

# Randomization of Sparse Matrix by Vector Multiplication

ABHISHEK JAIN, ISMAIL BUSTANY, and PAOLO D'ALBERTO

A sparse matrix by vector multiplication (SpMV) is simplified by the matrix non-zero elements and how we store them. There are many SpMV applications, many matrix storage formats, and thus algorithms. However, there is no optimality without considering the architecture: for example, the CPU is one among many.

By nature, randomization is resilient to counter techniques, thus suitable to avoid worst case scenarios because we tend to reduce to an average case; however, randomization does to the best case scenario the same thing it does to the worst case, it can nudge the optimal solution off. Like preconditioning, randomization is advantageous when the matrix is reused or a constant such as in the power method, Krilov's space, or convolutions for image classifications. Differently from preconditioning we do not change the values of the matrix, we randomize row and column of the matrix. We shall show that randomization is an optimization that any architecture may take advantage although in different ways. Most importantly, any developer can consider and deploy. We shall present cases where we can improve performance by 15% on AMD-based systems.

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## 1 INTRODUCTION

The obvious questions are what is randomization and why would we use it? We shall provide formal definitions in the following sections, in this context, we randomly permute rows and column of a sparse matrix before a (sparse) matrix by a (dense) vector operation. We do this because randomization is the poor man's preconditioning and we do not mean it in a pejorative sense.

Preconditioning is a method to help the convergence of an iterative solution, for example a sequence of matrix by vector operations. Each iteration does a better job in searching the space and converging to a solution. In general, it means better numerical properties and well defined properties of the matrix itself. It does not mean that each iteration is faster. We want to make each iteration faster. From a mathematical and scientific point of view may seem uninteresting. From the engineering and deployment point of view is just the beginning.

At this stage, we have too many knobs and tools to tune: algorithms, data structures, and dedicated hardware (CPU, GPUs, Custom). This is a (very) hard problem and we are not here for the solution of the inverse problem: find the best Hardware-Software solution for the one matrix by vector product. We are here to provide tools, we may say naive tools, to help understand how the structure of the matrix may affect the HW-SW solution. Randomization, or versions of it, is already used by custom hardware to re-organize the data flow to reduce communications and computation bottle necks. We come to play in this arena to show *how* to use randomization if at all.

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Authors' address: Abhishek Jain; Ismail Bustany; Paolo D'Alberto.

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For the readers in the field of algorithms, sparse matrix by (dense) vector is basically a sorting algorithm. Bare with us, Sorting is a method to find if an element is in a list without prior or limited knowledge of the list contents. Sorting is used to prepare the matrix and to find elements in between sparse matrices and sparse vectors. In custom architectures, sorting networks are used for routing elements of the matrix and vector to the proper functional unit. Interestingly, The best sorting algorithm is a function of the distribution of elements. If you are stuck with a sorting algorithm and the wrong distribution, randomization may change the distribution, and you do not need to talk to any HW designer

We organize our work as follows: In Section 2, we define the matrix by vector operation; in Section 3, we define what we mean for randomization. We use randomization to create a uniform distribution in Section 5 and we measure uniformity by nothing else than entropy in Section 4. We present how we drive our experiments to show the effects of randomization in Section 6. In the last sections we present a summary of the results: we present our work loads, benchmarks, in Section 7, and the complete set of measures for an AMD CPU and GPUs system in Section 8.

## 2 BASIC NOTATIONS

Let us start by describing the basic notations so we can clear the obvious (or not). A Sparse-matrix by vector multiplication *SpMV* on an (semi) ring based on the operations  $(+, *)$  is defined as  $\mathbf{y} = \mathbb{M}\mathbf{x}$  so that  $y_i = \sum_j M_{i,j} * x_j$  where  $M_{i,j}=0$  are not even represented and stored. Most of the experimental results in Section 8 are based on the classic addition  $(+)$  and multiplication  $(*)$  in floating point precision using 64bits (i.e., double floating point precision). *SpMV* based on semi-ring  $(\min, +)$  is a short path algorithm based on an adjacent matrix of a graph, and using a Boolean algebra we can check if two nodes are connected, which is slightly simpler.

We identify a sparse matrix  $\mathbb{M}$  of size  $M \times N$  as having  $O(M + N)$  non-zero elements, number of non zero *nnz*. Thus the complexity of  $\mathbb{M}\mathbf{x}$  is  $O(M + N) = 2nnz$ . Of course, the definition of sparsity may vary. We represent the matrix  $\mathbb{M}$  by using the Coordinate *COO* or and the compressed sparse row *CSR*<sup>1</sup> format. The *COO* represents the non-zero of a matrix by a triplet  $(i, j, val)$ , very often there are three identical-in-size vectors for the *ROW*, *COLUMN*, and *VALUE*. The *COO* format takes  $3 \times nnz$  space and two consecutive elements in the value array are not bound to be neither in the same row nor column. In fact, we know only that  $VALUE[i] = M_{ROW[i], COLUMN[i]}$ .

The *CSR* stores elements in the same row and with increasing column values consecutively. There are three arrays *V*, *COL*, and *ROW*. The *ROW* is sorted in increasing order, its size is  $M$ , and  $ROW[i]$  is an index in *V* and *COL* describing where row-*i* starts (i.e., if row *i* exists). We have that  $M_{i,*}$  is stored in  $V[ROW[i] : ROW[i + 1]]$  and the column are at  $COL[ROW[i] : ROW[i + 1]]$  and sorted increasingly. The *CSR* takes  $2 \times nnz + M$  space and a row vector of the matrix can be found in  $O(1)$ .

The computation as  $y_i = \sum_j M_{i,j} * x_j$  is a sequence of dot products and the *CSR* representation is a natural:

$$Index = ROW[i] : ROW[i + 1]$$

$$y_i = \sum_{\ell \in Index} V[\ell] * x_{COL[\ell]}$$

The matrix row is contiguous (in memory) and contiguous rows are contiguous. The access of the (dense) vector  $\mathbf{x}$  could have no pattern. The *COO* format could use a little preparation: For example, we can sort the array by row and add row information to achieve the same properties of *CSR*; however transposing a *COO* matrix is just a swap of the array *ROW* and *COL*. Think about matrix multiply. As today, each dot product achieves peak performance if the reads of the vector  $\mathbf{x}$  are streamlined as much as possible and so the reads of the vector *V*. If we have multiple cores, each

<sup>1</sup>a.k.a. Compressed row storage *CRS*.

could compute a sub set of the  $y_i$  and a clean data load balancing can go a long way. If we have a few functional units, we would like to have a constant stream of independent  $*$  and  $+$  operations but with data already in registers: that is, data pre-fetch will go a long way especially for  $x_{COL[i]}$ , which may have an irregular pattern.

### 3 RANDOMIZATION

We refer to *Randomization* as row or column permutations of the matrix  $\mathbb{M}$  (thus a permutation of  $\mathbf{y}$  and  $\mathbf{x}$ ) and we choose these by a pseudo-random process. Why we want to introduce uncertainty? The sparsity of our matrix  $\mathbb{M}$  has a pattern representing the nature of the original problem; such a pattern may exploit the wrong computation for an architecture; we could break such a pattern so that the only property left is a uniform distribution (of some sort). We must avoid the worst case and we would opt for an average case instead and we could do this to a class of  $\mathbb{M}$ .

If we know the matrix  $\mathbb{M}$  and we know the architecture, preconditioning must be a better solution. Well, it is. If we run experiments long enough, we choose the best permutations for the architecture, permute  $\mathbb{M}$ , and go on testing the next. On one end, preconditioning exerts a full understanding of both the matrix (the problem) and how the final solution will be computed (architecture). This is the culminating point of knowing and we must strive to it. On the other end, the simplicity of a random permutation requires no information about the matrix, the vector, and the architecture. Such a simplicity can be exploited directly in HW. We are after an understanding when randomization is just enough: we want to let the hardware do its best with the least effort, or at least with the appearance to be effortless. Also we shall show there are different flavors of random.

Interestingly, this work stems from a sincere surprise about randomization efficacy and its application on custom SpMV. Here, we want to study this problem systematically so that to help future hardware designs. Intuitively, if we can achieve a uniform distribution of the rows of matrix  $\mathbb{M}$  we can have provable expectation of its load balancing across multiple cores. If we have a uniform distribution of accesses on  $\mathbf{x}$  we could exploit column load balancing and exploit better sorting algorithms: in practice the reading of  $x_{COL[i]}$  can be reduces to a sorting and we know that different sparsity may require different algorithms. This is a lot to unpack but this translates to a better performance of the sequential algorithm without changing the algorithm or better HW utilization.

We will show that (different) randomness affects architectures and algorithms differently, making randomization a suitable optimization especially when the application and hardware are at odds, hardware is difficult to change and the matrix sparsity is simple to change. We want to show that there is a randomness hierarchy that we can distinguish as global and local; there are simple-to-find cases where the sparsity breaks randomness and the matrix has to be split into components. We want to show that this study uses common tool, open software tools and sometimes naive experiments; however, we can infer properties applicable to proprietary and custom solutions.

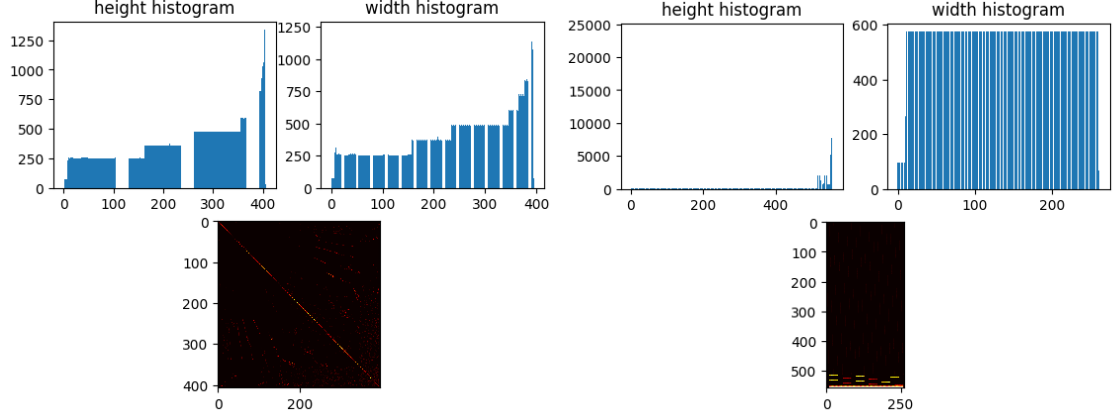


Fig. 1. Left: OPF 3754. Right: LP OSA 07. These are histograms where we represent normalized buckets and counts

#### 4 ENTROPY

Patterns in sparse matrices are often visually pleasing, see Figure 1 where we present the height histogram, the width histograms and a two-dimensional histogram as heat map. We will let someone else using AI picture classification. Intuitively, we would like to express a measure of uniform distribution and here we apply the basics: *Entropy*. Given an histogram  $i \in [0, M - 1]$   $h_i \in \mathbb{N}$ , we define  $S = \sum_{i=0}^{M-1} h_i$  and thus we have a probability distribution function  $p_i = \frac{h_i}{S}$ . The *information* of bin  $i$  is defined as  $I(i) = -\log_2 p_i$ . If we say that the stochastic variable  $X$  has PDF  $p_i$  than the entropy of  $X$  is defined as.

$$H(x) = - \sum_{i=0}^{M-1} p_i \log_2 p_i = \sum_{i=0}^{M-1} p_i I(i) = E[I_x] \quad (1)$$

The maximum entropy is when  $\forall i, p_i = p = \frac{1}{M}$ ; that is, we are observing a uniform distributed event. There is no conceptual difference when the PDF represents a two dimensional distribution. Thus our randomization should aim at higher entropy numbers. The entropy for matrix LP OSA 07 is 8.41 and for OPF 3754 is 8.39. We use the entropy specified in the Scipy stats module. A single number is concise and satisfying. If you are pondering why they are so close contrary to their sparsity we discuss this next.

#### 5 UNIFORM DISTRIBUTION

We know that we should **not** compare the entropy numbers of two matrices because entropy does not use any information about the order of the buckets only their probabilities. By construction, the matrices are quite different in sparsity and in shapes, however their entropy numbers are very close. Two matrices with the same number of non-zeros, spaced well enough in the proper number of bin, will have the same entropy. To appreciate their different sparsity, we should compare their entropy distributions by Jensen-Shannon measure (which is a symmetric measure, please do not use Kullback-Leibler KL divergence). Or we could use a representation of a hierarchical 2d-entropy, see Figure 2, where the entropy is split into 2x2, 4x4 and 8x8 (or fewer if the distribution is not square). We have a hierarchical entropy heat maps.

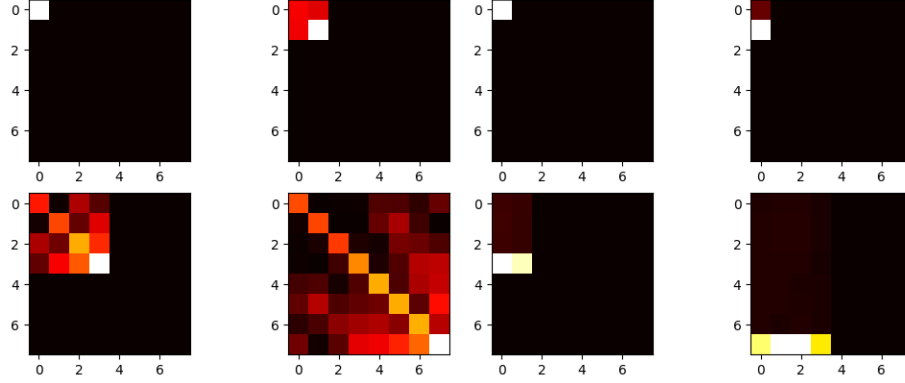


Fig. 2. Hierarchical 2D entropy for OPF 3754 (left) and LP OSA 07 (right).

We can see that a granular entropy summarizes better the nature of the matrix because it keep some spatial information. In this work, the entropy vector is used mostly for visualization purpose more than for comparison purpose. Of course, we can appreciate how the matrix LP OSA 07 has a few very heavy rows and they are clustered. This matrix will help us showing how randomization need some tips. Now we apply row and column random permutation once by row and one by column: Figure 3: OPF has now entropy 11.27 and LP 9.26. The numerical difference is significant. The good news is that for entropy, being an expectation, we can use simple techniques like bootstrap to show that the difference is significant or we have shown that Jensen-Shannon can be used and a significance level is available. What we like to see is the the hierarchical entropy heat map is becoming *more* uniform for at least one of the matrix.

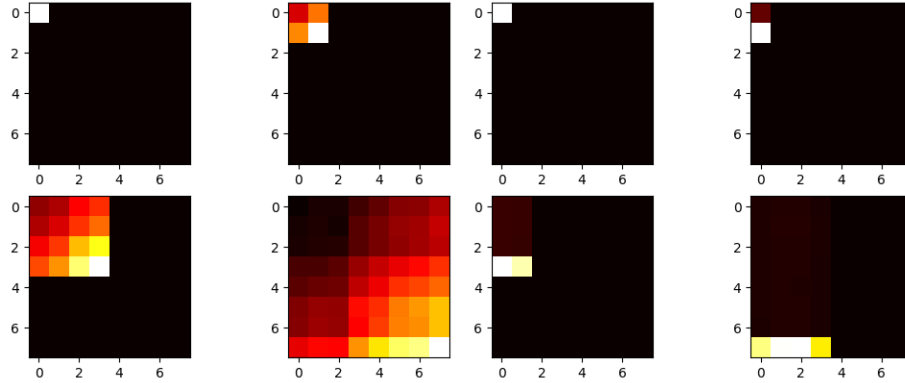


Fig. 3. Hierarchical 2D entropy after row and column random permutation for OPF 3754 (left) and LP OSA 07 (right).

In practice, permutations need some help especially for relatively large matrices. As you can see, the permutation affects locally the matrix. Of course, it depends on the implementation of the random permutation (we use numpy for this) but it is reasonable a slightly modified version of the original is still a random selection but unfortunately they seem more likely than they should. We need to compensate or help the randomization so that this current implementation does not get too lazy.

