

UNIVERSIDAD POLITÉCNICA DE MADRID

ESCUELA TÉCNICA SUPERIOR DE INGENIEROS DE TELECOMUNICACIÓN



ThesiX: L^AT_EX template for high-quality
document formatting with special emphasis
on thesis manuscripts - V1.0

TESIS DOCTORAL

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Graduado en Ciencias Físicas

2019

INSTITUTO DE ENERGÍA SOLAR

Departamento de Electrónica Física, Ingeniería Eléctrica y Física Aplicada

ESCUELA TÉCNICA SUPERIOR DE INGENIEROS DE TELECOMUNICACIÓN



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2019

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Dedication if any

Famous quote if any.
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Acknowledgements

Acknowledgements if any.

Acknowledgements

Resumen

Resumen means Abstract in Spanish, but obviously it should be replaced by the corresponding word in the mother tongue of the author. In my opinion, this should be always before the Abstract, as probably the acknowledgements will be mostly written in the author's mother tongue. Therefore it make sense to put these two sections together, and leave the Abstract closer to the rest of the document which will be probably written in English. In any case this depends on the personal view of the user.

Abstract

Thesis abstract.

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S_1 Symbol example 1

List of Acronyms

AE1 Acronym example 1

CHAPTER 1

Introduction

This chapter explains the basics of ThesiX as well as its installation process, how to use it properly, and give a brief outline of the overall manual.

1.1 About *ThesiX*

ThesiX was created during the redaction of my Ph.D. thesis. I found it difficult to find a \LaTeX template that eases the template build up while being easily extensible and customizable. Although there are some good works available, all of them fail to provide an out of the box template, easy to understand and modify without strong design constraints. My purpose is that this template will be use as the basis of any other work, modifying this template as necessary. Even if it is design to work as it is, all users are highly encourage to learn at least a basic \LaTeX and improve the template.

The latest template release is available at <https://github.com/ilomdez/ThesiX> for use under license GPL-3.0. It would be highly appreciated if the user thank the template availability explicitly stating in their document so, for instance by the use of the defined command “\ThankThesiX” or with any other sentence that fits better the user while maintaining the same meaning and explicitly staying the repository webpage and the *ThesiX* author name.:

This document make use of the latex template *ThesiX*, originally made by I. Lombardero and available at <https://github.com/ilomdez/ThesiX>.

ThesiX is its own manual and example, which means that the manual has been built using the *ThesiX* template. If the files are compiled as downloaded the output file will be this very same manual. Accordingly, several examples of all that can be achieved with *ThesiX* has been exemplified in the manual, so that every user can easily get examples of how to achieve most usual figures, tables or layouts in a thesis document.

I just would like to finish remembering that this is NOT a \LaTeX manual and that every user is encourage to learn at least the basis by themselves. This is easily accomplished given the tremendous amount of information and tutorials available on-line. The \LaTeX community has made an incredible effort during the last years so that everyone can learn on their own. In any case, *ThesiX* is built to be used by non- \LaTeX users straightforward.

Any requirement or suggestion should be requested at the Github webpage or my LinkedIn personal webpage (<https://www.linkedin.com/in/ilomdez/>). In any case, *ThesiX* is an ongoing work which is carried out in my free-time and accordingly, its extension, readability, number of examples or level of detail will be improved when possible. Nevertheless, the \LaTeX template is fully functioning and the main remaining work is to finish the manual.

1.2 Installation

In order to use *ThesiX* clone or download the whole repository at <https://github.com/ilomdez/ThesiX>. Compiling the code should be pretty straight forward, although some steps might vary depending on the operative system and the compiler chosen:

1.2.1 Windows - TextMaker - MikTeX

This section has been tested under Windows 10, TexMaker 5.0.3 and MikTeX 2.9.6972. The version of each package used in the compilation of the latest *ThesiX* manual can be found in the log file in the main folder of the repository.

Follow the instructions below:

1. Download the corresponding MikTeX version (<https://miktex.org/download>) and install it.

2. Download the corresponding TexMaker version (<https://www.xmlmath.net/texmaker/>) and install it.
3. Configure TexMaker as depicted in Figure 1.1.

