Reverse Engineering

Reverse engineering in EDWinXP is divided into two basic stages. Firstly, the graphic elements in the artworks are imported and distributed in relevant categories. For example graphic elements that constitute pads are imported to Pad Stack categories and those that constitute traces are imported to Trace Master category. Actual reconstruction is the second stage that may commence only when all necessary elements have been imported. Reconstruction consists of several steps that have to be executed in prescribed sequence. For example, it is impossible to reconstruct connections before reconstructing board outlines and components first. It depends very much on completeness of imported graphics, but in most cases all reconstruction steps with exception of component reconstruction may be executed automatically just by clicking on appropriate tool. Component reconstruction is basically a manual process, which is aided by several semi-automatic support features.

Graphic imports and **Reconstruct from graphics** are two features of Fabrication Manager allowing for reverse engineering of printed circuit boards from artworks in Gerber ASCII formats. This kind of reverse engineering in EDWinXP is divided into two basic stages. Firstly, the graphic elements in the artworks are imported and distributed in relevant categories. For example graphic elements that constitute pads are imported to Padstack categories and those that constitute traces are imported to Trace Master category.

Actual reconstruction is the second stage that may commence only when all necessary elements have been imported. Reconstruction consists of several steps that have to be executed in prescribed sequence. For example, it is impossible to reconstruct connections before reconstructing board outlines and components first. It depends very much on completeness of imported graphics, but in most cases all reconstruction steps with exception of component reconstruction may be executed automatically just by clicking on appropriate tool. Component reconstruction is basically a manual process, which is aided by several semi-automatic support features.

Two methods for reconstruction

There are two methods for reconstructing components in projects that are reverse engineered from imported graphics in Gerber ASCII format:

- The graphic elements in certain imported categories may be used as a template for placing components already created in Layout Editor. This method assumes that user knows what parts were used in reverse engineered board and that those parts are defined in System Libraries. This method allows not only to re-create PCB layout but also schematics– in other words a complete EDWinXP project. It is therefore worthwhile to check in advance whether needed parts are present in the System Library and eventually add those that are missing.
- Components (electronic parts) are graphically represented on the PCB by packages that are fetched from the System Library. Newly introduced features in EDWinXP 1.50 allow recreating complete packages from graphics and subsequently the components referencing them. The parts are also

recreated. However, since no information about their schematic view and structure may be derived from imported graphics, only PCB part of the project may be recreated in this way. Recreating component from recreated packages is faster and in case that the schematic diagram of the board is needed, there are options to recreate this part of project later.

Both methods may be of course combined and there are also ways for speeding up this process through applying certain other features of EDWinXP. In this document we shall focus on the first of above mentioned methods.

Co-ordinates of footprints

The basic elements that constitute the template for component placement are so called **"pad positions"**. These are nothing else but co-ordinates of Gerber D03* (flash) commands detected in artwork files. Most of the pads are plotted by selecting a **proper aperture** and **"flashing"** its shape (usually round or rectangular) at co-ordinates corresponding with component footprint positions. Those positions may be imported to following categories: **Thrupads Positions, SMD Pads Positions for Component Side and SMD Pads Positions for Solder Side**. It is impossible for the program to decide which pad position is which and user has to apply filters to direct import to proper category or transfer pad position from one category to another using editing tools.
Some footprints may not be flashed but plotted as lines or polygons and in such a case there is no way for detecting a pad position automatically. There is an option to add missing position in proper places to fill up the gaps if the import is ambiguous. Having footprint pattern defined in form of pad positions is mandatory as they are used for snapping components into their proper positions and rotations. Import of silkscreen is helpful as it usually contains readable text with component name and other graphics that inform about component locations on the board and which footprints may belong to which component.
Import of pad stacks is not required since we would be using library packages. Nevertheless, this graphics may be useful as help for distinguishing between PMD and SMD pads as well as in deciding whether imported pad position is for via hole. Another thing worth remembering with import is alignment of pads to some grid – metric or imperial – by applying proper offset to artwork file.