If we are able to identify the row and column that divide high and low density, we could use them as pivot for a shuffle like in a quick-sort algorithm. We could apply a sorting algorithm but its complexity will be the same as SpMV. We use a gradient operation to choose the element with maximum steepness, Figure 4 and 6

LP achieves entropy 8.67 and 9.58 and OPF achieves 10.47 and 11.40.

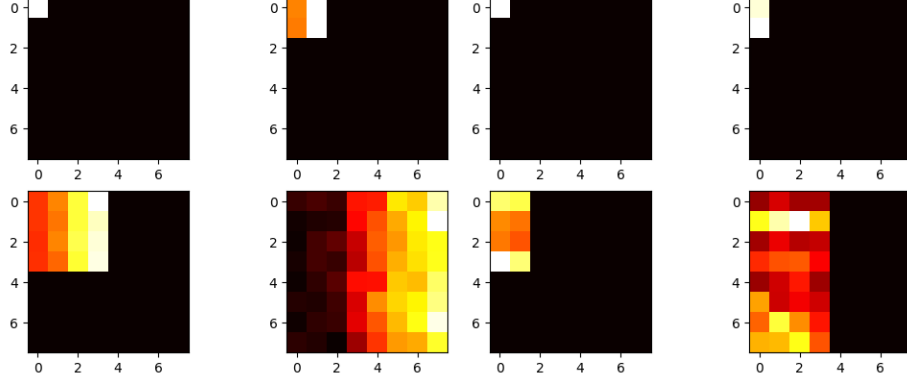


Fig. 4. Hierarchical 2D entropy after height gradient based shuffle and row random permutation for OPF 3754 (left) and LP OSA 07 (right).

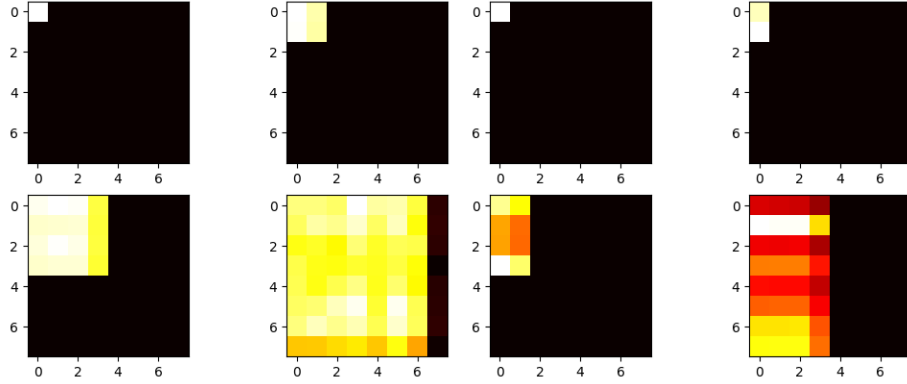


Fig. 5. Hierarchical 2D entropy after height and width gradient shuffle and row and column random permutation for OPF 3754 (left) and LP OSA 07 (right).

If the goal is to achieve a uniformly sparse matrix, it seems that we have the tools to compute and to measure such a sparsity. We admit that we do not try to find the best permutation. But our real goal is to create a work bench where randomization can be tested on different architectures and different algorithms. A randomization with a measurable uniform distribution is preferable than just random. We are interested to find out when random is enough or not enough. Also, consider that to achieve a uniform distribution, we do not need a random transformation and any permutation balancing the number of non-zero is possible, but for now not looked for.

## 6 MEASURING THE RANDOMIZATION EFFECTS

Whether or not this ever applied to the reader, when we have timed algorithms (i.e., measure execution time), we came to expect variation. The introduction of randomization may hide behind the ever present variance, after all these are algorithms on *small* inputs and small error can be comparable to the overall execution time. Here, we must address this concern even before describing the experiments.

First, we execute every algorithm between 1000 and 5000 times. The time of each experiment is in the seconds, providing a granularity for which we are confident the measuring time error is under control. Thus, for each experiment we provide an average execution time: we measure the time and we divide by the number of trials. Cold starts, the first iteration, are still accounted. To make the measure portable across platform we present GFLOPS, that is, Giga ( $10^{12}$ ) floating operations per second:  $2 * nnz$  divided by the average time in seconds.

Then we repeat the same experiment 32 times. Permutations in *numpy* Python uses a seed that is time sensitive: thus every experiment is independent from the previous. The number 32 is an old statistic trick and it is a minimum number of independent trials to approximate a normal distribution. In practice, they are not but the number is sufficient for most of the cases and it is an excellent starting point.

A short hand legend: **Reg** is the matrix without any permutation and thus is the regular; **R** stands for random Row permutation; **G-R** stands for gradient-based row shuffle and random row permutation; **G-C** stands for gradient-based column shuffle and random column permutation; **R-C** stands for random row and column permutation. This legend is used in the pictures to be concise, in the tables in the following sections, we use a verbose description. We shall clarify the gradient based approach in the experimental results section 8. Intuitively, we help the random permutation by a quick targeting of high and low volume of the histogram (and thus the matrix).

In Figure 6, We show CPU performance using COO and CSR SpMV algorithms for the matrix OPF 3754. We can see that the CSR algorithms are consistent and the Regular (i.e., the original) has always the best performance. For the COO, permutations introduce long tails, thus performance advantage.

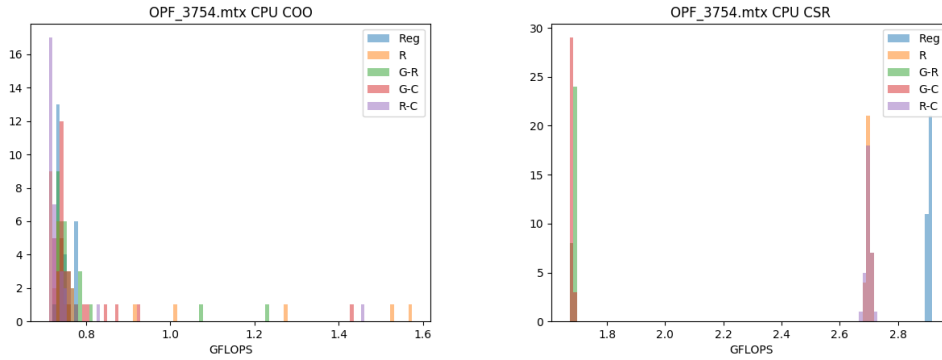


Fig. 6. CPU COO (left) and CPU CSR (left) for OPF 3754

In Figure 7, 8 and 9, randomization is harmful to the GPU implementation. The OPF 375 matrix is mostly diagonal, thus the vector  $\mathbf{x}$  is read in close quarters, randomization breaks it. If the load balance is fixed (i.e., by dividing the matrix by row and in equal row), randomization is beneficial.

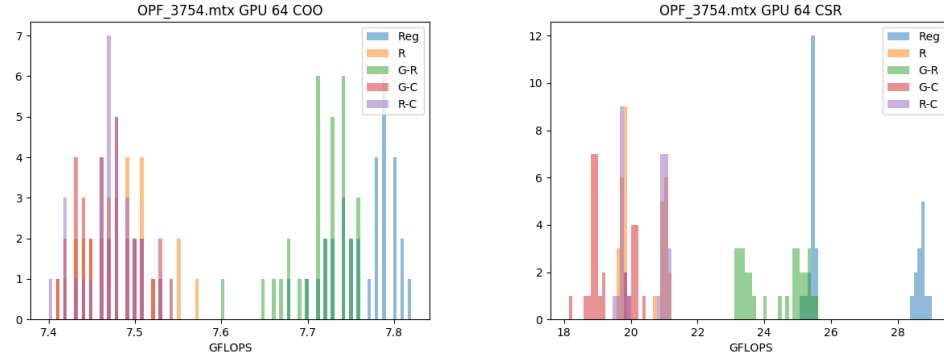


Fig. 7. Vega 20, GPU 64bits COO (left) and GPU CSR (right) for OPF 3754

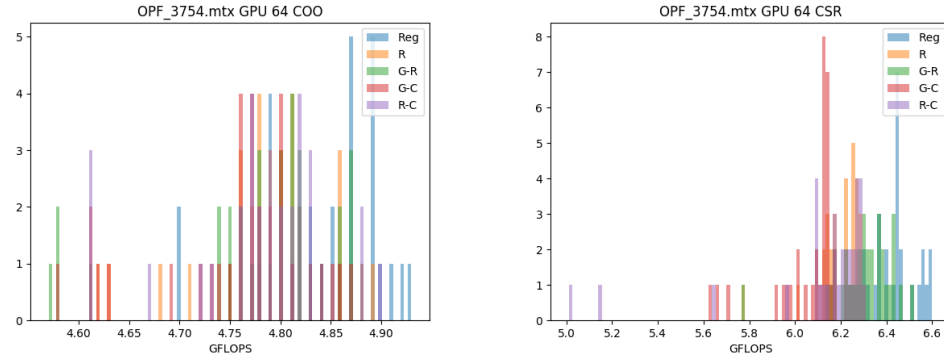


Fig. 8. Ellesmere, GPU 64bits COO (left) and GPU CSR (right) for OPF 3754

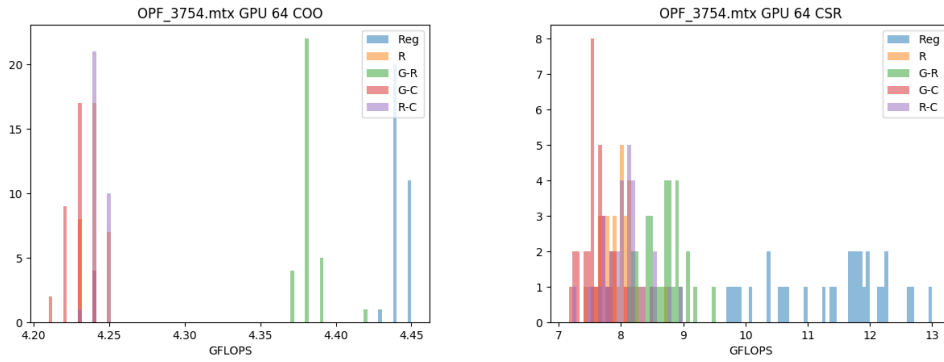


Fig. 9. Fiji, GPU 64bits COO (left) and GPU CSR (right) for OPF 3754



If we take the original matrix and split into part having the same number of rows, and execute them in parallel using different cores, we can see in Figure 10 that randomization is quite useful.

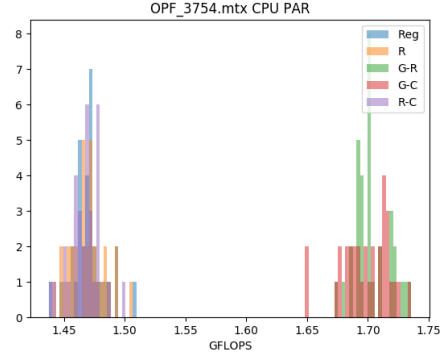


Fig. 10. Parallel CPU CSR for OPF 3754

For matrix LP OSA 07, randomization helps clearly only for CPU CSR as we show in Figure 11

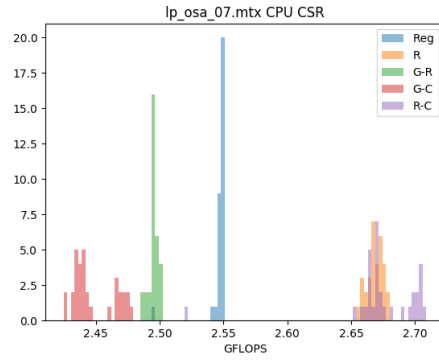


Fig. 11. CPU CSR for LP OSA 07

In Figure 12, 13, and 14, we can see that randomization is harmful but for one GPU, we can show that a single exception is possible (40% improvement).

An example, the matrix MULT DCOP 01, is where randomization is useful for the CPU, GPU, and the parallel version Figure 15, 16 - 19 and the gains can be up to 10-15%. Consider, we can achieve these improvements without any insights to the architecture, the algorithms and their relationships.

What does it mean when randomization does not work? The matrices we use in this work are not chosen randomly (pun not intended), they are the matrices that are difficult to handle in our custom SpMV engines using a combination of sorting networks and systolic arrays. If randomization does not work in our simplified work bench, will not work in our specialized architecture because the reorganization of the matrix or the input and output vector does not have the necessary parallelism, data locality, and data streaming. We need to do something else. In this case disrupting the memory pattern is not sufficient. Thus, if we cannot beat the pattern, we must exploit it, well not in this work.

