CME SPAN Algorithm on FPGA

Pramod Nayak (ppn2106@columbia.edu)
Ankit Pradhan (ap3188@columbia.edu)
Vidhatre Gathey (vvg@2111@columbia.edu)
Bharav Sethuam (bs2184@columbia.edu)

Overview

- Explanation of basic concepts
- The CME SPAN Algorithm
- Hardware Implementation
- Example Computation
- Lessons Learnt & Advice to the other groups

What are Futures ?

- A futures contract allows a trader to undertake a contract to accept or make delivery of a commodity or some kind of financial asset essentially in the

(a) future on a known date,

(b) under specified conditions,

(c) for a price contracted today.

Types of Futures

- When a trader is in a long trade, they have entered a trade by buying a contract (or group of shares, or forex lot), and are hoping that the price will go up.
- When a trader is in a short trade, they have entered a trade by selling a contract (or group of shares, or forex lot), and are hoping that the price will go down.

Example

Gold	Silver
Long	Short
1000 shares	1500 shares
33 $	22 $

Example

After 60 days

Gold	Silver
Long	Short
1000 shares	1500 shares
35 $	21 $

Why Initial Margin Requirements?

- Changing Demands in Futures Services
- Cost of doing transactions

Which are directly dependent on –

- Changes in the General Economy
- Especially in Agriculture

When is it calculated ?

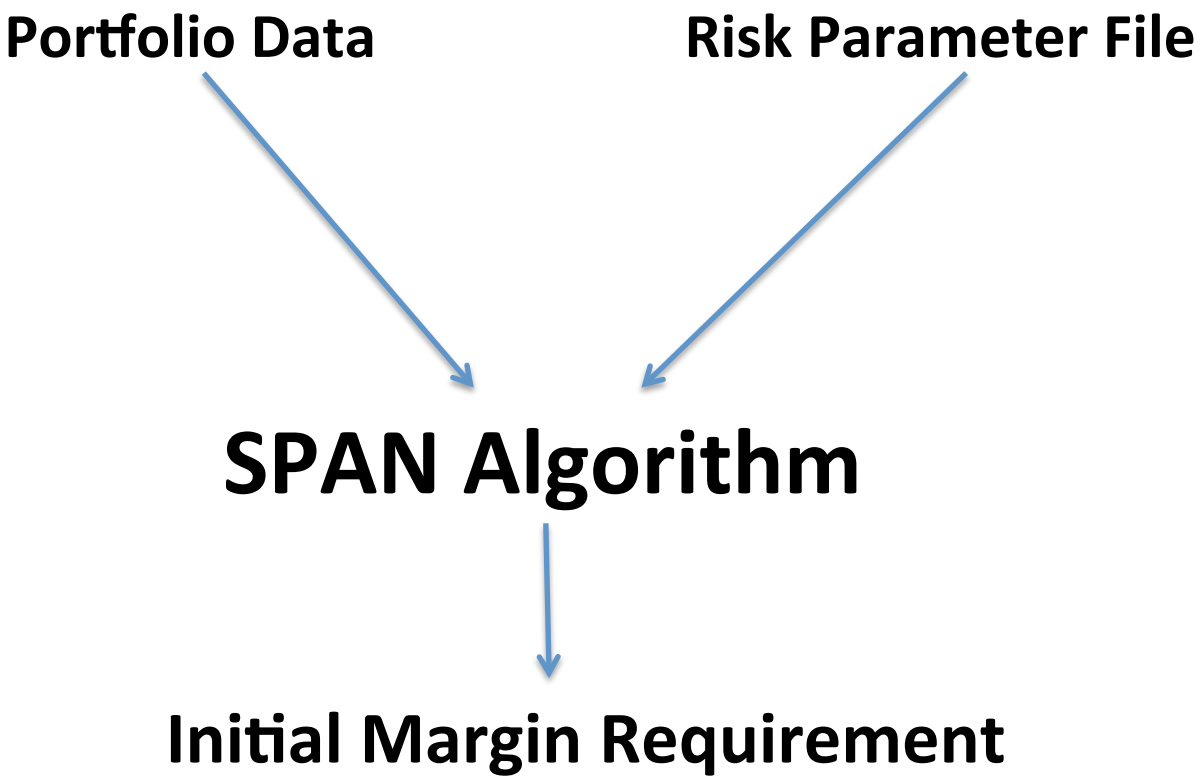
- In clearing organizations –

Value of contract is “marked to the Market”

Which means losses and gains related to the changing value of the contract are settled by the end of the day.

