

MASTER SLICE INTEGRATED CIRCUIT DEVICE

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a master slice integrated circuit device such as a gate array and more particularly to

the power supply circuitry between a main power supply circuit at the periphery of the chip and the internal cell region of the chip of such a device.

Related Art Statement

Master slice type gate arrays can be readily fabricated so as to provide the particular logic circuitry desired by the customer. In this type of gate array, internal cells each comprising one or more transistors of prescribed types are formed in an orderly arrangement on a wafer and external cells (I/O buffers) are formed at a peripheral region of the wafer. The desired logic circuitry is thereafter obtained by selecting the appropriate wiring process (wiring pattern). In gate arrays of this type, the power lines which branch off from the main power circuit region formed on the external cell array region and pass into the internal cell array region are generally formed at predetermined intervals with respect to the regularly arranged internal cells.

As seen in Figure 5, the conventional gate array comprises a plurality of rows of internal cells C ($C_{m,n} \dots C_{m+5, n+2}$) and external cells 20 ($20_m \dots 20_{n+3}$) disposed vertically at the external region of the chip. Each external cell C is constituted of one or more transistors, and internal and external wiring is provided via prescribed contacts (not shown) for interconnecting the internal cells themselves. As a result the vertical pitch P_{IN} of the internal cells C depends on the type of the internal cells and the number of transistors therein. On the other hand, the pitch P_{OUT} of the external cells 20 is ordinarily matched to the pitch of pads (not shown) formed exterior of the array. In the case of a master slice, a certain amount of fixed wiring is provided for interconnecting the transistors and the like into fixed devices in advance. Later the final wiring (signal and power lines) are provided for interconnecting the devices formed in advance so as to obtain the particular logic circuitry required by the customer. This final wiring is carried out by making up appropriate wiring patterns (pattern versions), fixing the original and inputting the pattern version to a wiring processing means (a computer).

The gate array shown in Figure 5 has a main power circuit 30 formed on the region of the external cells 20 and power lines ℓ ($\dots \ell_m, \ell_{m+1}, \ell_{m+2} \dots$) are provided to branch off from the power circuit region 30 and

each supplies power to two rows of the internal cell array.

As will be noted in the Figure, the array constituted of the internal cells C and the array constituted of the external cells 20 are out of phase as regards their repetition periods. More specifically, the relationship between the pitch P_{OUT} of the external cells and the pitch P_{IN} of the internal cells can be expressed as

$$j P_{OUT} \neq k P_{IN} \quad (1)$$

$$k > j \geq 1 \quad (2)$$

where j and k are positive integers. When the pitch of the positions at which lines $\ell (\dots \ell_m, \ell_{m+1}, \ell_{m+2} \dots)$ branch off from the main power circuit region 30 is set to match the pitch P_{OUT} of the external cells 20 (e.g. when in Figure 5 these lines are disposed at the boundary positions $\dots P_m, P_{m+1}, P_{m+2} \dots$ (between adjacent cells C), the periods of repetition of the internal cells C and the external cells 20 in the vertical direction will be out of the phase. Therefore, as can be seen in Figure 5, each of the power lines $\ell (\dots \ell_m, \ell_{m+1}, \ell_{m+2} \dots)$ has a different pattern so that the number of power line pattern versions is equal to the number of power lines.

For ensuring the voltage stability and the like of the power supplied to the individual internal cells, there is used a method of supplying power to these cells wherein

the power lines shown in Figure 5 are disposed in an orderly fashion so as each to fall at the boundary region between two adjacent rows of the internal cell array. On the other hand, the branch-off positions of the power lines are disposed at the fixed positions P_m, P_{m+1}, P_{m+2} so that they will fall in a fixed positional relationship to the external cells $(20_m \dots 20_{m+3})$ corresponding to contact window positions $(X_{m+1}, Y_{m+1}), (X_{m+2}, Y_{m+2}), (X_{m+3}, Y_{m+3})$ of the external cells $20_{m+1}, 20_{m+2}, 20_{m+3}$ whereby there can be obtained a single and commonly usable branch-off pattern.

