

D2P Technology Analysis – Reviewer #2

Pat. No.: US 7,184,723

“Systems and Methods for Vector Power Amplification”

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OVERVIEW

What follows are my immediate comments and reactions after reading the entire 128 pages of US Patent 7,184,723. They represent my own personal impressions and opinions, which may, quite conceivably, turn out to have elements of misunderstanding, misreading, and even mistakes on my part. I have tried to summarize my interpretations of what the patent is basically about. For each main line item I summarize my own reactions and opinions.

I should be clear up-front: I think the patent is technically flawed. As a means of designing RFPAs for the cited applications (OFDM, CDMA, wireless communications in general), the proposed methodology will not yield “high” efficiency, in the sense of being any higher than that which is currently obtained using conventional techniques.

The assignee, ParkerVision, is not a well known practitioner or manufacturer in the RF Power Amplifier (RFA) zone. I also note that none of the three inventors (sic) themselves have any previous publications in this specific technical field (either listed in the patent and/or in general, to the best of my knowledge). I also conclude (and here I could be off limits, but it is a relevant impression) that the inventors are not themselves experienced in the techniques and even the language of RFA design (that is to say, at frequencies approaching and/or exceeding 1GHz). They appear to talk the language of “analog” electronics, which can be roughly defined as the electronics of much lower frequencies (kHz to tens of MHz), where parasitic effects have only a minor impact and can to a first order be ignored. “RF” electronics is dominated by parasitic effects which limit, and often completely outlaw, design techniques and configurations that are widely used at lower frequencies. It is however a fact, and I should be clear about this, the “analog” world has been gradually intruding into the RF domain in recent years. Improved technologies and processes are enabling design methodologies to be transplanted from the analog to RF domain and this has been done in some notable cases with great technical and financial success, often to the considerable embarrassment of “head-shaking RF traditionalists”. So even though I see a serious flaw in this case, I report it with due caution, and the possibility that the concept may have ongoing value even if and when the flaw is acknowledged.

I found myself at first continually asking the question, “What’s the invention here? What’s new?” Despite its length, however, it seems that the new element is singular and easily defined, albeit not so clearly defined by the authors.

CLAIMS

I have attempted to reduce the 100 pages or so of technical description into these basic technical elements, for which for novelty and/or priority are being claimed:

- **The use of direct output “Single Node” (sic) connection for the summation of constituent constant envelope signals.**

This singular concept seems to be the one identifiable common thread throughout this patent. They think they can implement an outphasing PA by hard-wiring several device collectors together (drains, in the case of FETs, carefully delineated of course) into a common signal load and then by suitably modulating the differential phasing of the individual constant envelope drive signals they can generate amplitude modulated RF signals at an efficiency equal to the constituent constant-envelope amplifiers. **WRONG.**

I see this as a serious flaw, being as it is the main central concept and underpins just about all of the claims. It turns out they are not the first group that I have encountered who come running at supersonic speed from the analog/digital undergrowth waving this concept, telling the RFPA world that they are still in the stone age. The problem is that you **CAN** create complex modulated RF signals as claimed; the somewhat laborious mathematical details show this, and this mathematics has appeared in the literature in many places. But the **EFFICIENCY** will be as low, or lower, than using conventional PA techniques.

- **The use of more than two constituent constant envelope signals.**

There have been numerous papers, known to me, where a four signal system has been used. A system which combines four constant envelope signals in order to generate a complex amplitude modulated RF carrier is **not new**. I note with interest, that two recent publications on this subject (Campbell [1], Hegazi et.al. (2)) are not listed in the patent. I note also that the patent, unlike these references, does not actually say why there are significant benefits in the use of more than 2 constituent constant envelope signals. Such benefits appear as reduced range of phase modulation (2 quadrant rather than 4) and reduced spectral bandwidth of the constituent signals. In the patent I found the lengthy mathematical explanations of outphasing rather superfluous; such analysis has appeared in the public domain in many places.

- **The introduction of a “new” RFPA concept, the “Multiple Input Single Output” (MISO) PA.**

This intrigued me a little at first, until I discovered that the proposed implementation of the MISO (Figures 51A,B,C) is nothing more than the drawing of a box around a set of individual, conventional (=Single Input Single Output, SISO?!) amplifiers whose outputs are hard-wired together.

SUMMARY

I rather feel the fundamental problem here, and one which all should be wary about, is the uncontestable fact that radio signals as we currently permit them, are analog in form. Despite the many advances in digital electronics, there is indeed some truth in the statement (to be found, for

example, on ParkerVision's website!) that "on-air" radio signals we use are antiquated in concept. But innovation in this area is severely restricted by regulations; the ether is not freely available to all who wish to use it in any way they choose. I feel that there is a common denominator in many of these "novel" PA schemes, which is that it is relatively easy to generate a high power digital signal, even one which has bit rates in the GHz regime, and do so with high efficiency. The problem comes when we have to "convert" the high power digital signal into an acceptable, regulatory compliant, analogue signal. A reconstruction filter will, sadly, impose a low amplitude sinusoidal voltage back on the switching power transistors, with a massive reduction in efficiency.

The industry has, in general, found adequate solutions to the PA efficiency problem by engaging "traditional" methods, such as Doherty, EER ("Polar Transmitter"), and envelope tracking. Even these have not yet seen widespread installation, despite offering clear efficiency advantages. One of the reasons for this is that there is simply no efficiency enhancement technique that does not carry a penalty of reduced linearity. This would apply equally to the ParkerVision concept, despite indications to the contrary.

REFERENCES

1. Campbell, R.C., "A Novel High Frequency Single-Sideband Transmitter Using Constant Envelope Modulation", 1998 IEEE MTT Symposium, Vol. 2.
2. Hegazi, G.M., et.al., "Improved LINC Power Transmission Using a Quadrature Outphasing Technique", 2005 IEEE Int'l Microw. Symp. Digest.
3. Cripps, S.C., "RF Power Amplifiers For Wireless Communications", 2nd ed., Artech House 2006.