SPAN Methodology developed by Chicago Mercantile Exchange is used by most of the organizations to calculate margins on futures and options.

SPAN Algorithm



SPAN Algorithm

The algorithm is made up of four modules:

- Scanning Risk
- Intra Commodity Spread Credit
- Inter Commodity Spread Credit
- Short Option Charge.

Main basis of SPAN

- SPAN is based on the division of orders of financial instruments into so-called **combined commodities**, groupings of orders that share the same underlying asset.
- In other words, a portfolio containing futures contracts and options on futures contracts is segmented into different bins (combined commodities).

Scanning Risk

- Performed on a combined commodity level assuming correlations in price and volatility movements of the underlying instruments over time.

- More like an outcome of the stress tests in the risk array.

- The 16 risk scenarios are all different combinations of movements in price & implied volatility
  futures contracts, with applied weights to vary probabilities for these movements .

Scanning Risk

- Each bin of orders in the portfolio with the same underlying asset is subjected to a series of 16 different risk scenarios.
- Two parameters are used –

  Price Scan Range

  Volatility Scan Range

- What about the contracts with different maturity within the same commodity that is netted out during the Scanning risk process ???

Intra Commodity Spread Credit

- Evaluates the basis risk between contract with different expirations within the same commodity.
- There imperfect correlation of price and volatility movements over time .

- SPAN includes option contracts using the option's delta to create futures equivalent positions.

In this way the **true Inter-Month Spread Charge** is observed.

What if the portfolio contains multiple commodities ???

Cross Commodity Charge

- Performed in order to recognize the risk reducing aspects of the portfolio's containing multiple commodities containing offsetting positions in highly correlated instruments.

- The Inter-Commodity Spread Credits are formed taking into account:

  1) Which products are related, thereby, authorizing margin reduction for spread positions;

  2) The ratio of positions that must be present in an account for the spread to be applied;

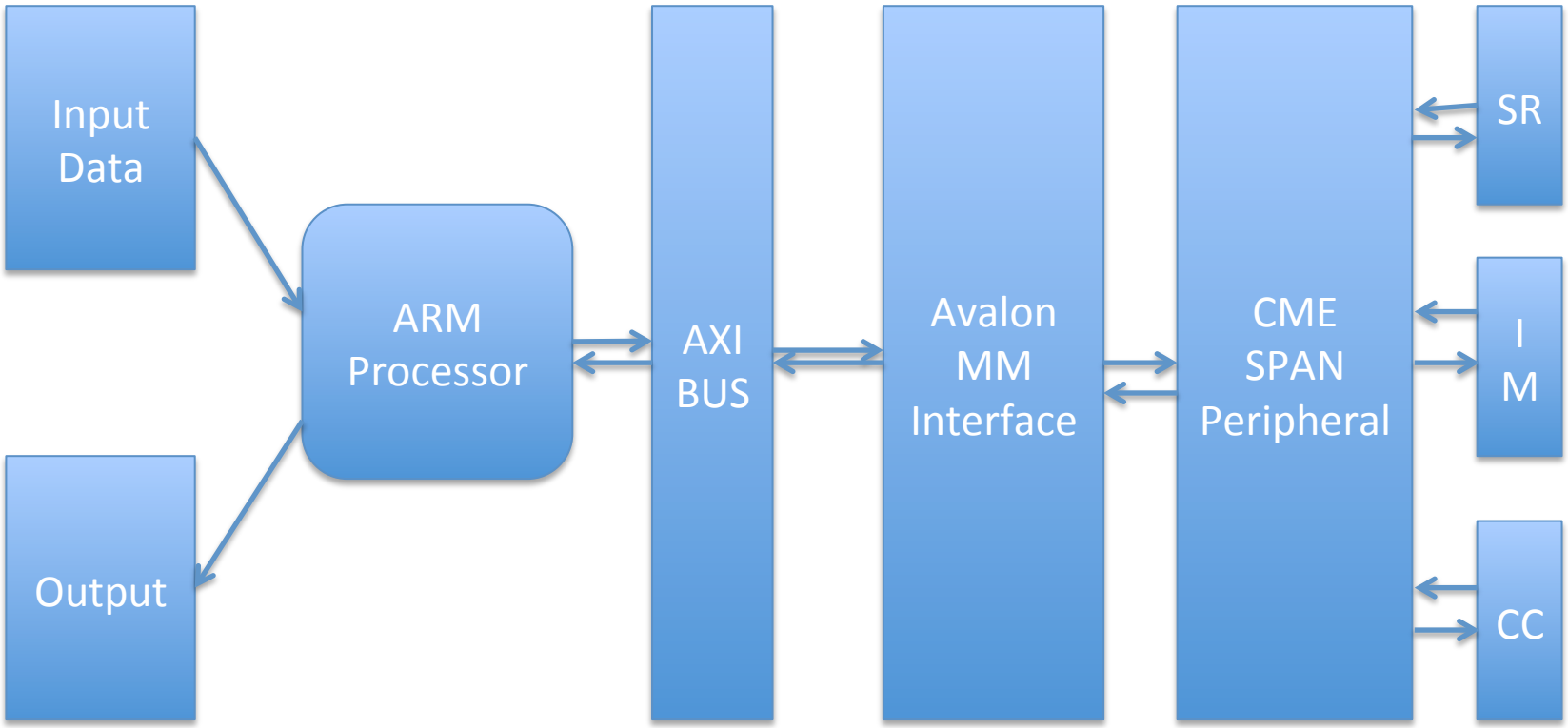
  3) The amount of the spread credit; and