Figure 6 shows the wiring pattern of another gate array. In this figure the numerals 5 with subscript $(\dots 5_L, \dots 5_{L+5} \dots)$ designate signal pads connected with the external cells 7 $(\dots 7_L, \dots 7_{L+5} \dots)$.

The external cells 7 are connected with contact windows $X_a - X_e$ via lead lines $a - e$. Power lines 9 are formed on the array region of the internal cells 11 so as to be spaced at the pitch P_{IN} of the internal cells 11 of the array. A main power circuit region (not shown) is formed on the region of the external cells 7, as in the case of the gate array shown in Figure 5. The pitch of the branch-off positions of the power lines 9 from the main power circuit region is the same as the pitch P_{IN} of the internal cells. In this case, the periods of repetition of the array of internal cells 11 and the array of external cells

are in phase. More specifically, the relationship between the pitch P_{OUT} of the external cells and the pitch P_{IN} of the internal cells can be expressed as

$$j P_{OUT} = k P_{IN} \quad (3)$$

$$K > J \geq 1 \quad (2)$$

where j and k are positive integers.

In this case under consideration, $j=4$ and $k=7$ so that the lead lines (a - e) from every fourth external cell 7 have the same pattern. For example, the pattern of the lead lines of external cells 7_L and 7_{L+4} have the same pattern. Because of this, only four pattern versions are required.

Nevertheless the wiring method of conventional gate arrays involves the following problems.

1) In the case where as shown in Figure 5 the periods of repetition of the external cells 20 and the internal cells C are out of phase, every power line ℓ has a different pattern. Moreover, the branch-off portions of the power lines may, depending on their configuration, constitute a hindrance to the provision of the contact windows at the prescribed position, whereby differences may arise between the position of the contact windows between external cells of the same logic type. The result is that differences arise in the patterns of the lead lines from the external

cells. As a consequence, there is an increase in the number of power line pattern versions and also, in some cases, in the number of lead line pattern versions. This makes automatic wiring difficult.

2) In the case where as shown in Figure 6 the periods of repetition of the external cells 7 and the internal cells 11 are in phase, the patterns of all power lines 9 are identical and the number of lead line patterns can be limited to the value of j in equation (3) so that it would appear that the number of pattern versions for the power lines and the lead lines is much smaller than in the case of the out-of-phase arrangement of Figure 5. However, not all of the contact window patterns have a common arrangement with respect to the external cells 7. Namely, there are j number of such patterns. Therefore, since the contact windows of the external cells are not all formed in the same fixed position, the actual work of providing the signal lines for connecting the contact windows of the external cells with the contact windows of the internal cells (not shown) is made even more complicated.

On the other hand, arrangement of the external and internal cells in an in-phase relationship diminishes the degree of freedom regarding such basic design factors as the circuitry and size of both types of cells. More specifically, since cell size cannot be freely selected, there is no choice but to fix discrete cell sizes, a

necessity which automatically puts a major limitation on the size or the circuitry which can be squeezed into the cell.

OBJECT AND SUMMARY OF THE INVENTION

One object of this invention is to overcome the aforesaid problems by providing a master slice integrated circuit device wherein the pattern of the power lines at the region where they branch off from the main power circuit region is so improved that, irrespective of whether the periods of repetition of the external and internal cells are in or out of phase, the total number of power line and lead line patterns can be reduced without loss of freedom in selecting the size and circuitry of the individual cells and without hindering the actual process for forming the signal and power lines between the contact windows of the external cells and the internal cells.

This object is achieved with a master slice integrated circuit device as claimed.