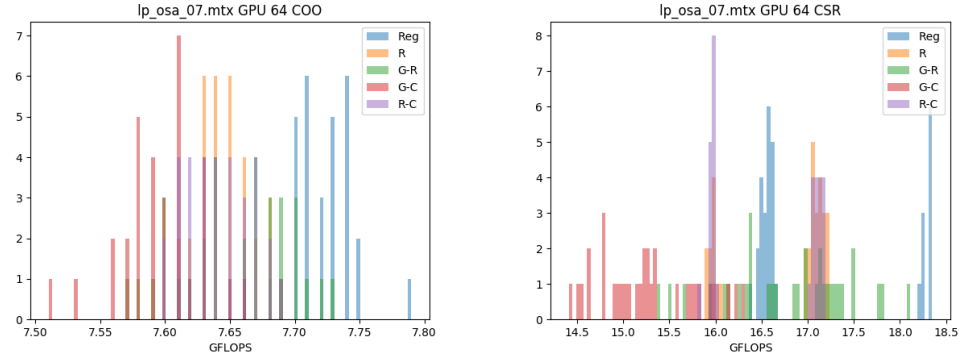


Fig. 12. Vega 20, GPU 64bits COO (left) and GPU CSR (right) for OPF 3754

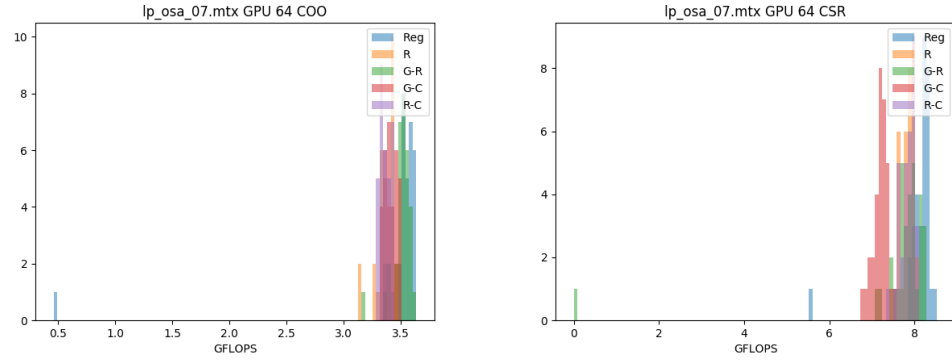


Fig. 13. Ellesmere, GPU 64bits COO (left) and GPU CSR (right) for OPF 3754

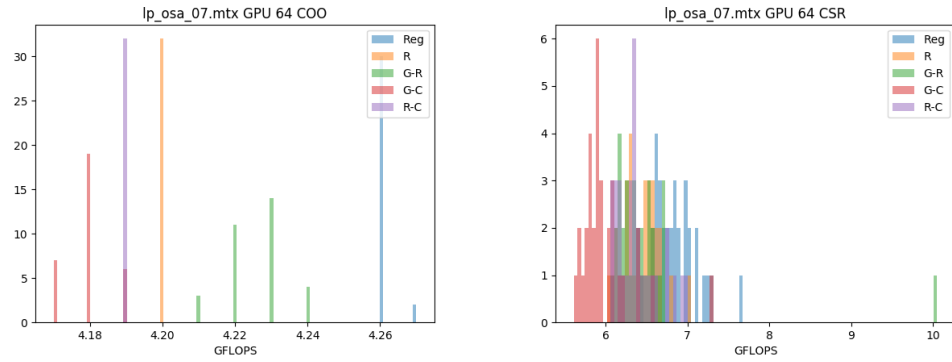


Fig. 14. Fiji, GPU 64bits COO (left) and GPU CSR (right) for OPF 3754

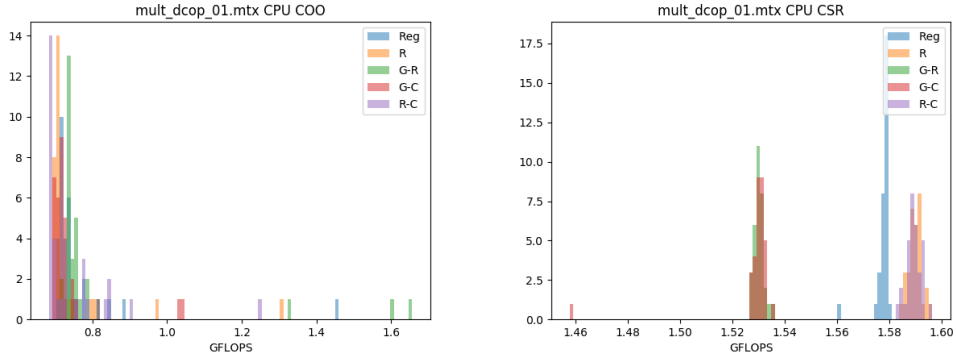


Fig. 15. CPU COO (left) and CPU CSR (right) for MULT DCOP 01

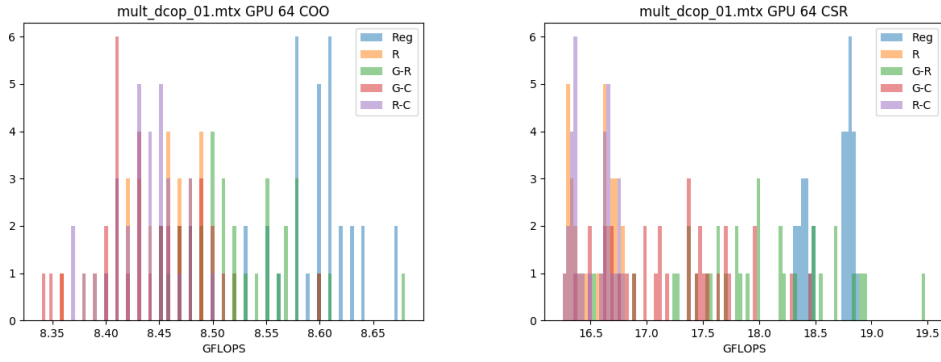


Fig. 16. Vega 20, GPU 64bits COO (left) and GPU CSR (right) for MULT DCOP 01

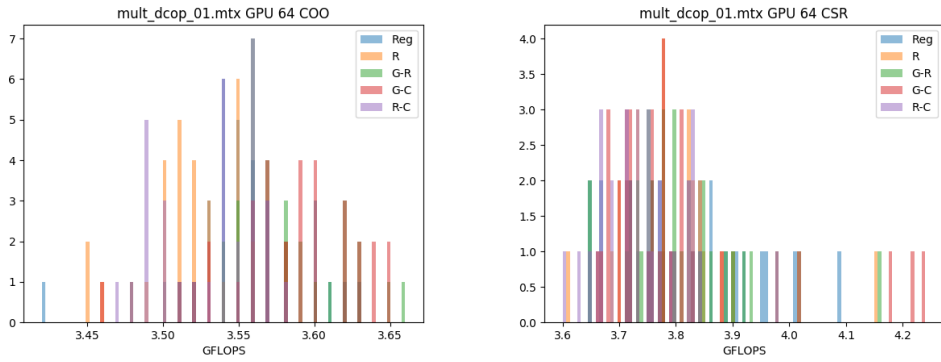


Fig. 17. Ellesmere, GPU 64bits COO (left) and GPU CSR (right) for MULT DCOP 01

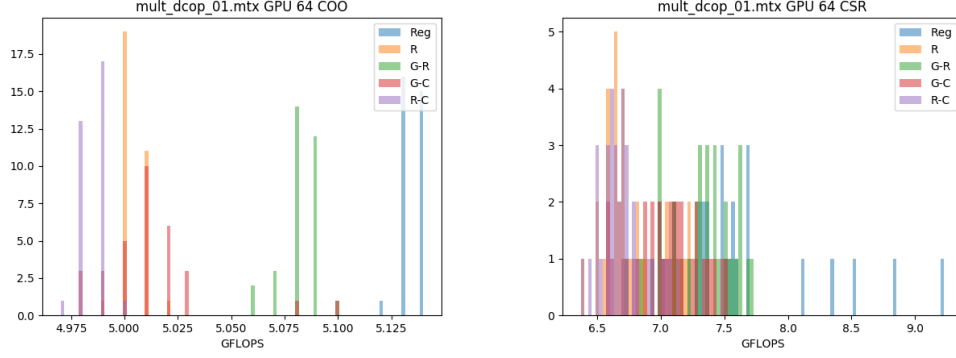


Fig. 18. Fiji, GPU 64bits COO (left) and GPU CSR (right) for MULT DCOP 01

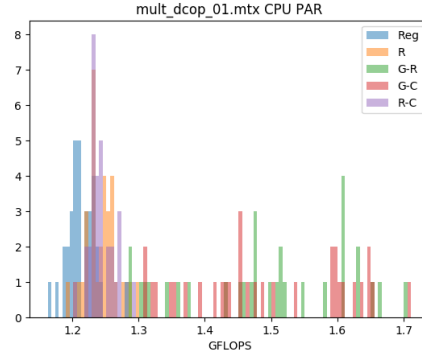


Fig. 19. Parallel CPU CSR for MULT DCOP 01

## 7 WORKLOADS

In the previous sections, we defined what we mean for randomization and we present our tools of tricks for the measure of the effects of randomization. Here we describe the work loads, the applications, we use to test the effects of the randomization.

### 7.1 Python COO and CSR algorithms

The simplicity to compute the SpMV by the code  $z = A * b$  in Python is very rewarding. By change of the matrix storage format,  $A = A.tocsr(); z = A * b$ , we have a different algorithm. The performance exploitation is moved to the lower level. The CSR implementation is often two times faster but there are edge cases where the COO and COO with randomization can go beyond and be surprisingly better: MUL DCOP 03 is an example where COO can do well.

Intuitively, Randomization can affect the performance because the basic implementation is a sorting algorithm and it is a fixed algorithm. There are many sorting algorithms and each can be optimal for a different initial distribution. If we knew what is the sorting algorithm we could tailor the input distribution. Here we just play with it.

In Section 8, we present all the results for CPU and GPUS. Keep in mind that these problems are hard, in the sense they do not have fancy performance sheets (these architectures can achieve Tera FLOPs sustained performance for dense computations). If we go through diligently, we can see that there is a 15x performance difference between the single thread CPU and Vega 20 GPU (i.e, 3 vs 40 GFLOPS).

## 7.2 Parallel CSR using up to 16 cores

Python provides the concept of Pool to exploit a naive parallel computation. We notice that work given to a Pool is split accordingly to the number of elements to separate HW cores. We also noticed that the work load move from a core to another, thus not ideal. Also we notice that Pool introduce a noticeable overhead: a Pool of 1, never achieves the performance of the single thread  $z = A * b$ . Using Pool allows us to investigate how a naive row partitioning without counting can scale up with number of cores. We tested by splitting the rows to 1–16 cores evenly (one thread per core) and we present the performance for only the best configuration. The randomization goal is to distribute the work uniformly: a balanced work distribution avoid the unfortunate case where a single core does all the work. We are pleased by the simplicity of the benchmark and we know we can do better.

## 7.3 GPU COO and CSR algorithms

In this work, we use AMD GPUs and *rocSPARSE* is their current software. The software has a few glitches but overall can be used for different generation of AMD GPUs. We use the COO and CSR algorithms and we provide performance measure for double precision only. The ideas of using different GPUs: it is important to verify that the randomization can be applied independently of the HW. We are not here to compare performance across GPUs and CPUs. Often the limitation is the software, how the software can exploit the hardware or how the software will make easy to use a specific GPU. For example, the Fiji architecture is clearly superior to the Ellesmere, however the latter have better support and the system overall is more stable and user friendly.

The performance of the CSR algorithm is about two times faster than the COO. Most of the algorithms count the number of sparse elements in a row and thus they can decide the work load partition accordingly. Counting give you an edge but without changing the order of the computation there could be cases where the work load is not balanced and a little randomization could help and it does.

## 7.4 Randomization sometimes works

For the majority of the cases we investigated and reported in the following sections, Randomization does not work. However, there are cases where randomization does work and does work for different algorithms and architectures. If you are in the business of preconditioning, permutations are pretty cheap. If you can find a good one just consider like a preconditioning matrix, which it is.

This shows also that HW has to be more conscious, well the HW designer should, and accept that there are options at software level, at matrix level and beyond.

# 8 EXPERIMENTAL RESULTS

The main hardware setup is a AMD Threadripper with 16 cores. We have three Radeon GPUs: Vega 20 7nm, Pro 2xFiji, and Pro 2xEllesmere.

Vega 20 can deliver 3.5TFLOPS in double precision and it has 1TB/s HBM memory. Each Fiji provides 0.5 TFLOPS in double precision and has 512GB/s HBM, the card has two chips. The Ellesmere provides 0.3TFLOPS in double precision

and has 224GB/s DDR5, the card has two chips. In the performance plots presented earlier and in the following, you will notice that the performance gap between these GPUs is not so marked. We can safely state that  $vega \sim 2 \times Fiji$  and  $Fiji \sim 2 \times ellesmere$

There are 4 basic randomization formats:

- **Random Row Permutation**, we take the original matrix and permute the rows.
- **Random Row and Column Permutation**, we take the original matrix and permute the rows and the columns.
- **Gradient based row permutation**, we compute the row histogram and we compute the gradient:  $h_{i+1} - h_i$ . We find a single point where the gradient is maximum, this is the pivot for a shuffle like a magician would shuffle a deck of cards. Then we permute the two parts randomly.
- **Gradient based row and column permutation**, As above but also for the columns.

For large matrices (large number of columns and rows) a permutation tends to be a close variation of the original, still a random permutation. The gradient allows us to describe two area of the original matrix where there is a clear and de-marked density variation: for example, there are two uniform distributed sub matrices but one denser than the other. A shuffle redistribute every other sample/card to different parts and these can be permuted locally.

We report in the following the performance results, we introduce a \* following the best performance. This is tedious to read and, we assure, to write. The code and the results are available as software repository.

## 9 VEGA VII AND THREADRIPPER

mult\_dcop\_03.mtx

Regular									
CPU COO	min	0.728	max	0.880	mean	0.757			
CPU CSR	min	1.563	max	1.581	mean	1.577			
GPU 64 COO	min	8.540	max*	8.670	mean	8.619			
CSR	min	18.320	max	18.930	mean	18.620			
CPU PAR	min	1.170	max	1.269	mean	1.226			
H	min	9.689	max	9.689	mean	9.689			
Row-Premute									
CPU COO	min	0.710	max	0.845	mean	0.724			
CPU CSR	min	1.549	max*	1.597	mean	1.589			
GPU 64 COO	min	8.360	max	8.540	mean	8.442			
CSR	min	16.260	max	16.780	mean	16.551			
CPU PAR	min	1.205	max	1.319	mean	1.263			
H	min	10.737	max	10.742	mean	10.740			
Row-Gradient									
CPU COO	min	0.706	max	1.603	mean	0.806			
CPU CSR	min	1.493	max	1.534	mean	1.528			
GPU 64 COO	min	8.430	max	8.610	mean	8.527			
CSR	min	17.070	max*	18.970	mean	18.115			
CPU PAR	min	1.331	max	1.695	mean	1.513			
H	min	10.576	max	10.585	mean	10.580			
Column-Gradient									
CPU COO	min	0.694	max*	1.632	mean	0.797			
CPU CSR	min	1.491	max	1.534	mean	1.529			
GPU 64 COO	min	8.350	max	8.520	mean	8.429			
CSR	min	15.970	max	18.180	mean	17.124			
CPU PAR	min	1.321	max*	1.728	mean	1.514			
H	min	10.826	max*	10.840	mean	10.833			
Row-Column-Permute									
CPU COO	min	0.688	max	0.757	mean	0.696			
CPU CSR	min	1.490	max	1.595	mean	1.584			
GPU 64 COO	min	8.380	max	8.500	mean	8.445			
CSR	min	16.230	max	16.780	mean	16.513			
CPU PAR	min	1.192	max	1.274	mean	1.237			
H	min	10.737	max	10.742	mean	10.740			
mult_dcop_01.mtx									
Regular									
CPU COO	min	0.710	max	1.453	mean	0.761			
CPU CSR	min	1.561	max	1.581	mean	1.578			
GPU 64 COO	min	8.520	max	8.670	mean	8.597			
CSR	min	18.320	max	18.870	mean	18.636			
CPU PAR	min	1.163	max	1.246	mean	1.212			
H	min	9.689	max	9.689	mean	9.689			
Row-Premute									
CPU COO	min	0.699	max	1.305	mean	0.745			
CPU CSR	min	1.585	max	1.597	mean	1.590			
GPU 64 COO	min	8.360	max	8.520	mean	8.446			
CSR	min	16.260	max	16.780	mean	16.528			
CPU PAR	min	1.192	max	1.298	mean	1.242			
H	min	10.738	max	10.742	mean	10.740			
Row-Gradient									
CPU COO	min	0.709	max*	1.656	mean	0.819			
CPU CSR	min	1.527	max	1.535	mean	1.530			
GPU 64 COO	min	8.450	max*	8.680	mean	8.527			
CSR	min	16.520	max*	19.480	mean	17.984			
CPU PAR	min	1.280	max	1.704	mean	1.485			
H	min	10.572	max	10.585	mean	10.581			
Column-Gradient									
CPU COO	min	0.698	max	1.042	mean	0.737			
CPU CSR	min	1.458	max	1.536	mean	1.528			
GPU 64 COO	min	8.340	max	8.600	mean	8.443			
CSR	min	16.360	max	18.450	mean	17.247			
CPU PAR	min	1.307	max*	1.712	mean	1.494			
H	min	10.823	max*	10.841	mean	10.835			
Row-Column-Permute									
CPU COO	min	0.683	max	1.247	mean	0.749			
CPU CSR	min	1.583	max*	1.595	mean	1.590			
GPU 64 COO	min	8.370	max	8.500	mean	8.435			
CSR	min	16.250	max	16.780	mean	16.518			
CPU PAR	min	1.206	max	1.291	mean	1.243			
H	min	10.738	max	10.742	mean	10.740			