Creating components

When pad positions are imported, the next stage would be creating components in Layout Editor. This is done by just selecting them from library and throwing them somewhere on the board. Actual placement is done in Fabrication Manager afterwards. Depending on number of components in reconstructed board, it may be a tedious task. Sometimes it may be easier to edit list of component in Notepad and import it with help of wire list import. (See **Project→ Netlist/Wirelist Export & Import** in **Project Explorer** menu). Such list has following format:

(**PATH,** board name **(MAINHIER)**
(COMPONENTS
Component name, library part name
. . .)**)**

The import of this component list will be successful if all required parts are found in the library. If not found, it will provide information which parts are missing and have to be added.

Whatever method for creating components would be applied, it is always convenient to have them pre-placed outside board boundaries. This may be simply accomplished by using tool Place components in bins from Layout Editor Autoplace toolbar.

With all components neatly arranged outside the board and their desired pad position imported and in proper places, the actual placement process may begin. For this task select tool **Reconstruct Component** in Fabrication Manager **Reconstruct from graphics** toolbar and subsequently option tool **Place selected existing components (F3)**. The display on the screen will present placement template in form of imported pad position and imported silkscreen elements (if any) and the components to place.

Fitting to pattern

The principle of operation is simple. Selected pad of the component is matched to its desired position on board marked by imported pad positions. With this information the program will attempt to rotate the component around selected pad to find best match for remaining pads in surrounding pattern of pad positions. There are two other options connected to this tool (F4 and F5) – one for ordering this rotation to take place in 90 degrees steps and the other for using steps specified by value in Angle Snap box.

This function operates in two modes. The simplest is to click on the **pad position** that corresponds with desired location of pin number 1 of the component we want to places. This component is then selected from the list that pops up after clicking on pad position. The other mode is reverse. Clicking on pad in existing component starts its relocation. It should be then moved in such way that this pad hovers over corresponding pad position. Subsequent click anchors the component and the program continues matching rotation automatically. This procedure has to be repeated for all components in the board.

The first section of the article describes first of two methods that may be used for reconstructing components in projects reverse engineered from graphics imported from artworks in Gerber ASCII format. This procedure utilizes graphic elements in certain imported categories only as template for placing components that first have to be created in Layout Editor. In tutorial kit NWSTUTOR.ZIP , you will find sample project database NWSTUT_IMP1.epb that already includes all necessary imports – those categories that are mandatory for complete reverse-engineering of a board when above component reconstruction method is applied. The actual components have been created by importing EDWinXP format wire list. NWSTUT.WRL that is also included in the kit. This project is intended for user who would like to try this procedure on a simple example.

Reconstructing packages

There is other reconstruction method that involves building complete packages solely from imported graphic elements and subsequently the components. The parts may be rebuilt too but there is also an option to assign matching parts from System

Library. Packages are reconstructed from elements imported to several categories. Silkscreen elements defines outline. Pads positions define not only footprint locations of but also locations of holes and their diameters. Elements extracted from pads categories are used to build pad stacks. Kit project NWSTUT_IMP2.epb has been especially prepared to illustrate this method of component reconstruction. It is more complete that the other sample and includes elements used for building pad stacks. In this particular case, the circuit consists only of pin mounted devices and elements were imported to category Thrupads Padstacks.

Holes diameters

The pad stacks in the reconstructed symbols are built from elements imported to categories Thrupads Padstacks, SMD Padstacks Comp. Side and SMD Padstacks Solder Side. Imported pad position for all above type of pads define among other things X=0 and Y=0 coordinates in reconstructed pad stack. Only those elements from pad stack categories that overlap pad position will be included in reconstruction. Pad stacks for PMD components must have holes diameters assigned. This should be done after importing all elements to Thrupads Padstacks. It is assumed that pads of certain size should have corresponding hole diameter. In other words, common hole diameter may be assigned to all pads of the same size and shape, which in turn depends on apertures defined in the Gerber artwork. Hole diameter assignments must be done prior to component reconstruction as the last stage of graphics import. The procedure is following. Select Graphics Import toolbar and Thrupads Positions as active category. Afterwards select tool Create graphic item and click on option tool Assign holes (F2). This action will result in pop-up dialog where hole diameters for all different apertures used in imported part positions may be entered. (This operation has already been done in our example)