The invention provides a master slice integrated circuit device comprising an internal cell array and an external cell array formed outwardly from the internal cell array, a main power circuit region provided on the external cell arrays, a plurality of power lines in electrical continuity with the main power circuit region and formed at certain intervals on the internal array region, and a plurality of signal lines for electrically interconnecting prescribed

contact members of the internal and external cells for thereby realizing a desired logic circuit. What characterizes the master slice integrated circuit device of this arrangement according to the present invention is the additional provision of intermediate circuit regions at the connection regions between the main power circuit region and the power lines. Each of the intermediate circuit regions comprises a fixed position branch-off portion extending by a prescribed length in the direction of the associated power line from a position on the main power circuit region coinciding with a specific position on the associated external cell and an intersecting connection allowance portion of prescribed length connected with the fixed position branch-off portion and disposed to be perpendicular to and connected with the power line. The intermediate circuit regions can, for instance, have a substantially T- or L-shaped configuration. The plurality of parallelly disposed power lines need not necessarily be provided one per row of the internal cells and may alternatively be provided one per every two rows of the internal cells, in which case they are provided along the boundaries between adjacent cell row pairs. Moreover, it does not matter whether the periods of repetition of the external and internal cells are in or out of phase.

When such intermediate circuit regions are employed in the formation of the wiring pattern, it becomes possible

to standardize the lead pattern of the external cells beneath the main power circuit region as well as to fix the position of the contact members of the external cells. In other words, irrespective of the circuitry or size of the external cells, each fixed position branch-off portion extends by a prescribed length in the direction of the associated power line from a position on the main power circuit region coinciding with a specified position on the associated external cell. Moreover, it is connected with the intersecting connection allowance portion extending perpendicularly thereto. Therefore, since the intermediate circuit regions do not interfere with the provision of the contact members of the external cells, these contact members can be provided in fixed positions. As a result, the patterns of the circuits within the external cells and of the lead lines connecting with the contact members of the external cells are the same for all of the external cells.

On the other hand, it is advantageous from, for example, the point of ensuring the stability of the voltage of the power supplied to the internal cells to dispose the power lines on the internal cell array region at a constant pitch. In accordance with the present invention, the power lines are not connected directly with the main power circuit region but connected with the intersecting connection allowance portions of the intermediate circuit

regions so that any offset between the power lines and the external cells that arises because the power lines are provided at a constant pitch on the internal cell array region will be absorbed by the intersecting connection allowance portions which have adequate length for this purpose. Thus no need arises for taking into account the connection pattern between the power lines and the main power circuit region. A single pattern version for the power lines thus suffices. Therefore, in the process for forming the wiring pattern, it is possible by adopting a substantially T- or L-shaped pattern for the lead lines of all external cells and a common pattern for the lead lines.

The foregoing discussion is based on the presumption that the periods of repetition of the external and internal cells are out of phase. However, even in the case where they are in phase, it has conventionally been impossible to use a uniform pattern for the lead lines of all of the external cells. In accordance with this invention, however, it is possible to use a single, common pattern for the lead lines irrespective of whether the periods of repetition are in or out of phase. The advantage of being able to use a common pattern is that since it is not presumed that the periods of repetition of the external and internal cells are in phase, there arises no limitation on the circuitry or the size of the internal cells, whereby

freedom in designing the cell functions is assured. Moreover, the positions of the contact members of the external cells can be made the same among all external cells and this facilitates the adoption of a common pattern for signal lines to be connected between the contact members of the external cells and those of the internal cells.

The above and other features of the present invention will become apparent from the following description made with reference to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a partial plan view of the wiring pattern of a gate array in accordance with a first embodiment of the invention.

Figure 2 is a schematic view showing different power line formation modes in the embodiment of Figure 1.

Figure 3 is a partial view of the wiring pattern of a gate array in accordance with a second embodiment of the invention.

Figure 4 is a schematic view showing different power line formation modes in the embodiment of Figure 3.

Figure 5 is a partial plan view of the wiring pattern of a conventional gate array.

Figure 6 is a partial plan view of the wiring pattern of another conventional gate array.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will now be explained in detail with reference to the attached drawings.