  4) The priority for applying spreads.

Short Option Charge

- Deep out-of-the-money options may present more risk to the portfolio than the scanning range covers.
- The Short Option Minimum is not a charge to be added to the portfolio risk. Rather, it is the absolute minimum margin assessed to a portfolio.

Hardware Implementation



Computation

- Parameters Independent of each other .
- Therefore the three modules are computed based on the availability of the required data.

The Inter Month Spread Charge is computed with the help of an FSM, which decides when a particular sub-module (Tier Spread Charge) be computed.

Working Example

Input Parameters

- Price Scan Range – 96 $

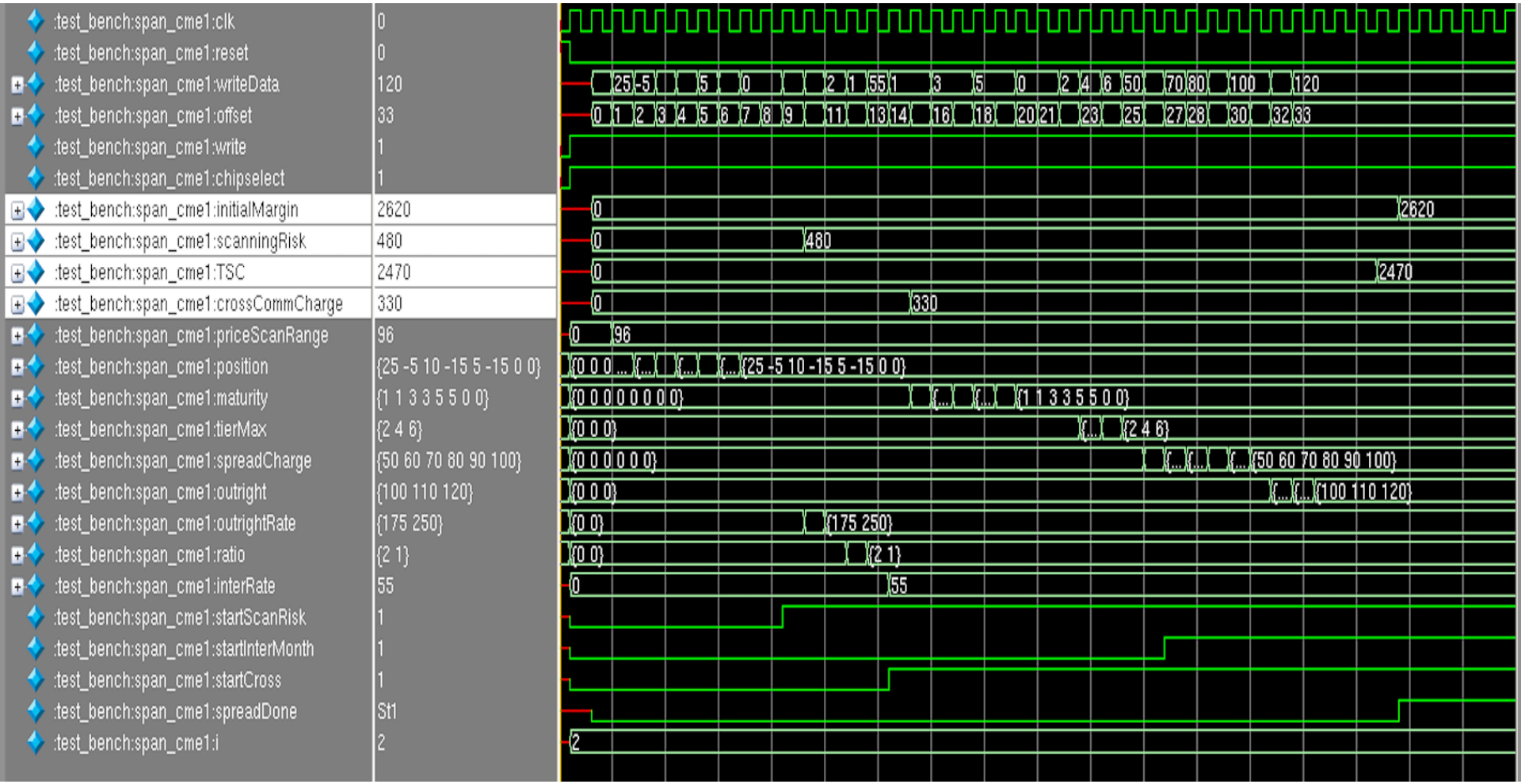
- Risk Parameter File –
  Risk Array File
  Outright Rate – Gold 175 $, Silver 250 $
  Ratio – 2:1
  Inter Rate – 55 %
  Tier Spread Table

Tier	Maturity	Tier 1	Tier 2	Tier 3
Tier 1	0-1 months	50 USD	X	X
Tier 2	1-2 months	80 USD	60 USD	X
Tier 3	2-3 months	90 USD	100 USD	70 USD