mult\_dcop\_02.mtx

Regular									
CPU COO	min	1.615	max*	1.677	mean	1.652			
CPU CSR	min	1.539	max	1.579	mean	1.575			
GPU 64 COO	min	8.530	max*	8.700	mean	8.614			
CSR	min	18.290	max	18.890	mean	18.597			
CPU PAR	min	1.120	max	1.248	mean	1.211			
H	min	9.689	max	9.689	mean	9.689			
Row-Premute									
CPU COO	min	0.684	max	0.780	mean	0.705			
CPU CSR	min	1.558	max*	1.596	mean	1.588			
GPU 64 COO	min	8.360	max	8.490	mean	8.433			
CSR	min	16.240	max	16.750	mean	16.552			
CPU PAR	min	1.182	max	1.277	mean	1.242			
H	min	10.737	max	10.742	mean	10.740			
Row-Gradient									
CPU COO	min	0.704	max	1.373	mean	0.790			
CPU CSR	min	1.518	max	1.535	mean	1.529			
GPU 64 COO	min	8.420	max	8.590	mean	8.517			
CSR	min	16.680	max*	19.550	mean	17.907			
CPU PAR	min	1.328	max*	1.713	mean	1.484			
H	min	10.572	max	10.585	mean	10.581			
Column-Gradient									
CPU COO	min	0.697	max	1.460	mean	0.742			
CPU CSR	min	1.517	max	1.534	mean	1.527			
GPU 64 COO	min	8.330	max	8.490	mean	8.420			
CSR	min	16.020	max	18.390	mean	17.303			
CPU PAR	min	1.321	max	1.709	mean	1.557			
H	min	10.823	max*	10.843	mean	10.835			
Row-Column-Permute									
CPU COO	min	0.691	max	0.746	mean	0.698			
CPU CSR	min	1.568	max	1.595	mean	1.587			
GPU 64 COO	min	8.350	max	8.500	mean	8.436			
CSR	min	16.250	max	16.780	mean	16.517			
CPU PAR	min	1.187	max	1.280	mean	1.228			
H	min	10.739	max	10.743	mean	10.740			
lp_fit2d.mtx									
Regular									
CPU COO	min	0.774	max	0.804	mean	0.793			
CPU CSR	min	2.538	max	2.550	mean	2.547			
GPU 64 COO	min	7.060	max	7.170	mean	7.101			
CSR	min	15.650	max*	18.700	mean	18.031			
CPU PAR	min	1.537	max	1.645	mean	1.590			
H	min	11.109	max	11.109	mean	11.109			
Row-Premute									
CPU COO	min	0.740	max	0.776	mean	0.746			
CPU CSR	min	3.302	max*	3.328	mean	3.317			
GPU 64 COO	min	7.040	max*	7.180	mean	7.098			
CSR	min	15.690	max	18.580	mean	16.732			
CPU PAR	min	1.327	max	1.482	mean	1.422			
H	min	11.098	max	11.105	mean	11.101			
Row-Gradient									
CPU COO	min	0.739	max*	2.092	mean	1.091			
CPU CSR	min	2.539	max	2.546	mean	2.543			
GPU 64 COO	min	7.040	max	7.150	mean	7.100			
CSR	min	15.520	max	18.560	mean	17.547			
CPU PAR	min	1.401	max	1.661	mean	1.525			
H	min	11.109	max	11.109	mean	11.109			
Column-Gradient									
CPU COO	min	0.726	max	2.065	mean	1.011			
CPU CSR	min	2.539	max	2.550	mean	2.546			
GPU 64 COO	min	6.800	max	7.140	mean	7.080			
CSR	min	15.480	max	18.560	mean	16.866			
CPU PAR	min	1.391	max*	1.737	mean	1.563			
H	min	11.329	max	11.333	mean	11.331			
Row-Column-Permute									
CPU COO	min	0.746	max	0.782	mean	0.754			
CPU CSR	min	3.310	max	3.324	mean	3.318			
GPU 64 COO	min	7.030	max	7.160	mean	7.100			
CSR	min	15.730	max	18.530	mean	17.362			
CPU PAR	min	1.340	max	1.451	mean	1.401			
H	min	11.099	max	11.104	mean	11.102			
bloweya.mtx									
Regular									

lp_osa_07.mtx Regular	Row-Premute	CPU COO	min	0.727	max*	1.815	mean	0.892	Row-Premute	GPU 64 COO	min	11.340	max*	11.860	mean	11.441
		CPU CSR	min	2.867	max*	2.936	mean	2.917		CSR	min	36.010	max*	40.960	mean	38.048
		GPU 64 COO	min	0.000	max	0.000	mean	0.000		CPU PAR	min	2.019	max	2.204	mean	2.130
		CSR	min	0.000	max	0.000	mean	0.000		H	min	8.228	max	8.228	mean	8.228
		CPU PAR	min	1.680	max*	1.751	mean	1.719		CPU COO	min	0.718	max	0.751	mean	0.732
		H	min	7.205	max	7.205	mean	7.205		CPU CSR	min	2.488	max	2.507	mean	2.498
		CPU COO	min	0.678	max	1.483	mean	0.746		GPU 64 COO	min	10.810	max	11.090	mean	10.949
		CPU CSR	min	2.311	max	2.326	mean	2.320		CSR	min	24.860	max	26.410	mean	25.527
		GPU 64 COO	min	6.840	max*	7.270	mean	6.930		CPU PAR	min	1.978	max	2.290	mean	2.135
		CSR	min	15.650	max	16.800	mean	16.233		H	min	11.836	max	11.840	mean	11.838
lp_osa_07.mtx Regular	Row-Gradient	CPU PAR	min	1.649	max	1.730	mean	1.682	Row-Gradient	CPU COO	min	0.722	max	1.794	mean	0.769
		H	min	11.026	max	11.031	mean	11.029		CPU CSR	min	2.407	max	2.421	mean	2.416
		CPU COO	min	0.708	max	1.209	mean	0.779		GPU 64 COO	min	11.210	max	11.480	mean	11.317
		CPU CSR	min	1.648	max	1.735	mean	1.709		CSR	min	31.920	max	34.690	mean	33.246
		GPU 64 COO	min	6.920	max	7.080	mean	7.015		CPU PAR	min	2.184	max*	2.302	mean	2.232
		CSR	min	16.950	max	19.500	mean	17.794		H	min	10.742	max	10.757	mean	10.748
		CPU PAR	min	1.497	max	1.743	mean	1.608		CPU COO	min	0.720	max	0.916	mean	0.742
		H	min	10.298	max	10.304	mean	10.301		CPU CSR	min	2.395	max	2.410	mean	2.402
		CPU COO	min	0.709	max	1.536	mean	0.817		GPU 64 COO	min	10.840	max	11.070	mean	10.946
		CPU CSR	min	1.705	max	1.753	mean	1.735		CSR	min	24.340	max	26.140	mean	25.393
lp_osa_07.mtx Regular	Column-Gradient	GPU 64 COO	min	6.800	max	7.120	mean	6.865	Column-Gradient	CPU PAR	min	2.184	max	2.272	mean	2.223
		CSR	min	15.480	max*	17.710	mean	16.470		H	min	11.873	max	11.882	mean	11.878
		CPU PAR	min	1.446	max	1.718	mean	1.591		CPU COO	min	0.707	max	0.748	mean	0.714
		H	min	10.880	max	10.886	mean	10.883		CPU CSR	min	2.458	max	2.511	mean	2.506
		CPU COO	min	0.670	max	1.024	mean	0.706		GPU 64 COO	min	10.880	max	11.070	mean	10.957
		CPU CSR	min	2.199	max	2.340	mean	2.326		CSR	min	24.890	max	26.490	mean	25.642
		GPU 64 COO	min	6.880	max	6.980	mean	6.933		CPU PAR	min	2.209	max	2.282	mean	2.240
		CSR	min	15.610	max	16.900	mean	16.227		H	min	11.834	max*	11.840	mean	11.838
		CPU PAR	min	1.598	max	1.668	mean	1.632		CPU COO	min	0.732	max	0.751	mean	0.744
		H	min	11.025	max*	11.032	mean	11.029		CPU CSR	min	2.885	max*	2.916	mean	2.909
lp_osa_07.mtx Regular	Row-Premute	CPU COO	min	0.715	max	1.798	mean	0.885	Row-Premute	GPU 64 COO	min	0.000	max	0.000	mean	0.000
		CPU CSR	min	2.495	max	2.551	mean	2.547		CSR	min	0.000	max	0.000	mean	0.000
		GPU 64 COO	min	7.650	max*	7.790	mean	7.718		CPU PAR	min	1.276	max	1.299	mean	1.286
		CSR	min	16.390	max*	18.350	mean	17.093		H	min	7.478	max	7.478	mean	7.478
		CPU PAR	min	0.963	max	1.012	mean	0.995		CPU COO	min	0.727	max	0.855	mean	0.736
		H	min	8.412	max	8.412	mean	8.412		CPU CSR	min	2.385	max	2.411	mean	2.397
		CPU COO	min	0.720	max*	2.078	mean	1.104		GPU 64 COO	min	8.120	max	8.410	mean	8.206
		CPU CSR	min	2.656	max*	2.679	mean	2.669		CSR	min	18.670	max	19.960	mean	19.536
		GPU 64 COO	min	7.610	max	7.690	mean	7.647		CPU PAR	min	1.293	max	1.340	mean	1.314
		CSR	min	15.910	max	17.210	mean	16.750		H	min	9.809	max	9.813	mean	9.811
lp_osa_07.mtx Regular	Row-Gradient	CPU PAR	min	0.890	max	0.940	mean	0.918	Row-Gradient	CPU COO	min	0.696	max*	1.546	mean	0.785
		H	min	9.255	max	9.258	mean	9.256		CPU CSR	min	1.361	max	1.420	mean	1.411
		CPU COO	min	0.725	max	2.078	mean	1.041		GPU 64 COO	min	8.190	max*	8.550	mean	8.302
		CPU CSR	min	2.487	max	2.502	mean	2.495		CSR	min	18.700	max*	21.000	mean	19.890
		GPU 64 COO	min	7.570	max	7.730	mean	7.655		CPU PAR	min	1.435	max	1.666	mean	1.549
		CSR	min	15.370	max	18.100	mean	16.803		H	min	9.721	max	9.727	mean	9.723
		CPU PAR	min	1.435	max	1.796	mean	1.592		CPU COO	min	0.698	max	1.467	mean	0.746
		H	min	8.637	max	8.678	mean	8.672		CPU CSR	min	1.377	max	1.423	mean	1.414
		CPU COO	min	0.724	max	1.990	mean	1.000		GPU 64 COO	min	8.110	max	8.290	mean	8.187
		CPU CSR	min	2.425	max	2.477	mean	2.448		CSR	min	18.090	max	20.190	mean	19.217
lp_osa_07.mtx Regular	Column-Gradient	GPU 64 COO	min	7.510	max	7.660	mean	7.596	Column-Gradient	CPU PAR	min	1.345	max*	1.681	mean	1.518
		CSR	min	14.410	max	16.290	mean	15.267		H	min	10.369	max*	10.372	mean	10.370
		CPU PAR	min	1.238	max	1.774	mean	1.534		CPU COO	min	0.698	max	1.390	mean	0.788
		H	min	9.447	max*	9.603	mean	9.576		CPU CSR	min	2.387	max	2.410	mean	2.399
		CPU COO	min	0.738	max	1.950	mean	1.071		GPU 64 COO	min	8.120	max	8.260	mean	8.191
		CPU CSR	min	2.522	max	2.709	mean	2.675		CSR	min	18.530	max	19.960	mean	19.307
		GPU 64 COO	min	7.600	max	7.690	mean	7.641		CPU PAR	min	1.295	max	1.347	mean	1.319
		CSR	min	15.820	max	17.190	mean	16.572		H	min	9.809	max	9.813	mean	9.811
		CPU PAR	min	0.891	max	0.944	mean	0.924		CPU COO	min	0.712	max	1.201	mean	0.756
		H	min	9.255	max	9.258	mean	9.256		CPU CSR	min	1.558	max	1.601	mean	1.596
ex19.mtx Regular	Row-Premute	CPU COO	min	0.732	max*	1.837	mean	1.076	Row-Premute	GPU 64 COO	min	7.080	max*	7.370	mean	7.184
		CPU CSR	min	2.563	max*	2.586	mean	2.577		CSR	min	17.580	max*	19.480	mean	18.770



Row-Premute	CPU PAR	min	1.286	max	1.511	mean	1.447	Row-Premute	CPU COO	min	0.724	max	1.100	mean	0.765
	H	min	8.600	max	8.600	mean	8.600		CPU CSR	min	2.581	max*	2.626	mean	2.609
	CPU COO	min	0.689	max	0.890	mean	0.704		GPU 64 COO	min	7.170	max	7.340	mean	7.253
	CPU CSR	min	1.600	max	1.630	mean	1.618		CSR	min	17.360	max	18.500	mean	18.014
	GPU 64 COO	min	7.000	max	7.180	mean	7.061		CPU PAR	min	1.494	max*	1.607	mean	1.558
Row-Gradient	CSR	min	15.760	max	17.240	mean	16.625	Row-Gradient	H	min	10.043	max	10.047	mean	10.044
	CPU PAR	min	1.296	max	1.419	mean	1.365		CPU COO	min	0.716	max	1.701	mean	0.804
	H	min	10.376	max	10.380	mean	10.379		CPU CSR	min	1.824	max	1.840	mean	1.832
	CPU COO	min	0.704	max	1.615	mean	0.806		GPU 64 COO	min	7.220	max*	7.510	mean	7.303
	CPU CSR	min	1.355	max	1.370	mean	1.362		CSR	min	17.540	max*	20.710	mean	19.302
Column-Gradient	GPU 64 COO	min	7.020	max	7.160	mean	7.083	Column-Gradient	CPU PAR	min	1.384	max	1.593	mean	1.526
	CSR	min	0.000	max	16.290	mean	15.076		H	min	9.681	max	9.706	mean	9.694
	CPU PAR	min	1.256	max	1.520	mean	1.405		CPU COO	min	0.711	max	1.029	mean	0.746
	H	min	9.915	max	9.925	mean	9.921		CPU CSR	min	1.817	max	1.834	mean	1.827
	CPU COO	min	0.702	max*	1.626	mean	0.844		GPU 64 COO	min	7.110	max	7.270	mean	7.193
Row-Column-Permute	CPU CSR	min	1.327	max	1.374	mean	1.364	Row-Column-Permute	CSR	min	16.530	max	18.590	mean	17.574
	GPU 64 COO	min	6.920	max	7.210	mean	7.030		CPU PAR	min	1.390	max	1.574	mean	1.511
	CSR	min	0.000	max	15.260	mean	14.279		H	min	10.612	max*	10.659	mean	10.634
	CPU PAR	min	1.283	max*	1.531	mean	1.385		CPU COO	min	0.719	max	1.391	mean	0.756
	H	min	10.572	max	10.595	mean	10.590		CPU CSR	min	2.546	max	2.625	mean	2.611
cvxqp3.mtx Regular	CPU COO	min	0.707	max	1.532	mean	0.924	TSOPF_FS_b9_c6.mtx Regular	GPU 64 COO	min	7.190	max	7.320	mean	7.248
	CPU CSR	min	1.606	max*	1.634	mean	1.624		CSR	min	17.500	max	18.640	mean	18.040
	GPU 64 COO	min	6.970	max	7.110	mean	7.045		CPU PAR	min	1.465	max	1.573	mean	1.533
	CSR	min	15.850	max	17.310	mean	16.783		H	min	10.041	max	10.046	mean	10.044
	CPU PAR	min	1.286	max	1.406	mean	1.357		CPU COO	min	0.705	max	0.734	mean	0.718
Row-Premute	H	min	10.377	max	10.382	mean	10.379	Row-Premute	CPU CSR	min	3.028	max*	3.052	mean	3.045
	CPU COO	min	0.697	max	0.720	mean	0.712		GPU 64 COO	min	0.000	max	0.000	mean	0.000
	CPU CSR	min	2.624	max*	2.643	mean	2.638		CSR	min	0.000	max	0.000	mean	0.000
	GPU 64 COO	min	6.060	max*	6.220	mean	6.121		CPU PAR	min	1.528	max*	1.602	mean	1.568
	CSR	min	19.450	max*	22.710	mean	21.277		H	min	7.380	max	7.380	mean	7.380
Row-Gradient	CPU PAR	min	1.733	max*	1.860	mean	1.804	Row-Gradient	CPU COO	min	0.733	max	1.640	mean	0.777
	H	min	8.646	max	8.646	mean	8.646		CPU CSR	min	2.450	max	2.543	mean	2.525
	CPU COO	min	0.695	max*	1.577	mean	0.894		GPU 64 COO	min	7.200	max	7.320	mean	7.268
	CPU CSR	min	2.452	max	2.471	mean	2.464		CSR	min	17.420	max	18.540	mean	18.102
	GPU 64 COO	min	5.870	max	6.060	mean	5.930		CPU PAR	min	1.474	max	1.595	mean	1.546
Column-Gradient	CSR	min	17.510	max	19.130	mean	18.516	Column-Gradient	H	min	10.042	max	10.046	mean	10.044
	CPU PAR	min	1.723	max	1.833	mean	1.774		CPU COO	min	0.712	max	0.926	mean	0.750
	H	min	11.028	max	11.033	mean	11.030		CPU CSR	min	1.819	max	1.846	mean	1.832
	CPU COO	min	0.693	max	1.523	mean	0.788		GPU 64 COO	min	7.210	max*	7.370	mean	7.298
	CPU CSR	min	1.287	max	1.305	mean	1.296		CSR	min	17.550	max*	20.740	mean	19.089
Row-Column-Permute	GPU 64 COO	min	5.920	max	6.000	mean	5.962	Row-Column-Permute	CPU PAR	min	1.256	max	1.554	mean	1.495
	CSR	min	16.810	max	18.410	mean	17.561		H	min	9.666	max	9.704	mean	9.690
	CPU PAR	min	1.378	max	1.485	mean	1.429		CPU COO	min	0.710	max*	1.690	mean	0.791
	H	min	11.061	max	11.069	mean	11.064		CPU CSR	min	1.813	max	1.836	mean	1.830
	CPU COO	min	0.693	max	1.521	mean	0.772		GPU 64 COO	min	7.130	max	7.310	mean	7.211
case9.mtx Regular	CPU CSR	min	1.291	max	1.302	mean	1.297	OPF_6000.mtx Regular	CSR	min	16.550	max	18.690	mean	17.617
	GPU 64 COO	min	5.900	max	6.060	mean	5.960		CPU PAR	min	1.385	max	1.539	mean	1.506
	CSR	min	16.620	max	18.330	mean	17.592		H	min	10.611	max*	10.659	mean	10.634
	CPU PAR	min	1.372	max	1.464	mean	1.409		CPU COO	min	0.709	max	1.531	mean	0.963
	H	min	11.127	max*	11.135	mean	11.130		CPU CSR	min	2.506	max	2.648	mean	2.622
Row-Premute	CPU COO	min	0.704	max	1.503	mean	0.875	Row-Premute	GPU 64 COO	min	7.140	max	7.330	mean	7.244
	CPU CSR	min	2.447	max	2.468	mean	2.459		CSR	min	17.410	max	18.520	mean	18.148
	GPU 64 COO	min	5.880	max	5.980	mean	5.931		CPU PAR	min	1.466	max	1.574	mean	1.528
	CSR	min	17.550	max	19.140	mean	18.227		H	min	10.041	max	10.046	mean	10.044
	CPU PAR	min	1.639	max	1.743	mean	1.704		CPU COO	min	0.689	max	0.710	mean	0.695
Row-Gradient	H	min	11.028	max	11.035	mean	11.030	Row-Gradient	CPU CSR	min	2.667	max*	2.770	mean	2.720
	CPU COO	min	0.721	max*	1.800	mean	1.177		GPU 64 COO	min	12.310	max*	12.550	mean	12.425
	CPU CSR	min	3.021	max*	3.046	mean	3.036		CSR	min	39.860	max*	43.770	mean	42.075
	GPU 64 COO	min	0.000	max	0.000	mean	0.000		CPU PAR	min	1.735	max	1.945	mean	1.845
	CSR	min	0.000	max	0.000	mean	0.000		H	min	8.799	max	8.799	mean	8.799