In the gate array according to a first embodiment of this invention shown in Figure 1 those members corresponding to members in the conventional arrangement shown in Figure 5 are assigned the same reference symbols as those in Figure 5 and no further explanation will be made with respect thereto.

The gate array illustrated in Figure 1 comprises a plurality of internal cells C formed in orderly horizontal rows and vertical columns at an inner region of the chip and external cells 20 formed in a vertical row along the periphery of the internal cells C (at an outer region of the chip). The pitch P_{IN} of the internal cells is smaller than the pitch P_{OUT} of the external cells 20. The main power circuit region 30 is formed on the external cell 20 region and electric power is supplied to the internal cell array by power lines ℓ ($\ell_m, \ell_{m+1}, \ell_{m+2}$) provided at a pitch of one power line ℓ per every two rows of the internal cells C (at a pitch of $2P_{IN}$). In this embodiment, the periods of repetition of the internal array constituted of the internal cells C and the external array constituted of the external cells 20 are out of phase.

Therefore the relationship between the pitch P_{OUT} of the external cells and the pitch P_{IN} of the internal cells is

$$j P_{out} \neq k P_{in} \quad (1)$$

$$K > J \geq 1 \quad (2)$$

where j and k are positive integers.

Each of the power lines ℓ , which extends along a straight horizontal line, is electrically connected with the main power circuit region 30 via an intermediate circuit region 40. The intermediate circuit regions 40 are constituted as T-shaped members comprised of a fixed position branch-off portion 42 and an intersecting connection allowance portion 44. The fixed position branch-off portions 42 extend substantially in the direction of the power lines ℓ by a prescribed length from positions on the main power circuit region 30 coinciding with positions $(\dots P_m, P_{m+1}, P_{m+2} \dots)$ between pairs of adjacent external cells 20, while the intersecting connection allowance portions 44 are connected with the inner ends of the fixed position branch-off portions 42 so as to extend in a direction substantially perpendicular to the power lines ℓ . The intersecting connection allowance portions 44 have such length as to enable each of them to intersect with at least one of the power lines ℓ . More specifically, in the present embodiment the power lines ℓ are disposed at a pitch of one power line ℓ per every two rows of the internal cells C (at a pitch of $2P_{in}$) and the pitch P_{out}

of the external cells is greater than the pitch P_{IN} of the internal cells so that the length h of the intersecting connection allowance portions 44 and the P_{IN} of the internal cells must satisfy the relationship

$$h \geq P_{IN} \quad (4)$$

It should be noted, however, that if their length should be made too great, the intersecting connection allowance portions 44 will interfere with the provision on the same layer as that of lead lines (not shown) from the contact window positions (X_{m+1}, Y_{m+1}) , (X_{m+2}, Y_{m+2}) , (X_{m+3}, Y_{m+3}) of the external cells 20_{m+1}, 20_{m+2}, 20_{m+3}. Therefore, the following relationship is established

$$h = P_{IN} \quad (5)$$

As a consequence, the interval between adjacent intersecting connection allowance portions 44, 44 becomes $P_{OUT} - P_{IN}$.

The contact window positions (X_{m+1}, Y_{m+1}) , (X_{m+2}, Y_{m+2}) , (X_{m+3}, Y_{m+3}) can be fixed. This is because the positions of the fixed position branch-off portions 42 are selected with respect to the external cells 20 so as to enable the contact window positions to be fixed. Namely, the position of the fixed position branch-off portions 42 is selected so as not to be a hindrance. Further, it is

preferable to make the length of the fixed position branch-off portions 42 greater than the size of the contact windows. While the positions (. . . P_m , P_{m+1} , P_{m+2} ) of the fixed position branch-off portions 42 are at the boundaries between adjacent external cells 20 in the gate array shown in Figure 1, other positions can be selected in accordance with the circuitry of the external cells. Further, for facilitating the connection of the actual signal lines (not shown) within the same layer as the power circuitry layer, the contact window positions (only two shown, as X and Y, in Figure 1) are made to fall at the center of the external cells so that the signal lines can be readily led out.