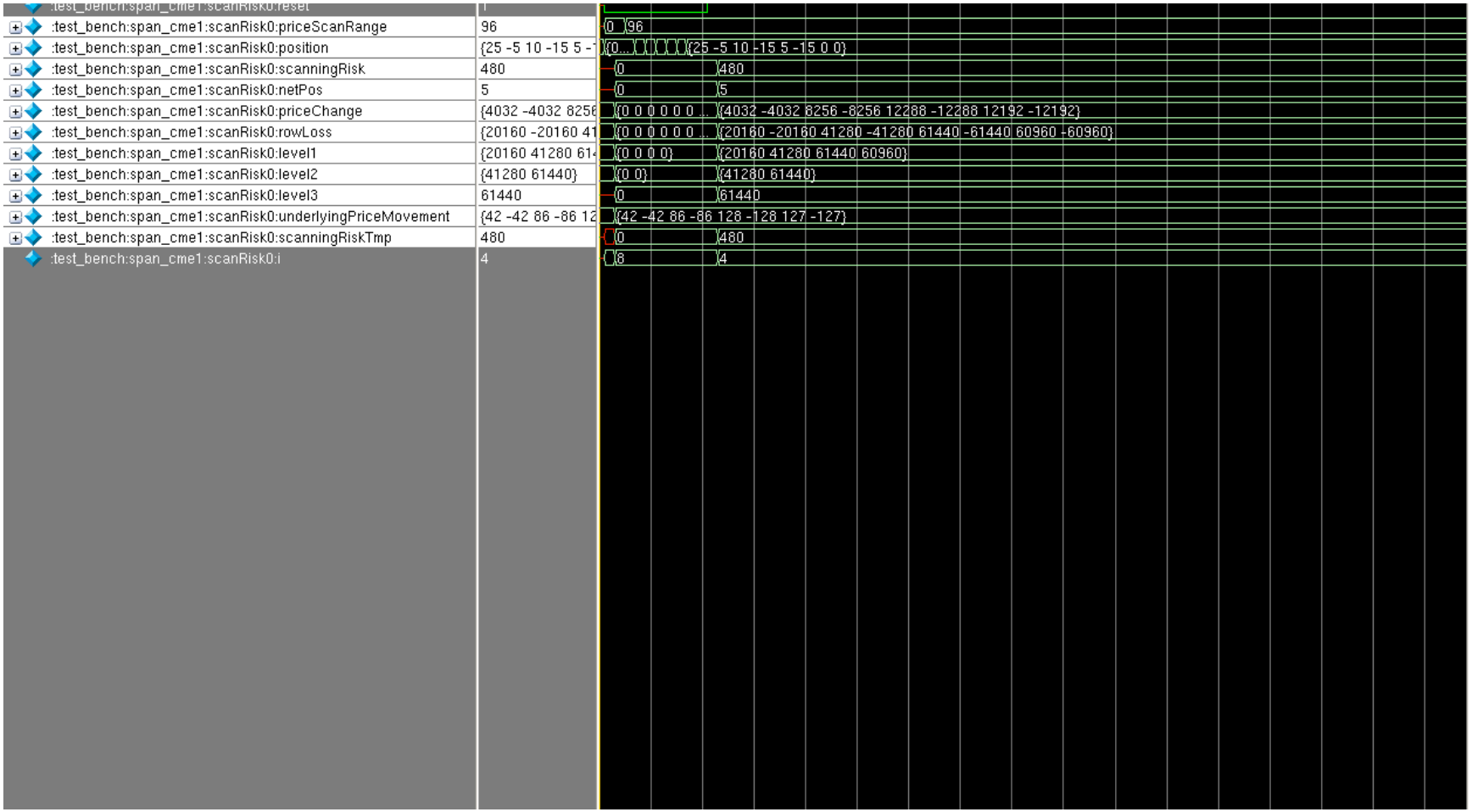
Sample Portfolio

Instrument	Future	Future	Future	Future	Future	Future
Position	15	-5	10	-15	5	5
Maturity	1	1	3	3	5	5

