Electrification and the Future of EVs

Nitin Dahad (00:00):

This is the Smarter World podcast, focusing on the technology and issues behind today's connected world. I'm host Nitin Dahad, technology journalist and editor at EE Times and Embedded.com. In this episode, we'll discuss the electrification of vehicles with Jens Hinrichsen, who's the executive vice president and general manager of the Advanced Analog business line at NXP Semiconductors.

(00:32):

So car makers around the world are working to roll out electric and hybrid vehicles in a competitive and profitable way against the backdrop of changing regulations, and the complexity it brings. Electric vehicles need to gain the trust of consumers for range, safety and environmental footprint, while being profitable. That's a tall order for both disruptive and traditional car makers alike. We'll discuss this and more with Jens Hinrichsen of NXP. Welcome, Jens.

Jens Hinrichsen (01:00):

Hi, Nitin.

Nitin Dahad (01:02):

We're going to talk a little bit about electric vehicles and electrification and adoption. So let's start with some key themes on the topic. What do you think driving electric adoption? There's been a lot of talk about it lately and a lot of disruption. People say there's a trend, electrification trend. People are buying electrics. What do you see? Is there growth or is it all hype? Tell us a little bit.

Jens Hinrichsen (01:24):

Yeah, that's a good question, Nitin. Indeed, we do see really that the need and the adoption rate for electric vehicles is constantly increasing. Even in challenging years like 2020 where the overall car production was down, the electrified vehicles was still increasing in such a year. So there is indeed a trend towards electrified vehicles.

Nitin Dahad (01:47):

Is there a particular driver, a major driver that's needed to keep that kind of trend going? I mean, what do you see, is there one driver, are there multiple drivers?

Jens Hinrichsen (01:55):

Yeah, it's actually very difficult to nail it down to one particular specific driver. So from my perspective, there are multiple elements that they are driving the increasing demand and the

increasing adoption rate of electrified vehicles. So overall, I think it really starts with the increasing desire to do something good for environment, to find a more sustainable and environmentally friendly way of mobility. I think that's really the key driver from my perspective.

(02:24):

But then, on top of it, it comes real quickly down to a compromise of cost and convenience. And you can imagine if the car, the electrified car or the electric vehicle is not performing in a similar way you need to do and you are used to based on cars with a combustion engine, I think you really wonder whether it really makes sense to go for such a car. So range and also the speed of charging is really critical from my perspective. So convenience is a key element as well.

Nitin Dahad (02:57):

Yes. I mean, that's what we hear as well when we're writing about this and listening to people, we hear a lot about two things. One is the range anxiety and the other one is it doesn't make sense from a cost point of view because it's too expensive. And we're going to dig into some of those issues later. But what about other things? Are government regulations and mandates going to help, or is it different in different regions? Tell me what you see from NXP's point of view.

Jens Hinrichsen (03:22):

Yeah. I think you also mentioned already that definitely cost and affordability is also another critical item next to the topics that I've mentioned driving the adoption rate. And so, while the car makers constantly have to increase the performance of the cars like I said, and we need to in the same way also drive down the cost and make these cars very affordable. And from that perspective, I really, truly think that a little bit of a catalyst is still needed to drive this process.

(03:50):

And there are two elements which are driving this. On the one hand, government regulations and mandates. That's basically to motivate the car makers to speed up the electrification of their entire fleet. And then the other part is more from a consumer perspective is really subsidies and tax incentives. This is really to make it affordable for the consumers to buy these cars. So these two catalysts are still needed and driving it to foster a little bit the speed of this development.

Nitin Dahad (04:18):

Yes. And I think, talking of those mandates, there are certain targets that various governments have set. I mean, for example, in Europe we have some mandate for electrification by a certain year. Is the trend towards those mandates and regulations more European or US or where else? What do you see?

Jens Hinrichsen (04:34):

Yeah, I think if you look on a global perspective, I truly see that China is really continuously leading the introduction of true electric vehicles, from the production as well as from a

consumer adoption rate. While in Europe, I see that they are very much driving the electrified vehicles in the sense of hybrids, plug-in hybrids or high voltage hybrid cars. This is very much related to the fact that based on these CO2 emission regulations which is basically established by the European government, that motivates the car makers to electrify their entire fleet, and that's what we are seeing in Europe to a large extent.

(05:14):

In the US, Tesla stay strong. So big player, of course. And then in the US, we also do see that the US American big threes have also increased their xEV focus significantly. At least, we have seen a lot of announcements recently.

Nitin Dahad (05:30):

You used an acronym there. xEV, what's that?

Jens Hinrichsen (05:32):

I mean, this I used for electrified vehicles. So this is all kind of level of electrification. The extreme level is the full electric vehicle and then probably the easiest is a very mild hybrid, a 48 volt hybrid. That's what I meant with xEVs.