The advantage of fixing the positions of the contact windows is that it enables standardization of the lead pattern between the respective external cells 20 and the associated contact windows. In other words, one aspect in which the presense of the intermediate circuit regions 40 is significant is that by uniformly providing the fixed position branch-off portion 42 to extend from the main power circuit region 30 by prescribed length it becomes possible to standardize the position of the contact windows, which in turn makes the pattern of the external cell leads uniform.

In the process for wiring formation, therefore, although it becomes necessary to form one additional pattern member (the intermediate circuit region 40), it suffices to use only

one pattern for the lead lines.

As regards the formation of the power lines ℓ on the other hand, it again suffices to use only a single pattern version. This is because, as can be seen from the schematic view of Figure 2, for ensuring that the tips of the respective power lines ℓ will connect with the associated connection allowance portions 44, it is only necessary either to dispose the power lines ℓ at prescribed pitches or to dispose them between adjacent rows of internal cells C_i, C_{i+1} at a pitch of $2P_{iN}$. While the position of interconnection between the fixed position branch-off portion 42 and the intersecting connection allowance portion 44 falls at the mid-section of the intersecting connection allowance portion 44, that between the intersecting connection allowance portion 44 and the power line ℓ varies from one power line to the next. However, this variation in the position of interconnection causes no problem in the automatic wiring process. This is because the substantial problems encountered in making up the wiring patterns is the complexity of the pattern versions and the number thereof, and variations in the connection positions between adjacent pattern versions are the result of the automatic wiring process. Therefore, standardization of the power lines greatly reduces the work load of the automatic wiring process.

It should be noted that the invention is not limited

to the case where only a single power line is connected with each intersecting connection allowance portion 44 but also encompasses cases in which a plurality of power lines are connected therewith.

A gate array according to a second embodiment of the invention is shown in Figure 3. Components similar to those in Figure 1 are assigned the same reference symbols and will not be explained again.

In this embodiment, the intermediate circuit regions 50 are of L-shaped configuration and are each constituted of a fixed position branch-off portion 52 of the same shape as the corresponding portion in the first embodiment and an intersecting connection allowance portion 54 attached to the inner end thereof. The fixed position branch-off portions 52 branch off from the main power circuit region 30 at positions coinciding with the center positions (. . . P'_m , P'_{m+1} , P'_{m+2} . . .) of the external cells 20. While the situation differs depending on the circuitry of the external cells, the purpose of this arrangement is to standardize the external cell signal contact window positions (X'_{m+1} , Y'_{m+1}), (X'_{m+2} , Y'_{m+2}), (X'_{m+3} , Y'_{m+3}) and to enable the lines extending from the one set of contact window positions Y'_{m+1} , Y'_{m+2} , Y'_{m+3} to the internal cell side to be formed straight in the horizontal direction. The intersecting connection allowance portions 54 are provided at the inner ends of the fixed position

branch-off portions 52 to form hook-like configurations. The length h of the intersecting connection allowance portion 54 is the same as the pitch P_{IN} of the internal cells C . While the intersecting connection allowance portions 54 interfere to some degree with the formation of straight signal lines to extend from the other set of contact window positions X'_{m+1} , X'_{m+2} , X'_{m+3} of the external cells to the internal cell side, it is possible by having them make a jog of a prescribed vertical magnitude to extend them to the internal cell side within the same layer as that in which the power lines are formed.

In this embodiment, too, the standardizing of the signal contact window positions (X'_{m+1}, Y'_{m+1}) , (X'_{m+2}, Y'_{m+2}) , (X'_{m+3}, Y'_{m+3}) makes it possible to use a common lead line pattern. As can be seen from the schematic view of Figure 4, for ensuring that the tips of the respective power lines ℓ will connect with the associated intersecting connection allowance portions 54, it is only necessary to dispose the power line ℓ at prescribed pitches.