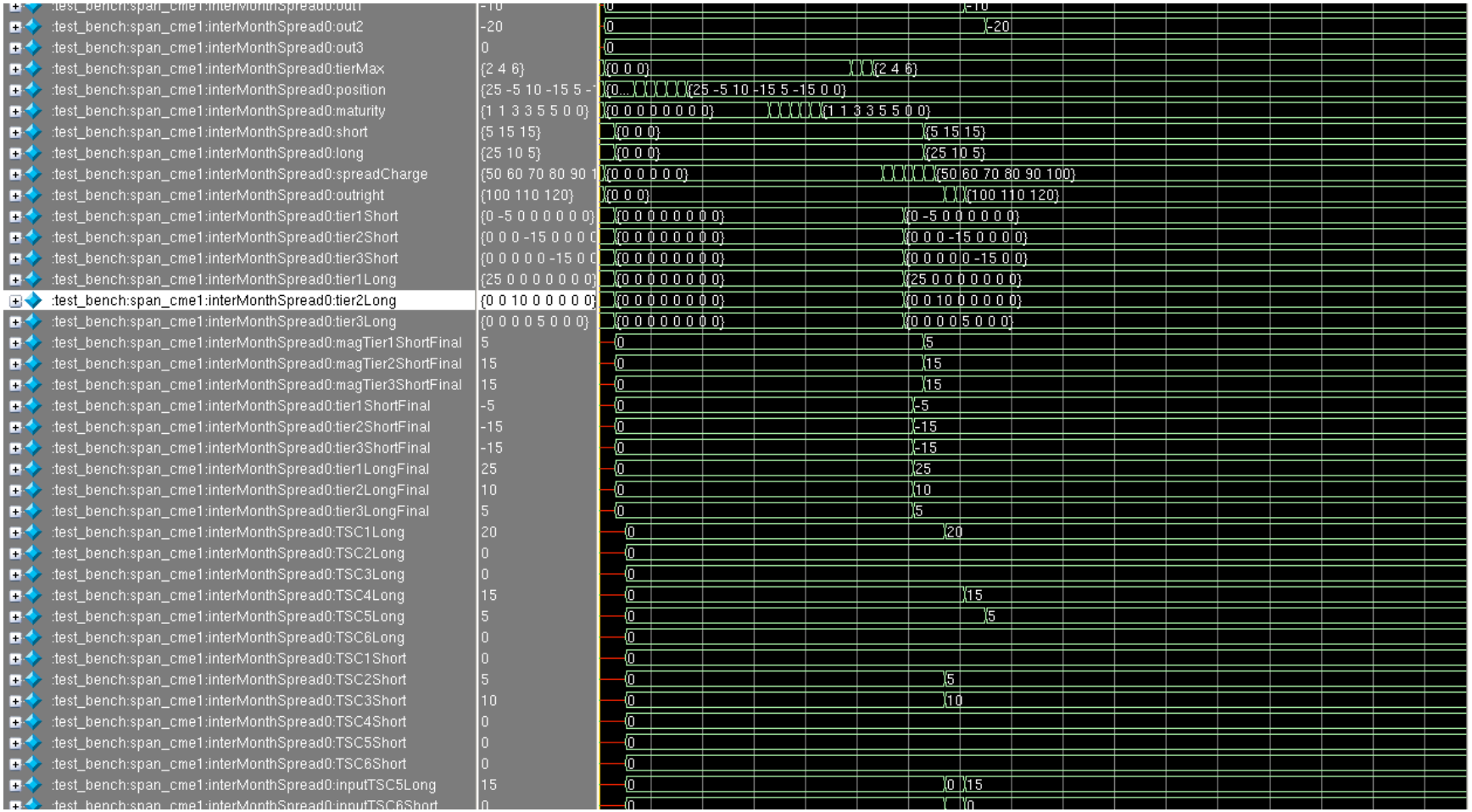
ModelSim Simulation of the Algorithm



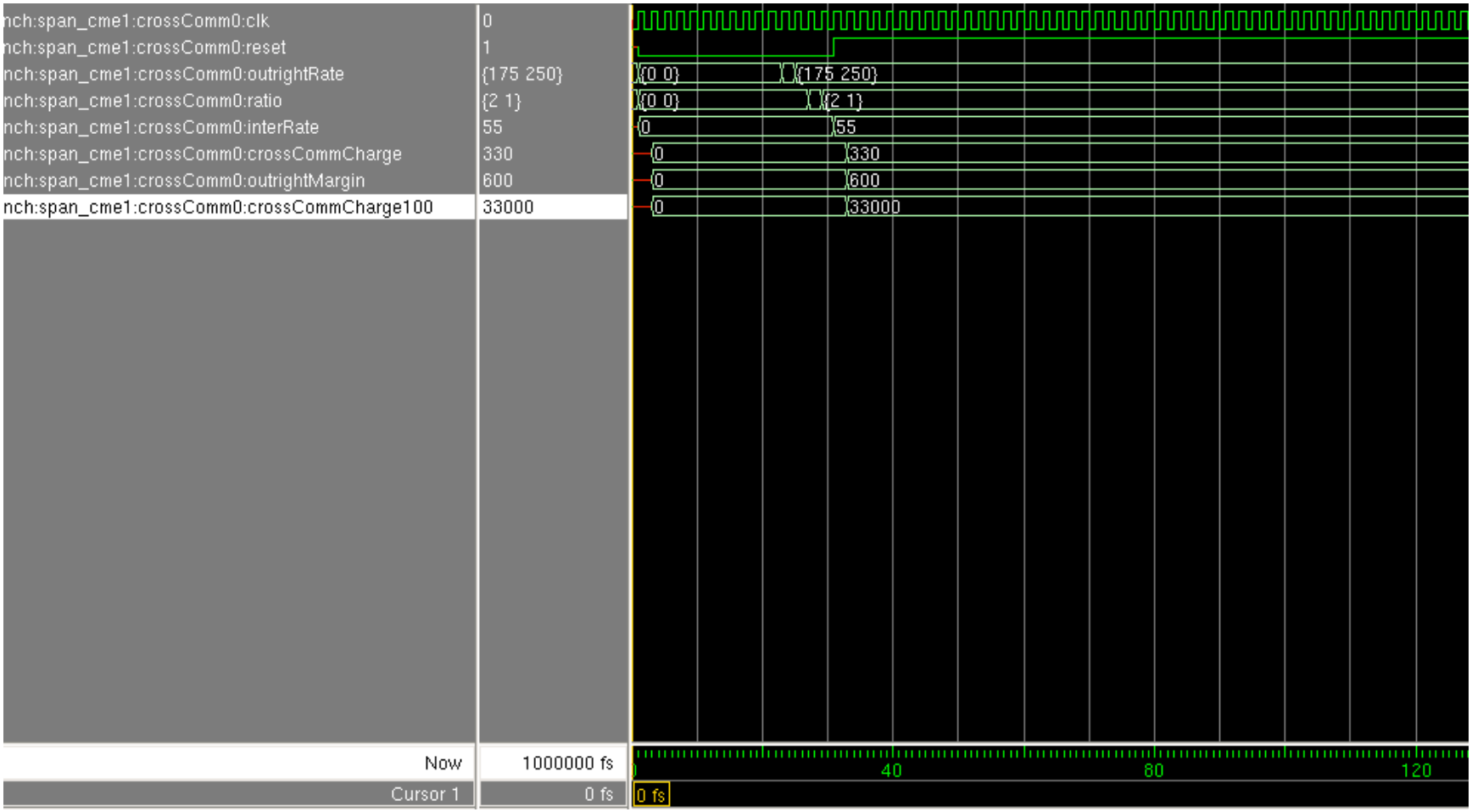
Scanning Risk



Inter Month Spread Charge



Cross Commodity Charge



Optimization in the Code

1) The start signal to Inter Month Spread Charge is sent early, before the entire data has arrived.

2) The Risk parameters are modified such that instead of division we perform left shift.

3) Before the Inter Month Spread Charge is calculated a validation is performed on the formation of spreads, and if no spreads can be formed then spread charge calculation is skipped.

4) If the sum of all the positions is 0 or negative, then the Scanning risk calculation is skipped and the output is set to 0

FPGA Implementation

- Tested in System Console
- Verified that the Initial Margin computed is the same as that obtained from

  -ModelSim

  -C++ Software Implementation

Scanning Risk – 480 $

Inter Month Spread Charge – 2470 $

Cross Commodity Charge - 330 $

Initial Margin Requirement – 2620 $

Advantages over doing on FPGA