Nitin Dahad (05:47):

Let's move onto some of the challenges for the car makers and how the various car makers approach electrification. Tell us a little bit about the challenges first in rolling out that EV technology?

Jens Hinrichsen (05:58):

I think it comes back to what we have mentioned earlier, which is driving the adoption rate from a consumer perspective. So I think the key challenges the car makers are facing is they constantly need to improve the performance of these cars, explicitly like we said range and maybe also the capability of faster charging.

(06:16):

Then they need to find ways to drive the cost down. And they need to also find ways basically to leverage the economy of scale of the electrification and find ways to basically do entire fleet electrification across all brands and models. And since the overall demand of these vehicles is increasing, they also need to find really truly ways to get to a level of making the true high volume mass production capability available in their companies for these electrified vehicles. So this is really a key element supporting all the automotive robustness, quality standards, as well as longevity commitments and also long-term service commitments. So these are the key challenges I'm seeing the car makers have.

Nitin Dahad (07:04):

We keep hearing headlines about risk and safety. I mean, what about functional safety and things like that?

Jens Hinrichsen (07:09):

Yeah, that's a good point. So come back to the point of performance. If you want to extend the range and also make fast charging possible, so you probably have to put way more energy and power into the battery, and also establish very, very quick speeds of charging. That makes the battery and also the charging process a fairly hazardous element of your car. So you have more and more power in this battery and leverage and unleash the maximum power and efficiency out of this battery.

(07:42):

So that has got super high level on functional safety. You need to ensure that that battery is constantly operating fine and that this battery is not getting into any kind of trouble. And if that is the case, that there are mechanisms around that it's basically shut down or stopped or controlled. So functional safety is becoming a critical element for this very, very important system in the car.

Nitin Dahad (08:07):

We will come onto battery management in a little while, but let's talk a little bit about the technology. So from a technology perspective, what's needed to deliver an electric vehicle? What are the different elements, the pieces?

Jens Hinrichsen (08:18):

I try to keep it simple. So the most important part is really the power train and electric or electrified vehicles like an hybrid, the only difference to what's a regular car with a combustion engine is truly the power train, right?

(08:33):

And if you take basically the power train of an hybrid vehicle, which is probably even a little bit more complex than of a pure electric vehicle, you need a couple of elements. And on the one hand, of course, like I said, you still have the combustion engine and that needs a bit of a motor control for the combustion engine. And then on top of it, you have an e-motor, and the e-motor needs an inverter platform, and that inverter platform is just there to make the e-motor move.

(09:00):

Then you usually, you have a low voltage battery in your car and you have a high voltage battery in the car. The low voltage battery is clearly just simply there to support your board net, so that you can do the regular features, your infotainment system, your seat control, everything. The high voltage battery is the energy source for the e-motor, and that's a real critical element.

(09:22):

And then, very quickly, when you have a low voltage and a high voltage net in your car, you need a DC-DC converter to connect these systems. And usually, if you have a plug-in hybrid, you need an AC-DC converter for onboard charging that you can take your normal, let's say, power supply and plug it in and then the car is doing the conversion. Usually you have a bit of a power train. The main controller that's a little bit a brain that is controlling, when do I use now my electric and when do I use my combustion? When do I do the charging? When do I do the consumption everything?

(09:58):

And then, of course, on top of the high voltage battery, which is the energy source for the electric motor, you need a smart and a pretty sophisticated battery management system, which is really critical in such a set-up. That's pretty much all you need.

Nitin Dahad (10:13):

Wow. I mean, to somebody who doesn't know about technology, that sounds very complex and you think, "Let's just stick with simple mechanical engines." But obviously there's huge benefits to electrification. I know battery management is one big thing, but tell me about some of the other parts of the puzzle than NXP gets involved in? So what's NXP's role in enabling all of those technology pieces?

Jens Hinrichsen (10:36):

You know, NXP is always providing the semiconductors which are controlling the power and controlling and monitoring the systems. We are not providing solutions to basically provide the power towards the motor. These are usually the power semiconductors such as MOSFETs and IGBT, so silicon carbide solutions. So we are not providing these. We are not focusing on the power semiconductors. We do all the control systems. So basically all the processors, which do the intelligent processing. We have all the networking components. We have basically the power management components to support the intelligent processors. We have the entire connectivity to interlink all these systems. And we also do have, and that's basically a key element, all the analog front-end solutions. So the battery cell controllers, which are basically sensing all the data in this system from the outside. And then, we are basically processing and controlling the system. That's what we do. We don't provide the power to the system.

Nitin Dahad (11:40):

I mean, that's quite important. You're providing a lot of the control systems and intelligence and conversion?

Jens Hinrichsen (11:46):

That's correct.