Row-Gradient	CPU CSR	min	2.358	max	2.413	mean	2.392	Row-Gradient	CSR	min	19.960	max	21.190	mean	20.696
	GPU 64 COO	min	11.430	max	11.770	mean	11.549		CPU PAR	min	1.303	max	1.371	mean	1.345
	CSR	min	24.470	max	25.580	mean	24.785		H	min	10.059	max	10.062	mean	10.061
	CPU PAR	min	1.758	max	1.896	mean	1.829		CPU COO	min	0.723	max	0.984	mean	0.753
Column-Gradient	H	min	11.872	max	11.877	mean	11.875	Column-Gradient	CPU CSR	min	1.781	max	1.809	mean	1.803
	CPU COO	min	0.716	max	0.775	mean	0.739		GPU 64 COO	min	9.380	max	9.660	mean	9.464
	CPU CSR	min	1.651	max	1.689	mean	1.675		CSR	min	15.770	max	19.090	mean	18.037
	GPU 64 COO	min	12.100	max	12.410	mean	12.205		CPU PAR	min	1.775	max*	1.924	mean	1.868
Row-Column-Permute	CSR	min	31.670	max	34.910	mean	33.370	Row-Column-Permute	H	min	10.205	max	10.233	mean	10.219
	CPU PAR	min	2.079	max*	2.286	mean	2.207		CPU COO	min	0.715	max	0.926	mean	0.757
	H	min	11.111	max	11.116	mean	11.113		CPU CSR	min	1.729	max	1.802	mean	1.791
	CPU COO	min	0.715	max*	1.021	mean	0.743		GPU 64 COO	min	9.080	max	9.270	mean	9.158
OPF_3754.mtx Regular	CPU CSR	min	1.655	max	1.674	mean	1.666	OPF_3754.mtx Regular	CSR	min	13.980	max	15.780	mean	14.938
	GPU 64 COO	min	11.340	max	11.560	mean	11.463		CPU PAR	min	1.751	max	1.906	mean	1.846
	CSR	min	23.770	max	25.470	mean	24.489		H	min	11.213	max*	11.232	mean	11.222
	CPU PAR	min	2.056	max	2.172	mean	2.118		CPU COO	min	0.732	max	1.598	mean	0.785
Row-Gradient	H	min	12.040	max*	12.047	mean	12.043	Row-Gradient	CPU CSR	min	2.594	max	2.602	mean	2.599
	CPU COO	min	0.677	max	0.785	mean	0.687		GPU 64 COO	min	9.340	max	9.460	mean	9.394
	CPU CSR	min	2.325	max	2.434	mean	2.369		CSR	min	19.950	max	21.500	mean	20.544
	GPU 64 COO	min	11.450	max	11.650	mean	11.538		CPU PAR	min	1.326	max	1.374	mean	1.354
Row-Gradient	CSR	min	24.330	max	25.560	mean	25.008	Row-Gradient	H	min	10.059	max	10.062	mean	10.061
	CPU PAR	min	1.631	max	1.776	mean	1.709		CPU COO	min	0.759	max	0.795	mean	0.780
	H	min	11.873	max	11.877	mean	11.875		CPU CSR	min	2.479	max*	2.565	mean	2.557
	CPU COO	min	0.726	max	0.774	mean	0.747		GPU 64 COO	min	5.490	max*	5.650	mean	5.552
Row-Gradient	CPU CSR	min	2.898	max*	2.919	mean	2.908	Row-Gradient	CSR	min	16.700	max	19.460	mean	18.004
	GPU 64 COO	min	7.680	max*	7.820	mean	7.766		CPU PAR	min	1.456	max*	1.523	mean	1.492
	CSR	min	25.070	max*	29.030	mean	26.756		H	min	7.132	max	7.132	mean	7.132
	CPU PAR	min	1.437	max	1.508	mean	1.471		CPU COO	min	0.695	max	0.943	mean	0.726
Row-Gradient	H	min	8.393	max	8.393	mean	8.393	Row-Gradient	CPU CSR	min	2.480	max	2.488	mean	2.485
	CPU COO	min	0.714	max*	1.574	mean	0.817		GPU 64 COO	min	5.410	max	5.490	mean	5.453
	CPU CSR	min	2.686	max	2.711	mean	2.699		CSR	min	15.700	max	17.520	mean	16.678
	GPU 64 COO	min	7.410	max	7.570	mean	7.484		CPU PAR	min	1.422	max	1.514	mean	1.474
Row-Gradient	CSR	min	19.600	max	21.190	mean	20.307	Row-Gradient	H	min	10.959	max	10.966	mean	10.963
	CPU PAR	min	1.443	max	1.505	mean	1.469		CPU COO	min	0.723	max*	2.029	mean	0.990
	H	min	11.267	max	11.272	mean	11.269		CPU CSR	min	2.411	max	2.427	mean	2.421
	CPU COO	min	0.723	max	1.232	mean	0.775		GPU 64 COO	min	5.490	max	5.560	mean	5.534
Row-Gradient	CPU CSR	min	1.672	max	1.691	mean	1.685	Row-Gradient	CSR	min	16.350	max*	19.560	mean	17.784
	GPU 64 COO	min	7.600	max	7.760	mean	7.716		CPU PAR	min	1.441	max	1.509	mean	1.477
	CSR	min	23.160	max	25.590	mean	24.304		H	min	9.512	max	9.526	mean	9.520
	CPU PAR	min	1.675	max*	1.736	mean	1.703		CPU COO	min	0.721	max	1.802	mean	0.871
Row-Gradient	H	min	10.463	max	10.472	mean	10.468	Row-Gradient	CPU CSR	min	2.393	max	2.408	mean	2.404
	CPU COO	min	0.726	max	1.431	mean	0.778		GPU 64 COO	min	5.410	max	5.480	mean	5.453
	CPU CSR	min	1.671	max	1.685	mean	1.679		CSR	min	15.680	max	17.870	mean	16.540
	GPU 64 COO	min	7.410	max	7.530	mean	7.467		CPU PAR	min	1.429	max	1.488	mean	1.468
Row-Gradient	CSR	min	18.140	max	20.350	mean	19.315	Row-Gradient	H	min	10.931	max	10.945	mean	10.938
	CPU PAR	min	1.650	max	1.736	mean	1.699		CPU COO	min	0.728	max	1.646	mean	1.037
	H	min	11.393	max*	11.401	mean	11.397		CPU CSR	min	2.472	max	2.488	mean	2.480
	CPU COO	min	0.711	max	1.458	mean	0.751		GPU 64 COO	min	5.410	max	5.480	mean	5.449
Row-Gradient	CPU CSR	min	2.678	max	2.717	mean	2.700	Row-Gradient	CSR	min	15.760	max	17.560	mean	16.654
	GPU 64 COO	min	7.400	max	7.540	mean	7.471		CPU PAR	min	1.428	max	1.513	mean	1.474
	CSR	min	19.560	max	21.150	mean	20.453		H	min	10.959	max*	10.967	mean	10.963
	CPU PAR	min	1.440	max	1.499	mean	1.467		CPU COO	min	0.737	max	1.977	mean	1.431
Row-Gradient	H	min	11.266	max	11.272	mean	11.269	Row-Gradient	CPU CSR	min	2.674	max	2.688	mean	2.681
	CPU COO	min	0.754	max*	1.829	mean	1.204		GPU 64 COO	min	5.900	max	6.000	mean	5.954
	CPU CSR	min	2.610	max*	2.624	mean	2.618		CSR	min	13.650	max	15.410	mean	14.657
	GPU 64 COO	min	9.530	max*	9.870	mean	9.640		CPU PAR	min	1.468	max	1.521	mean	1.491
Row-Gradient	CSR	min	23.990	max*	25.910	mean	24.992	Row-Gradient	H	min	9.234	max	9.234	mean	9.234
	CPU PAR	min	1.311	max	1.380	mean	1.357		CPU COO	min	0.740	max*	2.048	mean	1.121
	H	min	8.364	max	8.364	mean	8.364		CPU CSR	min	2.777	max	2.798	mean	2.790
	CPU COO	min	0.740	max	0.885	mean	0.755		GPU 64 COO	min	5.910	max	5.970	mean	5.944
Row-Gradient	CPU CSR	min	2.574	max	2.611	mean	2.597	Row-Gradient	CSR	min	13.700	max	15.370	mean	14.541
	GPU 64 COO	min	9.320	max	9.510	mean	9.397		CPU PAR	min	1.468	max	1.546	mean	1.502
	CPU COO	min	0.740	max	0.885	mean	0.755		CPU CSR	min	2.777	max	2.798	mean	2.790
	CPU CSR	min	2.574	max	2.611	mean	2.597		GPU 64 COO	min	5.910	max	5.970	mean	5.944
Row-Gradient	GPU 64 COO	min	9.320	max	9.510	mean	9.397	Row-Gradient	CSR	min	13.700	max	15.370	mean	14.541
	CPU COO	min	0.740	max	0.885	mean	0.755		CPU PAR	min	1.468	max	1.546	mean	1.502
	CPU CSR	min	2.574	max	2.611	mean	2.597		CPU CSR	min	2.777	max	2.798	mean	2.790
	GPU 64 COO	min	9.320	max	9.510	mean	9.397		GPU 64 COO	min	5.910	max	5.970	mean	5.944