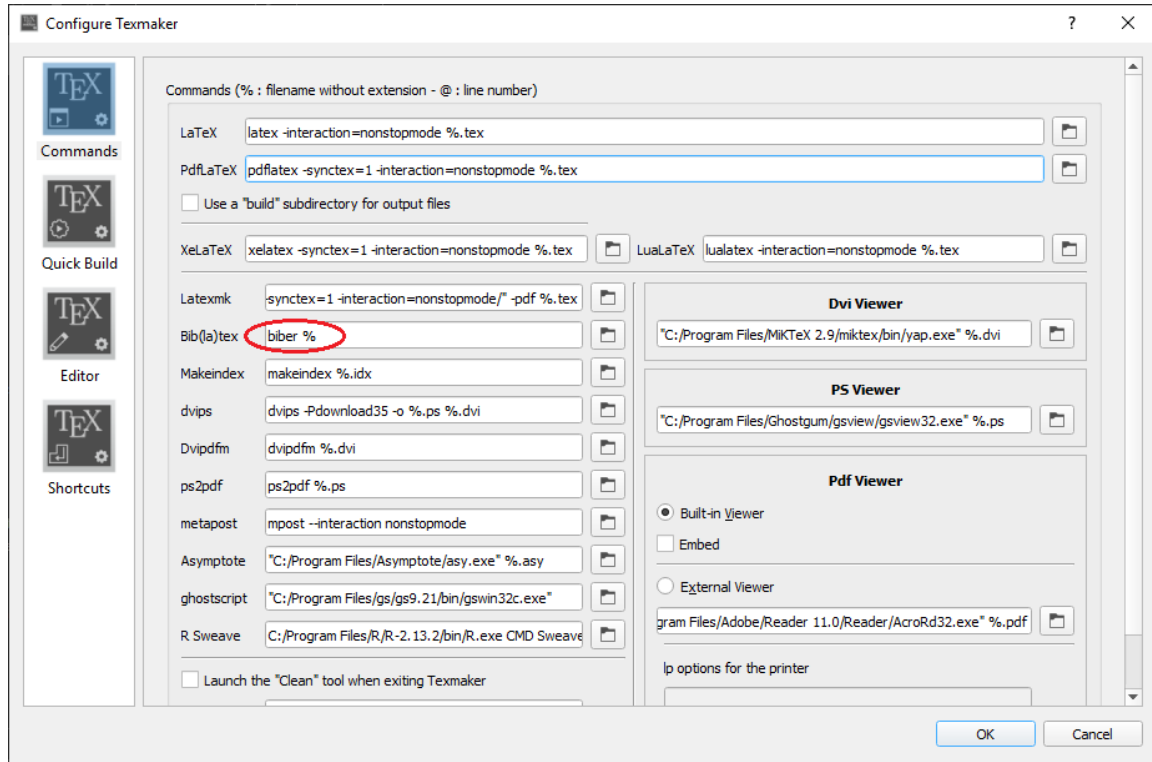


Figure 1.1: Screenshot of the main configuration settings in TexMaker.

4. SVG images can be easily implemented although the explanation of how to install such a feature is still pending.
5. TIF images can be easily implemented although the explanation of how to install such a feature is still pending.

1.2.2 Windows - TexStudio - MikTeX

Coming soon!

1.2.3 Linux

Coming soon!

1.3 How to Use *ThesiX*

ThesiX have the following structure:

```
\documentclass[a4paper,11pt,openright]{book}
\input{settings/define_basic} % Definition of basic info or LaTeX environments
\input{settings/define_shortcut} % Definition of useful word shortcuts
\input{settings/packages} % Packages and settings
```

```
\input{settings/acronyms} % Acronyms definition
\input{settings/symbols} % Symbols definition
%-----
\begin{document}
\pagenumbering{gobble} %No page numbers
\input{covers/title}
\input{covers/titleb}
\blankpage
\input{covers/tribunal}
\blankpage
\input{covers/dedication}
\blankpage
\input{covers/phrase}
\blankpage
\input{settings/coverstyle}
\input{covers/acknowledgements}
\frontmatter
\input{covers/resumen}
\input{covers/abstract}
\input{covers/tableofcontents}
\mainmatter
\input{settings/chapterstyle}
\include{chapters/chapter_Intro}
\include{chapters/chapter_Elements}
%-----
\input{settings/coverstyle}
\appendix
\input{appendix/appendix_Example}
%%-----
\input{bibliography/bibliography}
\input{extrainfo/extrainfo}
%%-----
\cleardoublepage % Ensure finishing the last section on an even page
\pagestyle{empty} % Remove page number, headers, etc.
\blankpage % Add two blankpages to add a final blank paper sheet
\blankpage
\end{document}
```

1.4 Thesis outline

This manual explains every step from the installation to the compilation of the L^AT_EX template including the use of figures, lists, acronyms and many other useful elements to use in the course of any manuscript redaction. *ThesiX* is outline as follows:

- Chapter 1, *Introduction*, reviews .
- Chapter 2 reviews .
- Chapter 3 analyses zed.
- Chapter 4 the simulations.