Nitin Dahad (11:47):

Let's go onto a little bit more about battery management. Obviously a big part of electrification is enabling good battery management. Tell us a little bit more, maybe go into a little bit more specifics into what it's compromised of and how it works?

Jens Hinrichsen (11:58):

Yeah. Maybe I start with how it works, and then we see which components you need to make that happen, and I try to keep it fairly simple. Actually, the battery management system is constantly monitoring the battery. Actually, it's monitoring and controlling the battery. And it's basically nearly real-time checking constantly the state of health, the state of charge and the state of function. And that is basically checked for each particular cell of this huge battery pack.

(12:31):

And then what that basically means is that the system is checking what is the status of each particular cell? So what's the temperature? And it measures a couple of other critical items and really high precision analog performance. And it needs to measure this one fairly accurate. And then, it can decide, "Can I consume the power out of this cell at the moment or is the cell maybe too hot and I should leave it alone for a while? Is the cell now empty and do I need to basically charge this particular cell? And is there anything basically I need to do to leverage basically each particular cell of the system in an optimized way to unleash the full energy density, the full energy power of that particular system without damaging it and without overstressing it so that we are not getting into a status of malfunction?"

(13:27):

And the more precise you can do this, the more you can unleash truly the full power out of a battery and therefore you can basically achieve a very long range with the battery so you can get the maximum out of your particular power while at the same time you are not damaging the battery. And that basically results into long lifetime. And, on the short-term, of course, like I said, you need to really ensure that that thing is not getting out of control and so you need to ensure constantly the functional operations and the functional safety of this particular system. That's what the battery management system does.

Nitin Dahad (14:05):

I mean, just to underline the complexity, and I guess most of the listeners would probably know, but just for the sake of others, how many battery cells are there typically that you need to manage? I mean, this is quite complex, isn't it?

Jens Hinrichsen (14:16):

Right, it is. It's really complex. And let's take a simple example and hopefully I get the math right here. A typical system is a 400 volt system. For a sports car, it can even go up higher. For a high performance car, it can be 800, 900 volts. So that's basically the voltage you need to manage. And in each particular cell can handle, based on your setup, between three and four volt, roughly. So now, if you take the ... let's stick to the 400 volt example and let's say four volt per

cell, that means you have 100 cells which you need in the battery. And you need to control 100 cells, and they need to be controlled constantly real-time, like I said.

Nitin Dahad (14:58):

I mean, that really puts it into perspective, then. Thank you. So the battery management is quite important. You provide battery management devices. In terms of the percentage of the system or the cost of the system, how big is that sort of role? The battery management role and NXP's piece of that?

Jens Hinrichsen (15:15):

It really depends on the voltage level you're supporting like I have mentioned. And I have also not yet completely explained what are the components being in the battery management system, so I forgot about that part of your question, Nitin. So basically, what you need is you need a processor, which is processing all the data you get out of that system. You need a bit of connectivity to connect this system to the other electronics of your car. And then the main part you need is the cell controller, the battery cell controller, which that is an high-precision analog front-end, which is doing these real-time measurements of each particular cell. And usually you have a six cell or 14 or 18 cell controller which can control that many cells in parallel to support this control.

(16:04):

So the majority of the semiconductor content and the majority of the value is truly in the analog front-end part. And you need to scale this analog front-end. You need always one processor. You need a bit of connectivity. But you need cell controllers depending on how many cells you want to control. And if you have a low voltage hybrid, like a 48 volt hybrid, or if you have a simple start-stop system in your car with the lithium-ion battery where you have a 12, 14 volt battery, you do not need so many cell controllers because you don't need so many cells.

(16:38):

If you have a high-performance hybrid or a pure electric vehicle, or maybe even a powerful sports car, electric sports car, yeah, something which is probably not affordable. Now really a very nice, sophisticated car. You need quite a few of these analog front-end solutions, a lot of cell controllers, and they drive mainly the value. And depending on what kind of system you have, in average across all the voltage ranges, all the models, all the brands, in average roughly we do see that a system cost $60 approximately of semiconductor value, in average. But it can go up and it can go down.

Nitin Dahad (17:19):

Yeah, that's a ballpark, obviously. Is there anything else you want to cover on battery management before we go towards consumer drivers again?

Jens Hinrichsen (17:25):

No, I think we can probably speak endlessly about this, but I think this is covering basically the main parts and it's really important to understand what is really the system doing, and I think we covered it very well.

Nitin Dahad (17:37):

Right. So coming back to consumer in market, we've looked at what's driving the adoption, we've looked at the challenges and some of the areas like battery management. Where are we in this evolving world? Are we at an inflection point or is there still a lot more to do before we get to that inflection point?