- Conventionally done using PC-SPAN, proprietary software.

- **Advantages**

-Speed

-Massive Parallelization of computation

-Easy integration with the existing pre-trade risk checking architecture.

About the Project

- Man Hours invested to get a strong understanding of the algorithm
- Understood the methodology used by other major exchanges – ICE, ASX, HKEx,
- Robust Implementation covering all worst corner cases

Milestones Achieved

- Understood Algorithm
- Implemented the Algorithm in C++
- Implemented the Algorithm in SystemVerilog
- Simulation verified in ModelSim
- Implemented Algorithm on the Board
- Added the Cross Commodity Module for multiple commodities in the portfolio

Lessons Learnt

- Importance of Initial Margin Requirements in the High Frequency Trading Environment
- The implementation of the complex Algorithm in C++ helped a lot in the SystemVerilog Implementation
- Starting to work early on the project gave us an edge to improve the Algorithm and add some extra modules.

Advice to other groups

- Start working early on the project
- Discussing with the Professor helps you get a better understanding of the resources.
- Make sure the sources you are referring to are reliable
- Confirm the implementation of the project at each stage.

Work Distribution

- Pramod Nayak – System Verilog Implementation(InterMonth Spread Charge & Cross Commodity) , Report and Presentation, Debugging Hardware Implementation
- Ankit Pradhan - System Verilog Implementation(Scanning Risk & InterMonth Spread Charge) , Debugging Hardware Implementation, Testing Corner Cases.
- Vidhatre Gathey – System Verilog Implementation(Scanning Risk, InterMonth Spread Charge), Software Testing of the Hardware Implementation
- Bhargav Sethuram- System Verilog Implementation(InterMonth Spread Charge), Software Testing of the Hardware Implementation, Software Model of the Algorithm

Future Work

- Implementing the Algorithm to take into account the options contracts in the portfolio.
- Short Option Minimum module to be included in the SPAN Algorithm for the Options Market.

Thank you !

Questions ?