- Chapter 5 analysed.
- Chapter 6 summarizes work.
- Appendix A thesis.
- Appendix B gives .

CHAPTER 2

Elements

This chapter contains examples of the main elements to be used in a document (figures, tables, references, etc.)

It has been written focusing on the user convenience, so that the code that makes every element is depicted so that it can be copied and paste to replicate it.

A more detailed explanation of the use of the code or the different possibilities will be explained in the chapters devoted to each element.

2.1 Figures

```
\begin{figure}[h]
\centering
\includegraphics[width=.45\textwidth]{Intro_TexMakerConf.png}
\caption[Resume line]{An example graph}
\label{fig:example}
\end{figure}
```

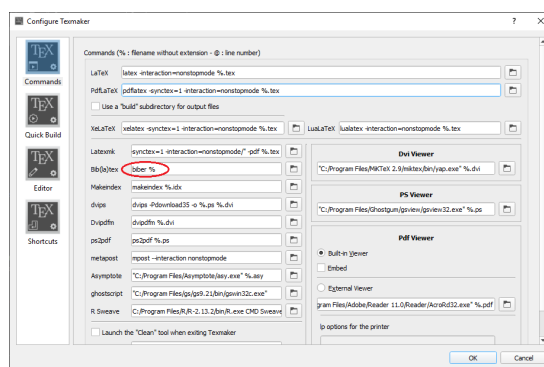


Figure 2.1: An example graph

```
\begin{figure}[h]
\centering
\begin{subfigure}[b]{.3\textwidth}
\centering
\includegraphics[width=\textwidth]{Intro_TexMakerConf.png}
\caption{$y=x$}
\label{fig:triple_x}
\end{subfigure}
\hfill
\begin{subfigure}[b]{0.3\textwidth}
\centering
\includegraphics[width=\textwidth]{Intro_TexMakerConf.png}
\caption{$y=3\sin x$}
\label{fig:triple_3sinx}
\end{subfigure}
\hfill
\begin{subfigure}[b]{0.3\textwidth}
\centering
\includegraphics[width=\textwidth]{Intro_TexMakerConf.png}
\caption{$y=5/x$}
\label{fig:triple_5overx}
\end{subfigure}
\caption[Resume line]{Three simple graphs}
\label{fig:triple}
\end{figure}
```

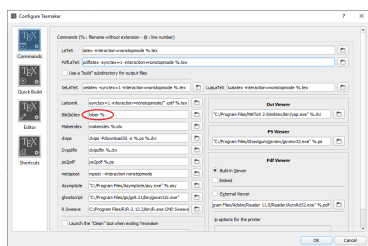
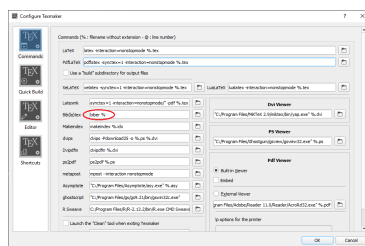
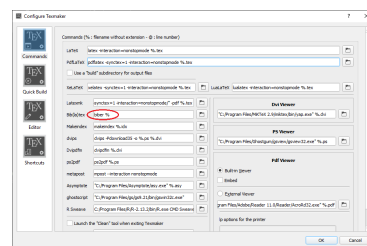
(a) $y = x$ (b) $y = 3\sin x$ (c) $y = 5/x$

Figure 2.2: Three simple graphs

2.2 Tables

```
\begin{table}[ht]
  \centering
  \begin{tabular}{1 | 1 | 1}
    A & B & C \\
    \hline
    1 & 2 & 3 \\
    4 & 5 & 6
  \end{tabular}
  \caption{very basic table}
  \label{tab:example}
\end{table}
```

A	B	C
1	2	3
4	5	6

Table 2.1: very basic table

2.3 Equations

Ecuaciones:

