### [Public] **F-TFM: Accelerating Total Focu**

#### INTRODUCTION

The Total Focusing Method (TFM) is a specialized ultrasound imaging algorithm employed for nondestructive testing in various industries. It finds applications in material science, aerospace, and beyond. The TFM Imaging System utilizes a 01D/2D ultrasonic phased array, incorporating Full/Half Matrix Capture for comprehensive data acquisition. The system also includes a dedicated post-processing processor to enhance the quality of imaging results. This integrated approach makes TFM an effective and versatile solution for precise imaging in non-destructive testing across different sectors, ensuring its relevance in fields such as material science and the aerospace industry.



cusing Method	l on FPGA	<b>OpenHW20</b>	23
<ul> <li>Workflow organization</li> <li>Real-time pixel-wise DLC         <ul> <li>Reduce more than 90% memory access</li> <li>DPP-PIT Dataflow</li> </ul> </li> </ul>	$\begin{tabular}{ c c c c c c c c c c c c c c c c c c c$		
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<ul> <li>F-IFM SO</li> <li>Overall accelerator architecture des</li> <li>Parallel compute units in DPP and PIT mc</li> <li>In-DDR ping-pong buffer.</li> </ul>	ign bdules. Workflow Design Configs Uniter Real-time Colculate (released Phased Array Doteflow Stage 2 Disp Phased Array Doteflow Stage 2 Stream N Image	L design L high-p syster	າ, and p ວerforn n with
Data Pre-processing (DPP) Module Dispatcher FFT+ELE+IFFT+ SUR P-way Compute Units STW Ultrasonic Input Data Ping-pong	Pixel Interpolation (PIT) Module FPGA Combination Batch Controller S-sway Proc. Units J HR BHRW BHRW Adder Tree CR BHRW Configuration DDR	DES I 100 100 100 100 100 100 100	65.3
<ul> <li>Accelerator architecture design</li> </ul>		N	Throu
Data Pre-processing (DPP) Module	row-wise Adder tree BPRW Pixel Interpolation (PT) Module FPGA Combination Bach Controller 5-wey Proc. Units	G NORMAL Format Platform RTX 3080Ti FMC Jetson TX1 F-TFM (Ours) RTX 3080Ti HMC Jetson TX1 F-TFM (Ours)	JZED EI alu-1d 1.00× 1.49× <b>34.13</b> × 1.00× 2.13× <b>67.77</b> ×
TK <sup>2</sup> TK <sup>2</sup> Pway Compute Units		E.	norau

F-TFM Solution ——Hardware Design

**Ping-pong Buffer** 

Ultrasonic Input Data

Output Image Configuration

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## **OpenHW2023**



On board test by AMD KU19P

# R Ξ S U

The F-TFM (Full Total Focusing Method) is

summarized through a comprehensive examination of its algorithm and workflow. This includes an indepth analysis of its efficient accelerator design, encompassing workflow organization, dataflow design, and parameter optimizations. The result is a high-performance and high-efficiency TFM imaging system with notable scalability.



#### NORMALIZED ENERGY EFFICIENCY COMPARISONS

Format	Platform	alu-1d	com-1d	obl-1d	imm-1d	alu-2d	ani-2d
FMC	RTX 3080Ti	$1.00 \times$	1.00  imes	$1.00 \times$	1.00  imes	$1.00 \times$	$1.00 \times$
	Jetson TX1	$1.49 \times$	$0.69 \times$	$1.55 \times$	$0.85 \times$	$1.98 \times$	$1.86 \times$
	F-TFM (Ours)	34.13  imes	f 47.15 imes	<b>19.54</b> imes	46.63  imes	<b>14.26</b> imes	<b>15.32</b> imes
нмс	RTX 3080Ti	$1.00 \times$	$1.00 \times$	$1.00 \times$	$1.00 \times$	$1.00 \times$	$1.00 \times$
	Jetson TX1	2.13  imes	$0.96 \times$	1.90  imes	$0.98 \times$	1.93  imes	$1.85 \times$
	F-TFM (Ours)	$67.77 \times$	$108.20 \times$	$39.95 \times$	<b>147.21</b> imes	<b>26.48</b> imes	$26.86 \times$

**Energy efficiency of F-TFM**