    | PRB2      | 1465 | 76  | 23    | PRC2       | 739  | 2204 |
| 11    | PRA0      | 1626 | 76  | 24    | PRC3       | 631  | 2204 |
| 12    | PRA1      | 1787 | 76  | 25    | PRB3/Reset | 469  | 2204 |
| 13    | PRA2      | 1948 | 76  | 26    | Vdd1       | 307  | 2204 |