1. In-line equation:

This is $E=mc^2$ in-line \rightarrow This is $E = mc^2$ in-line

This is $\frac{\frac{1}{x}+\frac{1}{y}}{y-z}$ as well \rightarrow This is $\frac{\frac{1}{x}+\frac{1}{y}}{y-z}$ as well

2. Numbered equation:

```
\begin{equation}\label{eq:someequation}
\sqrt[n]{1+x+x^2+x^3+\dots+x^n}
\end{equation}
```

$$\sqrt[n]{1+x+x^2+x^3+\dots+x^n} \quad (2.1)$$

3. Unnumbered equation:

```
\begin{equation*}
\frac{n!}{k!(n-k)!} = \binom{n}{k}
\end{equation*}
```

$$\frac{n!}{k!(n-k)!} = \binom{n}{k}$$

2.4 Cites

1. Cita estándar:

```
\cite{Hovel1997b} → [HW97]
\cite{Rau2007,King2011} → [Rau07; Kin+11]
```

2. Cita comentada:

```
\parencite[e.g.] [page 300]{Miller2012} → [e.g. MYK12, page 300]
```

2.5 References

1. Figure reference:

```
\ref{fig:example} → 2.1
\ref{fig:triple} → 2.2
```

2. Subfigure reference:

```
\ref{fig:triple_x} → 2.2a
\subref{fig:triple_x} → a
```

3. Table reference:

```
\ref{tab:example} → 2.1
```

4. Equation reference:

```
\ref{eq:someequation} → 2.1
\eqref{eq:someequation} → (2.1)
```

5. Chapter reference:

```
\ref{ch:Elements} → 2
\nameref{ch:Elements} → Elements
```

6. Section reference:

`\ref{sec:Elements_refs}` \rightarrow 2.5

`\nameref{sec:Elements_refs}` \rightarrow References

2.6 Acronyms and symbols

1. Symbol:

`\gls{symbol1}` $\rightarrow S_1$

2. Acronym:

`\gls{acronym1}` \rightarrow AE1

2.7 Lists

This is a list

```
\begin{enumerate}
  \item First points
  \item Second
  \item Etc
\end{enumerate}
%\end{tabular}
Esto es una lista.
```

1. First points

2. Second

3. Etc

This is another list set to start at 8

```
\begin{enumerate}
  \setcounter{enumi}{7}
  \item First points
  \item Second
  \item Etc
\end{enumerate}
%\end{tabular}
Esto es una lista.
```

8. First points

9. Second

10. Etc

APPENDIX A

Example of Appendix

This chapter behaves as any other one but it is numbered as an appendix.

Bibliography

- [HW97] H. J. Hovel and J. M. Woodall. “Theoretical and Experimental Evaluations of Ga_{1-x}Al_xAs-GaAs Solar Cells”. In: *Knowledge Creation Diffusion Utilization* (1997), pp. 20–54.
- [Kin+11] R. R. King, D. Bhusari, A. Boca, D. Larrabee, X.-Q. Liu, W. Hong, C. M. Fetzer, D. C. Law, and N. H. Karam. “Band gap-voltage offset and energy production in next-generation multijunction solar cells”. In: *Progress in Photovoltaics: Research and Applications* 19.7 (Nov. 2011), pp. 797–812. ISSN: 10627995. DOI: 10.1002/pip.1044. URL: <http://doi.wiley.com/10.1002/pip.1044>.
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- [Rau07] Uwe Rau. “Reciprocity relation between photovoltaic quantum efficiency and electroluminescent emission of solar cells”. In: *Physical Review B* 76.8 (Aug. 2007), p. 085303. ISSN: 1098-0121. DOI: 10.1103/PhysRevB.76.085303. URL: <https://journals.aps.org/prb/abstract/10.1103/PhysRevB.76.085303>.