Row-Gradient	H	min	10.250	max	10.255	mean	10.252					CPU COO	min	0.735	max	1.806	mean	0.878												
	CPU COO	min	0.740	max	1.790	mean	0.994					CPU CSR	min	2.706	max	2.744	mean	2.726												
	CPU CSR	min	2.663	max	2.682	mean	2.674					GPU 64 COO	min	6.390	max	6.500	mean	6.433												
	GPU 64 COO	min	5.890	max*	6.160	mean	5.946					CSR	min	19.780	max	22.870	mean	20.936												
	CSR	min	13.780	max*	17.520	mean	15.601					CPU PAR	min	1.710	max	1.865	mean	1.785												
	CPU PAR	min	1.479	max*	1.619	mean	1.569					H	min	10.251	max	10.267	mean	10.257												
	H	min	9.939	max	9.955	mean	9.948					Column-Gradient					CPU COO	min	0.728	max	1.792	mean	0.986							
	CPU COO	min	0.743	max	1.991	mean	0.981					CPU CSR	min	2.521	max	2.720	mean	2.703												
	CPU CSR	min	2.620	max	2.654	mean	2.646					GPU 64 COO	min	6.280	max	6.370	mean	6.327												
	GPU 64 COO	min	5.840	max	5.910	mean	5.885					CSR	min	18.000	max	19.720	mean	19.040												
Column-Gradient	CSR	min	13.130	max	17.040	mean	15.008					CPU PAR	min	1.649	max	1.741	mean	1.702												
	CPU PAR	min	1.477	max	1.607	mean	1.559					H	min	11.113	max	11.121	mean	11.117												
	H	min	10.858	max*	10.876	mean	10.864					Row-Column-Permute					CPU COO	min	0.714	max	1.525	mean	0.957							
	CPU COO	min	0.742	max	2.010	mean	1.124					CPU CSR	min	2.876	max	2.892	mean	2.884												
	CPU CSR	min	2.789	max*	2.800	mean	2.795					GPU 64 COO	min	6.280	max	6.370	mean	6.322												
	GPU 64 COO	min	5.900	max	5.980	mean	5.941					CSR	min	17.960	max	19.670	mean	18.670												
	CSR	min	13.640	max	15.410	mean	14.556					CPU PAR	min	1.667	max	1.754	mean	1.710												
	CPU PAR	min	1.462	max	1.540	mean	1.504					H	min	11.162	max*	11.168	mean	11.165												
	H	min	10.250	max	10.253	mean	10.252					TSOPF_RS_b39_c7.mtx					Regular													
	Regular									CPU COO	min	0.771	max	0.793	mean	0.780														
Maragal_6.mtx	CPU CSR	min	2.345	max	2.409	mean	2.372					CPU CSR	min	3.219	max*	3.232	mean	3.227												
	GPU 64 COO	min	18.200	max	18.770	mean	18.357					GPU 64 COO	min	11.070	max*	11.200	mean	11.142												
	CSR	min	38.310	max*	40.240	mean	39.477					CSR	min	37.050	max*	42.100	mean	39.040												
	CPU PAR	min	0.789	max	0.813	mean	0.797					CPU PAR	min	1.910	max	2.027	mean	1.982												
	H	min	9.930	max	9.930	mean	9.930					H	min	7.304	max	7.304	mean	7.304												
	Row-Premute									CPU COO	min	0.701	max	0.722	mean	0.707														
	CPU COO	min	0.709	max	0.779	mean	0.715					CPU CSR	min	2.931	max	2.952	mean	2.942												
	CPU CSR	min	2.675	max	2.715	mean	2.696					GPU 64 COO	min	10.860	max	11.030	mean	10.928												
	GPU 64 COO	min	17.810	max	18.030	mean	17.935					CSR	min	28.730	max	30.880	mean	29.483												
	CSR	min	29.650	max	30.580	mean	30.109					CPU PAR	min	1.760	max	1.922	mean	1.851												
Row-Premute	CPU PAR	min	0.857	max	0.940	mean	0.904					H	min	10.537	max	10.541	mean	10.539												
	H	min	10.777	max	10.779	mean	10.778					Row-Gradient					CPU COO	min	0.747	max	0.808	mean	0.757							
	CPU COO	min	0.710	max*	1.566	mean	0.755					CPU CSR	min	2.606	max	2.648	mean	2.624												
	CPU CSR	min	2.042	max	2.159	mean	2.120					GPU 64 COO	min	10.850	max	11.120	mean	10.999												
	GPU 64 COO	min	18.460	max*	18.960	mean	18.665					CSR	min	33.910	max	37.600	mean	35.909												
	CSR	min	25.650	max	27.330	mean	26.549					CPU PAR	min	2.154	max*	2.245	mean	2.203												
	CPU PAR	min	2.257	max	2.612	mean	2.416					H	min	9.636	max	9.646	mean	9.642												
	H	min	11.251	max	11.301	mean	11.285					Column-Gradient					CPU COO	min	0.718	max*	1.693	mean	0.802							
	CPU COO	min	0.711	max	0.743	mean	0.725					CPU CSR	min	2.502	max	2.585	mean	2.547												
	CPU CSR	min	2.036	max	2.161	mean	2.110					GPU 64 COO	min	10.700	max	10.990	mean	10.804												
Column-Gradient	GPU 64 COO	min	17.840	max	18.860	mean	18.149					CSR	min	27.230	max	29.380	mean	28.488												
	CSR	min	19.410	max	20.690	mean	20.066					CPU PAR	min	2.128	max	2.227	mean	2.172												
	CPU PAR	min	2.174	max*	2.546	mean	2.349					H	min	11.131	max*	11.222	mean	11.208												
	H	min	12.011	max*	12.072	mean	12.052					Row-Column-Permute					CPU COO	min	0.709	max	0.726	mean	0.716							
	CPU COO	min	0.712	max	0.971	mean	0.737					CPU CSR	min	2.917	max	2.958	mean	2.940												
	CPU CSR	min	2.732	max*	2.751	mean	2.743					GPU 64 COO	min	10.840	max	11.030	mean	10.930												
	GPU 64 COO	min	17.720	max	18.070	mean	17.911					CSR	min	28.780	max	30.810	mean	29.578												
	CSR	min	29.600	max	30.500	mean	29.961					CPU PAR	min	1.757	max	1.834	mean	1.792												
	CPU PAR	min	0.827	max	0.954	mean	0.913					H	min	10.537	max	10.540	mean	10.539												
	H	min	10.776	max	10.778	mean	10.777					10 ELLESMERE					aft01.mtx													
aft01.mtx									CPU COO	min	0.735	max*	2.079	mean	1.069	aft01.mtx					Regular									
Regular									CPU CSR	min	3.132	max*	3.154	mean	3.145	Regular					GPU 64 COO	min	4.080	max*	4.280	mean	4.186			
Row-Premute	GPU 64 COO	min	6.390	max*	6.610	mean	6.457					CSR	min	19.990	max*	23.250	mean	21.820	H	min	7.811	max	7.811	mean	7.811					
	CSR	min	19.990	max*	23.250	mean	21.820					CPU PAR	min	1.746	max*	1.865	mean	1.812	Row-Premute					GPU 64 COO	min	3.860	max	4.090	mean	4.001
	CPU PAR	min	1.746	max*	1.865	mean	1.812					H	min	7.811	max	7.811	mean	7.811	H	min	11.161	max	11.167	mean	11.165					
	H	min	7.811	max	7.811	mean	7.811					Row-Gradient					GPU 64 COO	min	4.010	max	4.240	mean	4.135							
	CPU COO	min	0.714	max	1.648	mean	0.840					CPU CSR	min	2.864	max	2.892	mean	2.883	CSR	min	5.890	max	11.350	mean	6.882					
	CPU CSR	min	2.864	max	2.892	mean	2.883					GPU 64 COO	min	6.280	max	6.380	mean	6.329	H	min	10.246	max	10.262	mean	10.256					
	GPU 64 COO	min	6.280	max	6.380	mean	6.329					CSR	min	17.980	max	19.700	mean	19.105	10 ELLESMERE					aft01.mtx						
	CSR	min	17.980	max	19.700	mean	19.105					CPU PAR	min	1.729	max	1.850	mean	1.782	Regular					GPU 64 COO	min	4.010	max	4.240	mean	4.135
	CPU PAR	min	1.729	max	1.850	mean	1.782					H	min	11.162	max	11.168	mean	11.165	CSR	min	5.890	max	11.350	mean	6.882					
	H	min	11.162	max	11.168	mean	11.165					Column-Gradient					H	min	10.246	max	10.262	mean	10.256							

Row-Column-Permute	GPU 64 COO min 3.850 max 4.100 mean 4.012	H	min 7.380 max 7.380 mean 7.380	Row-Premute	GPU 64 COO min 4.820 max 4.940 mean 4.859
	CSR min 5.460 max 8.790 mean 6.005				CSR min 5.080 max 6.520 mean 6.342
	H min 11.112 max 11.122 mean 11.117				H min 10.042 max 10.047 mean 10.044
bloweya.mtx Regular	GPU 64 COO min 3.850 max 4.080 mean 3.990	H	min 9.681 max 9.704 mean 9.694	Row-Gradient	GPU 64 COO min 4.810 max* 4.940 mean 4.876
	CSR min 5.420 max 6.760 mean 5.977				CSR min 6.100 max* 6.560 mean 6.307
	H min 11.162 max*11.169 mean 11.165				H min 10.041 max 10.047 mean 10.044
Row-Premute	GPU 64 COO min 0.000 max 0.000 mean 0.000	H	min 10.554 max*10.661 mean 10.638	Column-Gradient	GPU 64 COO min 4.810 max 4.930 mean 4.869
	CSR min 0.000 max 0.000 mean 0.000				CSR min 4.820 max 6.460 mean 6.208
	H min 7.205 max 7.205 mean 7.205				H min 10.554 max*10.661 mean 10.638
Row-Gradient	GPU 64 COO min 3.800 max 3.940 mean 3.875	H	min 10.041 max 10.047 mean 10.044	Row-Column-Permute	GPU 64 COO min 4.810 max 4.940 mean 4.864
	CSR min 3.710 max 4.570 mean 4.399				CSR min 5.930 max 6.520 mean 6.379
	H min 11.025 max 11.031 mean 11.028				H min 10.041 max 10.047 mean 10.044
Column-Gradient	GPU 64 COO min 3.800 max* 4.120 mean 3.962	H	min 10.041 max 10.047 mean 10.044	cvxqp3.mtx Regular	GPU 64 COO min 3.350 max* 3.590 mean 3.483
	CSR min 4.340 max* 4.670 mean 4.546				CSR min 5.430 max* 9.260 mean 8.333
	H min 10.296 max 10.307 mean 10.300				H min 8.646 max 8.646 mean 8.646
Row-Column-Permute	GPU 64 COO min 3.880 max 4.100 mean 3.978	H	min 11.027 max 11.033 mean 11.030	Row-Premute	GPU 64 COO min 3.230 max 3.480 mean 3.371
	CSR min 4.240 max 4.570 mean 4.412				CSR min 7.560 max 8.220 mean 7.900
	H min 10.881 max 10.886 mean 10.883				H min 11.027 max 11.033 mean 11.030
brainpc2.mtx Regular	GPU 64 COO min 3.800 max 3.980 mean 3.885	H	min 11.025 max*11.033 mean 11.029	Row-Gradient	GPU 64 COO min 3.240 max 3.510 mean 3.396
	CSR min 4.130 max 4.540 mean 4.399				CSR min 6.990 max 7.890 mean 7.574
	H min 11.025 max*11.033 mean 11.029				H min 11.060 max 11.069 mean 11.064
Row-Premute	GPU 64 COO min 0.000 max 0.000 mean 0.000	H	min 11.126 max*11.134 mean 11.130	Column-Gradient	GPU 64 COO min 3.240 max 3.480 mean 3.374
	CSR min 0.000 max 0.000 mean 0.000				CSR min 6.980 max 7.900 mean 7.557
	H min 7.478 max 7.478 mean 7.478				H min 11.126 max*11.134 mean 11.130
Row-Gradient	GPU 64 COO min 3.840 max* 6.750 mean 4.110	H	min 11.026 max 11.032 mean 11.030	Row-Column-Permute	GPU 64 COO min 3.110 max 3.470 mean 3.365
	CSR min 4.260 max* 4.580 mean 4.437				CSR min 4.810 max 8.210 mean 7.742
	H min 9.809 max 9.813 mean 9.811				H min 11.026 max 11.032 mean 11.030
Column-Gradient	GPU 64 COO min 0.640 max 4.030 mean 3.864	H	min 11.026 max 11.032 mean 11.030	ex19.mtx Regular	GPU 64 COO min 2.450 max* 2.610 mean 2.564
	CSR min 4.270 max 4.470 mean 4.383				CSR min 4.490 max 4.760 mean 4.714
	H min 9.722 max 9.727 mean 9.724				H min 8.228 max 8.228 mean 8.228
Row-Column-Permute	GPU 64 COO min 0.640 max 4.070 mean 3.898	H	min 11.835 max 11.840 mean 11.838	Row-Premute	GPU 64 COO min 2.000 max 2.040 mean 2.021
	CSR min 4.230 max 4.580 mean 4.386				CSR min 4.640 max 4.780 mean 4.733
	H min 10.368 max*10.372 mean 10.370				H min 11.835 max 11.840 mean 11.838
c-47.mtx Regular	GPU 64 COO min 3.980 max 4.110 mean 4.027	H	min 10.742 max 10.752 mean 10.747	Row-Gradient	GPU 64 COO min 2.240 max 2.390 mean 2.329
	CSR min 4.320 max 4.490 mean 4.437				CSR min 4.570 max* 4.850 mean 4.807
	H min 9.809 max 9.813 mean 9.811				H min 10.742 max 10.752 mean 10.747
Row-Premute	GPU 64 COO min 3.980 max* 4.080 mean 4.026	H	min 11.872 max*11.881 mean 11.878	Column-Gradient	GPU 64 COO min 2.010 max 2.050 mean 2.034
	CSR min 4.760 max 4.850 mean 4.812				CSR min 4.570 max 4.760 mean 4.701
	H min 8.364 max 8.364 mean 8.364				H min 11.872 max*11.881 mean 11.878
Row-Gradient	GPU 64 COO min 3.880 max 4.010 mean 3.942	H	min 11.835 max 11.840 mean 11.838	Row-Column-Permute	GPU 64 COO min 2.000 max 2.040 mean 2.023
	CSR min 4.040 max 4.900 mean 4.807				CSR min 0.770 max 4.780 mean 4.594
	H min 10.059 max 10.063 mean 10.061				H min 11.835 max 11.840 mean 11.838
Column-Gradient	GPU 64 COO min 3.900 max 4.050 mean 3.976	H	min 11.835 max 11.840 mean 11.838	gen4.mtx Regular	GPU 64 COO min 4.880 max 4.980 mean 4.900
	CSR min 4.380 max 4.740 mean 4.630				CSR min 10.020 max*11.300 mean 10.716
	H min 10.201 max 10.228 mean 10.214				H min 9.234 max 9.234 mean 9.234
Row-Column-Permute	GPU 64 COO min 3.860 max 3.990 mean 3.936	H	min 10.249 max 10.254 mean 10.252	Row-Premute	GPU 64 COO min 4.860 max 4.930 mean 4.890
	CSR min 4.350 max 4.610 mean 4.525				CSR min 0.330 max 11.200 mean 10.038
	H min 11.204 max*11.241 mean 11.222				H min 10.249 max 10.254 mean 10.252
case9.mtx Regular	GPU 64 COO min 3.890 max 4.020 mean 3.953	H	min 11.835 max 11.840 mean 11.838	Row-Gradient	GPU 64 COO min 4.860 max* 4.990 mean 4.908
	CSR min 4.490 max* 4.920 mean 4.840				CSR min 9.160 max 11.240 mean 10.435
	H min 10.058 max 10.063 mean 10.061				H min 9.939 max 9.961 mean 9.947
	GPU 64 COO min 0.000 max 0.000 mean 0.000	H	min 11.835 max 11.840 mean 11.838	Column-Gradient	GPU 64 COO min 4.780 max 4.880 mean 4.816
	CSR min 0.000 max 0.000 mean 0.000				

Row-Column-Permute	H	CSR min 7.770 max 10.570 mean 9.407	Row-Premute	GPU 64 COO min 4.420 max 4.520 mean 4.445	
		min 10.851 max*10.876 mean 10.864			
	GPU 64 COO min 4.850 max 4.950 mean 4.886	Row-Gradient		H	CSR min 10.520 max 10.880 mean 10.696
	CSR min 10.220 max 11.280 mean 10.748			min 10.960 max*10.968 mean 10.963	
lp_fit2d.mtx Regular	H	min 10.250 max 10.255 mean 10.252	Column-Gradient	GPU 64 COO min 4.570 max 4.690 mean 4.605	
					CSR min 4.550 max 13.350 mean 12.479
	GPU 64 COO min 4.360 max* 4.640 mean 4.515	H		min 9.508 max 9.527 mean 9.520	
	CSR min 10.080 max 10.900 mean 10.491	GPU 64 COO min 4.430 max 4.530 mean 4.461			
Row-Premute	H	min 11.109 max 11.109 mean 11.109	Row-Column-Permute	CSR min 10.250 max 10.940 mean 10.603	
					min 10.934 max 10.945 mean 10.939
	GPU 64 COO min 4.170 max 4.630 mean 4.476	GPU 64 COO min 4.420 max 4.520 mean 4.450			
	CSR min 0.910 max 10.910 mean 10.257	CSR min 7.380 max 10.900 mean 10.598			
Row-Gradient	H	min 11.098 max 11.104 mean 11.101	mult_dcop_01.mtx Regular	H	min 10.959 max 10.967 mean 10.963
	GPU 64 COO min 4.370 max 4.630 mean 4.529	GPU 64 COO min 3.420 max 3.630 mean 3.555			
	CSR min 10.030 max 10.970 mean 10.624	CSR min 3.650 max 4.090 mean 3.814			
Column-Gradient	H	min 11.109 max 11.109 mean 11.109	Row-Premute	H	min 9.689 max 9.689 mean 9.689
	GPU 64 COO min 4.250 max 4.640 mean 4.499	GPU 64 COO min 3.450 max 3.580 mean 3.521			
	CSR min 8.510 max*11.010 mean 10.505	CSR min 3.610 max 4.150 mean 3.785			
Row-Column-Permute	H	min 11.328 max*11.333 mean 11.331	Row-Gradient	H	min 10.738 max 10.742 mean 10.740
	GPU 64 COO min 4.350 max 4.640 mean 4.511	GPU 64 COO min 3.510 max* 3.660 mean 3.579			
	CSR min 10.040 max 10.790 mean 10.468	CSR min 3.650 max 4.160 mean 3.806			
lp_osa_07.mtx Regular	H	min 11.097 max 11.106 mean 11.101	Column-Gradient	H	min 10.576 max 10.585 mean 10.580
	GPU 64 COO min 0.460 max* 3.640 mean 3.456	GPU 64 COO min 3.460 max 3.650 mean 3.584			
	CSR min 5.570 max* 8.530 mean 8.106	CSR min 3.660 max* 4.240 mean 3.799			
Row-Premute	H	min 8.412 max 8.412 mean 8.412	Row-Column-Permute	H	min 10.826 max*10.842 mean 10.836
	GPU 64 COO min 3.140 max 3.450 mean 3.367	GPU 64 COO min 3.470 max 3.580 mean 3.532			
	CSR min 7.600 max 8.070 mean 7.853	CSR min 3.600 max 3.980 mean 3.743			
Row-Gradient	H	min 9.255 max 9.258 mean 9.256	mult_dcop_02.mtx Regular	H	min 10.738 max 10.742 mean 10.740
	GPU 64 COO min 3.190 max 3.610 mean 3.509	GPU 64 COO min 3.390 max 3.660 mean 3.585			
	CSR min 0.000 max 8.260 mean 7.597	CSR min 0.960 max 4.330 mean 4.162			
Column-Gradient	H	min 8.583 max 8.678 mean 8.670	Row-Premute	H	min 9.689 max 9.689 mean 9.689
	GPU 64 COO min 3.330 max 3.500 mean 3.416	GPU 64 COO min 3.310 max 3.600 mean 3.488			
	CSR min 6.730 max 7.540 mean 7.199	CSR min 0.620 max 4.290 mean 4.132			
Row-Column-Permute	H	min 9.542 max* 9.604 mean 9.581	Row-Gradient	H	min 10.738 max 10.743 mean 10.740
	GPU 64 COO min 3.290 max 3.430 mean 3.365	GPU 64 COO min 3.310 max* 3.670 mean 3.593			
	CSR min 7.390 max 8.060 mean 7.832	CSR min 4.130 max* 4.430 mean 4.331			
Maragal_6.mtx Regular	H	min 9.255 max 9.258 mean 9.256	Column-Gradient	H	min 10.576 max 10.584 mean 10.580
	GPU 64 COO min 4.160 max 4.310 mean 4.217	GPU 64 COO min 0.550 max 3.660 mean 3.486			
	CSR min 4.940 max 4.960 mean 4.956	CSR min 3.890 max 4.410 mean 4.275			
Row-Premute	H	min 9.930 max 9.930 mean 9.930	Row-Column-Permute	H	min 10.831 max*10.843 mean 10.836
	GPU 64 COO min 4.220 max 4.240 mean 4.225	GPU 64 COO min 3.470 max 3.590 mean 3.542			
	CSR min 4.750 max*13.040 mean 5.133	CSR min 4.190 max 4.290 mean 4.242			
Row-Gradient	H	min 10.776 max 10.778 mean 10.777	mult_dcop_03.mtx Regular	H	min 10.738 max 10.742 mean 10.740
	GPU 64 COO min 4.180 max* 4.450 mean 4.245	GPU 64 COO min 3.360 max* 3.660 mean 3.550			
	CSR min 4.880 max 4.940 mean 4.915	CSR min 3.650 max 4.090 mean 3.813			
Column-Gradient	H	min 11.259 max*11.302 mean 11.281	Row-Premute	H	min 9.689 max 9.689 mean 9.689
	GPU 64 COO min 4.200 max 4.250 mean 4.236	GPU 64 COO min 3.450 max 3.580 mean 3.521			
	CSR min 4.800 max 4.890 mean 4.859	CSR min 3.610 max 4.160 mean 3.784			
Row-Column-Permute	H	min 12.022 max 12.073 mean 12.051	Row-Gradient	H	min 10.738 max 10.743 mean 10.740
	GPU 64 COO min 4.210 max 4.230 mean 4.222	GPU 64 COO min 3.470 max 3.660 mean 3.572			
	CSR min 4.860 max 4.890 mean 4.887	CSR min 3.640 max 4.190 mean 3.809			
mhd4800a.mtx Regular	H	min 10.776 max 10.778 mean 10.778	Column-Gradient	H	min 10.572 max 10.584 mean 10.580
	GPU 64 COO min 4.570 max* 4.710 mean 4.608	GPU 64 COO min 3.430 max 3.650 mean 3.562			
	CSR min 12.690 max*13.940 mean 13.369	CSR min 3.670 max* 4.290 mean 3.793			