Jens Hinrichsen (17:52):

I think that's a real critical point. So I truly believe that looking at the market evolution, I think we have reached a certain inflection point. While in the past, electric vehicles were very much a small, specific, niche market with a few players, a few models being electric, we are now moving towards really, truly high volume typical automotive mass production market. We expect that by 2023 already, approximately 20 million dollars of electrified vehicles will be produced. So hybrids as well as some electric vehicles. And 20 million cars. 20 million cars. That's quite a bit.

(18:32):

We do see really truly that we are moving towards high volume mass production and that the market is really evolving rapidly from a niche market into a real, typical high-volume automotive market. And that's, for us, an inflection point. Yeah.

Nitin Dahad (18:47):

Let's talk a little bit about, when we're talking about driving electric adoption, tell me a little bit about comparison of cost between a conventional combustion engine versus electric vehicle? And where do we get to a point where we get cost parity?

Jens Hinrichsen (18:56):

That's a good question, and it's very crucial, like we discussed in driving, really, the adoption of the electric and electrified vehicles. What we do see overall is, Nitin, is that we expect that we are reaching round about in the years 2024 in this timeframe approximately cost parity between an electric vehicle and a vehicle with a combustion engine. That's what we basically see.

(19:25):

And the key cost driver of the electric car is indeed the battery and the battery management system, including all the wiring, the wiring harness related to this. While on the other hand, of course, you have, for a pure electric vehicle, no combustion engine, which is then basically the offset on the other side.

(19:45):

But it is really essential that you get the cost for the battery down, and there are some guidances. And if you are able to basically pay or have approximately a hundred dollar of cost per kilowatt hour, that's the point where you reach cost parity between an electric vehicle and a combustion engine.

Nitin Dahad (20:05):

Okay. So are you able to sort of put a marker on where we are now in terms of that scale and in terms of cost parity?

Jens Hinrichsen (20:11):

Yeah. We still above, in average, above the a hundred dollars per kilowatt hours, right? But we've seen an increasing trend towards different battery chemistries and battery constellation as well as with an increasingly sophisticated electronic system around the battery management. We really expect that, in the next three years, round about, I would see basically three, four years, I would see this hundred dollar landmark being reached.

Nitin Dahad (20:36):

And are there any players ... I mean, I don't want you to show favoritism to any customers, but are there any particular manufacturers? I think, like for example Volkswagen or others, that are doing quite well in this area? I mean, I know they have a modular approach on that.

Jens Hinrichsen (20:52):

Yeah. I think many car makers are facing now the challenges to be ready, like I said, for this high volume mass production. And car makers basically need to then also take down the total cost of ownership in this step. So they need to find ways on scaling their technology, scaling their hardware, scaling the software, making it relatively more and more affordable also to produce the car, have a high level of automation established in their assembly lines.

(21:22):

And some car makers are basically, like also for combustion engines, have a very modular approach, like Volkswagen for instance. But there are also other large car makers who have a modular approach. And they basically do electrify complete platforms, and these platforms then can be used for multiple of their brands as well as for multiple models within this particular brand.

(21:48):

And then once you basically have this platform established, you can scale it everywhere, which is then a very nice way of doing entire fleet electrification. And that's what we are seeing increasingly. Like I said, driven by the government mandates and emission control regulations, et cetera. But also because they really want to drive down the total cost of ownership.

Nitin Dahad (22:10):

So crucial questions. You've mentioned a figure of 20 million by 2023. When will we see the EV, or electric vehicle, as being the number one seller by volume? I guess we're not including hybrids here. We're talking electrics, aren't we?

Jens Hinrichsen (22:24):

Yeah, exactly. Like I said, approximately 50% of all the cars being produced in 2030 are seeing some sort of electrification. But that is like you said, including all the hybrids, et cetera. Still less than a quarter, I would say, is pure electric vehicles by then. But it's still, if you look a hundred million cars, it would be also approximately 20, 25 million electric vehicles by then. But I truly believe it will take a while until really the pure electric vehicle will be the number one selling car.

Nitin Dahad (23:00):

Now, another question to put you on the spot, and I wonder whether you'll be able to answer it. Do you have an electric vehicle?

Jens Hinrichsen (23:05):

That's a good question, Nitin. No, I don't have. But actually, I have to say, I don't have yet because I'm in the process of ordering electric vehicle. Currently I have a family car, and that is not electric, and most of the commute I do by bicycle. But since I now moved to a house with a driveway and I established there and installed a charging station there, so that basically enables me to get an electric vehicle, and so that's why I started ordering one.

Nitin Dahad (23:31):

Excellent, Jens. You're part of the movement.

Jens Hinrichsen (23:35):

I am.

Nitin Dahad (23:37):

Jens, thank you very much. It's been a pleasure talking to you.

Jens Hinrichsen (23:39):

All right, Nitin. It was my pleasure likewise. Thank you very much.

Nitin Dahad (23:44):

This has been the Smarter World podcast with me, guest host Nitin Dahad with EE Times and Embedded.com. Thanks for listening and see you next time.