Publications

Journal Publications

- 1 I. Lombardero and C. Algora. “Understanding the influence of shunts in the I–V curves and electroluminescence of multijunction solar cells”. In: *Solar Energy Materials and Solar Cells* 204.October 2019 (2020), p. 110236. ISSN: 09270248. DOI: 10.1016/j.solmat.2019.110236. URL: <https://doi.org/10.1016/j.solmat.2019.110236>.
- 2 Laura Barrutia, Iván Lombardero, Mario Ochoa, Gabás Mercedes, Iván García, Tomás Palacios, Andrew Johnson, Ignacio Rey Stolle, and Carlos Algora. “On the use of graphene to improve the performance of concentrator III - V multijunction solar cells”. In: *Progress in Photovoltaics: Research and Applications* September (2019), pp. 1–11. DOI: 10.1002/pip.3207. URL: <https://onlinelibrary.wiley.com/doi/abs/10.1002/pip.3207>.
- 3 Pengyun Huo, Iván Lombardero, Iván García, and Ignacio Rey-Stolle. “Enhanced performance of GaInP/GaAs/Ge solar cells under high concentration through Pd/Ge/Ti/Pd/Al grid metallization”. In: *Progress in Photovoltaics: Research and Applications* April (2019), pp. 1–9. ISSN: 1099159X. DOI: 10.1002/pip.3149. URL: <https://onlinelibrary.wiley.com/doi/abs/10.1002/pip.3149>.
- 4 Vincenzo Orlando, Iván Lombardero, Mercedes Gabás, Neftalí Nuñez, Manuel Vázquez, Pilar Espinet-Gonzalez, Jesús Bautista, Rocío Romero, and Carlos Algora. “Temperature Accelerated Life Test and Failure Analysis on Junction Solar Cells”. In: *Progress in Photovoltaics: Research and Applications* November (2019), pp. 1–19. DOI: 10.1002/pip.3223. URL: <https://onlinelibrary.wiley.com/doi/pdf/10.1002/pip.3223>.
- 5 A. Navarro, O. Martinez, B. Galiana, I. Lombardero, M. Ochoa, I. García, M. Gabás, C. Ballesteros, J. Jimenez, and C. Algora. “Cathodoluminescence Characterization of Dilute Nitride GaNSbAs Alloys”. In: *Journal of Electronic Materials* (2018). ISSN: 03615235. DOI: 10.1007/s11664-018-6325-3.
- 6 Ivan García, Mario Ochoa, Iván Lombardero, Luis Cifuentes, Manuel Hinojosa, Pablo Caño, Ignacio Rey-Stolle, Carlos Algora, Andrew Johnson, Iwan Davies, Kian Hua Tan, Wan Khai Loke, Satrio Wicaksono, and Soon Fatt Yoon. “Degradation of subcells and tunnel junctions during growth of GaInP/Ga(In)As/GaNAsSb/Ge 4-junction solar cells”. In: *Progress in Photovoltaics: Research and Applications* May (2017), pp. 1–9. ISSN: 10627995. DOI: 10.1002/pip.2930. URL: <http://doi.wiley.com/10.1002/pip.2930>.

Conference Publications

- 1 Neftali Nuñez, Manuel Vazquez, Laura Barrutia, Jesus Bautista, Ivan Lombardero, Juan Carlos Zamorano, Manuel Hinojosa, Mercedes Gabas, and Carlos Algora. “Innovative Temperature Accelerated Life Test for the determination of the activation energy of space solar