Row-Column-Permute	H	min 10.828 max*10.840 mean 10.834	GPU 64 COO min 4.540 max 4.940 mean 4.874 CSR min 6.280 max 6.520 mean 6.403 H min 10.042 max 10.047 mean 10.044
	GPU 64 COO	min 3.370 max 3.610 mean 3.502	
	CSR	min 3.610 max 3.970 mean 3.744	
OPF_3754.mtx Regular	H	min 10.738 max 10.741 mean 10.740	GPU 64 COO min 4.830 max 4.930 mean 4.875 CSR min 5.790 max* 6.560 mean 6.289 H min 9.675 max 9.706 mean 9.692
	GPU 64 COO	min 4.700 max* 4.930 mean 4.842	
	CSR	min 6.230 max* 6.600 mean 6.411	
Row-Premute	H	min 8.393 max 8.393 mean 8.393	GPU 64 COO min 4.790 max* 4.960 mean 4.880 CSR min 5.760 max 6.450 mean 6.204 H min 10.601 max*10.661 mean 10.626
	GPU 64 COO	min 4.620 max 4.890 mean 4.787	
	CSR	min 5.780 max 6.310 mean 6.192	
Row-Gradient	H	min 11.265 max 11.272 mean 11.269	GPU 64 COO min 4.330 max 4.950 mean 4.845 CSR min 5.740 max 6.500 mean 6.375 H min 10.041 max 10.046 mean 10.044
	GPU 64 COO	min 4.570 max 4.870 mean 4.776	
	CSR	min 5.770 max 6.510 mean 6.302	
Column-Gradient	H	min 10.464 max 10.473 mean 10.468	TSOPF_RS_b39_c7.mtx Regular
	GPU 64 COO	min 4.580 max 4.870 mean 4.756	
	CSR	min 5.630 max 6.180 mean 6.055	
Row-Column-Permute	H	min 11.394 max*11.401 mean 11.397	GPU 64 COO min 4.300 max* 4.430 mean 4.364 CSR min 4.480 max 4.750 mean 4.716 H min 7.304 max 7.304 mean 7.304
	GPU 64 COO	min 4.610 max 4.900 mean 4.780	
	CSR	min 5.010 max 6.300 mean 6.113	
OPF_6000.mtx Regular	H	min 11.268 max 11.272 mean 11.270	GPU 64 COO min 4.260 max 4.400 mean 4.353 CSR min 4.490 max 4.770 mean 4.734 H min 10.536 max 10.541 mean 10.539
	GPU 64 COO	min 3.780 max* 3.920 mean 3.864	
	CSR	min 4.270 max 4.360 mean 4.332	
Row-Premute	H	min 8.799 max 8.799 mean 8.799	GPU 64 COO min 3.970 max 4.420 mean 4.338 CSR min 4.620 max* 4.820 mean 4.789 H min 9.638 max 9.644 mean 9.641
	GPU 64 COO	min 3.770 max 3.870 mean 3.821	
	CSR	min 3.970 max*11.050 mean 4.439	
Row-Gradient	H	min 11.872 max 11.877 mean 11.875	GPU 64 COO min 4.240 max 4.430 mean 4.368 CSR min 4.710 max 4.770 mean 4.736 H min 11.129 max*11.222 mean 11.205
	GPU 64 COO	min 3.700 max 3.870 mean 3.795	
	CSR	min 4.330 max 4.440 mean 4.403	
Column-Gradient	H	min 11.109 max 11.116 mean 11.113	GPU 64 COO min 4.260 max 4.410 mean 4.359 CSR min 4.660 max 4.760 mean 4.738 H min 10.537 max 10.541 mean 10.539
	GPU 64 COO	min 3.690 max 3.870 mean 3.804	
	CSR	min 4.260 max 4.340 mean 4.308	
Row-Column-Permute	H	min 12.041 max*12.045 mean 12.043	GPU 64 COO min 5.140 max* 5.140 mean 5.140 CSR min 10.340 max*10.390 mean 10.365 H min 9.689 max 9.689 mean 9.689
	GPU 64 COO	min 3.780 max 3.860 mean 3.819	
	CSR	min 4.090 max 4.290 mean 4.259	
shermanACb.mtx Regular	H	min 11.873 max 11.877 mean 11.876	GPU 64 COO min 4.970 max 4.990 mean 4.980 CSR min 9.420 max 9.430 mean 9.425 H min 10.739 max 10.739 mean 10.739
	GPU 64 COO	min 2.920 max* 3.140 mean 3.048	
	CSR	min 5.550 max 5.980 mean 5.803	
Row-Premute	H	min 8.600 max 8.600 mean 8.600	GPU 64 COO min 5.080 max 5.090 mean 5.085 CSR min 9.720 max 10.300 mean 10.010 H min 10.579 max 10.582 mean 10.580
	GPU 64 COO	min 2.760 max 3.020 mean 2.898	
	CSR	min 2.660 max 5.830 mean 5.632	
Row-Gradient	H	min 10.377 max 10.381 mean 10.379	GPU 64 COO min 5.030 max 5.120 mean 5.075 CSR min 9.330 max 9.770 mean 9.550 H min 10.835 max*10.838 mean 10.836
	GPU 64 COO	min 2.800 max 3.040 mean 2.944	
	CSR	min 5.330 max* 6.020 mean 5.742	
Column-Gradient	H	min 9.919 max 9.925 mean 9.922	GPU 64 COO min 5.000 max 5.010 mean 5.005 CSR min 7.580 max 9.460 mean 8.520 H min 10.739 max 10.741 mean 10.740
	GPU 64 COO	min 2.720 max 3.010 mean 2.926	
	CSR	min 0.000 max 5.840 mean 5.513	
Row-Column-Permute	H	min 10.587 max*10.596 mean 10.591	GPU 64 COO min 5.140 max* 5.140 mean 5.140 CSR min 10.340 max*10.390 mean 10.365 H min 9.689 max 9.689 mean 9.689
	GPU 64 COO	min 2.780 max 3.030 mean 2.939	
	CSR	min 4.860 max 5.810 mean 5.667	
TSOPF_FS_b9_c6.mtx Regular	H	min 10.376 max 10.382 mean 10.379	GPU 64 COO min 4.970 max 4.990 mean 4.980 CSR min 9.420 max 9.430 mean 9.425 H min 10.739 max 10.739 mean 10.739
	GPU 64 COO	min 0.000 max 0.000 mean 0.000	
	CSR	min 0.000 max 0.000 mean 0.000	
Row-Premute	H	min 7.380 max 7.380 mean 7.380	GPU 64 COO min 5.080 max 5.090 mean 5.085 CSR min 9.720 max 10.300 mean 10.010 H min 10.579 max 10.582 mean 10.580
	GPU 64 COO	min 0.000 max 0.000 mean 0.000	
	CSR	min 0.000 max 0.000 mean 0.000	

## 11 FIJI

mult\_dcop\_03.mtx  
Regular

Row-Premute

Row-Gradient

Column-Gradient

Row-Column-Permute

mult\_dcop\_03.mtx  
Regular

Row-Premute

Row-Gradient

Column-Gradient	GPU 64 COO min 5.030 max 5.120 mean 5.075				Row-Premute	CSR min 6.360 max 7.450 mean 6.711				
	CSR min 9.330 max 9.770 mean 9.550					H min 11.109 max 11.109 mean 11.109				
	H min 10.835 max*10.838 mean 10.836					GPU 64 COO min 3.950 max* 3.980 mean 3.953				
Row-Column-Permute	GPU 64 COO min 5.000 max 5.010 mean 5.005				Row-Gradient	CSR min 6.330 max 7.400 mean 6.661				
	CSR min 7.580 max 9.460 mean 8.520					H min 11.098 max 11.104 mean 11.101				
	H min 10.739 max 10.741 mean 10.740					GPU 64 COO min 3.960 max 3.980 mean 3.961				
mult_dcop_03.mtx Regular	GPU 64 COO min 5.130 max* 5.220 mean 5.142				Column-Gradient	CSR min 6.270 max*10.770 mean 7.017				
	CSR min 7.250 max* 9.320 mean 7.722					H min 11.109 max 11.109 mean 11.109				
	H min 9.689 max 9.689 mean 9.689					GPU 64 COO min 3.940 max 3.960 mean 3.950				
Row-Premute	GPU 64 COO min 4.980 max 5.030 mean 4.999				Row-Column-Permute	CSR min 6.270 max 7.370 mean 6.696				
	CSR min 6.460 max 8.470 mean 6.950					H min 11.329 max*11.334 mean 11.331				
	H min 10.738 max 10.742 mean 10.740					GPU 64 COO min 3.950 max 3.960 mean 3.952				
Row-Gradient	GPU 64 COO min 5.070 max 5.140 mean 5.088				bloweya.mtx Regular	CSR min 6.180 max 7.420 mean 6.641				
	CSR min 6.780 max 8.700 mean 7.268					H min 11.098 max 11.105 mean 11.101				
	H min 10.572 max 10.584 mean 10.580					GPU 64 COO min 0.000 max 0.000 mean 0.000				
Column-Gradient	GPU 64 COO min 4.980 max 5.030 mean 5.010				Row-Premute	CSR min 0.000 max 0.000 mean 0.000				
	CSR min 6.390 max 7.640 mean 6.982					H min 7.205 max 7.205 mean 7.205				
	H min 10.825 max*10.845 mean 10.836					GPU 64 COO min 4.020 max 4.030 mean 4.023				
Row-Column-Permute	GPU 64 COO min 4.990 max 5.010 mean 4.997				Row-Gradient	CSR min 6.070 max 6.750 mean 6.340				
	CSR min 6.300 max 7.160 mean 6.636					H min 11.025 max 11.031 mean 11.028				
	H min 10.738 max 10.743 mean 10.740					GPU 64 COO min 4.090 max* 4.160 mean 4.111				
mult_dcop_01.mtx Regular	GPU 64 COO min 5.120 max* 5.140 mean 5.134				Column-Gradient	CSR min 5.980 max* 7.370 mean 6.678				
	CSR min 6.990 max* 9.230 mean 7.546					H min 10.295 max 10.304 mean 10.300				
	H min 9.689 max 9.689 mean 9.689					GPU 64 COO min 3.980 max 4.010 mean 3.995				
Row-Premute	GPU 64 COO min 4.990 max 5.020 mean 5.004				Row-Column-Permute	CSR min 5.880 max 6.780 mean 6.295				
	CSR min 6.370 max 7.220 mean 6.771					H min 10.881 max*10.887 mean 10.883				
	H min 10.738 max 10.743 mean 10.740					GPU 64 COO min 4.020 max 4.030 mean 4.023				
Row-Gradient	GPU 64 COO min 5.060 max 5.100 mean 5.082				lp_osa_07.mtx Regular	CSR min 5.970 max 6.420 mean 6.183				
	CSR min 6.730 max 7.720 mean 7.317					H min 11.025 max 11.033 mean 11.028				
	H min 10.574 max 10.585 mean 10.580					GPU 64 COO min 4.260 max* 4.270 mean 4.261				
Column-Gradient	GPU 64 COO min 4.980 max 5.100 mean 5.012				Row-Premute	CSR min 6.440 max 7.640 mean 6.863				
	CSR min 6.580 max 7.510 mean 7.054					H min 8.412 max 8.412 mean 8.412				
	H min 10.828 max*10.842 mean 10.835					GPU 64 COO min 4.200 max 4.200 mean 4.200				
Row-Column-Permute	GPU 64 COO min 4.970 max 5.000 mean 4.986				Row-Gradient	CSR min 6.020 max 7.030 mean 6.418				
	CSR min 6.390 max 7.050 mean 6.677					H min 9.255 max 9.257 mean 9.256				
	H min 10.738 max 10.742 mean 10.740					GPU 64 COO min 4.210 max 4.240 mean 4.226				
mult_dcop_02.mtx Regular	GPU 64 COO min 5.120 max 5.140 mean 5.133				Column-Gradient	CSR min 6.070 max*10.050 mean 6.498				
	CSR min 6.950 max 7.590 mean 7.336					H min 8.607 max 8.678 mean 8.671				
	H min 9.689 max 9.689 mean 9.689					GPU 64 COO min 4.170 max 4.190 mean 4.180				
Row-Premute	GPU 64 COO min 4.970 max 4.990 mean 4.984				Row-Column-Permute	CSR min 5.610 max 7.300 mean 5.988				
	CSR min 6.440 max 7.110 mean 6.719					H min 9.534 max* 9.601 mean 9.585				
	H min 10.738 max 10.742 mean 10.740					GPU 64 COO min 4.190 max 4.190 mean 4.190				
Row-Gradient	GPU 64 COO min 5.070 max* 5.150 mean 5.086				ex19.mtx Regular	CSR min 6.070 max 7.000 mean 6.386				
	CSR min 6.650 max* 7.930 mean 7.304					H min 9.255 max 9.257 mean 9.256				
	H min 10.574 max 10.587 mean 10.580					GPU 64 COO min 6.140 max* 6.180 mean 6.159				
Column-Gradient	GPU 64 COO min 4.980 max 5.040 mean 5.012				Row-Premute	CSR min 12.780 max*14.400 mean 13.328				
	CSR min 6.520 max 7.650 mean 7.139					H min 8.228 max 8.228 mean 8.228				
	H min 10.829 max*10.846 mean 10.836					GPU 64 COO min 5.820 max 5.850 mean 5.833				
Row-Column-Permute	GPU 64 COO min 4.970 max 5.050 mean 4.983				Row-Gradient	CSR min 9.870 max 11.070 mean 10.372				
	CSR min 6.440 max 7.380 mean 6.779					H min 11.836 max 11.840 mean 11.838				
	H min 10.738 max 10.743 mean 10.740					GPU 64 COO min 6.070 max 6.120 mean 6.104				
lp_fit2d.mtx Regular	GPU 64 COO min 3.960 max 3.960 mean 3.960				Column-Gradient	CSR min 11.290 max 12.760 mean 12.088				
						H min 10.743 max 10.752 mean 10.748				