As will be clear from the foregoing explanation, the present invention is characterized in that a master slice integrated circuit device such as a gate array, the period of repetition of the external and internal cells of which may or may not be in phase, is provided at prescribed intervals along its main power circuit region with intermediate circuit regions each consisting of a fixed

position branch-off portion branching off from the main power circuit region and an intersecting connection allowance portion connected with the free end of the fixed position branch-off portion so as to lie perpendicular thereto. As a result of this feature, the invention has the following effects:

- 1) As the presence of the fixed position branch-off portion enables the contact members of the external cells always to be disposed in a fixed position relative to the external cell concerned, the pattern of the lead lines with respect to external cells of the same logic type can be made uniform, whereby the number of pattern versions that need be prepared at the time of determining the wiring layout can be greatly reduced. As this reduction in the number of pattern versions also reduces the number of tables required for automatic wiring layout, the program therefor becomes simpler and, as a result, the overall reliability of the system is improved.
- 2) The presence of the intersecting connection allowance portion makes it possible to use only a single power line pattern version. As this also provides the effect mentioned in 1) above, the presence of the uniform intermediate circuit regions produces a synergistic effect toward reducing the required number of pattern versions.
- 3) As aforesaid benefits can be realized even when the repetition periods of the internal and external cells are

out of phase, there are no limitations on the circuitry, size or other basic design factors of the external and internal cells. This means that in the design of the cell circuitry it is unnecessary to take into account the conditions to which the wiring pattern design to be conducted thereafter will be subject. This is highly significant from the point of ease in carrying out step-by-step design of a gate array or other such device.

What is claimed is:

1. A master slice integrated circuit device comprising an internal cell array (C) and an external cell array (20) formed outwardly from the internal cell array, a main power region (30) formed on the external cell array, and a plurality of power lines (1) in electrical continuity with the main power region and formed on the internal array region, characterized in that each power line is connected with the main power region via an intermediate region (40; 50) comprising a fixed position branch-off portion (42; 52) originating at a position on the main power region and extending substantially in the direction of an associated one of the power lines and an intersecting connection allowance portion (44; 54) of prescribed length attached to the fixed position branch-off portion.

2. The master slice integrated circuit device according to claim 1, wherein said intersecting connection allowance portion (44; 54) is arranged substantially perpendicularly to said fixed position branch-off portion (42; 52).

3. The master slice integrated circuit device according to claim 1 or 2, wherein said intersecting connection allowance portion (44; 54) has such a length as to enable it to intersect with at least one of the power lines (1).

4. The master slice integrated circuit device according to any of claims 1 to 3, wherein the intermediate regions (40) have a substantially T-shaped configuration.

5. The master slice integrated circuit device according to any of claims 1 to 3, wherein the intermediate regions (50) have a substantially L-shaped configuration.



6. The master slice integrated circuit device according to any of the preceding claims, wherein the positions of the fixed position branch-off portions (42) are at the boundaries between adjacent external cells (20).

7. The master slice integrated circuit device according to any of claims 1 to 5, wherein the positions of the fixed position branch-off portions (52) coincide with the center positions of the external cells (20).

8. The master slice integrated circuit device according to any of the preceding claims, wherein each of the power lines (1) is formed along the boundary between an adjacent pair of internal cells (C).

9. The master slice integrated circuit device according to any of the preceding claims, wherein the relationship between the pitch P_{out} of the external cells (20) and the pitch P_{in} of the internal cells (C) can be expressed as

$$\begin{matrix} jP_{out} & \neq & kP_{in} \\ k & > & j \geq 1 \end{matrix}$$

where j and k are positive integers.

10. The master slice integrated circuit device according to the preceding claims, wherein the relationship among the pitch P_{out} of the external cells (20), the pitch P_{in} of the internal cells (C), and the length h of the intersecting connection allowance portion can be expressed as

$$\begin{matrix} P_{out} & > & P_{in} \\ h & \geq & P_{in} \end{matrix}$$