- cells". In: *2019 European Space Power Conference (ESPC)*. IEEE, 2019, pp. 1–7. ISBN: 9781728121260. DOI: 10.1109/ESPC.2019.8931993.
- 2 L. Barrutia, I. García, E. Barrigón, M. Ochoa, I. Lombardero, M. Hinojosa, P. Caño, J. Bautista, L. Cifuentes, I. Rey-Stolle, and C. Algora. "Development of the Lattice Matched GaInP/GaInAs/Ge Triple Junction Solar Cell with an Efficiency Over 40%". In: *Proceedings of the 2018 12th Spanish Conference on Electron Devices, CDE 2018*. 2018, pp. 1–4. ISBN: 9781538657799. DOI: 10.1109/CDE.2018.8596996.
- 3 G. Duggan, A. D. Johnson, J. I. Davies, P. Nitz, M. Wiesenfarth, P. Jakob, D. Iankov, I. Rey-Stolle, C. Algora, I. Garcia, I. Lombardero, P. Caño, O. Alburquerque, M. Theristis, and G. E. Georghiou. "ALCHEMI – A low cost, high efficiency, optoelectronic HCPV module for 1000X operation". In: vol. 020005. 2018, p. 020005. ISBN: 9780735417281. DOI: 10.1063/1.5053493. URL: <http://aip.scitation.org/doi/abs/10.1063/1.5053493>.
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- 6 Mario Ochoa, Iván García, Iván Lombardero, Ignacio Rey-Stolle, and Carlos Algora. "Lowering perimeter recombination losses in micro-concentrator solar cells: A simulation study". In: vol. 040008. AIP Conference Proceedings 2012, 2018, p. 040008. ISBN: 9780735417281. DOI: 10.1063/1.5053516. URL: <http://aip.scitation.org/doi/abs/10.1063/1.5053516>.
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- 8 Iván García, Mario Ochoa, Iván Lombardero, Luis Cifuentes, Pablo Caño, Manuel Hinojosa, Ignacio Rey-Stolle, Carlos Algora, Andrew D. Johnson, Junior Iwan Davies, K. H. Tan, W. K. Loke, S. Wicaksono, and S. F. Yoon. "Component Integration Effects in 4-junction Solar Cells with Dilute Nitride 1eV Subcell". In: *2017 IEEE 44th Photovoltaic Specialist Conference, PVSC 2017*. IEEE, 2017, pp. 1–4. ISBN: 9781509056057. DOI: 10.1109/PVSC.2017.8366250. URL: <https://doi.org/10.1109/PVSC.2017.8366250>.
- 9 I Lombardero, M Ochoa, I García, M Hinojosa, P Caño, C Algora, A Johnson, and J I Davies. "Preliminary analysis of annealing impact on 1 eV GaNAsSb Solar Cells". In: *11th Spanish Conference on Electron Devices (CDE11)*. Barcelona, Spain: IEEE, 2017, pp. 10–13. DOI: 10.1109/CDE.2017.7905216. URL: <https://ieeexplore.ieee.org/document/7905216>.
- 10 M. Ochoa, I. Garcia, I. Lombardero, L. Ayllon, L. Cifuentes, I. Rey-Stolle, C. Algora, A.D. Johnson, J.I. Davies, K.H. Tan, W.K. Loke, S. Wicaksono, S.F. Yoon, E. Ochoa, M. Gabas, T. Thomas, N.J. Ekins-Daukes, H. Garcia, H. Castan, S. Duenas, S. Estrade, and F. Peiro. "Advances towards 4J lattice-matched including dilute nitride subcell for terrestrial and space applications". In: *Conference Record of the IEEE Photovoltaic Specialists Conference*. Vol. 2016-Novem. 2016. ISBN: 9781509027248. DOI: 10.1109/PVSC.2016.7749407.

- 11 M. Ochoa, I. García, I. Lombardero, L. Ayllón, I. Rey-Stolle, C. Algora, A. Johnson, J.I. Davies, K.H. Tan, W.K. Loke, S. Wicaksono, S.F. Yoon, E. Ochoa-Martínez, and M. Gabás. “Modelling of lattice matched dilute nitride 4-junction concentrator solar cells on Ge substrates”. In: *AIP Conference Proceedings*. Vol. 1766. 2016. ISBN: 9780735414242. DOI: 10.1063/1.4962101.

Extra Information

Unnumbered chapter to add any relevant information that should not be part of the main chapters of the thesis itself nor an appendix. For instance, all the patents, awards, projects, etc. achieved or accomplished could be presented here, in one or different chapters. See the example below depicting the projects I was involved in during my thesis.

One last thing, although this chapter has been added after the bibliography, similar ones could be added at any place in the document with similar results. Nevertheless, attention should be paid to the page style, which might be set different depending on where the the chapter is placed in the *ThesisX* template.

Projects as Principal Investigator

1. **Title:** Adelgazamiento de Células Solares para Reducir su Huella Ecológica y Maximizar su Rendimiento
P.I: Iván Lombardero
Funding: 20,000 €
Duration: 15/09/2019 - 15/09/2020
2. **Title:** Desarrollo de Células Solares con Nitruros Diluidos de Última Generación para Alcanzar la Competitividad en la Energía Solar Fotovoltaica
P.I: Iván Lombardero
Funding: 20,000 €
Duration: 15/09/2018 - 15/09/2020

Projects as Participant

1. **Title:** Evaluación de arquitecturas de nueva generación en células solares multiunión para lograr eficiencias del 50 %
P.I: Carlos Algora
Funding: 314,358 €
Duration: 01/01/2015 - 31/12/2017
2. **Title:** Dilute Nitride Based Concentrator Multijunction Solar Cells, With Efficiencies Over 47 %
P.I: Carlos Algora
Funding: 191,250 €
Duration: 11/12/15 - 30/11/18