brainpc2.mtx Regular	Row-Column-Permute	GPU 64 COO min 5.760 max 5.840 mean 5.813 CSR min 9.710 max 14.220 mean 10.376 H min 11.873 max*11.882 mean 11.878	Row-Premute	H min 7.380 max 7.380 mean 7.380
		GPU 64 COO min 5.810 max 5.860 mean 5.838 CSR min 9.920 max 10.820 mean 10.240 H min 11.836 max 11.841 mean 11.838		GPU 64 COO min 4.130 max 4.170 mean 4.134 CSR min 6.180 max* 9.200 mean 6.796 H min 10.041 max 10.046 mean 10.044
		GPU 64 COO min 0.000 max 0.000 mean 0.000 CSR min 0.000 max 0.000 mean 0.000 H min 7.478 max 7.478 mean 7.478		GPU 64 COO min 4.150 max* 4.220 mean 4.163 CSR min 6.410 max 7.500 mean 6.816 H min 9.682 max 9.706 mean 9.693
shermanACb.mtx Regular	Row-Premute	GPU 64 COO min 4.760 max 4.790 mean 4.773 CSR min 6.930 max 7.780 mean 7.310 H min 9.810 max 9.813 mean 9.811	Column-Gradient	GPU 64 COO min 4.080 max 4.110 mean 4.096 CSR min 6.020 max 7.220 mean 6.309 H min 10.597 max*10.658 mean 10.631
		GPU 64 COO min 4.820 max* 4.840 mean 4.831 CSR min 7.220 max 8.290 mean 7.583 H min 9.721 max 9.725 mean 9.723		GPU 64 COO min 4.120 max 4.140 mean 4.130 CSR min 6.210 max 7.200 mean 6.609 H min 10.041 max 10.046 mean 10.044
		GPU 64 COO min 4.760 max 4.820 mean 4.779 CSR min 6.870 max* 8.300 mean 7.393 H min 10.368 max*10.373 mean 10.370		TSOPF_FS_b9_c6.mtx Regular
cvxqp3.mtx Regular	Column-Gradient	GPU 64 COO min 4.750 max 4.780 mean 4.765 CSR min 6.940 max 7.580 mean 7.298 H min 9.809 max 9.814 mean 9.811	Row-Premute	GPU 64 COO min 0.000 max 0.000 mean 0.000 CSR min 0.000 max 0.000 mean 0.000 H min 7.380 max 7.380 mean 7.380
		GPU 64 COO min 4.090 max* 4.130 mean 4.112 CSR min 6.320 max* 7.200 mean 6.779 H min 8.600 max 8.600 mean 8.600		GPU 64 COO min 4.120 max 4.140 mean 4.129 CSR min 6.170 max 7.160 mean 6.664 H min 10.041 max 10.045 mean 10.043
		GPU 64 COO min 4.020 max 4.050 mean 4.036 CSR min 5.670 max 6.460 mean 6.014 H min 10.376 max 10.382 mean 10.379		GPU 64 COO min 4.150 max* 4.180 mean 4.162 CSR min 6.420 max 7.360 mean 6.723 H min 9.682 max 9.706 mean 9.693
case9.mtx Regular	Row-Gradient	GPU 64 COO min 4.050 max 4.100 mean 4.074 CSR min 5.580 max 6.420 mean 5.996 H min 9.918 max 9.924 mean 9.921	Row-Column-Permute	GPU 64 COO min 4.080 max 4.120 mean 4.096 CSR min 5.880 max 7.090 mean 6.403 H min 10.611 max*10.660 mean 10.637
		GPU 64 COO min 4.010 max 4.080 mean 4.033 CSR min 0.000 max 6.320 mean 5.527 H min 10.543 max*10.595 mean 10.589		GPU 64 COO min 4.130 max 4.140 mean 4.130 CSR min 6.330 max* 7.390 mean 6.695 H min 10.042 max 10.047 mean 10.044
		GPU 64 COO min 4.020 max 4.050 mean 4.036 CSR min 5.670 max 6.510 mean 6.092 H min 10.377 max 10.381 mean 10.379		OPF_6000.mtx Regular
case9.mtx Regular	Column-Gradient	GPU 64 COO min 3.500 max* 3.540 mean 3.501 CSR min 11.860 max*13.100 mean 12.694 H min 8.646 max 8.646 mean 8.646	Row-Premute	GPU 64 COO min 7.270 max* 7.370 mean 7.293 CSR min 12.890 max*14.500 mean 13.566 H min 8.799 max 8.799 mean 8.799
		GPU 64 COO min 3.360 max 3.370 mean 3.365 CSR min 6.210 max 7.610 mean 6.631 H min 11.027 max 11.032 mean 11.030		GPU 64 COO min 6.640 max 6.720 mean 6.678 CSR min 9.680 max 11.600 mean 10.040 H min 11.873 max 11.877 mean 11.875
		GPU 64 COO min 3.370 max 3.380 mean 3.376 CSR min 6.170 max 7.070 mean 6.499 H min 11.059 max 11.068 mean 11.064		GPU 64 COO min 7.090 max 7.140 mean 7.122 CSR min 11.250 max 13.030 mean 12.142 H min 11.110 max 11.117 mean 11.114
case9.mtx Regular	Row-Column-Permute	GPU 64 COO min 3.350 max 3.390 mean 3.371 CSR min 6.150 max 7.180 mean 6.531 H min 11.125 max*11.133 mean 11.130	Column-Gradient	GPU 64 COO min 6.590 max 6.710 mean 6.644 CSR min 9.400 max 13.140 mean 9.991 H min 12.040 max*12.046 mean 12.043
		GPU 64 COO min 3.350 max 3.380 mean 3.364 CSR min 6.040 max 7.440 mean 6.603 H min 11.028 max 11.033 mean 11.030		GPU 64 COO min 6.640 max 6.710 mean 6.679 CSR min 9.690 max 10.740 mean 10.050 H min 11.874 max 11.877 mean 11.875
		GPU 64 COO min 0.000 max 0.000 mean 0.000 CSR min 0.000 max 0.000 mean 0.000		OPF_3754.mtx Regular
case9.mtx Regular	Row-Gradient		Row-Premute	GPU 64 COO min 4.430 max* 4.450 mean 4.443 CSR min 9.710 max*13.000 mean 11.377 H min 8.393 max 8.393 mean 8.393
				GPU 64 COO min 4.230 max 4.250 mean 4.240 CSR min 7.430 max 8.750 mean 7.986 H min 11.266 max 11.272 mean 11.269
				GPU 64 COO min 4.370 max 4.420 mean 4.382 CSR min 8.160 max 9.470 mean 8.682 H min 10.462 max 10.473 mean 10.468
case9.mtx Regular	Column-Gradient		Column-Gradient	GPU 64 COO min 4.210 max 4.240 mean 4.227



Row-Column-Permute	H	CSR min 7.160 max 8.080 mean 7.595	Row-Premute	GPU 64 COO min 10.340 max 10.430 mean 10.362
		min 11.394 max*11.401 mean 11.398		CSR min 12.880 max 13.340 mean 13.057
		GPU 64 COO min 4.230 max 4.250 mean 4.243		H min 10.777 max 10.778 mean 10.777
		CSR min 7.230 max 8.940 mean 8.056		Row-Gradient
c-47.mtx Regular	H	min 11.264 max 11.271 mean 11.269		GPU 64 COO min 10.650 max*10.740 mean 10.688
		GPU 64 COO min 5.320 max* 5.340 mean 5.329		CSR min 12.310 max 13.670 mean 12.562
		CSR min 8.890 max* 9.590 mean 9.249		H min 11.247 max 11.300 mean 11.281
		H min 8.364 max 8.364 mean 8.364		Column-Gradient
Row-Premute	GPU 64 COO min	5.240 max 5.250 mean 5.241		GPU 64 COO min 10.340 max 10.440 mean 10.398
		CSR min 7.790 max 8.890 mean 8.214		CSR min 9.480 max 10.110 mean 9.782
		H min 10.059 max 10.063 mean 10.061		H min 12.023 max*12.069 mean 12.047
		GPU 64 COO min 5.240 max 5.260 mean 5.241		Row-Column-Permute
Row-Gradient	CSR min	7.790 max 8.890 mean 8.214		GPU 64 COO min 10.330 max 10.380 mean 10.356
		H min 10.059 max 10.063 mean 10.061		CSR min 12.840 max 13.530 mean 13.119
		GPU 64 COO min 5.230 max 5.260 mean 5.242		H min 10.776 max 10.778 mean 10.777
		CSR min 7.080 max 8.050 mean 7.673		aft01.mtx Regular
Column-Gradient	H	min 10.206 max 10.226 mean 10.218		GPU 64 COO min 3.680 max* 3.690 mean 3.688
		GPU 64 COO min 5.080 max 5.120 mean 5.105		CSR min 13.860 max*14.830 mean 14.560
		CSR min 5.780 max 6.970 mean 6.359		H min 7.811 max 7.811 mean 7.811
		H min 11.205 max*11.233 mean 11.222		Row-Premute
Row-Column-Permute	GPU 64 COO min	5.220 max 5.250 mean 5.227	GPU 64 COO min 3.510 max 3.530 mean 3.513	
		CSR min 7.860 max 8.710 mean 8.247	CSR min 6.420 max 10.520 mean 7.265	
		H min 10.059 max 10.064 mean 10.061	H min 11.161 max*11.170 mean 11.165	
		GPU 64 COO min 3.630 max 3.670 mean 3.643	Row-Gradient	
mhd4800a.mtx Regular	CSR min	10.760 max 13.510 mean 12.199	GPU 64 COO min 3.630 max 3.670 mean 3.643	
		H min 10.248 max 10.265 mean 10.258	CSR min 10.760 max 13.510 mean 12.199	
		GPU 64 COO min 3.090 max* 3.100 mean 3.098	H min 10.248 max 10.265 mean 10.258	
		CSR min 11.570 max*12.290 mean 12.092	Column-Gradient	
Row-Premute	H	min 7.132 max 7.132 mean 7.132	GPU 64 COO min 3.510 max 3.520 mean 3.519	
		GPU 64 COO min 3.020 max 3.020 mean 3.020	CSR min 6.490 max 11.230 mean 7.645	
		CSR min 5.560 max 7.270 mean 6.007	H min 11.112 max 11.121 mean 11.117	
		H min 10.959 max*10.968 mean 10.963	Row-Column-Permute	
Row-Gradient	GPU 64 COO min	3.020 max 3.020 mean 3.020	GPU 64 COO min 3.510 max 3.540 mean 3.515	
		CSR min 5.560 max 7.270 mean 6.007	CSR min 6.510 max 11.650 mean 7.311	
		H min 10.959 max*10.968 mean 10.963	H min 11.161 max 11.168 mean 11.165	
		GPU 64 COO min 3.080 max 3.100 mean 3.088	TSOPF_RS_b39_c7.mtx Regular	
Column-Gradient	CSR min	10.250 max 12.150 mean 11.340	GPU 64 COO min 5.970 max* 6.010 mean 5.988	
		H min 9.509 max 9.528 mean 9.520	CSR min 12.470 max*21.120 mean 13.816	
		GPU 64 COO min 3.020 max 3.050 mean 3.026	H min 7.304 max 7.304 mean 7.304	
		CSR min 5.530 max 10.580 mean 6.432	Row-Premute	
Row-Column-Permute	H	min 10.933 max 10.946 mean 10.939	GPU 64 COO min 5.840 max 5.870 mean 5.856	
		GPU 64 COO min 3.020 max 3.020 mean 3.020	CSR min 10.780 max 15.810 mean 11.425	
		CSR min 5.510 max 6.830 mean 6.136	H min 10.537 max 10.540 mean 10.539	
		H min 10.959 max 10.967 mean 10.963	Row-Gradient	
gen4.mtx Regular	GPU 64 COO min	3.020 max 3.020 mean 3.020	GPU 64 COO min 5.950 max 6.000 mean 5.975	
		CSR min 5.510 max 6.830 mean 6.136	CSR min 11.520 max 17.250 mean 12.799	
		H min 10.959 max 10.967 mean 10.963	H min 9.638 max 9.646 mean 9.641	
		GPU 64 COO min 3.300 max* 3.320 mean 3.308	Column-Gradient	
Row-Premute	CSR min	5.250 max 6.340 mean 5.705	GPU 64 COO min 5.790 max 5.860 mean 5.827	
		H min 9.234 max 9.234 mean 9.234	CSR min 10.500 max 14.080 mean 11.237	
		GPU 64 COO min 3.290 max 3.310 mean 3.299	H min 11.128 max*11.223 mean 11.209	
		CSR min 5.190 max 7.420 mean 5.683	Row-Column-Permute	
Row-Gradient	H	min 10.249 max 10.254 mean 10.252	GPU 64 COO min 5.850 max 5.870 mean 5.855	
		GPU 64 COO min 3.300 max 3.310 mean 3.301	CSR min 10.790 max 15.250 mean 11.718	
		CSR min 5.370 max 6.310 mean 5.659	H min 10.537 max 10.541 mean 10.539	
		H min 9.934 max 9.958 mean 9.948	mult_dcop_03.mtx Regular	
Column-Gradient	GPU 64 COO min	3.300 max 3.310 mean 3.301	GPU 64 COO min 5.130 max* 5.220 mean 5.142	
		CSR min 5.370 max 6.310 mean 5.659	CSR min 7.250 max* 9.320 mean 7.722	
		H min 9.934 max 9.958 mean 9.948	H min 9.689 max 9.689 mean 9.689	
		GPU 64 COO min 3.240 max 3.260 mean 3.249	Row-Premute	
Row-Column-Permute	CSR min	5.090 max* 8.660 mean 5.546	GPU 64 COO min 4.980 max 5.030 mean 4.999	
		H min 10.853 max*10.873 mean 10.864	CSR min 6.460 max 8.470 mean 6.950	
		GPU 64 COO min 3.290 max 3.320 mean 3.296	H min 10.738 max 10.742 mean 10.740	
		CSR min 5.190 max 7.550 mean 5.659	Row-Gradient	
Maragal_6.mtx Regular	H	min 10.249 max 10.255 mean 10.252	GPU 64 COO min 5.070 max 5.140 mean 5.088	
		GPU 64 COO min 10.580 max 10.620 mean 10.599	CSR min 6.780 max 8.700 mean 7.268	
		CSR min 15.620 max*16.470 mean 15.832	H min 10.572 max 10.584 mean 10.580	
		H min 9.930 max 9.930 mean 9.930	Column-Gradient	
	GPU 64 COO min	4.980 max 5.030 mean 5.010	GPU 64 COO min 4.980 max 5.030 mean 5.010	
		CSR min 6.390 max 7.640 mean 6.982	CSR min 6.390 max 7.640 mean 6.982	

Row-Column-Permute	H	min	10.825	max	10.845	mean	10.836
	GPU 64 COO	min	4.990	max	5.010	mean	4.997
	CSR	min	6.300	max	7.160	mean	6.636
	H	min	10.738	max	10.743	mean	10.740