Selecting silkscreen and pad template

Open this project NWSTUT_IMP2.epb and invoke Fabrication manager. Select toolbar Reconstruct from graphics and subsequently tool Reconstruct Component. It should be clearly visible on the screen that silkscreen and footprints form five distinct patterns in the imported graphic, equivalent to component images on the PCB. Let's assume that these components should be reconstructed as:

U1 – part 7474
U2 – part 7474
U3 – part 7404
U4 – part 7486
U5 – part 7420

Activate option tool Reconstruct component/package from graphics (F1). Graphic pattern containing image of 14 pin DIL package of U1 may be selected by dragging a bounding rectangle around it. In result of this operation all elements inside rectangle are highlighted and will be used as template for reconstruction. At this stage four additional tools are temporarily added to the option tools toolbar.

Removing redundancies

There may be some redundant elements closed within bounding rectangle. For example there may be lines in the silkscreen that constitute component name. There is no need to include them in reconstructed package (component names are generated automatically). Option tool Toggle inclusion of selected silkscreen graphic item (F4) may be used to exclude redundant silkscreen pattern elements from taking part in reconstruction. Single item selection or selection by dragging bounding rectangle may be applied at this point In similar fashion, but using tool Toggle inclusion

Renumbering pads

It is important that pads – pins in the reconstructed package - are properly numbered. Pin numbers are initially assigned when the pattern is selected, but these numbering may not necessarily be correct. Tool Assign pin number to select pad (F6) is provided for the purpose of arranging proper pad numbering sequence.

Finishing up

Clicking on the tool Finish reconstruction (F7) results in pop-up dialog where user has to specify additional information needed for reconstruction. Package name is mandatory and has to be unique within the project. By setting Component name to "none" user may direct the program to reconstruct only the package that will be placed in project library. Such package may be farther edited

Assigning part

Entering project unique component name means that the program is set to reconstruct the package and finally the component. In this case part name has to be entered in the corresponding box in the dialog. There are two possible modes for assigning parts to the reconstructed components. The program may create a new part with entered name (Assign box set to "Scratch"). Such part will have only reference to reconstructed package. No reference to schematics view will be generated at this stage and if needed has to be added later by editing this part in Library Editor. By setting Assign box to "Library Part" user may order the program to fetch part from the System Library. The part will be assigned if its description (number of defined pins) matches reconstructed package. If this is a case, the part will be loaded to project library and it original package reference altered to reconstructed package. Assigning part from System Library results also in creation of schematic representation of the component, since necessary information (schematic symbol and pin-out) is defined in the part description. There are certain restrictions in using this mode. Part cannot be already in use in the project and if reconstructed package differs in number of pins then this mode will be refused. Accepting reconstruction parameters orders the program to complete the procedure. The reconstructed component will appear in place of highlighted template. Elements of template are no longer needed and the program will remove all of them if Do not remove package template box is left unchecked.

Reconstruction through copying

Usually there are more components on reverse-engineered board that share the same package or part. This applies to our example too. In such instances it is not necessary to repeat reconstruction of each component in above described manner. Instead, they may be copied and snapped into desired location using pattern of pad positions as a placement template. For this purpose the tool Copy select component and place (F2) is provided. The procedure consists of two steps. In the first step the "source" source component has to be identified by clicking on any of its pads. If not specified otherwise, the program will ask for copied component name, create it and start its relocation. The actual placement of the new component is done exactly in the same way as described in Part 1 of this article. The component should be moved in such way that selected pad hovers over corresponding pad position. Subsequent click anchors the component. The program continues automatically to rotate the component around selected pad to find best match for remaining pads in surrounding pattern of pad positions. There are two other options connected to this tool (F4 and F5) – one for ordering this rotation to take place in 90 degrees steps and the other for using steps specified by value in Angle Snap box. In our example this procedure may be used to copy U1 to U2 since they are instances of the same part – 7474. But because each of other components represents different part, the part reference has to be re-assigned while copying. Additional option tool Change part assignment (F6) should be active in order to assign part to copied component in case it differs from part referenced by "source" component. Identical rules apply here as with part assignment for component reconstructed from package template (see above). This option has to be ON while copying U2 to U3, U3 to U4 and U4 to U5. When this last copying is done all components on this board are reconstructed. To rebuild the rest of the board, use automatic reconstructing tools for via holes, traces/netlist and finally for copper pour areas